

DCS GUIDE

F-4E PHANTOM II

BY CHUCK

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This document has been created for recreational purposes only. Do not use for training or real life flying.

The author of this document has never had access to restricted or classified documentation on the F-4E Phantom II. The author has never had access to OEM (Original Equipment Manufacturer) data related to the F-4, its armament systems nor its defensive systems. All the information within this document is taken from public documentation (i.e. Heatblur F-4 Wiki) and non-official tutorials (player-made videos on Youtube). The list of references used is listed in Part 20 – Reference Material & Acronyms.

The procedures listed in this document are deliberately simplified for gameplay purposes due to the limitations of the DCS World simulation environment and the limitations of the DCS F-4 module by Heatblur.

This document is merely a free, personal project that is used for entertainment. This document is not meant nor designed to teach someone to fly a real F-4 Phantom.

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The Phantom's History

The **McDonnell Douglas F-4 Phantom II** is an American tandem two-seat, twin-engine, all-weather, long-range supersonic jet interceptor and fighter-bomber that was developed by McDonnell Aircraft for the United States Navy. It entered service with the Navy in 1961, then was adopted by the United States Marine Corps, and the United States Air Force, and within a few years became a major part of their air arms.

In 1952, McDonnell's Chief of Aerodynamics, David Lewis, was appointed by CEO Jim McDonnell to be the company's preliminary design manager. With no new aircraft competitions on the horizon, internal studies concluded the Navy had the greatest need for a new and different aircraft type: an attack fighter. In 1953, McDonnell Aircraft began work on revising its F3H Demon naval fighter, seeking expanded capabilities and better performance. The company developed several projects, including a variant powered by a Wright J67 engine, and variants powered by two Wright J65 engines, or two General Electric J79 engines. The J79-powered version promised a top speed of Mach 1.97.

On 19 September 1953, McDonnell approached the United States Navy with a proposal for the "Super Demon". Uniquely, the aircraft was to be modular, as it could be fitted with one- or two-seat noses for different missions, with different nose cones to accommodate radar, photo cameras, four 20 mm cannon, or 56 FFAR unguided rockets in addition to the nine hardpoints under the wings and the fuselage. The Navy was sufficiently interested to order a full-scale mock-up of the F3H-G/H, but felt that the upcoming Grumman XF9F-9 and Vought XF8U-1 (which would eventually become the F-9F Panther and F-8 Crusader) already satisfied the need for a supersonic fighter.

The McDonnell design was therefore reworked into an all-weather fighter-bomber with 11 external hardpoints for weapons and on 18 October 1954, the company received a letter of intent for two YAH-1 prototypes. On 26 May 1955, four Navy officers arrived at the McDonnell offices and, within an hour, presented the company with an entirely new set of requirements. Because the Navy already had the Douglas A-4 Skyhawk for ground attack and F-8 Crusader for dogfighting, the project now had to fulfill the need for an all-weather fleet defense interceptor. A second crewman was added to operate the powerful radar; designers believed that air combat in the next war would overload solo pilots with information.

Thus, the XF4H-1 prototype was developed. On 25 July 1955, the Navy ordered two XF4H-1 test aircraft and five YF4H-1 pre-production examples. The Phantom made its maiden flight on 27 May 1958 with Robert C. Little at the controls. The aircraft was soon in competition with the XF8U-3 Crusader III. Due to cockpit workload, the Navy wanted a two-seat aircraft and on 17 December 1958 the F4H was declared the winner. There were proposals to name the F4H "Satan" and "Mithras". In the end, the aircraft was given the less controversial name "Phantom II", the first "Phantom" being another McDonnell jet fighter, the FH-1 Phantom.



McDonnell F3H-G/H "Demon" Mockup (1954)
U.S. Navy National Museum of Naval Aviation Photograph



Herman Barkley (Head of Design), Robert Little (Test Pilot) and David Lewis (Chief of Aerodynamics) next to the XF4H-1 Prototype
USAF Photograph

The Phantom's History

The Phantom II was briefly given the designation F-110A and named "Spectre" by the USAF (to fit in with the Air Force's Century Series), but in the end the "F-4" designation was adopted on 18 September 1962 as per the newly introduced Tri-Service aircraft designation system instigated by Robert McNamara.

An initial delivery of Navy-configured F4Hs (re-designated F-4A) were provided for training and evaluation later that year. A total of 45 F-4As were built; none saw combat, and most ended up as test or training aircraft. The Phantom became the F-4 with the **USN naval version designated F-4B** and **USAF version designated F-4C**.

The first Air Force Phantom flew on 27 May 1963, exceeding Mach 2 on its maiden flight. Reconfiguration of the Phantom II for the USAF focused on service-compliant alterations. These included:

- Altering of the landing gear system for higher speed field operations
- Addition of dual flight controls
- Anti-skid implementation
- Conversion to boom refueling compatibility
- Addition of the LN-12 Inertial Navigation System (INS)
- Conversion to the APQ-100 radar with air to ground specific functionality
- A cartridge starting system for field use without a compressed air cart in combination with an internal battery

This F-4C configuration would be the first Phantom used during the USAF's involvement in Vietnam, beginning in December of 1964. Although the F-4C was essentially identical to the Navy/Marine Corps F-4B in-flight performance and carried the AIM-9 Sidewinder missiles,

USAF-tailored **F-4Ds** initially arrived in June 1967 equipped with the infamous AIM-4 Falcon missiles. The performance of the new configuration was quickly met with derision. The AIM-4, like its predecessors, was designed to shoot down heavy bombers flying straight and level. Its reliability proved no better than others and its complex firing sequence and limited seeker-head cooling time made it virtually useless in combat against agile fighters. The employment envelope was too small compared to the Sidewinder, the lead time too long, and the weapon far too unreliable to put into practice in the dynamic maneuvering environment of air combat as it was waged in Southeast Asia. The F-4Ds reverted to using Sidewinders under the "Rivet Haste" program in early 1968, and by 1972 the AIM-7E-2 "Dogfight Sparrow" had become the preferred missile for USAF pilots.



F-4B of VF-41 "Black Aces" Squadron in flight during 1973
US Navy Photograph

The Phantom's History

The program update plan for the **F-4E** variant (yep, the very one simulated for DCS!) intended to have the jet carry the M61A1 Vulcan gun internally and the Westinghouse APQ-120 radar would be selected in January 1968. The APQ-120 was a full solid-state conversion of the APQ-109/117, re-engineered to meet the requirements of the internal cannon installation. The ASG-26A Lead Computing Optical Sighting System was installed along with updated aircrew in-range and shoot warning cues, providing pilots with a clearer picture of the weapons envelopes of the Sparrow and Sidewinder.

The updates to the Echo Phantom would not stop there; compatibility with multi-ejection racks and updates to the Weapon Release Computer to match provided further bombing capabilities, the AGM-65 Maverick was made available in both IR and electro-optical variants, the leading edge of the wings were fitted with slats for increased maneuvering potential, and the Digital Scan Converter Group (DSCG) interface for the APQ-120 was installed. The F-4E's initial deliveries from October of 1967 would align its operational entry with the drawdown of the US' Rolling Thunder bombing campaign over North Vietnam. The type would have to wait until 1972 to put the true extent of the jet's upgrades to the test. With the resumption of the air campaign in February of that year, the E-model Phantom II would fly thousands of missions.

The **F-4J** (updated F-4B version for U.S. Navy and Marine Corps) improved both air-to-air and ground-attack capability; deliveries begun in 1966 and ended in 1972 with 522 built. It was equipped with J79-GE-10 engines with 17,844 lbf of thrust, the Westinghouse AN/AWG-10 Fire Control System (making the F-4J the first fighter in the world with operational look-down/shoot-down capability), a new integrated missile control system and the AN/AJB-7 bombing system for expanded ground attack capability.

The **F-4N** (updated F-4Bs) with smokeless engines and F-4J aerodynamic improvements started in 1972 under a U.S. Navy-initiated refurbishment program called "Project Bee Line" with 228 converted by 1978. The **F-4S** model resulted from the refurbishment of 265 F-4Js with J79-GE-17 smokeless engines of 17,900 lbf, AWG-10B radar with digitized circuitry for improved performance and reliability, Honeywell AN/AVG-8 Visual Target Acquisition Set or VTAS (world's first operational Helmet Sighting System), classified avionics improvements, airframe reinforcement and leading edge slats for enhanced maneuvering.

The Phantom had a remarkably long and eventful operational life. The **F-4G "Wild Weasel" V**, basically a converted F-4E dedicated to SEAD (Suppression of Enemy Air Defences), saw action in the 1991 Gulf War during Operation Provide Comfort and Operation Southern Watch. Its cannon was replaced by the APR-38 RHAW (Radar Homing and Warning System) and later the AN/APR-47. The F-4G was equipped with several ECM (Electronic Countermeasure) pods, an infrared jammer, the AGM-45 Shrike, AGM-78 Standard, and AGM-88 HARM anti-radiation missiles.



F-4E Variant



F-4G with Wild Weasel Payload (AGM-45, AGM-65, AGM-78, and AGM-88), 1981
USAF Photograph

The Phantom's History

The F-4's nine external hardpoints have a capability of up to 18,650 lbs of weapons, including air-to-air and air-to-surface missiles, and unguided, guided, and thermonuclear weapons. Like other interceptors of its day, the early F-4s were designed without an internal cannon… which would become a major issue during its air war over Vietnam. This was rectified with the F-4E's M61A1 Vulcan internal gun.

Despite its imposing dimensions, extensive use of titanium in its airframe and a maximum takeoff weight of over 60,000 lbs, the F-4 has a top speed of Mach 2.23 and an initial climb rate of over 41,000 ft/min. The performance of the Phantom was remarkable for its time and set 16 world records; 5 of its speed records remained unbeaten until the F-15 Eagle appeared in 1975. The baseline performance of the F-4, a Mach 2-class fighter with long range and a bomber-sized payload, would become the template for the next generation of large and light/middle-weight fighters optimized for daylight air combat.

"Speed is life" was F-4 pilots' slogan, as the Phantom's greatest advantage in air combat was acceleration and thrust, which permitted a skilled pilot to engage and disengage from the fight at will. MiGs usually could outturn the F-4 because of the high drag on the Phantom's airframe; as a massive fighter aircraft designed to fire radar-guided missiles from beyond visual range, the F-4 lacked the agility of its Soviet opponents and was subject to adverse yaw during hard maneuvering. Although the F-4 was subject to irrecoverable spins during aileron rolls, pilots reported the aircraft to be very responsive and easy to fly on the edge of its performance envelope.

In the United States, the aging Phantom II was eventually outclassed by the more modern "Teen Series" fighter jets; the F-4 was officially retired from US service in 1996. The F-4 was replaced by the F-15 Eagle (USAF), F-16 Fighting Falcon (USAF), F-14 Tomcat (USN) and the F/A-18 Hornet (USN, USMC).





The Vietnam War

In the early phases of the Vietnam War, the USAF and the US Navy had high expectations of the F-4 Phantom, assuming that the massive firepower, the best available on-board radar, the highest speed and acceleration properties, coupled with new tactics, would provide Phantoms with an advantage over the MiGs. However, in confrontations with the lighter MiG-21, F-4s did not always succeed and began to suffer losses.

Doctrine initially held that turning combat would be impossible at supersonic speeds and little effort was made to teach pilots air combat maneuvering. In reality, engagements quickly became subsonic, as pilots would slow down in an effort to get behind their adversaries. Furthermore, the relatively new heat-seeking and radar-guided missiles at the time were frequently reported as unreliable and pilots had to fire multiple missiles just to hit one enemy fighter. To compound the problem, rules of engagement in Vietnam precluded long-range missile attacks in most instances, as visual identification was normally required. Many pilots found themselves on the tail of an enemy aircraft, but too close to fire short-range Falcons or Sidewinders. This eventually forced the creation of training programs dedicated to mastering the art of air combat maneuvering (Top Gun, anyone?).

One of the most successful uses of the F-4 was during **Operation Bolo**, a daring mission against the VPAF. On 2 January 1967, **Colonel Robin Olds**' Phantoms of the 8th Tactical Fighter Wing (TFW) ambushed Vietnamese MiG-21s. How? By flying a route typically used by US bombers during Operation Rolling Thunder, drawing MiGs expecting to find heavily loaded fighter-bombers like the F-105 Thunderchief... but instead facing much more agile F-4Cs. F-4 pilots claimed seven Vietnamese MiG-21s without suffering any losses (although, Vietnamese records show five MiGs being lost). The battle prompted VPAF pilots and strategists, as well as Soviet tacticians, to re-evaluate the tactics and deployment of the MiG-21. The story behind this operation is fascinating, especially considering how the ambush was planned and executed.

Over the course of the air war in Vietnam, between 3 April 1965 and 8 January 1973, each side would ultimately claim favorable kill ratios. Overall, F-4 pilots were credited with a total of 150+1⁄2 MiG kills at a cost of 42 Phantoms in air-combat.

- U.S. Navy F-4 Phantoms claimed 40 air-to-air victories at a loss of seven Phantoms to enemy aircraft.
- USMC F-4 pilots claimed three enemy MiGs at the cost of one aircraft in air-combat.
- USAF F-4 Phantom crews scored 107+1⁄2 MiG kills (including 33+1⁄2 MiG-17s, eight MiG-19s and 66 MiG-21s) at a cost of 33 Phantoms in air-combat.



Colonel Robin Olds preflights his F-4C Phantom Ubon Air Base, Thailand, September 1967
Official USAF Photograph, USAF Museum

Fighting in the Phantom

The F-4 has often been compared to its Soviet counterpart: the MiG-21. The MiG-21 with a good pilot was a tough fight for any of its 1960's contemporaries; it was small and very hard to see head on (its silhouette being difficult to acquire visually at any great distance), and it had a very good first turn rate. In a turning fight, the big burly Phantom was definitely at a disadvantage since it was almost twice as heavy… F-4 pilots had to use their aircraft's power and acceleration in the vertical plane like an energy fighter. These differences boil down to drastically different design philosophies: the MiG-21 was meant to be a nimble short-range interceptor, while the Phantom was a better-armed long-range aircraft that could perform a greater variety of missions.

Here are a few pointers when it comes to compare these two adversaries in terms of flight characteristics :

- The F-4 has less instantaneous energy available than the MiG-21 at any speed below G limits. The F-4 has a larger turn radius and lower turn rate at any speed below the MiG-21 G limits.
- The F-4 cannot successfully turn close-in at medium to slow speeds against an aggressively flown MiG-21.
- The F-4 has superior zoom performance up to 32000 ft compared to the MiG-21.
- The F-4 has a higher sustained G capability than the MiG-21 below 16000 ft at speeds above 425 kts.
- The F-4 has superior longitudinal control response above 510 kts below 16000 ft compared to the MiG-21, limited by the design of its longitudinal control system limiting available G in these conditions. Full aerodynamic control of the F-4 is available up to 750 kts.
- The F-4 has significantly higher G limits than the MiG-21 below 16000 ft. The F-4 has an airspeed limit of 750 kts below 30000 ft and 710 kts (or Mach 2.1) above 30000 ft. The MiG-21has a maximum allowable airspeed of 595 kts below 16000 ft.

In other words, dictating the conditions of the fight meant fighting on your own terms, which allows you to leverage the strengths and weaknesses of each aircraft in your favor. Keep in mind that Phantom crews also have the benefit of having two pairs of eyes instead of one, which can provide superior situational awareness to a well-trained crew.



Pardo's Push

Here is a fun bit of Phantom trivia. During the Vietnam War, a rather unusual aviation maneuver was carried out by then-Captain (Lt Col USAF Ret) John R. "Bob" Pardo.

In March 1967 Captain Bob Pardo (with WSO 1st Lt Steve Wayne) and wingman Captain Earl Aman (with WSO 1st Lt Robert Houghton), they were trying to attack a steel mill in North Vietnam just north of Hanoi. Both F-4s were hit by anti-aircraft fire. Aman's plane took the worst damage; his fuel tank had been hit, and he quickly lost most of his fuel. Aman and Houghton then determined that they did not have enough fuel to make it to a KC-135 tanker aircraft over Laos.

To avoid having Aman and Houghton bail out over hostile territory, Pardo decided to try pushing the airplane. Pardo first tried pushing the plane using Aman's drag chute compartment but turbulence interfered. Pardo then tried to use Aman's heavy duty tailhook to push the plane against Pardo's windscreen. Incredibly, the push worked, reducing the rate of descent considerably, but the tailhook slipped off the windscreen every 15 to 30 seconds, and each time Pardo had to reposition his plane to do it again. Pardo also struggled with a fire in one of his own engines and eventually had to shut it down. In the remaining 10 minutes of flight time, Pardo used the one last engine to slow the descent of both planes.

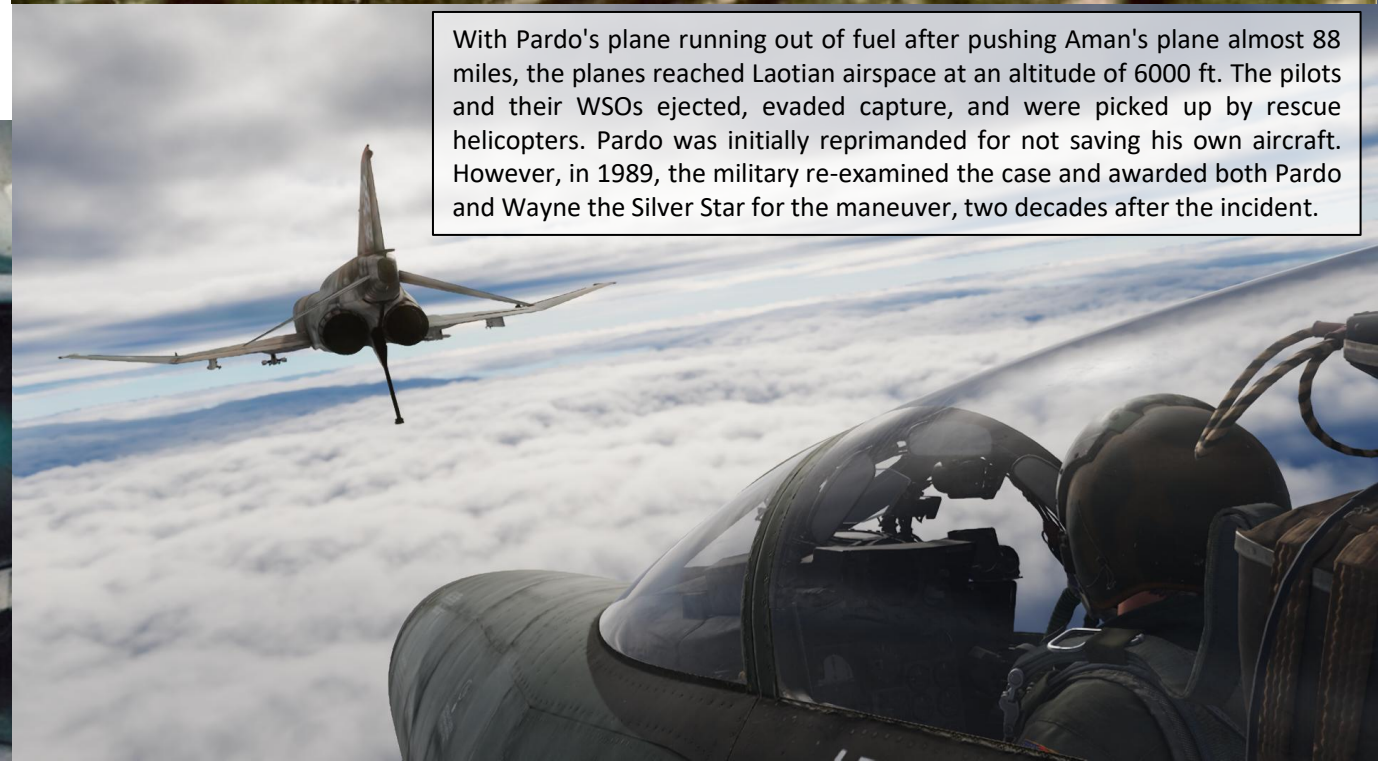


Bob Pardo and Stephen A. Wayne
After Wayne's 100th combat mission
U.S. Air Force



Painting depicting the Pardo Push
S.W. Ferguson, Luke Air Force Base

With Pardo's plane running out of fuel after pushing Aman's plane almost 88 miles, the planes reached Laotian airspace at an altitude of 6000 ft. The pilots and their WSOs ejected, evaded capture, and were picked up by rescue helicopters. Pardo was initially reprimanded for not saving his own aircraft. However, in 1989, the military re-examined the case and awarded both Pardo and Wayne the Silver Star for the maneuver, two decades after the incident.



F-4 Variants

A total of 5195 Phantoms were built from 1958 to 1981, making it the most-produced American supersonic military aircraft in history and a signature combat aircraft of the Cold War. While its production officially ended in the United States in 1979, the very last Phantom was built by Mitsubishi on 20 May 1981 with its 127th F-4EJ (Serial 17-8440).

The Phantom variant currently simulated in DCS is the F-4E Block 45-MC. This is a "classic era" F-4E which includes blocks 36 through 45 with updates retrofitted in 1974 and before (including new slats, DSCG and AGM-65 Maverick missile).

Of all Phantom models, the F-4E was the most numerous version that has been built (1370 units). The F-4E Phantom II is still in service at some operators across NATO including the Hellenic Air Force, the South Korean Air Force and the Turkish Air Force. They are expected to fly at least until 2030.

F-4 Production Numbers for Major Versions

*(Asterisk * indicates converted from other version)*

Variant	Aircraft Built	Variant	Aircraft Built
F-4A	45	**F-4F (Germany)**	175
F-4B	649	**F-4G Wild Weasel**	134*
RF-4B	46	**F-4J**	522
F-4C	583	**F-4J Phantom F.3 (RAF)**	15*
RF-4C	503	**F-4K Phantom FG.1 (FAA)**	50
F-4D	825	**F-4M Phantom FGR.2 (RAF)**	116
F-4E	1370	**F-4N**	228*
F-4E 2020 (Turkey)	54*	**F-4S**	302*
F-4EJ (Japan)	140		
RF-4E	149		
RF-4EJ (Japan)	15*		

F-4 Variant Overview

Variant	Description	Base Variant	First Flight
A	Prototype and pre-production model		1958
B	First production ready model for the US Navy	A	1961
C	Several improvements for more effective use by the USAF	B	1963
D	Modernization and improved air-to-ground capabilities	C	1965
E	Further improvements, better radar and nose gun	D	1965
F	Slimmed down export variation use by Germany	E	1973
G	Wild Weasel upgrade to locate and fight SAM systems	E	1976
J	US Navy variation for carrier operation	B	1966
K	UK Royal Navy (Fleet Air Arm) variation with a different engine (Rolls-Royce Spey Turbofan)	J	1966
M	UK Royal Air Force variation with a different engine (Rolls-Royce Spey Turbofan)	J	1966
N	Modernized systems and structural improvements	B	1970
S	Modernized systems and smoke-free engines	J	1977
RF	Several Phantom variants modified for reconnaissance	B, C, E	
QF-4	Retrofitted as remote-controlled target droned for research	Many	

USN/USMC vs USAF Phantoms

Being operated by the USN, USMC and USAF branches, the Phantom had to perform different missions. The Navy's focus was on air-to-air interception in the Fleet Air Defense mission, while the USAF emphasized both an air-to-air and an air-to-ground fighter-bomber role.

Navy crews flew the Phantom with a Naval Aviator (pilot) in the front seat and a naval flight officer as a radar intercept officer (RIO) in the back seat, which did not have any flight controls. Navy fighter pilots were not used to flying with a non-pilot RIO, but learned from air combat in Vietnam the benefits of the GiB "guy in back" or "voice in the luggage compartment" helping with the workload. Navy Phantoms (F-4B/J/S) had a stronger landing gear for naval operations and aircraft carrier landings, and their primary roles were engaging enemy aircraft and providing support for naval operations. Air refueling was done with a probe and drogue refueling system and a retractable probe to the right of the rear cockpit.

Unlike the U.S. Navy and U.S. Marine Corps, the **USAF** initially flew its Phantoms with a rated Air Force Pilot in both the front and back seats (which had a set of flight controls). Pilots usually did not like flying in the back seat; while the "guy in back" could fly and ostensibly land the aircraft, he had fewer flight instruments and a very restricted forward view. The Air Force later assigned a rated Air Force Navigator qualified as a weapon/targeting systems officer (later designated as weapon systems officer or WSO) in the rear seat instead of another pilot. The main roles of USAF Phantoms (F-4C/D/E) were air superiority, ground attack, and reconnaissance. Air refueling was done with a flying boom air refueling system, with a receptacle on the spine of the fuselage.

As an interesting side note, the Phantom was the only aircraft ever used by both U.S. flight demonstration teams: the United States Air Force Thunderbirds (F-4E) and the United States Navy Blue Angels (F-4J).





USAF F-4E Thunderbirds

Upgrades

Later F-4E variants came equipped with new upgrades, including DMAS, TISEO and the AN/AVQ-26 Pave Tack targeting pod ***(not available yet in DCS)***.

The **DMAS** (*Digital Modular Avionics System*) was a complete replacement of the Phantom's navigation computer, inertial navigation set, and the WRCS (Weapon Release Computer Set), which used LORAN (Long Range Navigation) radio signals to accurately define the aircraft's position anywhere in the world. The inclusion of DMAS provided a substantial improvement in the F-4E's navigation options and weapon release precision, and an expansion of the Phantom's delivery mode capabilities.

The **TISEO** (*Target Identification System Electro-Optical*) was a passive infrared sensor, designed to detect and track targets at night and in adverse weather conditions. The system consisted of a 4x/10x camera installed in the left wing. It provided visual identification of distant, radar-locked targets, enabling the AIM-7 Sparrow to be used to its full extent when combined with the APX-80 IFF system. Crews could now independently confirm two ID (identification) factors before the merge, entering the fight with more of an advantage - even if they would not be cleared to fire beyond visual range.





TISEO on a F-4E of the 335th TFS
TSGT Ken Hammond, USAF

Phantom Operators

The F-4E's foreign service was not merely a chapter in the history of US military aviation… it was a saga that also unfolded across continents and through the corridors of foreign geopolitical power.

The first nation to receive the F-4E on export, **Israel**, designated it ”**Kurnass” (Sledgehammer)**. It would see combat with the IAF within months of delivery, seeing multiple kills in the war of attrition against Egypt and skirmishes with Syria. The 1973 Yom Kippur War would see the Phantom acquit itself spectacularly, downing 85 Arab aircraft in exchange for 5 lost in air combat. The Kurnass would ultimately receive a number of vital upgrades to keep the type viable beginning in 1987, with the installation of the APG-76 radar, a new mission computer and HUD, and the ability to deliver the Popeye air to surface missile. The IAF would ultimately receive between 212 and 222 F-4Es. The last Israeli F-4s were retired in 2004.

Australia would be the second import customer for the F-4E, but only on a limited time basis. Twenty-four F-4Es were provided to the RAAF on a lease basis by the United States as a stopgap measure due to delays in deliveries of the F-111C. The F-4E would operate in Australian service for just three years, beginning in September of 1970 to 1973.

With permission of the US State Department and license terms with McDonnell Douglas, Mitsubishi Heavy Industries would build the F-4E locally in **Japan**, designated as the **F-4EJ**. The F-4EJ would be provided compatibility with Japanese built weapons, but the omission of the refueling probe and AJB-7 bombing computer due to treaty restrictions on the JASDF. The F-4EJ was updated as the **“Kai**” in 1984, receiving the APG-66J radar and anti-shipping missiles. The F-4EJ would serve Japan over 40 years, with the final examples being withdrawn in March of 2021.



IAF F-4E ”Kurnass”



JASDF F-4EJ ”Kai”

Phantom Operators

Greece's initial **F-4E** deliveries for the Hellenic Air Force (HAF) began in 1974, with annual deliveries stopped due to politics in 1981. The HAF's combined Phantom II force topped out at 121 airframes purchased (F-4E and RF-4E), with reinforcement stocks of former USAF jets bringing that number to is final value in the post-Desert Storm drawdown. Upgrades by DASA to Greek Phantoms has been extensive, and was built around a similar model to the Luftwaffe's F-4F ICE. Most notably, the HAF F-4E has received the APG-65 for AMRAAM (including a replacement digital BUS), HUD, and LITENING pod compatibility. The HAF Phantoms have also received specific upgrades based on their intended squadron roles, with inertial navigation replacement and GPS inclusion for those specializing in the air to surface role. Greece currently retains over 30 Phantoms on active duty.

Turkey's Phantom service has been extensive, with over 160 F-4Es procured (along with an additional 60+ RF-4Es), beginning in 1974. Deliveries of Phantoms have been both new build and former USAF, and in the mid-90s, Israeli Aerospace Industries (IAI) was tapped to bring them into the next century. Based around a proposed upgrade program for the IAF, the **F-4E "Terminator 2020"** deleted over 1600 lbs of excess weight from the aircraft by wiring and hydraulic system replacements, integrated the Elta M-2032 radar, a full HOTAS (Hands-On-Throttle-And-Stick) implementation, MFDs (Multi-Function Displays), a true HUD (Heads-Up Display), and extensive weapons systems updates, Popeye and GBU integration, as well as the LITENING II targeting pod. The Turkish Air Force intends to maintain the remaining 30 or so airframes in service until the mid-2030s.

First receiving the **F-4E** in 1971, **Iran**'s IIAF (Imperial Iranian Air Force) received 177 F-4Es through various delivered batches into the late 1970s. In the aftermath of the Iranian Revolution, now-IRIAF (Islamic Republic Iranian Air Force) F-4Es heavy action in the 1980's against the Iraqi forces of Saddam Hussein during the Iran-Iraq war. Interestingly, Iranian F-4s were kept operational by overhaul and servicing from Iran's aerospace industry . The first raid on the Osirak Nuclear Plant in September of 1980 was performed by four F-4Es, damaging the reactor and control facilities; this raid preempted the more famous IAF (Israeli Air Force) attack on the same facility that destroyed it permanently. In like fashion, April of 1981 saw F-4E's as the primary strike aircraft during the raid on all three airfields of the H-3 complex in western Iraq. The conflict with Iraq came at substantial cost to both airframes and crews, with western weapons embargoes severely limiting the ability of the IRIAF to maintain the Phantom II effectively. By the end of the war, even local estimates put the available number of flyable F-4s below four dozens. While local industry attempted to revitalize the Phantom in the aftermath of the conflict, current evaluations put their total F-4 force near 60, between their remaining F-4D, F-4E, and RF-4Es.



Turkish (TuAF) and Greek (HAF) F-4Es



IRIAF F-4E

Phantom Operators

The West German Air Force (*Luftwaffe*) found itself in need of numerous new aircraft following the December 1967 publication of NATO's new flexible response doctrine. **West Germany** was primarily an F-4F and RF-4E customer and the largest F-4 export recipient with 263 delivered overseas. Germany would also purchase 10 F-4Es to be based in the United States for the type conversion of their aircrews training alongside USAF units. German Air Force F-4Fs flew 279000 hours from entering service on 31 August 1973 until retirement on 29 June 2013.

A long time F-4 recipient, **South Korea** supplanted its force of F-4Ds with brand new **F-4E**s beginning in 1977, ultimately purchasing a total of 103. South Korea was the recipient of the final US built F-4 Phantom, 78-0744, in October of 1979. The RoKAF retained the F-4E in service until its withdrawal in June 2024.

The final **F-4E** export customer, **Egypt**, received purchasing rights through its peace treaty with Israel and the Peace Pharaoh agreement; rather than new build airframes, Egypt received 35 former USAF aircraft. The Phantom was ultimately a precursor towards the nation's purchase of the F-16, and went through initial difficulties in servicing by their maintenance crews. McDonnell Douglas advisors aided the Egyptian squadrons to get their operational ready rates back up to standard, and the Phantom II went on to serve the EAF into the late 90s. Egyptian Air Force (EAF) F-4Es were retired in 2020, with their former base at Cairo West Air Base being reconfigured for the operation of F-16C/D.



EAF F-4F



Luftwaffe F-4F

Republic of Korea Air Force F-4D Phantom II at Daegu Air Base, 1979
TSgt. Don C. Sutherland, USAF



The Phantom's Legacy

The F-4 has become an icon of the Vietnam War and the archetype of the third-generation jet fighter designs that entered service in the 1960s. However, its record in air-to-air combat has left it with a reputation of being a clumsy bruiser reliant on brute engine power and obsolete weapons technology. Keep in mind that these flaws were gradually ironed out in the 1970s and 1980s with upgrades throughout its long operational life. The aircraft is (grudgingly) admired as brutally effective by those who have flown it. Colonel (Ret.) Chuck DeBellevue allegedly once said that "*the F-4 Phantom was the last plane that looked like it was made to kill somebody. It was a beast. It could go through a flock of birds and kick out barbecue from the back*."

There is a whole mythology around the Phantom, as it earned a number of rather colorful nicknames during its career. Some of these names included "Snoopy", "Rhino", "Double Ugly", "Old Smokey", the "Flying Anvil", "Flying Footlocker", "Flying Brick", "Lead Sled", the "Big Iron Sled", and the "St. Louis Slugger" (owing to it being produced in St. Louis). In recognition of its record of downing large numbers of Soviet-built MiGs, it was often referred as the "World's Leading Distributor of MiG Parts". As a reflection of excellent performance in spite of its bulk, the F-4 was dubbed "the triumph of thrust over aerodynamics". German Luftwaffe crews called their F-4s the *Eisenschwein* ("Iron Pig"), *Fliegender Ziegelstein* ("Flying Brick") and *Luftverteidigungsdiesel* ("Air Defense Diesel"). In the RAF it was most commonly referred to as "The Toom", whilst the Turkish Air Force crewmen nicknamed it as *Baba* ("Father").

Needless to say, this jet left quite an impression its crews. Plenty of great books have been written about it. "Palace Cobra" by Ed Rasimus remains one of my favourite reads to this day.

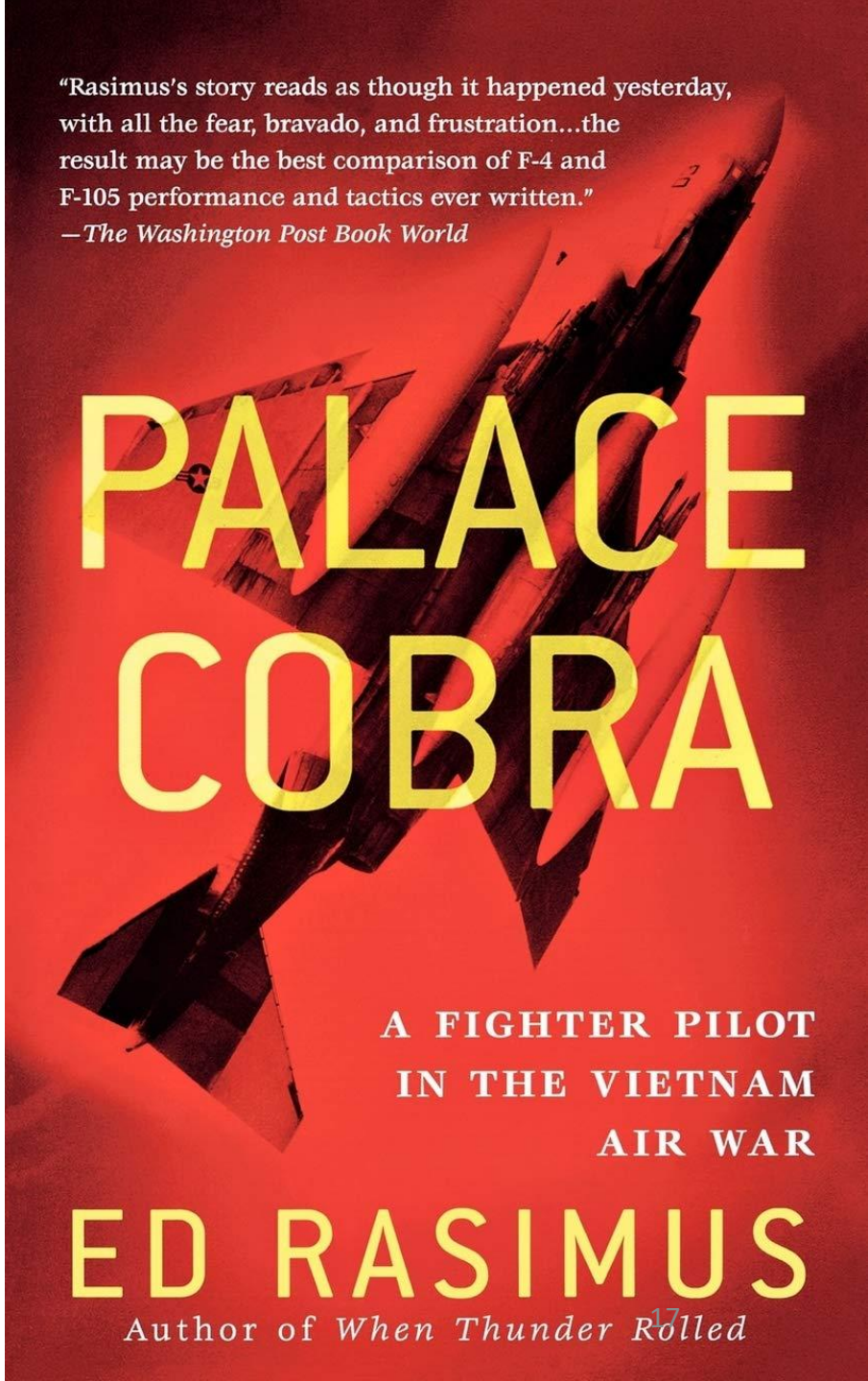
Imitating the spelling of the aircraft's name, McDonnell issued a series of patches. Pilots became "Phantom Phlyers", backseaters became "Phantom Pherrets", fans of the F-4 "Phantom Phanatics", and call it the "Phabulous Phantom". Ground crewmen who worked on the aircraft are known as "Phantom Phixers".

The aircraft's emblem is a whimsical cartoon ghost called "The Spook", which was created by McDonnell Douglas technical artist Anthony "Tony" Wong for shoulder patches.





Captain Charles B. "Chuck" DeBellevue
One of only five Americans to achieve flying ace status during the Vietnam War and the first as a USAF WSO



On a Personal Note

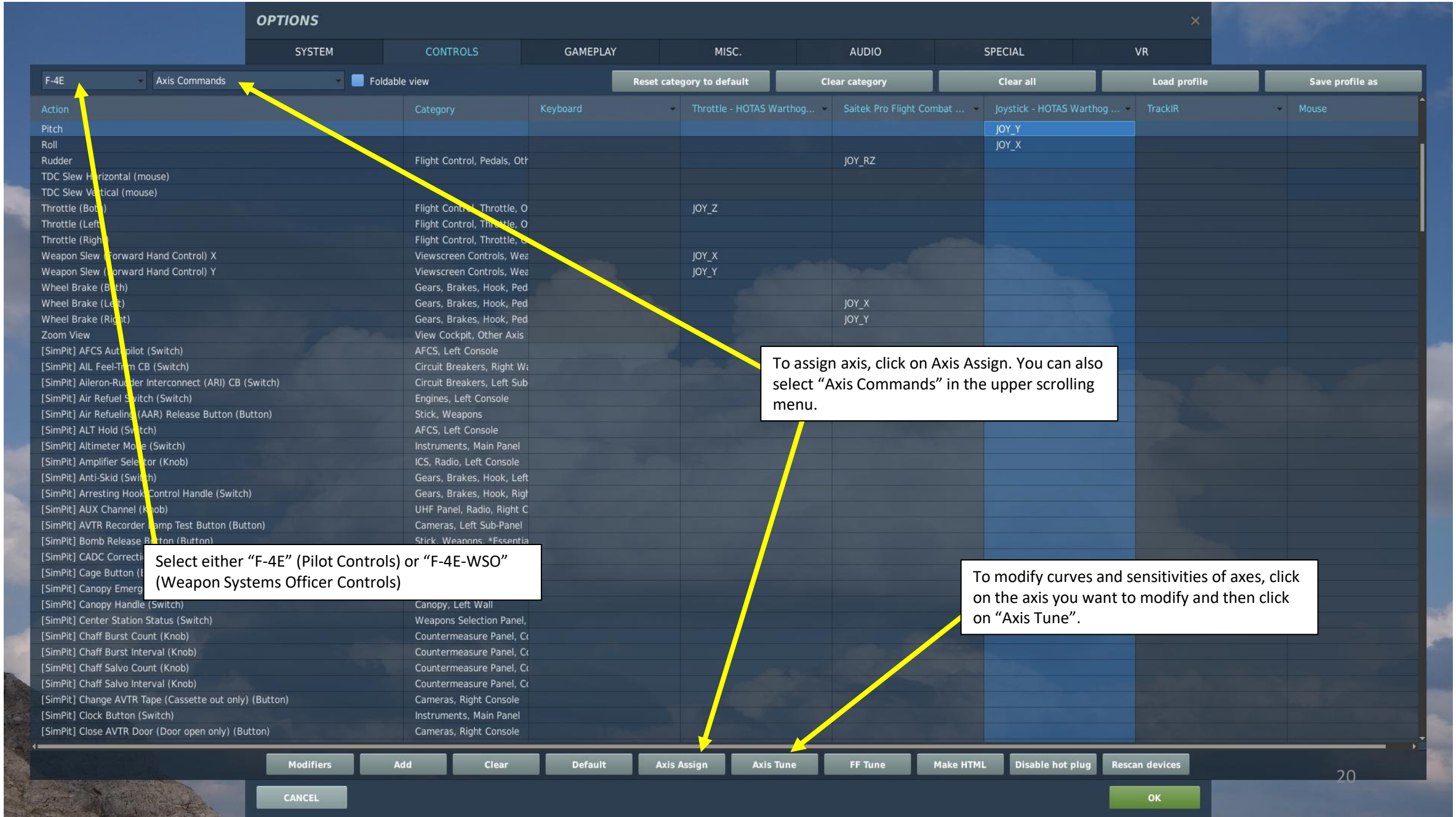
The F-4 Phantom II is an interesting piece of aviation history. This aircraft bridged the gap between the first jets of the 1950's and today's modern multirole fighters bristling with fancy smart weapons and arrays of intuitive sensors with pinpoint accuracy. Avionics were still their infancy, and as new technologies improved at breakneck speed with the increasing tensions of the Cold War, the F-4 was the perfect test bed to integrate them. The Phantom II was more than a flying brick propelled by ungodly amounts of sheer power with wonky gizmos strapped to the airframe… it pushed the boundaries of what was feasible. Air forces around the world had to re-evaluate their reliance on outdated doctrines, pilots had to re-learn the art of air combat, and it rapidly became apparent that war in the air was fought with more than mere capabilities at the end of a stick; pilots and WSOs were just as invaluable to the success of a mission as proper training… or as the necessity to constantly adapt to the ever-increasing danger of modern warfare.

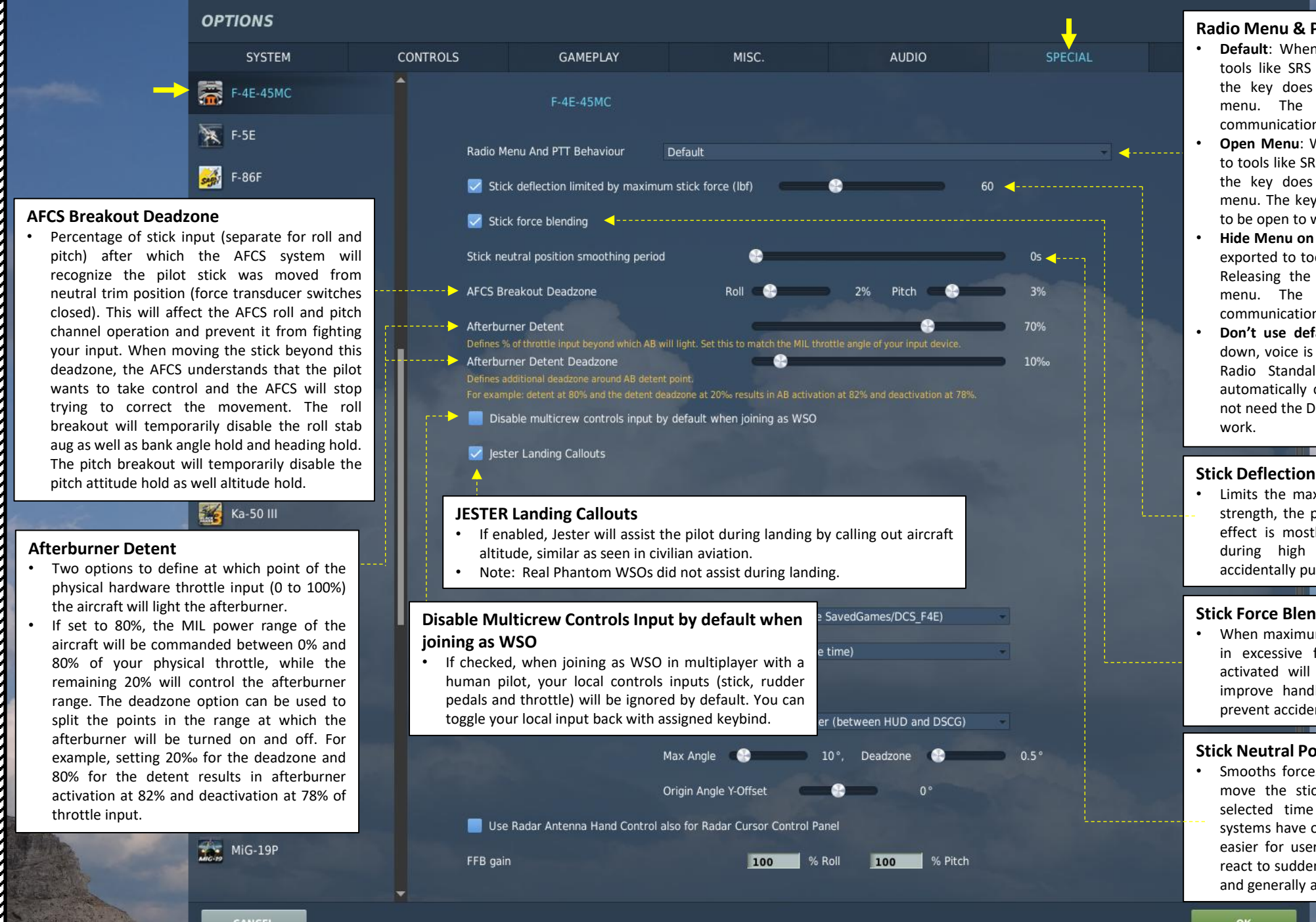
This guide means a lot to me. This legendary aircraft embodies so much of what I grew up loving about airplanes and engineering. You will strap yourself in this clunky, wobbly hunk of cramped panels, analog gauges, hard-to-reach switches, buzzing CRTs (Cathode Ray Tube) and occasionally unreliable indications. You will find yourself gasping for air during engine flameouts, laughing like a lunatic when you manage to blast a MiG out of the sky with a heater, curse like a sailor when the fuselage rattles through heavy turbulence… the F-4 will make you feel many things, some of which I will let you discover for yourself. Heatblur Simulations did a truly "phantastic" job with their DCS F-4E Phantom II, and I sincerely hope this guide can do their hard work justice. Enjoy the read!





Note: In your controls, make sure you check your “Trim” controls since the default version of the game has your trim hat set to changing your view rather than trim the aircraft. Since most of you are probably equipped with a TRACKIR already, I suggest you make sure the Trim Hat Switch is set up properly.





AFCS Breakout Deadzone

- Percentage of stick input (separate for roll and pitch) after which the AFCS system will recognize the pilot stick was moved from neutral trim position (force transducer switches closed). This will affect the AFCS roll and pitch channel operation and prevent it from fighting your input. When moving the stick beyond this deadzone, the AFCS understands that the pilot wants to take control and the AFCS will stop trying to correct the movement. The roll breakout will temporarily disable the roll stab aug as well as bank angle hold and heading hold. The pitch breakout will temporarily disable the pitch attitude hold as well altitude hold.

Afterburner Detent

- Two options to define at which point of the physical hardware throttle input (0 to 100%) the aircraft will light the afterburner.
- If set to 80%, the MIL power range of the aircraft will be commanded between 0% and 80% of your physical throttle, while the remaining 20% will control the afterburner range. The deadzone option can be used to split the points in the range at which the afterburner will be turned on and off. For example, setting 20‰ for the deadzone and 80% for the detent results in afterburner activation at 82% and deactivation at 78% of throttle input.

JESTER Landing Callouts

- If enabled, Jester will assist the pilot during landing by calling out aircraft altitude, similar as seen in civilian aviation.
- Note: Real Phantom WSOs did not assist during landing.

Disable Multicrew Controls Input by default when joining as WSO

- If checked, when joining as WSO in multiplayer with a human pilot, your local controls inputs (stick, rudder pedals and throttle) will be ignored by default. You can toggle your local input back with assigned keybind.

Radio Menu & PTT (Push-to-Talk) Behaviour

- **Default**: When pressed down, voice is exported to tools like SRS (Simple Radio Standalone). Releasing the key does not automatically close DCS comm menu. The key does not need the DCS communication menu to be open to work.
- **Open Menu**: When pressed down, voice is exported to tools like SRS (Simple Radio Standalone). Releasing the key does not automatically close DCS comm menu. The key needs the DCS communication menu to be open to work.
- **Hide Menu on Release**: When pressed down, voice is exported to tools like SRS (Simple Radio Standalone). Releasing the key automatically closes DCS comm menu. The key does not need the DCS communication menu to be open to work.
- **Don't use default PTT (No Export):** When pressed down, voice is not exported to tools like SRS (Simple Radio Standalone). Releasing the key does not automatically close DCS comm menu. The key does not need the DCS communication menu to be open to work.

Stick Deflection Limited by max stick force (lbf)

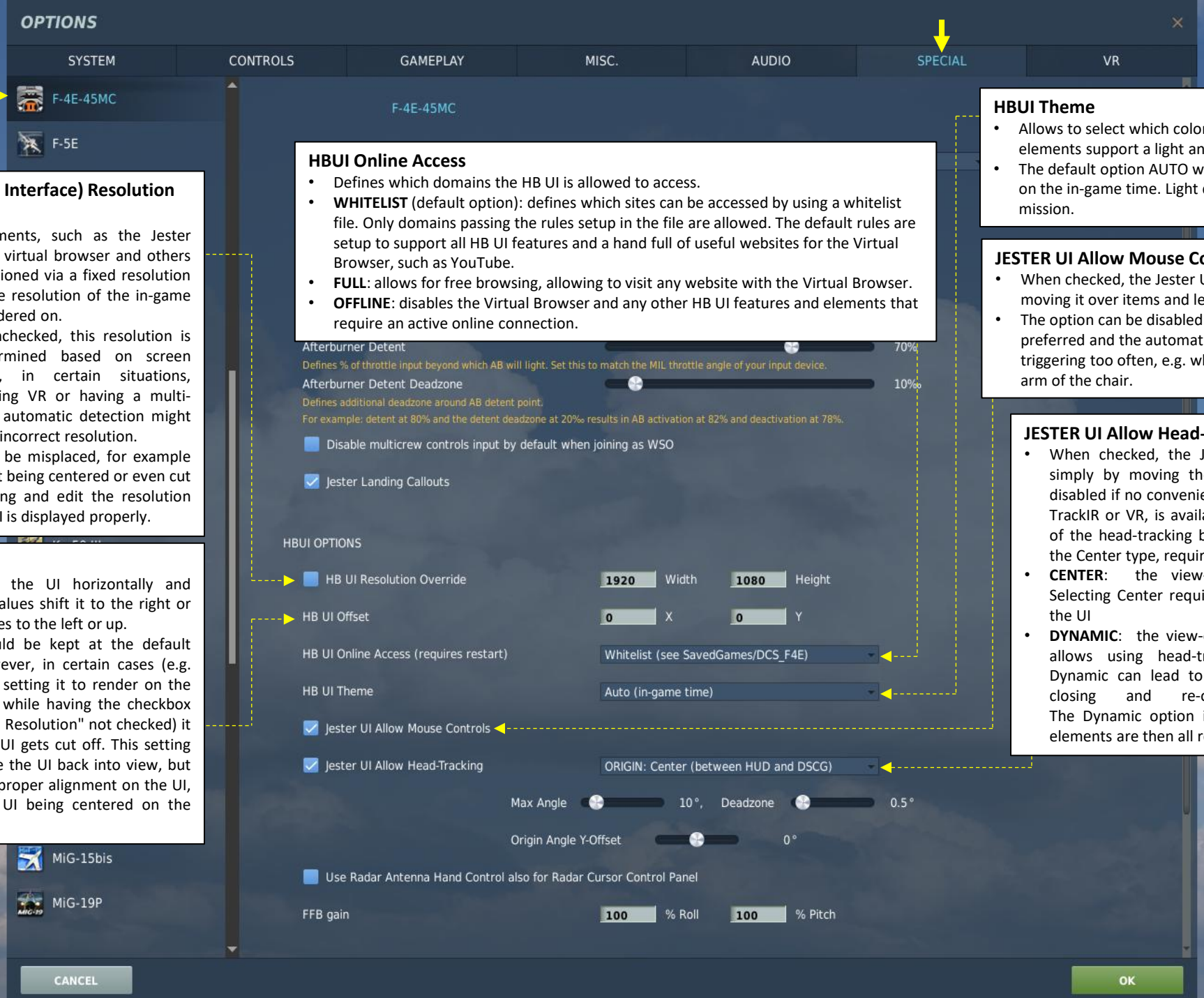
- Limits the maximum force in lbf (Pound-Force), i.e. strength, the pilot is able to pull the stick with. This effect is mostly seen when controlling the aircraft during high G maneuvers and can prevent accidentally pulling extreme Gs.

Stick Force Blending

- When maximum movement of the stick would result in excessive forces being generated, having this activated will scale down the generated force to improve handling precision, but also can help to prevent accidentally pulling extreme Gs.

Stick Neutral Position Smoothing Period

- Smooths forces applied by the aircraft systems that move the sticks neutral position. The higher the selected time period, the less impact do these systems have on the sticks movements. This makes it easier for users of non-force-feedback hardware to react to sudden changes of the sticks neutral position and generally achieve more stable flight.



HBUI (Heatblur User Interface) Resolution Override

- User interface elements, such as the Jester Wheel, the manual, virtual browser and others are scaled and positioned via a fixed resolution that must match the resolution of the in-game surface they are rendered on.
- With the option unchecked, this resolution is automatically determined based on screen settings. However, in certain situations, especially when using VR or having a multi-monitor setup, this automatic detection might fail and compute an incorrect resolution.
- Should UI elements be misplaced, for example the Jester Wheel not being centered or even cut off, check this setting and edit the resolution manually until the UI is displayed properly.

HBUI Offset

- Allows to displace the UI horizontally and vertically. Positive values shift it to the right or down, negative values to the left or up.
- Normally, this should be kept at the default value of 0 px. However, in certain cases (e.g. when using VR and setting it to render on the LEFT or RIGHT eye, while having the checkbox for "Use DCS System Resolution" not checked) it is possible that the UI gets cut off. This setting then allows to move the UI back into view, but therefore giving up proper alignment on the UI, such as the Jester UI being centered on the screen.

HBUI Online Access

- Defines which domains the HB UI is allowed to access.
- **WHITELIST** (default option): defines which sites can be accessed by using a whitelist file. Only domains passing the rules setup in the file are allowed. The default rules are setup to support all HB UI features and a hand full of useful websites for the Virtual Browser, such as YouTube.
- **FULL**: allows for free browsing, allowing to visit any website with the Virtual Browser.
- **OFFLINE**: disables the Virtual Browser and any other HB UI features and elements that require an active online connection.

HBUI Theme

- Allows to select which color theme is used by the UI. All UI elements support a light and a dark theme.
- The default option AUTO will pick the theme dynamically based on the in-game time. Light during the day and Dark for a night mission.

JESTER UI Allow Mouse Controls

- When checked, the Jester UI allows interaction with the mouse moving it over items and left clicking.
- The option can be disabled if for example only head-tracking is preferred and the automatic mouse detection is perhaps triggering too often, e.g. when having placed the mouse on the arm of the chair.

JESTER UI Allow Head-Tracking

- When checked, the Jester UI allows moving the cursor simply by moving the in-game character head. Can be disabled if no convenient head-tracking equipment, such as TrackIR or VR, is available. The dropdown allows selection of the head-tracking behavior. JESTER Dialogs always use the Center type, requiring to look forward.
- **CENTER**: the view-origin is at the aircraft center. Selecting Center requires looking forward when operating the UI
- **DYNAMIC**: the view-origin is where the UI was opened, allows using head-tracking from any view position. Dynamic can lead to having to chase the cursor when closing and re-opening the UI frequently. The Dynamic option is less meaningful in VR, as the UI elements are then all rendered on the front always.



Use Radar Antenna Hand Control also for Radar Cursor Control Panel

- When checked, the binds mapped to control the Antenna Hand Control can also be used to move the cursor used for Offset Bombing and similar, making binding the two Track Wheels obsolete.

FFB (Force Feedback) Gain

- For users with force-feedback sticks, this setting can be used to adjust the gain of the forces per axis. The default setting is 100% for Roll and Pitch axis. Greater values will increase the force used by the stick, while smaller values will decrease it.

Performance Option: CPU Lower Simulation Update Rate

- This experimental option allows reducing the update rate of the majority of the planes components. Doing so may reduce the stress on the CPU, improving game performance for machines that are bottlenecked by their CPU. However, it can also result in not only visual cuts, such as animations running slower, but will also cause some systems to degrade. For example the Pave Spike, running slower, can not update its ground stabilization algorithm fast enough anymore. So ticking this option can cause issues and lead to bugs.

JESTER UI Parameters

- **Max Angle**: Defines the angle (in degrees) the head has to be moved off-center to reach the corners of the UI. In other words, reducing this value from its default of 10° makes head-tracking more sensitive to head movement, while increasing it will reduce the sensitivity.
- **Deadzone**: Defines the angle (in degrees) the head has to be moved off-center to for the UI to recognize head-movement and engage head-tracking. If the head is moved less than the deadzone (0.5° by default), the cursor is automatically set to the center instead and not moved.
- **Origin Angle Y-Offset**: Defines the offset (in degrees) to displace the center point of head-tracking vertically. Positive values shift it up, negative values down. The default setting is 0°. This setting can be useful if the center point should not be properly lined up with the natural forward view. That is, when opening the menu from a natural head position and the cursor already shows a displacement instead of being centered, tweaking this setting mitigates the issue.

Performance Option: CPU Lower HB UI (Heatblur User Interface) Refresh Rate

- When checked, all HB UI elements are rendered at a significantly lower rate. This can help improving performance while HB UI elements are shown by reducing CPU load. However, it can also cause UI animations to not look smooth anymore.

Performance Option: CPU Radar Performance Mode

- This experimental option allows reducing the update rate of the radar. Doing so may reduce the stress on the CPU, improving game performance for machines that are bottlenecked by their CPU. However, it can also result in not only visual cuts, such as animations running slower, but will also cause radar detection algorithm to potentially degrade. So, ticking this option can cause issues and lead to bugs.

PILOT CONTROL SETUP



Dispense Countermeasures
(hidden grey button on right hand side)

Trim Nose Down
Trim Right Wing Down
Trim Nose Up
Trim Left Wing Down

Bomb Release Button
(RALT+Space)

ZOOM IN SLOW
ZOOM OUT SLOW

First Detent: Trigger Half-Action (2-stage trigger)
Second Detent: Trigger Full-Action (2-stage trigger) (Space)

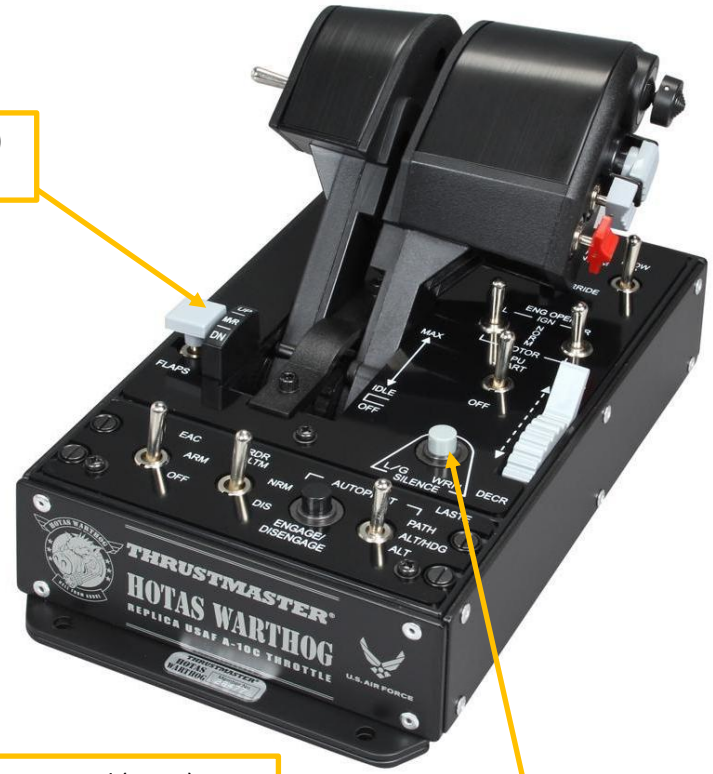
P Air Refuel (AAR) Release Button – PRESS

Nose Gear Steering / Auto Acquisition Button

Emergency Quick Release Lever

+ Wheel (Toe) Brakes (mapped on pedals)

PILOT CONTROL SETUP



← Flaps/Slats Switch – Out&Down/Out (3-way Down)
→ Flaps/Slats Switch – Norm/Out (3-way Down)

↑
→ Microphone Switch – UHF (Hold) (RSHIFT+\) – FWD
↓
← Microphone Switch – ICS (Hold) (RALT+\) – AFT

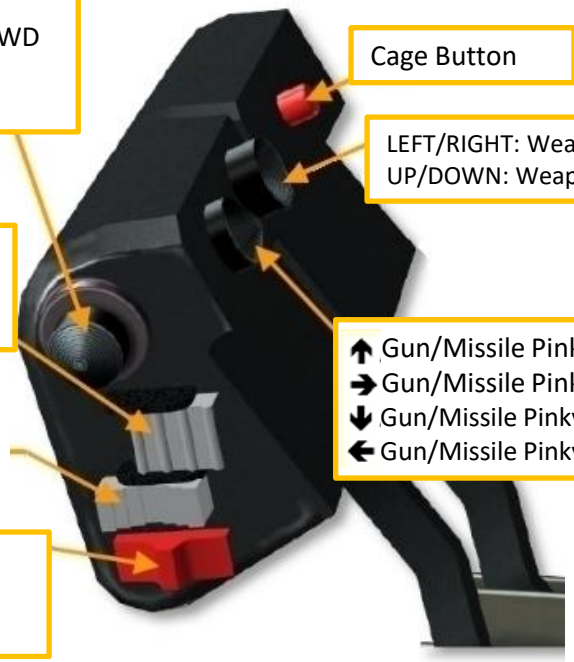
Cage Button

LEFT/RIGHT: Weapon Slew (Forward Hand Control) Axis – Horizontal (JOY X)
UP/DOWN: Weapon Slew (Forward Hand Control) Axis – Vertical (JOY Y Inverted)

Landing Gear Toggle (G)

← Speed Brake In (LSHIFT+B) – AFT

→ Speed Brake Out (Hold) (LCTRL+B) – FWD



↑ Gun/Missile Pinky Switch – REJECT (UP)
→ Gun/Missile Pinky Switch – RADAR (FWD)
↓ Gun/Missile Pinky Switch – HEAT MISSILES (CENTER)
← Gun/Missile Pinky Switch – GUN (AFT)

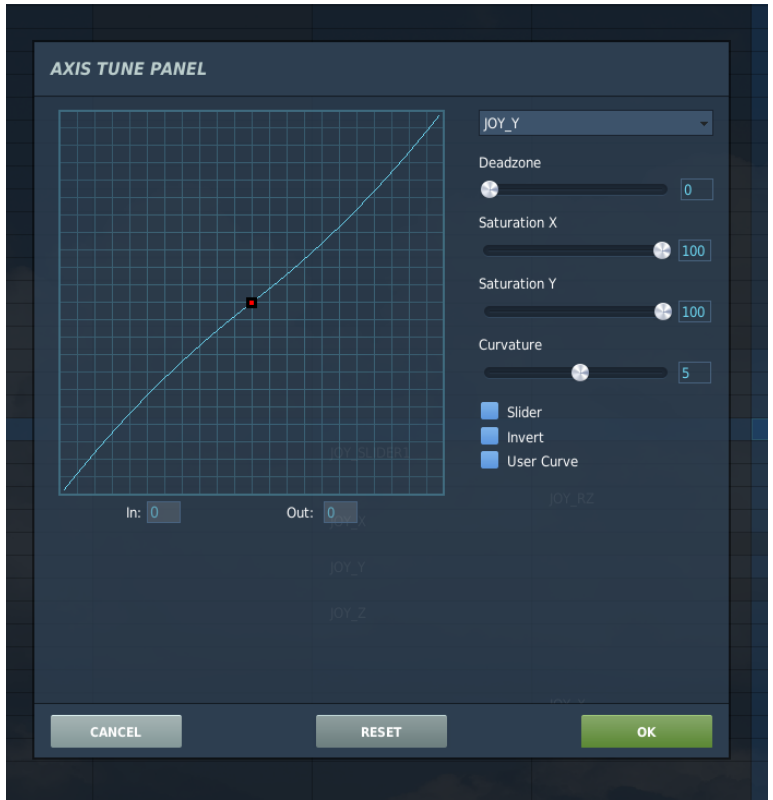
← Drag Parachute – Deploy (P)

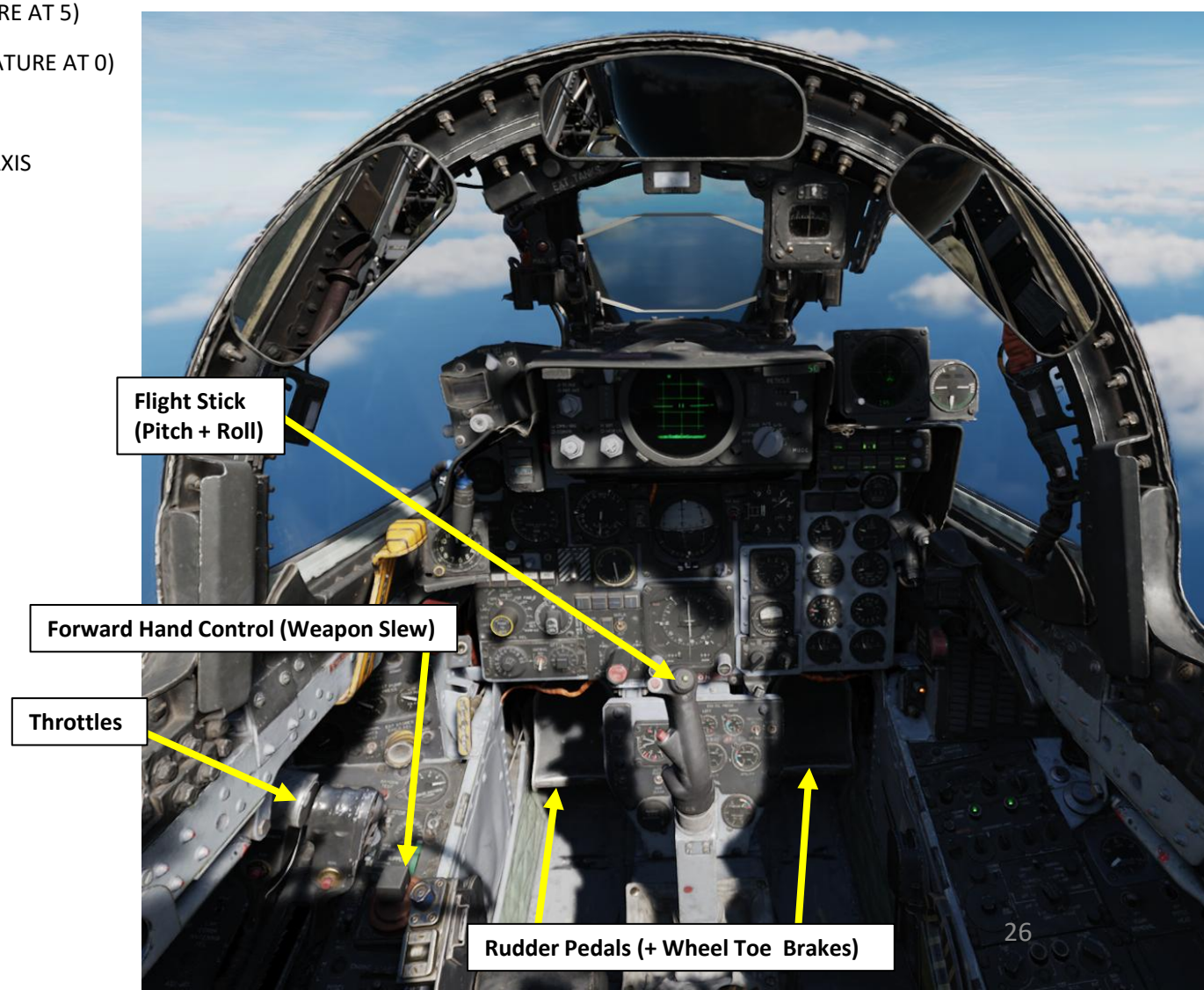
→ Drag Parachute – IN

PILOT AXIS COMMANDS

Bind the following axes:

- PITCH (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 5)
- ROLL (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 5)
- RUDDER (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 0)
- THROTTLES (ENGINE RPM CONTROL)
- WEAPON SLEW (FORWARD HAND CONTROL) – HORIZONTAL (X) & VERTICAL (Y) AXIS
- WHEEL BRAKE LEFT / RIGHT **(needs to be inverted)**





WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



Antenna Hand Control Challenge Button (hidden grey button on right hand side)

Trim Nose Down
Trim Right Wing Down
Trim Nose Up
Trim Left Wing Down

Antenna Hand Control Slew – UP
Antenna Hand Control Slew – RIGHT
Antenna Hand Control Slew – DOWN
Antenna Hand Control Slew – LEFT

Bomb Release Button (RALT+Space)

ZOOM IN SLOW
ZOOM OUT SLOW

Antenna Hand Control Trigger (Half-Action Detent)
Antenna Hand Control Trigger (Full-Action Detent)

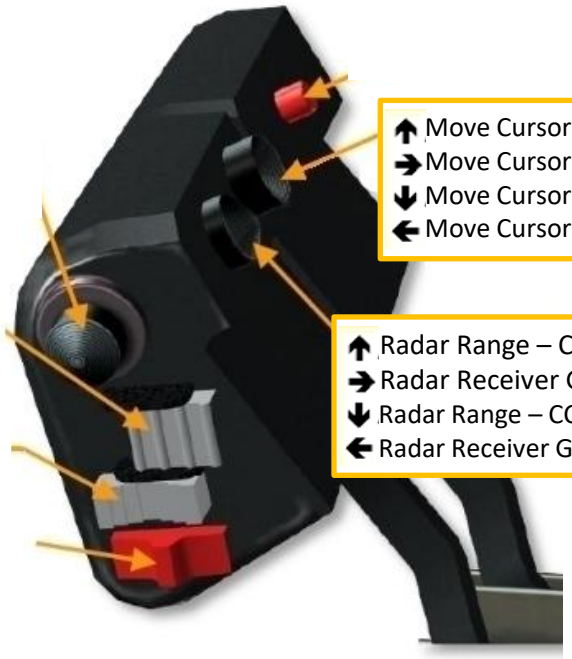
Insert Target Button
Freeze Button
Stow Button
P Reject Override Button – PRESS

Nose Gear Steering / Auto Acquisition Button

Emergency Quick Release Lever

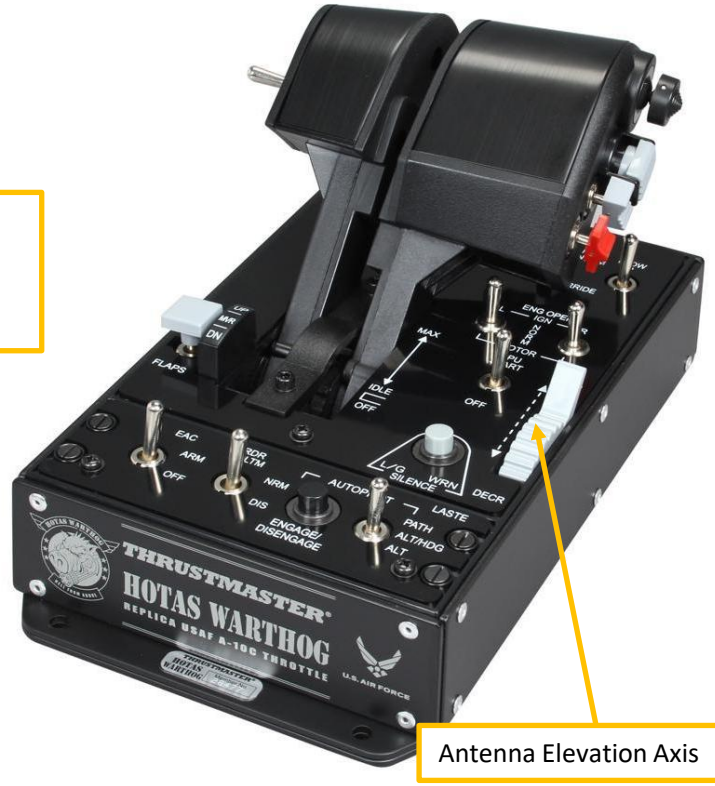
+ Wheel (Toe) Brakes (mapped on pedals)

WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



↑ Move Cursor (Along Track) (JOY_Y) – Inverted
→ Move Cursor (Cross Track) (JOY_X)
↓ Move Cursor (Along Track) (JOY_Y) – Inverted
← Move Cursor (Cross Track) (JOY_X)

↑ Radar Range – CW (Clockwise)
→ Radar Receiver Gain (Coarse) – Increase
↓ Radar Range – CCW (Counter-Clockwise)
← Radar Receiver Gain (Coarse) – Decrease

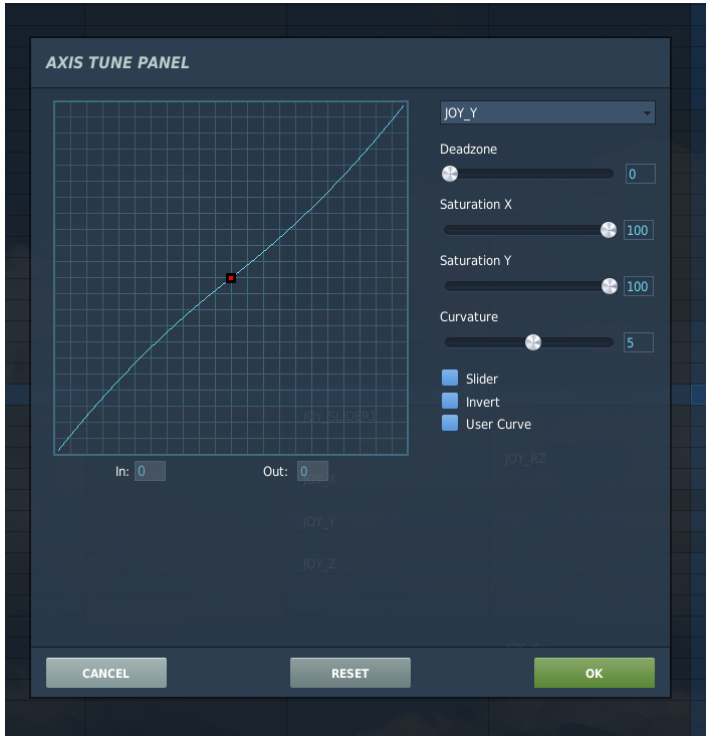


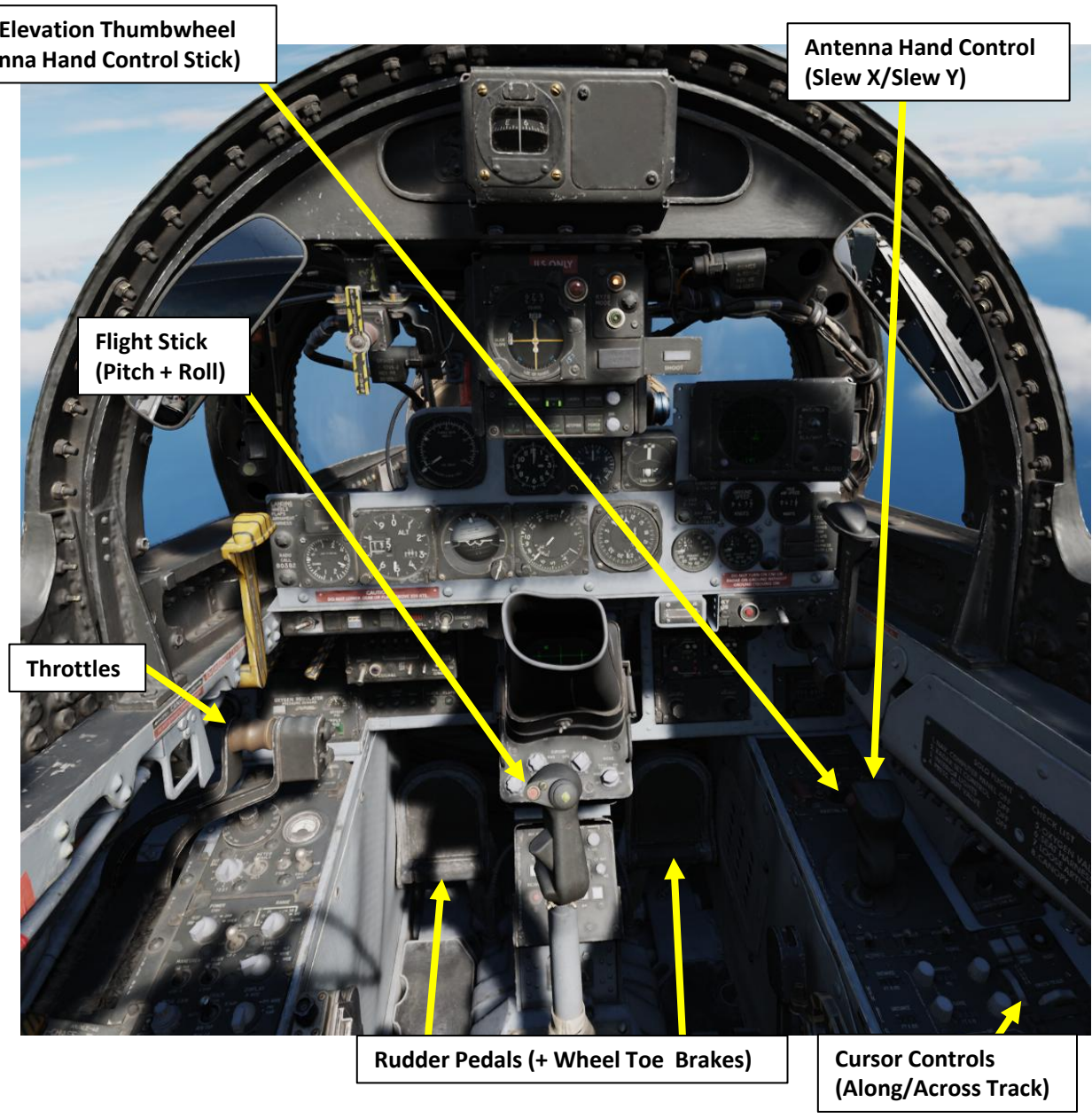
Antenna Elevation Axis

WSO (WEAPON SYSTEMS OFFICER) AXIS COMMANDS

Bind the following axes:

- PITCH (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 5)
- ROLL (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 5)
- RUDDER (DEADZONE AT 0, SATURATION X AT 100, SATURATION Y AT 100, CURVATURE AT 0)
- THROTTLES (ENGINE RPM CONTROL)
- WHEEL BRAKE LEFT / RIGHT **(needs to be inverted)**
- ANTENNA HAND CONTROL SLEW (X & Y AXIS)
- ANTENNA ELEVATION
- MOVE CURSOR (ALONG TRACK / ACROSS TRACK)

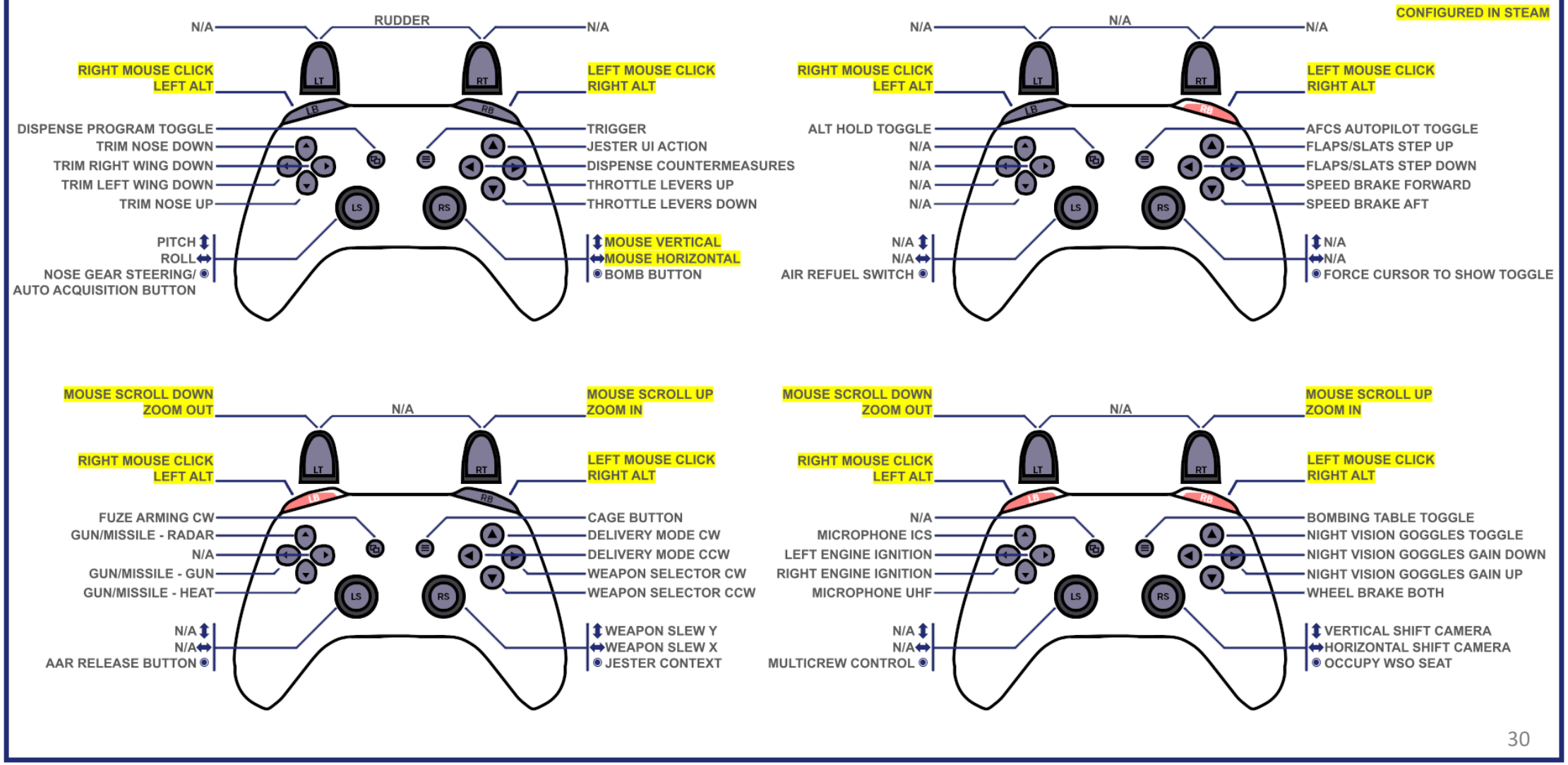




GAMEPAD CONTROLLER PROFILE

(BY TUUVAS, GAMEPAD GURU)

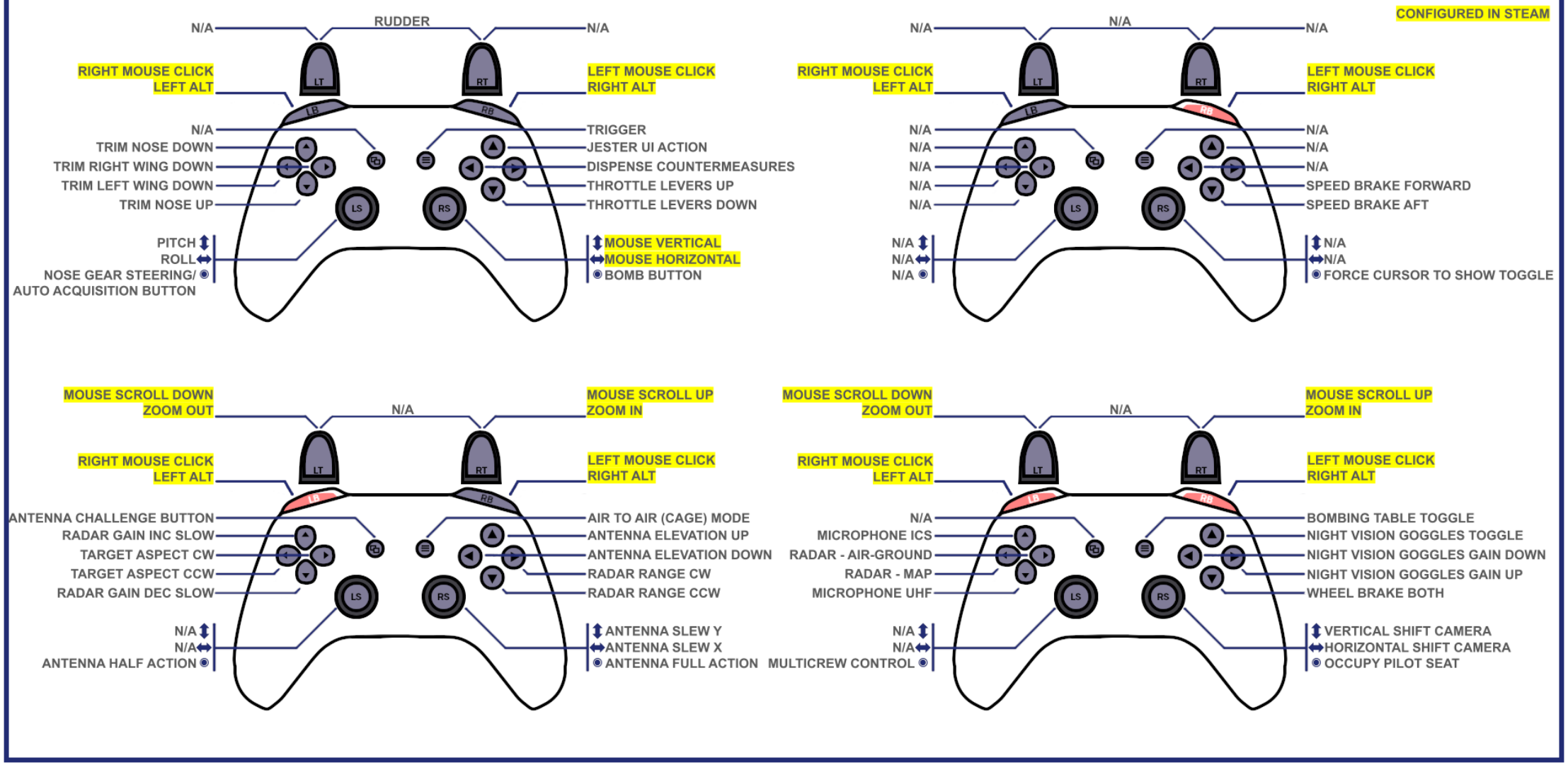
DCS WORLD: F-4E PHANTOM (PILOT) (work-in-progress)



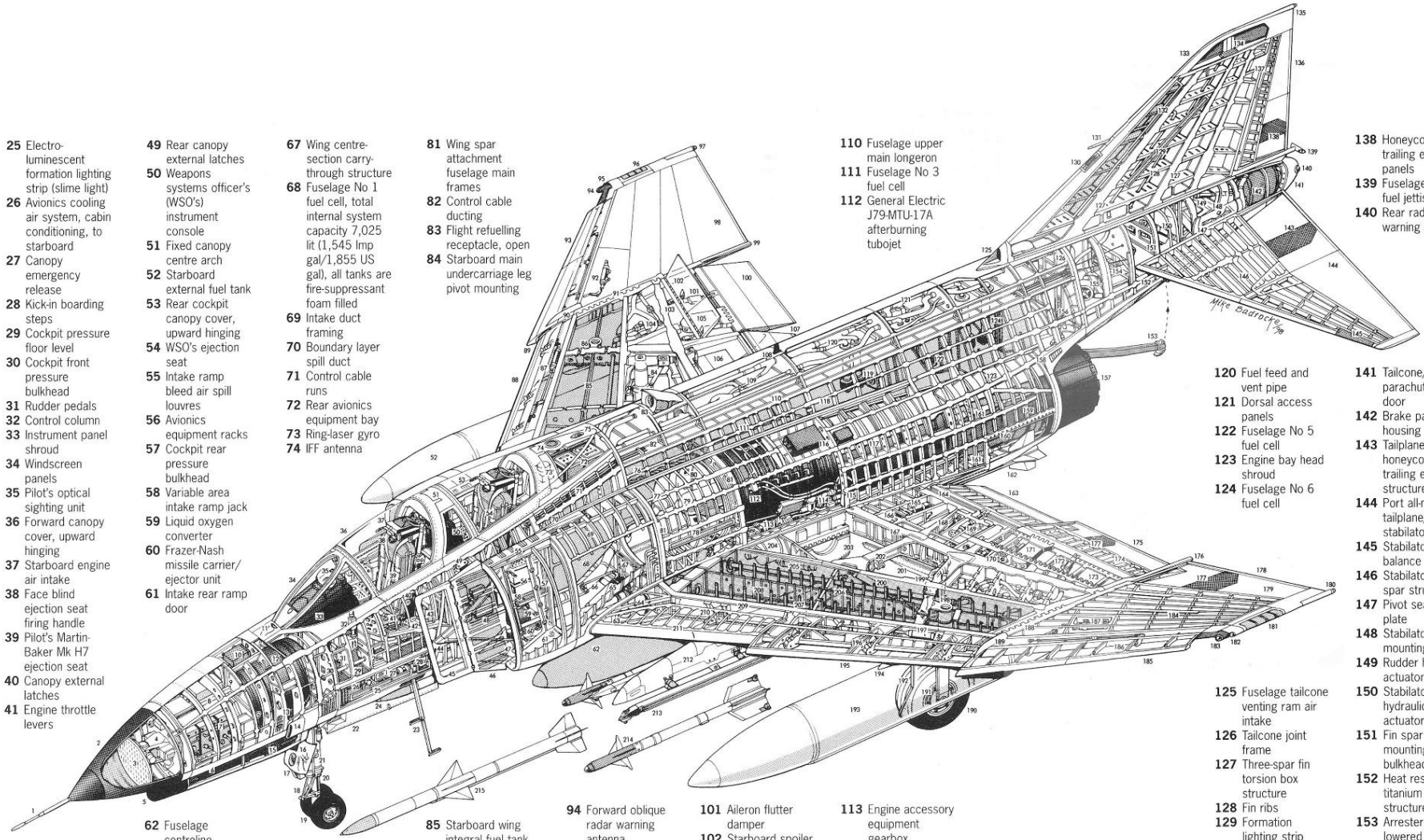
GAMEPAD CONTROLLER PROFILE

(BY TUUVAS, GAMEPAD GURU)

DCS WORLD: F-4E PHANTOM (WSO) (work-in-progress)



EXT TANKS
SHOOT
CAUTION



Douglas F-4F ICE Phantom II

1 Pitot head
2 Glass-fibre radome, hinged to starboard
3 Planar radar scanner
4 Scanner tracking mechanism
5 Cannon port with MIDAS flash suppressor
6 Cannon barrels
7 Hughes AN/APG-65 radar equipment module
8 Radar withdrawal rail
9 Radar mounting bulkhead
10 ADF sense antenna
11 Windscreen rain dispersal air duct
12 Cannon ammunition magazine, 820 rounds
13 Ammunition feed and cartridge case return chutes
14 Air conditioning system heat exchanger ram air intake
15 M61A-1 Vulcan six-barrel rotary cannon
16 Nosewheel leg door-mounted UHF/VHF antenna
17 Landing/taxiing lights
18 Torque scissor links, offset to port
19 Twin nosewheels, aft retracting
20 Shock absorber leg strut
21 Hydraulic steering unit
22 Nosewheel door
23 Extended boarding ladder
24 Forward fuselage semi-recessed missile carriage
25 Electro-luminescent formation lighting strip (slime light)
26 Avionics cooling air system, cabin conditioning, to starboard
27 Canopy emergency release
28 Kick-in boarding steps
29 Cockpit pressure floor level
30 Cockpit front pressure bulkhead
31 Rudder pedals
32 Control column
33 Instrument panel shroud
34 Windscreen panels
35 Pilot's optical sighting unit
36 Forward canopy cover, upward hinging
37 Starboard engine air intake
38 Face blind ejection seat firing handle
39 Pilot's Martin-Baker Mk H7 ejection seat
40 Canopy external latches
41 Engine throttle levers
42 Port side console panel
43 Document stowage
44 Boundary layer diverter
45 Boundary layer splitter plate
46 Intake front ramp
47 Port engine air intake
48 Intake ramp boundary layer bleed air perforations
49 Rear canopy external latches
50 Weapons systems officer's (WSO's) instrument console
51 Fixed canopy centre arch
52 Starboard external fuel tank
53 Rear cockpit canopy cover, upward hinging
54 WSO's ejection seat
55 Intake ramp bleed air spill louvres
56 Avionics equipment racks
57 Cockpit rear pressure bulkhead
58 Variable area intake ramp jack
59 Liquid oxygen converter
60 Frazer-Nash missile carrier/ ejector unit
61 Intake rear ramp door
62 Fuselage centreline external tank, capacity 600 US gal (2,273l)
63 Position of pressure refuelling connection, on port side
64 Starter cartridge housing
65 Pneumatic system air bottle
66 Engine bleed air ducting to conditioning pack
67 Wing centre-section carry-through structure
68 Fuselage No 1 fuel cell, total internal system capacity 7,025 lit (1,545 Imp gal/1,855 US gal), all tanks are fire-suppressant foam filled
69 Intake duct framing
70 Boundary layer spill duct
71 Control cable runs
72 Rear avionics equipment bay
73 Ring-laser gyro
74 IFF antenna
75 Upper identification light
76 Fuselage No 2 fuel cell
77 Centre-fuselage frame structure
78 Formation lighting strip
79 Engine intake centrebody fairing
80 Intake duct overpressure rotary spill valve
81 Wing spar attachment fuselage main frames
82 Control cable ducting
83 Flight refuelling receptacle, open
84 Starboard main undercarriage leg pivot mounting
85 Starboard wing integral fuel tank
86 Wing outboard pylon mounting
87 Inboard slat hydraulic actuator
88 Inboard slat segment
89 Leading edge dogtooth
90 Wing fence
91 Outer wing panel joint
92 Outboard slat hydraulic actuator
93 Outboard slat segment
94 Forward oblique radar warning antenna
95 Starboard navigation light
96 Electro-luminescent wing tip formation light
97 Rear position light
98 Fixed dihedral outer wing panel
99 Wing tank vent jettison
100 Starboard drooping aileron, down position
101 Aileron flutter damper
102 Starboard spoiler panels, open
103 Spoiler hydraulic actuators
104 Fuel jettison and vent valves
105 Aileron hydraulic actuator
106 Starboard ventral airbrake panel
107 Starboard 'blown' flap, down position
108 TACAN antenna
109 Fuel system piping
110 Fuselage upper main longeron
111 Fuselage No 3 fuel cell
112 General Electric J79-MTU-17A afterburning tubojet
113 Engine accessory equipment gearbox
114 Afterburner fuel control equipment
115 Wing rear spar attachment joint
116 AN/APR-36/37 radar warning receiver and analyser
117 Port engine bay frame structure
118 Fuselage No 4 fuel cell
119 Immersed fuel pumps
120 Fuel feed and vent pipe
121 Dorsal access panels
122 Fuselage No 5 fuel cell
123 Engine bay head shroud
124 Fuselage No 6 fuel cell
125 Fuselage tailcone venting ram air intake
126 Tailcone joint frame
127 Three-spar fin torsion box structure
128 Fin ribs
129 Formation lighting strip
130 Anti-collision beacon
131 Stabilator feel system pressure head
132 Flush HF antenna
133 Fin tip antenna fairing
134 Upper UHF/VHF antenna
135 Tail navigation light
136 Rudder
137 Rudder horn balance
138 Honeycomb trailing edge panels
139 Fuselage tank fuel jettison
140 Rear radar warning antennas
141 Tailcone/brake parachute hinged door
142 Brake parachute housing
143 Tailplane honeycomb trailing edge structure
144 Port all-moving tailplane/ stabilator
145 Stabilator mass balance weight
146 Stabilator multi-spar structure
147 Pivot sealing plate
148 Stabilator hinge mounting
149 Rudder hydraulic actuator
150 Stabilator hydraulic actuator
151 Fin spar mounting bulkheads
152 Heat resistant all-titanium tailcone structure
153 Arrester hook, lowered
154 Stabilator feel system balance mechanism
155 Feel system pneumatic bellows unit
156 Arrester hook jack and shock absorber
157 Variable area afterburner nozzle
158 Engine bay venting air spill duct
159 Afterburner ducting
160 Hinged engine bay access doors
161 Exhaust nozzle actuators
162 Aft semi-recessed missile carriage
163 Port 'blown' flap, down position
164 Flap blowing slot
165 Flap emergency actuating pneumatic reservoir
166 Lateral autopilot servo
167 Wing rear spar
168 Ventral airbrake jack
169 Flap hydraulic jack
170 Port spoiler actuator
171 Aileron hydraulic actuator
172 Flutter damper
173 Port spoiler housing
174 Aileron rib structure
175 Port drooping aileron, down position
176 Port wing tank fuel jettison
177 Honeycomb trailing edge panels
178 Port dihedral outer wing panel
179 Fixed trailing edge panel
180 Rear position light
181 Formation lighting panel
182 Port navigation light
183 Port forward/ oblique radar warning antenna
184 Outer wing panel multi-spar structure
185 Outboard leading edge slat segment
186 Slat guide rails
187 Outboard slat hydraulic actuator
188 Outer wing panel hinge joint, fold system de-activated on land-based aircraft
189 Port wing fence
190 Port mainwheel
191 Wheel hub multi-plate disc brake
192 Mainwheel leg door
193 Port wing external tank, capacity 370 US gal (1,402l)
194 Outboard tank pylon
195 Inboard slat segment
196 Slat hinge links
197 Inboard slat hydraulic actuator
198 Pylon mounting hardpoint
199 Main undercarriage leg pivot mounting
200 Hydraulic retraction jack
201 Port ventral airbrake panel, open
202 Undercarriage leg up lock
203 Mainwheel bay and inner wheel door
204 Hydraulic reservoir
205 Hydraulic accumulator
206 Port wing integral fuel tank
207 Two-spar torsion box; wing tank structure
208 Skin support posts
209 Front spar
210 Inboard pylon mounting hardpoint
211 Fixed inboard leading edge panel
212 Inboard wing pylon
213 Missile launch rails
214 AIM-9L/M Sidewinder air-to-air missiles
215 AIM-120A AMRAAM air-to-air missile


WSO (Weapon Systems Officer)
• Press “2” to select
Pilot
• Press “1” to select
CAUTION
WARNING
DANGER
EJECTION SEAT & CANOPY
BATTERY
RESCUE

Pilot Cockpit



Pilot Cockpit



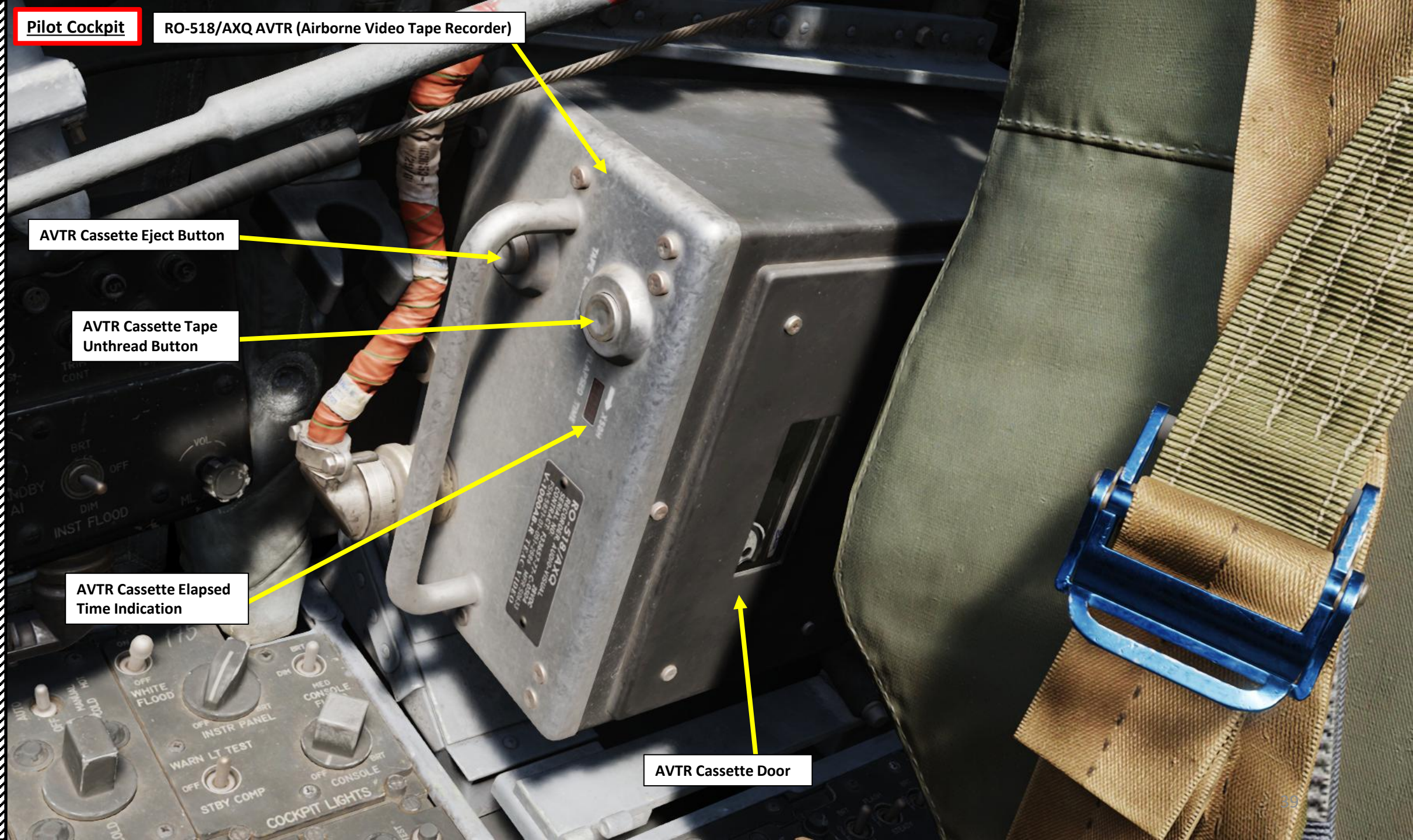
Tip: Pilot body can be toggled on/off by using the “First Person Pilot Body - Toggle” binding. Recommended binding: “LSHIFT+P”.

Pilot Cockpit



Pilot Cockpit

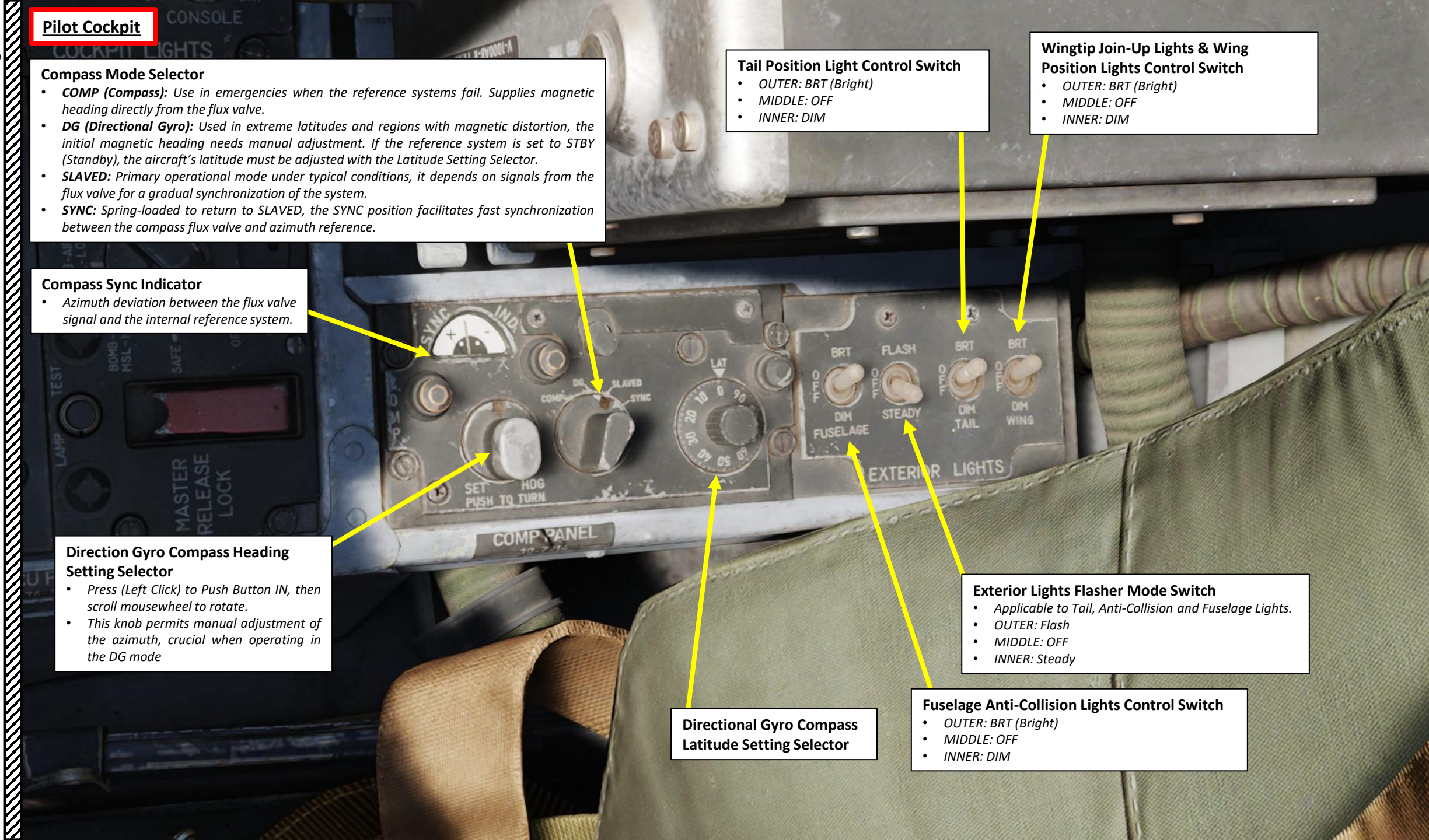



Pilot Cockpit
RO-518/AXQ AVTR (Airborne Video Tape Recorder)
AVTR Cassette Eject Button
AVTR Cassette Tape Unthread Button
AVTR Cassette Elapsed Time Indication
AVTR Cassette Door
RO-518/AXQ
WHITE FLOOD
INSTR PANEL
WARN LT TEST
STBY COMP
CONSOLE
COCKPIT LIGHTS
INST FLOOD

Pilot Cockpit



Pilot Cockpit



Compass Mode Selector

- ***COMP (Compass):*** *Use in emergencies when the reference systems fail. Supplies magnetic heading directly from the flux valve.*
- ***DG (Directional Gyro):*** *Used in extreme latitudes and regions with magnetic distortion, the initial magnetic heading needs manual adjustment. If the reference system is set to STBY (Standby), the aircraft's latitude must be adjusted with the Latitude Setting Selector.*
- ***SLAVED:*** *Primary operational mode under typical conditions, it depends on signals from the flux valve for a gradual synchronization of the system.*
- ***SYNC:*** *Spring-loaded to return to SLAVED, the SYNC position facilitates fast synchronization between the compass flux valve and azimuth reference.*

Compass Sync Indicator

- *Azimuth deviation between the flux valve signal and the internal reference system.*

Direction Gyro Compass Heading Setting Selector

- *Press (Left Click) to Push Button IN, then scroll mousewheel to rotate.*
- *This knob permits manual adjustment of the azimuth, crucial when operating in the DG mode*

Tail Position Light Control Switch

- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Wingtip Join-Up Lights & Wing Position Lights Control Switch

- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Directional Gyro Compass Latitude Setting Selector

Exterior Lights Flasher Mode Switch

- *Applicable to Tail, Anti-Collision and Fuselage Lights.*
- *OUTER: Flash*
- *MIDDLE: OFF*
- *INNER: Steady*

Fuselage Anti-Collision Lights Control Switch

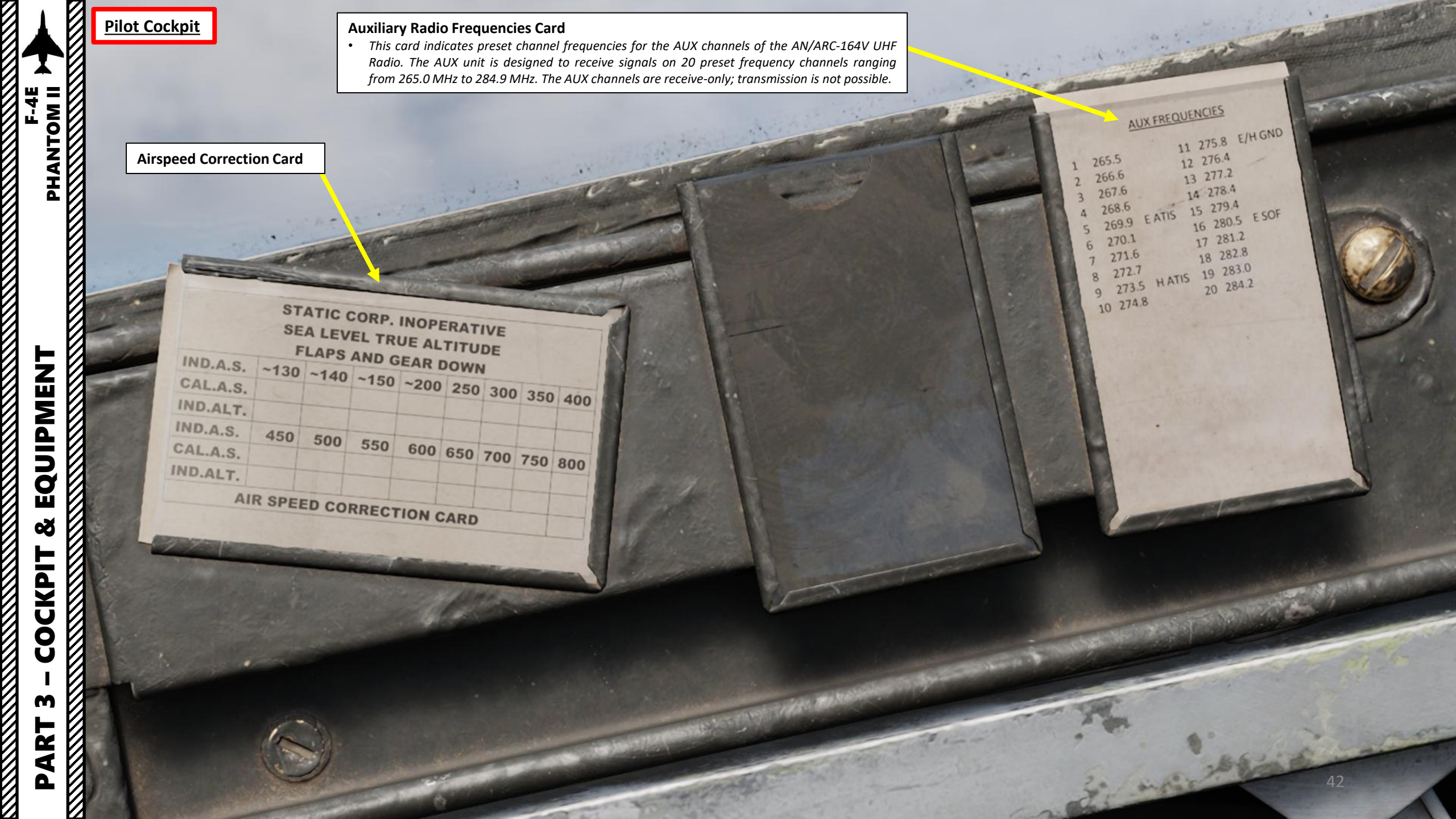
- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Pilot Cockpit

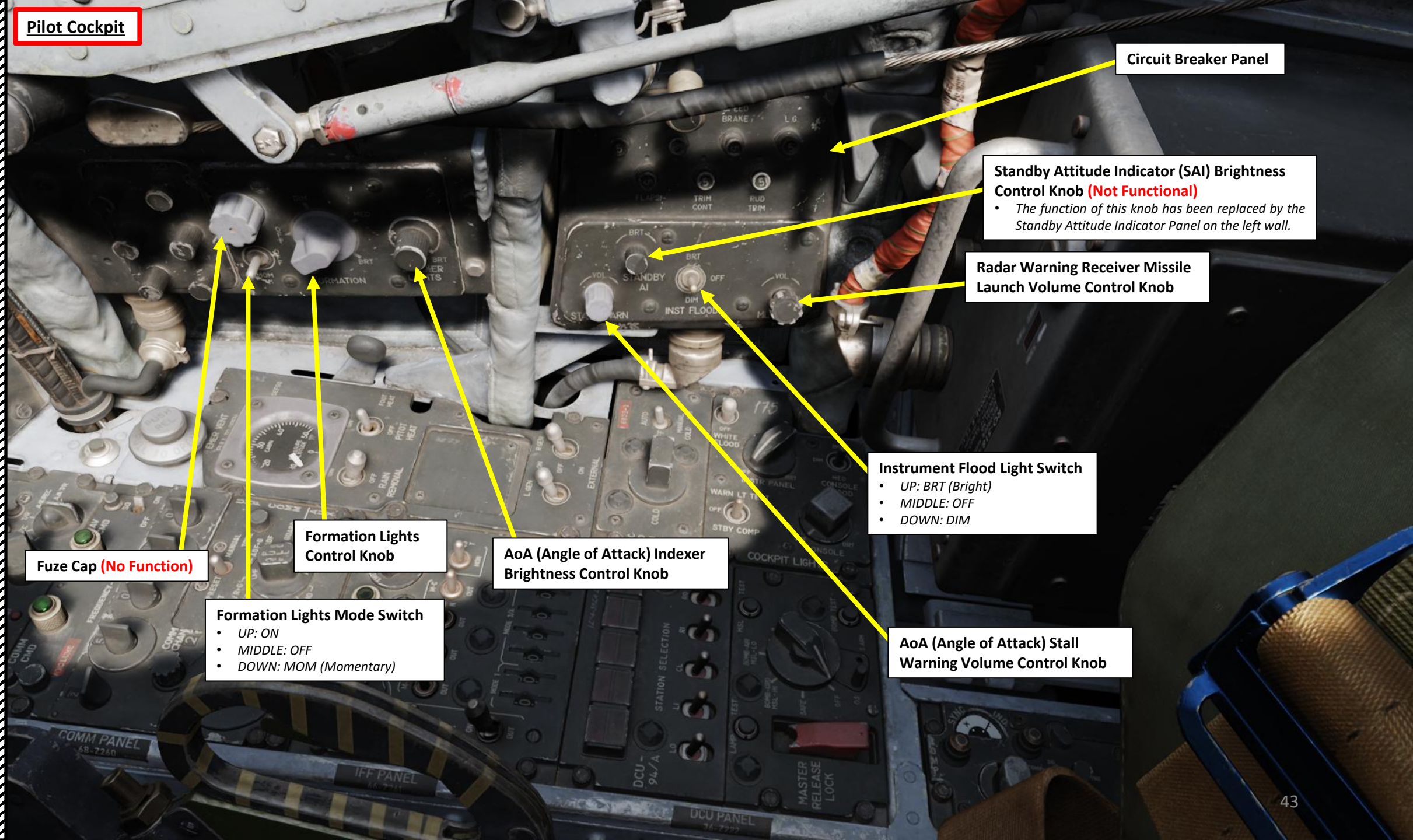
Auxiliary Radio Frequencies Card

- *This card indicates preset channel frequencies for the AUX channels of the AN/ARC-164V UHF Radio. The AUX unit is designed to receive signals on 20 preset frequency channels ranging from 265.0 MHz to 284.9 MHz. The AUX channels are receive-only; transmission is not possible.*

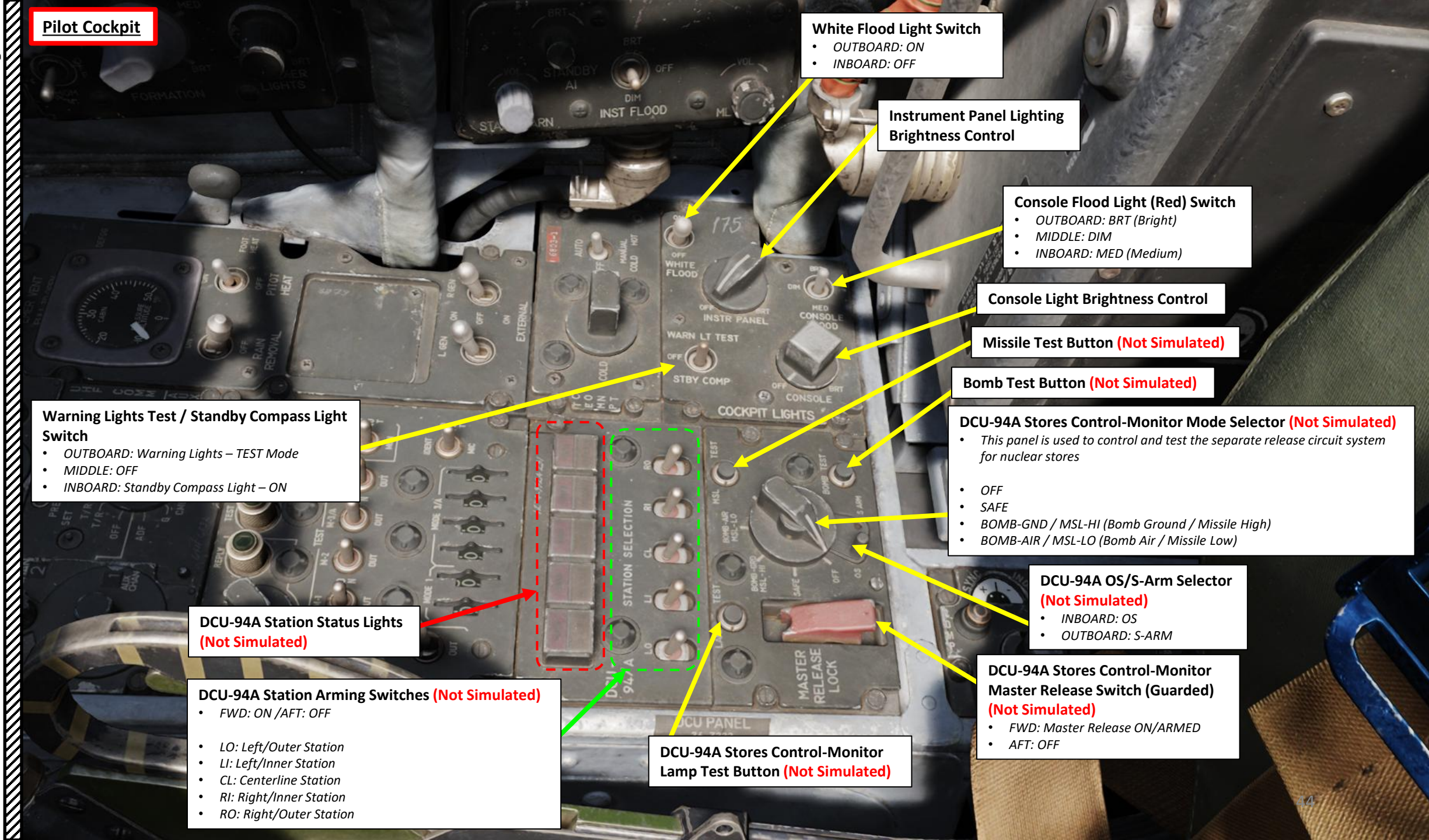
Airspeed Correction Card



Pilot Cockpit



Pilot Cockpit



White Flood Light Switch
- *OUTBOARD: ON*
- *INBOARD: OFF*

Instrument Panel Lighting Brightness Control

Console Flood Light (Red) Switch
- *OUTBOARD: BRT (Bright)*
- *MIDDLE: DIM*
- *INBOARD: MED (Medium)*

Console Light Brightness Control

Missile Test Button (Not Simulated)

Bomb Test Button (Not Simulated)

Warning Lights Test / Standby Compass Light Switch
- *OUTBOARD: Warning Lights – TEST Mode*
- *MIDDLE: OFF*
- *INBOARD: Standby Compass Light – ON*

DCU-94A Stores Control-Monitor Mode Selector (Not Simulated)
- *This panel is used to control and test the separate release circuit system for nuclear stores*
- *OFF*
- *SAFE*
- *BOMB-GND / MSL-HI (Bomb Ground / Missile High)*
- *BOMB-AIR / MSL-LO (Bomb Air / Missile Low)*

DCU-94A OS/S-Arm Selector (Not Simulated)
- *INBOARD: OS*
- *OUTBOARD: S-ARM*

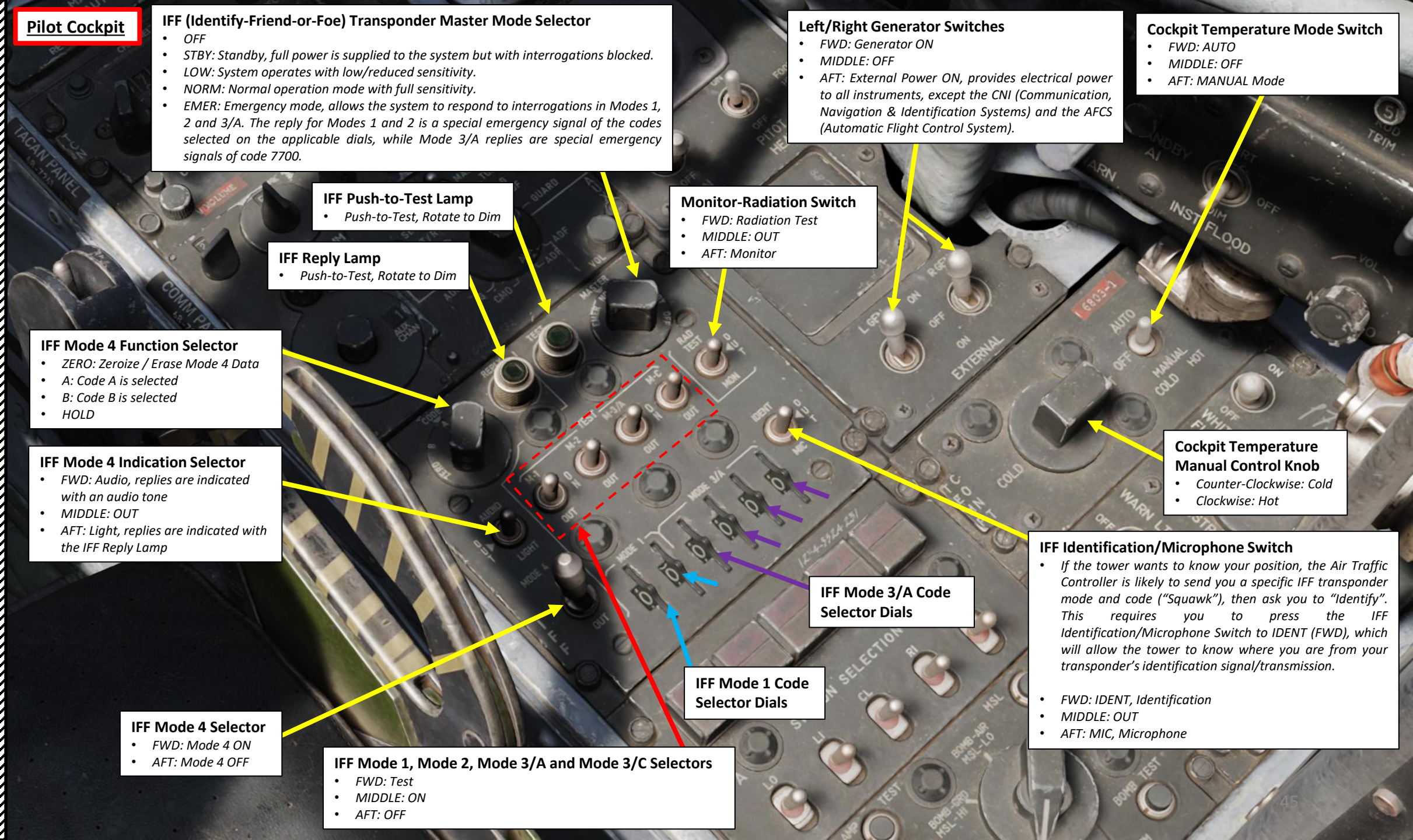
DCU-94A Station Status Lights (Not Simulated)

DCU-94A Station Arming Switches (Not Simulated)
- *FWD: ON /AFT: OFF*
- *LO: Left/Outer Station*
- *LI: Left/Inner Station*
- *CL: Centerline Station*
- *RI: Right/Inner Station*
- *RO: Right/Outer Station*

DCU-94A Stores Control-Monitor Lamp Test Button (Not Simulated)

DCU-94A Stores Control-Monitor Master Release Switch (Guarded) (Not Simulated)
- *FWD: Master Release ON/ARMED*
- *AFT: OFF*

Pilot Cockpit



IFF (Identify-Friend-or-Foe) Transponder Master Mode Selector
- *OFF*
- *STBY: Standby, full power is supplied to the system but with interrogations blocked.*
- *LOW: System operates with low/reduced sensitivity.*
- *NORM: Normal operation mode with full sensitivity.*
- *EMER: Emergency mode, allows the system to respond to interrogations in Modes 1, 2 and 3/A. The reply for Modes 1 and 2 is a special emergency signal of the codes selected on the applicable dials, while Mode 3/A replies are special emergency signals of code 7700.*

Left/Right Generator Switches
- *FWD: Generator ON*
- *MIDDLE: OFF*
- *AFT: External Power ON, provides electrical power to all instruments, except the CNI (Communication, Navigation & Identification Systems) and the AFCS (Automatic Flight Control System).*

Cockpit Temperature Mode Switch
- *FWD: AUTO*
- *MIDDLE: OFF*
- *AFT: MANUAL Mode*

IFF Push-to-Test Lamp
- *Push-to-Test, Rotate to Dim*

IFF Reply Lamp
- *Push-to-Test, Rotate to Dim*

Monitor-Radiation Switch
- *FWD: Radiation Test*
- *MIDDLE: OUT*
- *AFT: Monitor*

IFF Mode 4 Function Selector
- *ZERO: Zeroize / Erase Mode 4 Data*
- *A: Code A is selected*
- *B: Code B is selected*
- *HOLD*

IFF Mode 4 Indication Selector
- *FWD: Audio, replies are indicated with an audio tone*
- *MIDDLE: OUT*
- *AFT: Light, replies are indicated with the IFF Reply Lamp*

Cockpit Temperature Manual Control Knob
- *Counter-Clockwise: Cold*
- *Clockwise: Hot*

IFF Identification/Microphone Switch
- *If the tower wants to know your position, the Air Traffic Controller is likely to send you a specific IFF transponder mode and code ("Squawk"), then ask you to "Identify". This requires you to press the IFF Identification/Microphone Switch to IDENT (FWD), which will allow the tower to know where you are from your transponder's identification signal/transmission.*

- *FWD: IDENT, Identification*
- *MIDDLE: OUT*
- *AFT: MIC, Microphone*

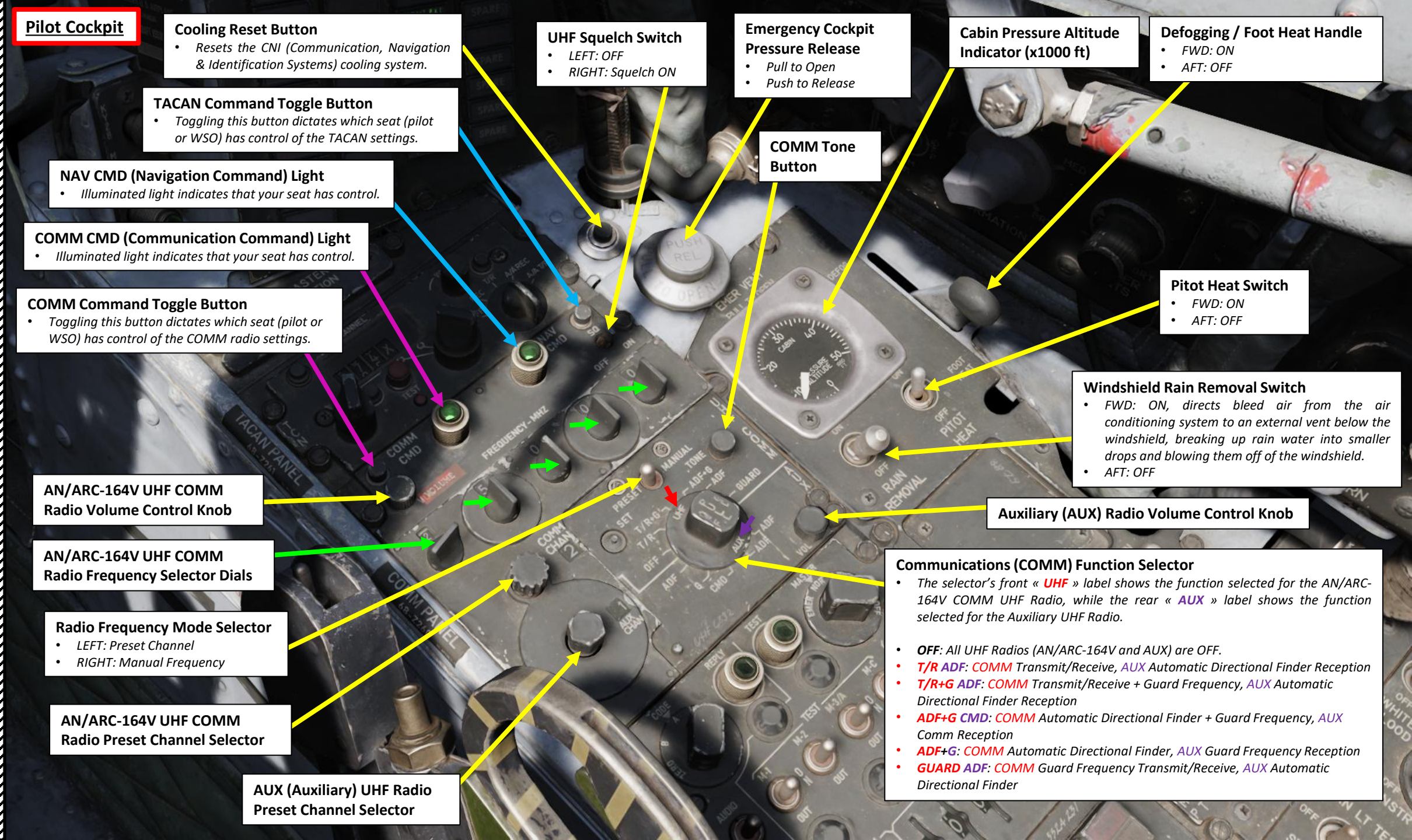
IFF Mode 3/A Code Selector Dials

IFF Mode 1 Code Selector Dials

IFF Mode 4 Selector
- *FWD: Mode 4 ON*
- *AFT: Mode 4 OFF*

IFF Mode 1, Mode 2, Mode 3/A and Mode 3/C Selectors
- *FWD: Test*
- *MIDDLE: ON*
- *AFT: OFF*

Pilot Cockpit



Cooling Reset Button
- *Resets the CNI (Communication, Navigation & Identification Systems) cooling system.*

TACAN Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the TACAN settings.*

NAV CMD (Navigation Command) Light
- *Illuminated light indicates that your seat has control.*

COMM CMD (Communication Command) Light
- *Illuminated light indicates that your seat has control.*

COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*

AN/ARC-164V UHF COMM Radio Volume Control Knob

AN/ARC-164V UHF COMM Radio Frequency Selector Dials

Radio Frequency Mode Selector
- *LEFT: Preset Channel*
- *RIGHT: Manual Frequency*

AN/ARC-164V UHF COMM Radio Preset Channel Selector

AUX (Auxiliary) UHF Radio Preset Channel Selector

UHF Squelch Switch
- *LEFT: OFF*
- *RIGHT: Squelch ON*

Emergency Cockpit Pressure Release
- *Pull to Open*
- *Push to Release*

COMM Tone Button

Cabin Pressure Altitude Indicator (x1000 ft)

Defogging / Foot Heat Handle
- *FWD: ON*
- *AFT: OFF*

Pitot Heat Switch
- *FWD: ON*
- *AFT: OFF*

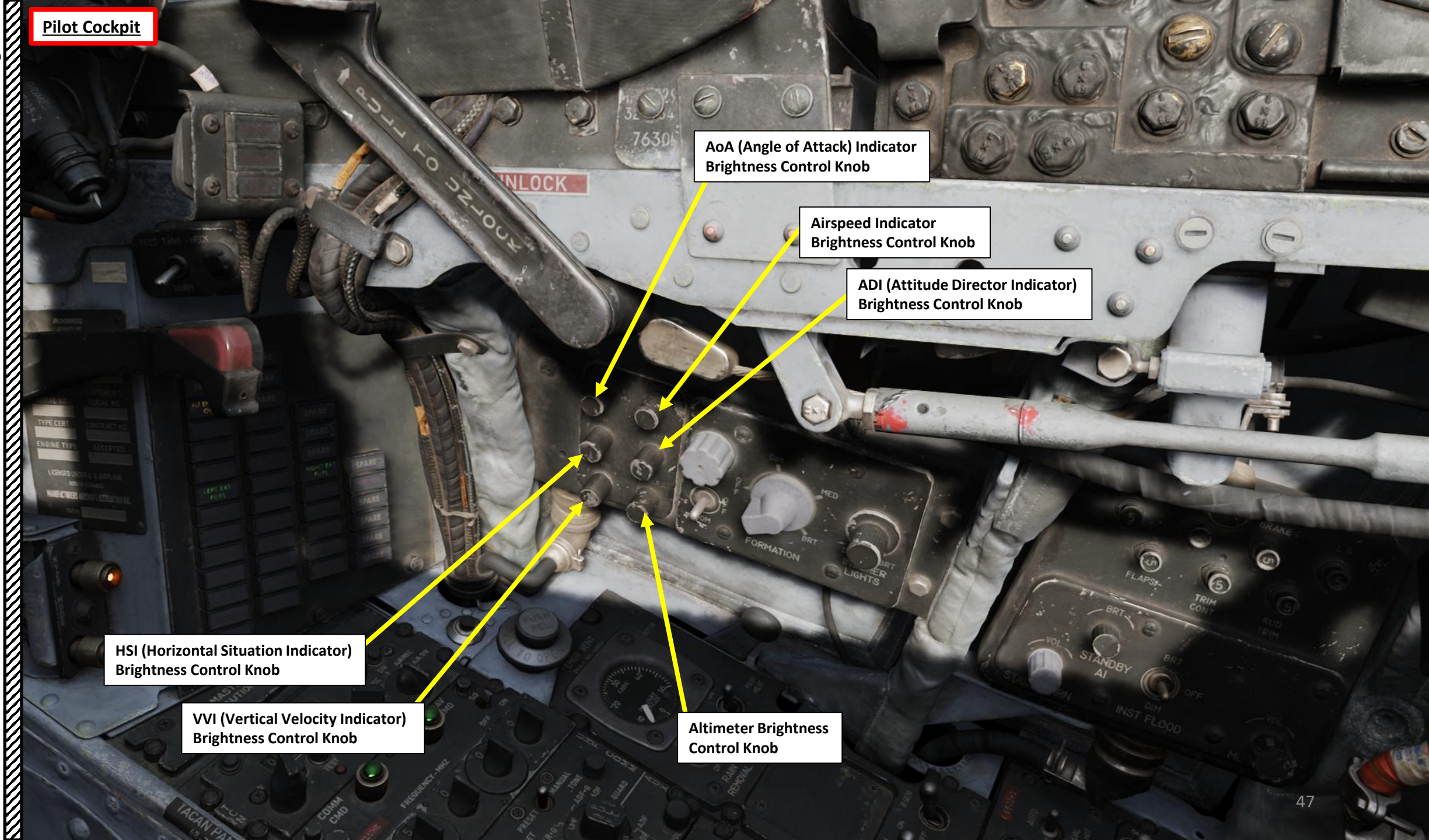
Windshield Rain Removal Switch
- *FWD: ON, directs bleed air from the air conditioning system to an external vent below the windshield, breaking up rain water into smaller drops and blowing them off of the windshield.*
- *AFT: OFF*

Auxiliary (AUX) Radio Volume Control Knob

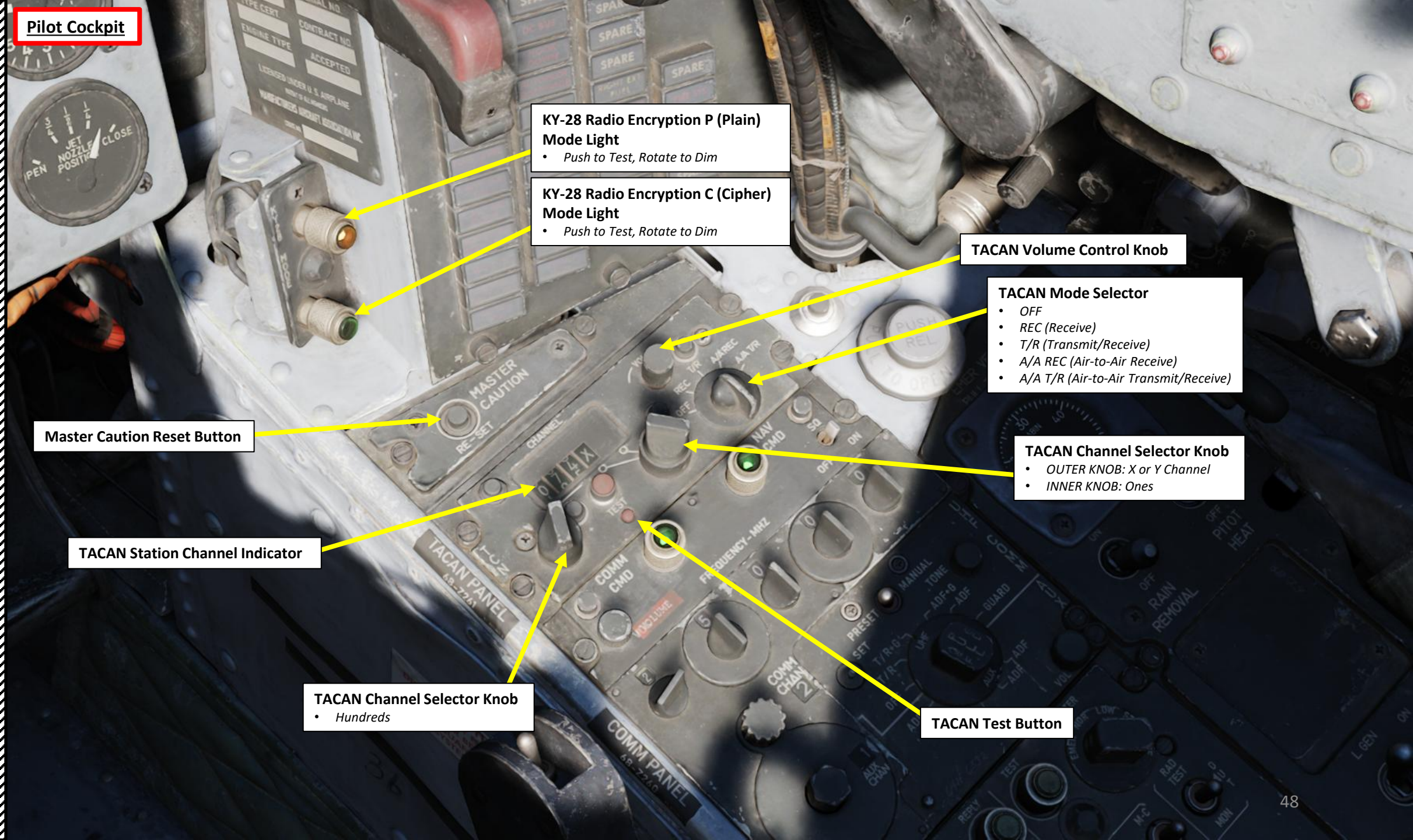
Communications (COMM) Function Selector
- *The selector's front « **UHF** » label shows the function selected for the AN/ARC-164V COMM UHF Radio, while the rear « **AUX** » label shows the function selected for the Auxiliary UHF Radio.*

- ***OFF**: All UHF Radios (AN/ARC-164V and AUX) are OFF.*
- ***T/R ADF**: COMM Transmit/Receive, AUX Automatic Directional Finder Reception*
- ***T/R+G ADF**: COMM Transmit/Receive + Guard Frequency, AUX Automatic Directional Finder Reception*
- ***ADF+G CMD**: COMM Automatic Directional Finder + Guard Frequency, AUX Comm Reception*
- ***ADF+G**: COMM Automatic Directional Finder, AUX Guard Frequency Reception*
- ***GUARD ADF**: COMM Guard Frequency Transmit/Receive, AUX Automatic Directional Finder*

Pilot Cockpit



Pilot Cockpit



Pilot Cockpit

Warning Telelight Panel

ALT ENCODER OUT *Unreliable signal or no signal from the altitude encoder unit.*	- SPARE -	- SPARE -	- SPARE -
IFF *Identify-Friend-or-Foe Mode 4 code is zeroed or no code is inserted.*	**DC BUS** *Both generators fail or if a voltage drop occurs between the main DC bus and essential DC bus.*	- SPARE -	- SPARE -
CANOPY UNLOCKED *Canopy is not lowered and locked.*	**HOOK DOWN** *Arresting hook is not up and locked.*	- SPARE -	- SPARE -
AUTOPILOT PITCH TRIM *AFCS is engaged and the automatic pitch trim follow up is inoperative or lagging sufficiently behind the airplane maneuvering.*	**AUTOPILOT DISENGAGE** *Autopilot is disengaged after initial engagement of the AFCS.*	- SPARE -	- SPARE -
LEFT EXT FUEL *Left external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*	**CTR EXT FUEL** *Centerline external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*	**RIGHT EXT FUEL** *Right external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*	- SPARE -
FUEL LEVEL LOW *Fuel level in cells 1 and 2 has reached a predetermined fuel state of 1650 ± 200 pounds.*	**CHK FUEL FILTERS** *Fuel filter is clogged. The filter automatically opens to bypass, allowing normal fuel flow to the engine.*	**RADAR CNI COOL OFF** *Overtemperature condition in the equipment cooling system is detected.*	**FIRE SYS** *Either a fire/overheat detector sensor tube is burned through, a detector wire chafes to ground or the control module fails.*



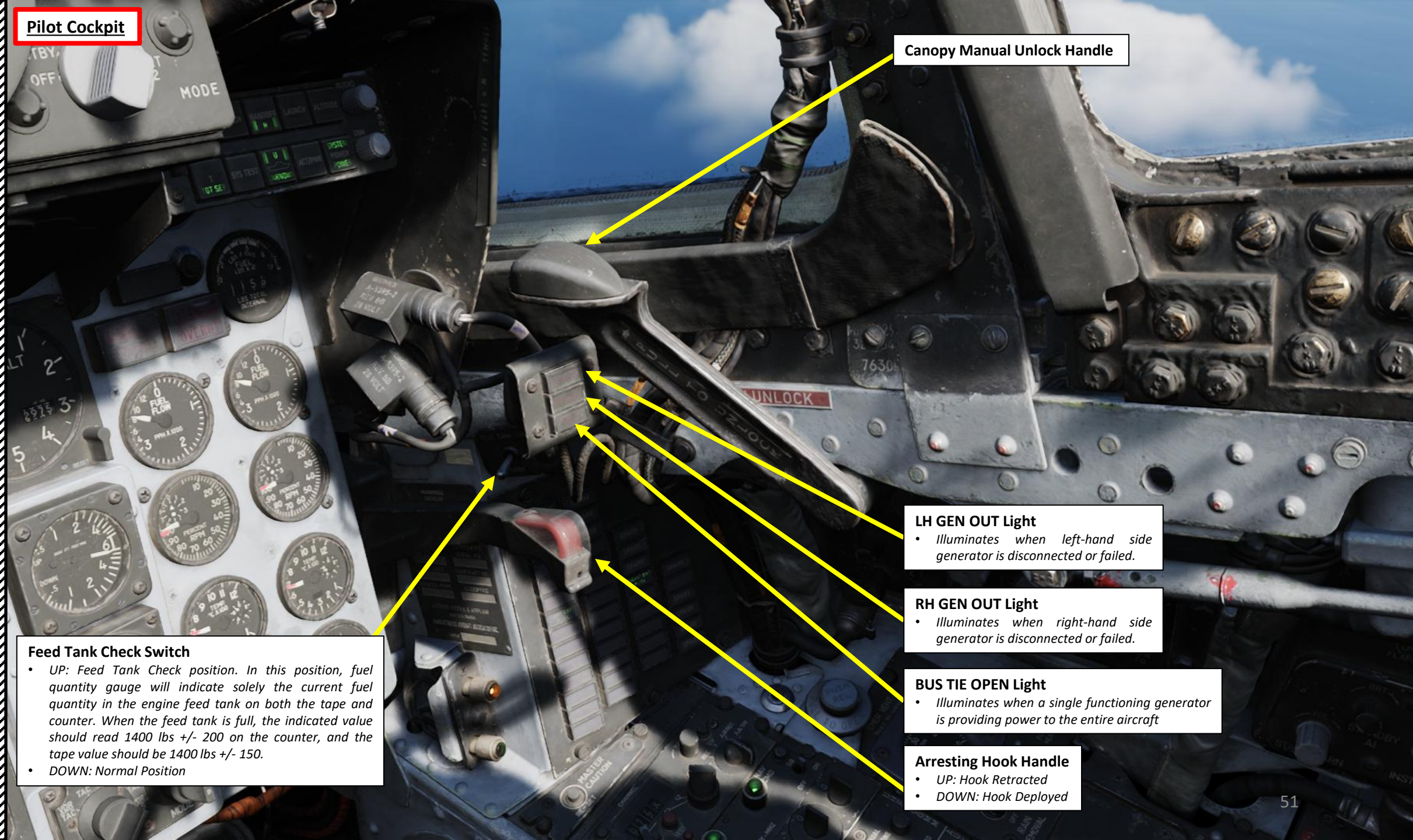
Pilot Cockpit

Warning Telelight Panel

L ANTI ICE ON *Left anti-ice bleed air system is on.*	**R ANTI ICE ON** *Right anti-ice bleed air system is on.*	**STATIC CORR OFF** *SPC (Static Pressure Compensator) fails or the CADC (Central Air Data Computer) switch is placed to CORR OFF.*	- SPARE -
L AUX AIR DOOR Left auxiliary air door operates out of phase with the landing gear handle.	**R AUX AIR DOOR** Right auxiliary air door operates out of phase with the landing gear handle.	**SPEEDBRAKE OUT** Speed brake is out or not fully closed	- SPARE -
WINDSHIELD TEMP HIGH Windshield approaches a temperature which will cause optical distortion while the windshield rain removal is used. Windshield rain removal should be turned off immediately.	**DUCT TEMP HIGH** Temperature within the engine intake duct is beyond allowable limits.	**CHECK HYD GAUGES** *Hydraulic pressure of any system drops below 1500 ± 100 psi.*	- SPARE -
SLATS IN Slats Override Switch is placed to the IN position, forcing the slats to stop moving as a function of the AOA (Angle of Attack).	**PITCH AUG OFF** Power is on the airplane and the pitch stab aug (Stability Augmentation) switch is not engaged.	**CABIN TURB OVERSPEED** Cabin turbine of the refrigeration unit is subjected to pressures and temperatures in excess of the normal operation.	- SPARE -
INERTIAL NAV SYS OUT Inertial Navigation system is either out or off.	**TANK 7 FULL** Tank 7 fuel transfer valve fails to open.	- SPARE -	- SPARE -
OXYGEN LOW Oxygen amount is below 1 litre.	- SPARE -	- SPARE -	- SPARE -



Pilot Cockpit



Canopy Manual Unlock Handle

LH GEN OUT Light
- *Illuminates when left-hand side generator is disconnected or failed.*

RH GEN OUT Light
- *Illuminates when right-hand side generator is disconnected or failed.*

BUS TIE OPEN Light
- *Illuminates when a single functioning generator is providing power to the entire aircraft*

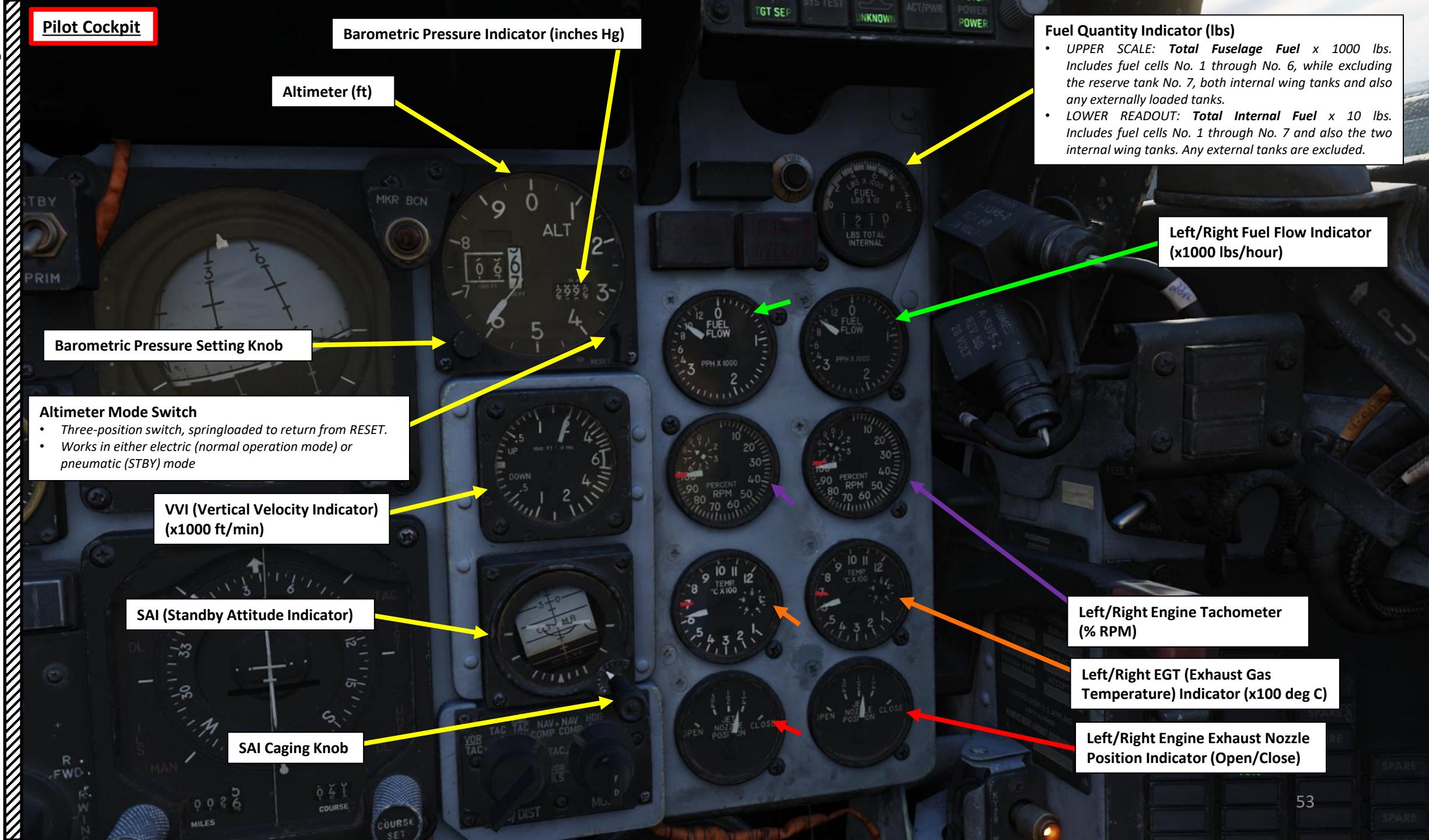
Arresting Hook Handle
- *UP: Hook Retracted*
- *DOWN: Hook Deployed*

Feed Tank Check Switch
- *UP: Feed Tank Check position. In this position, fuel quantity gauge will indicate solely the current fuel quantity in the engine feed tank on both the tape and counter. When the feed tank is full, the indicated value should read 1400 lbs +/- 200 on the counter, and the tape value should be 1400 lbs +/- 150.*
- *DOWN: Normal Position*

Pilot Cockpit



Pilot Cockpit



Barometric Pressure Indicator (inches Hg)

Altimeter (ft)

Fuel Quantity Indicator (lbs)

- *UPPER SCALE:* ***Total Fuselage Fuel*** *x 1000 lbs. Includes fuel cells No. 1 through No. 6, while excluding the reserve tank No. 7, both internal wing tanks and also any externally loaded tanks.*
- *LOWER READOUT:* ***Total Internal Fuel*** *x 10 lbs. Includes fuel cells No. 1 through No. 7 and also the two internal wing tanks. Any external tanks are excluded.*

Left/Right Fuel Flow Indicator (x1000 lbs/hour)

Barometric Pressure Setting Knob

Altimeter Mode Switch

- *Three-position switch, springloaded to return from RESET.*
- *Works in either electric (normal operation mode) or pneumatic (STBY) mode*

VVI (Vertical Velocity Indicator) (x1000 ft/min)

SAI (Standby Attitude Indicator)

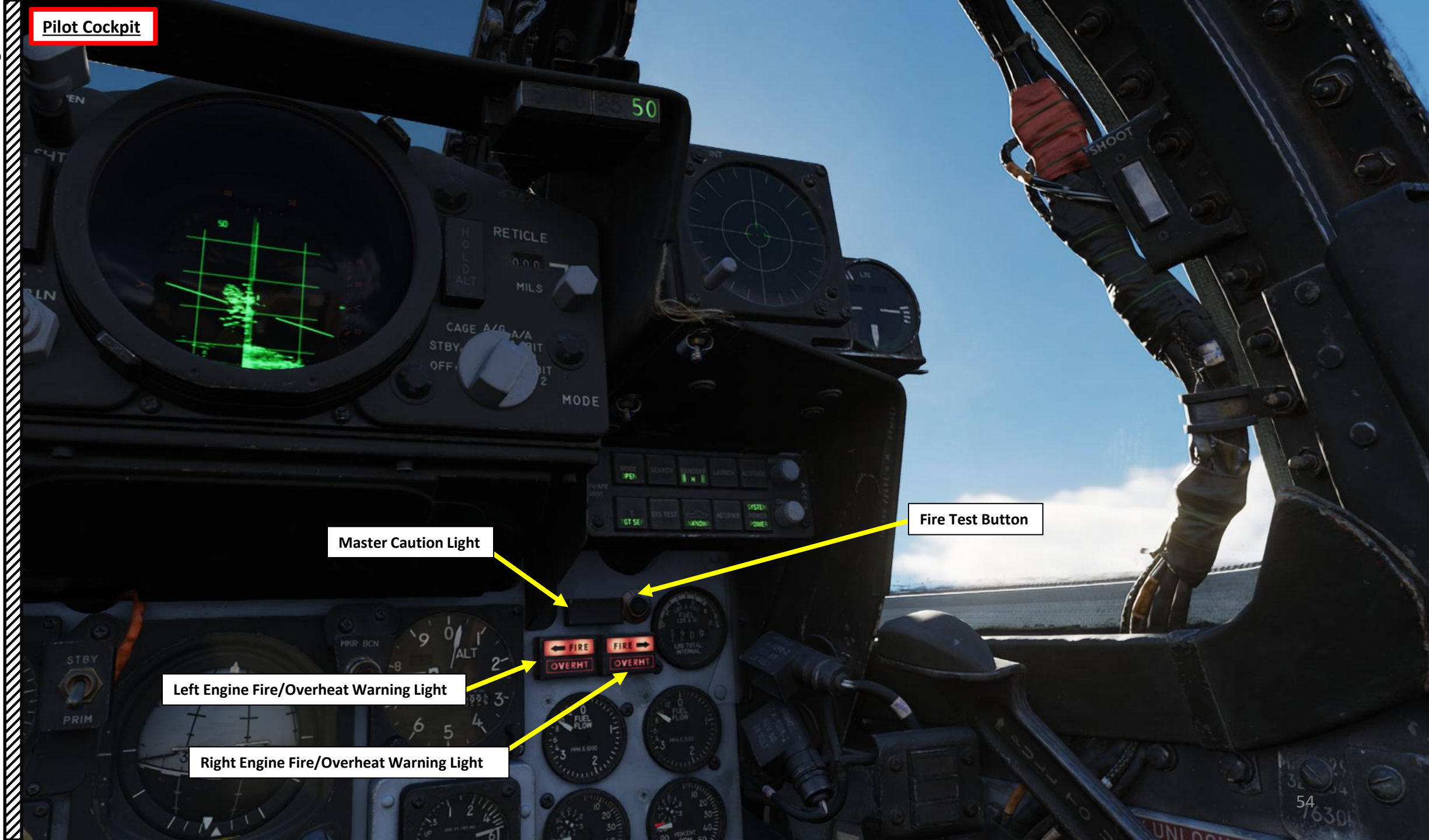
SAI Caging Knob

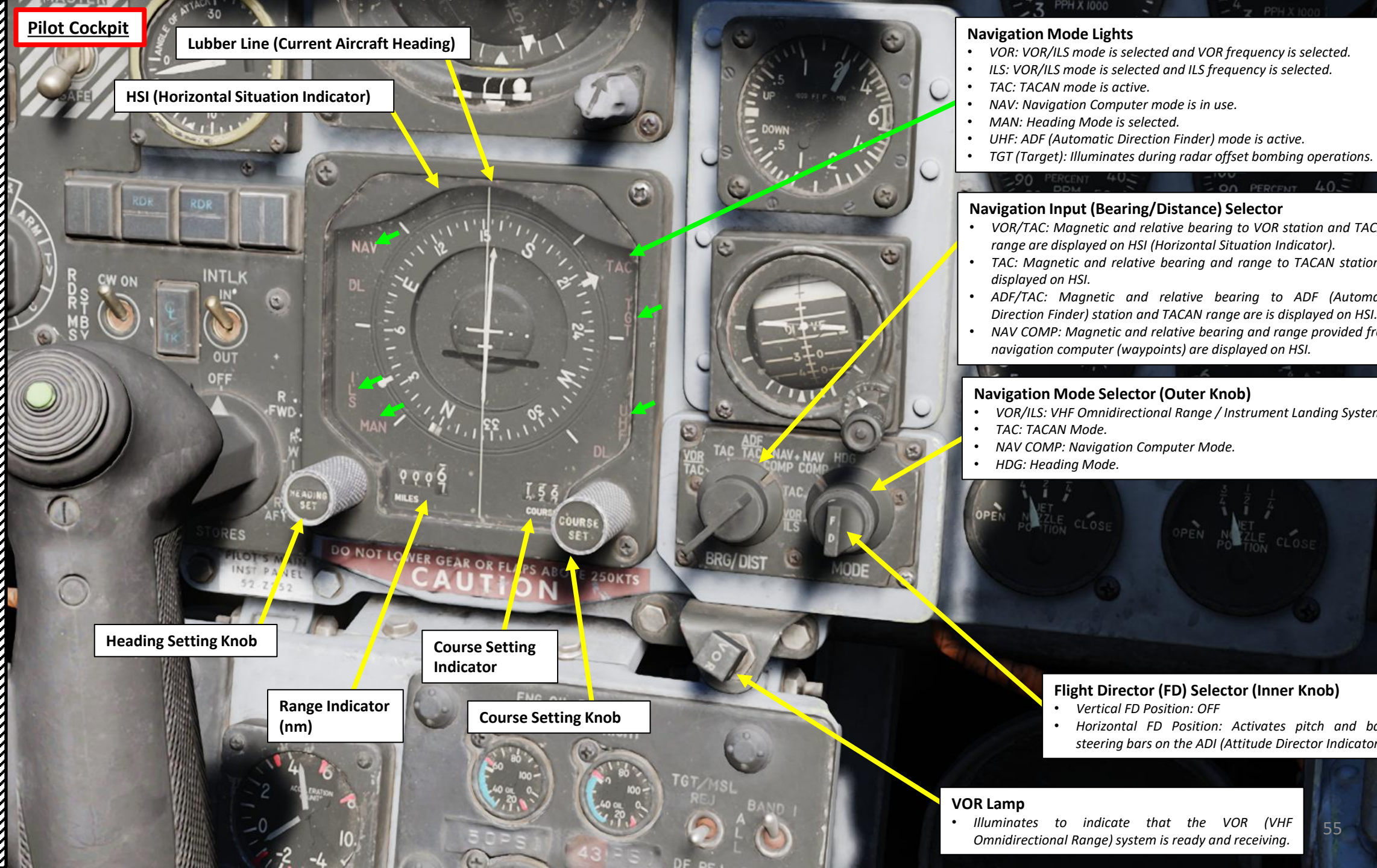
Left/Right Engine Tachometer (% RPM)

Left/Right EGT (Exhaust Gas Temperature) Indicator (x100 deg C)

Left/Right Engine Exhaust Nozzle Position Indicator (Open/Close)

Pilot Cockpit





Pilot Cockpit

Lubber Line (Current Aircraft Heading)

HSI (Horizontal Situation Indicator)

Heading Setting Knob

Range Indicator (nm)

Course Setting Indicator

Course Setting Knob

Navigation Mode Lights

- *VOR: VOR/ILS mode is selected and VOR frequency is selected.*
- *ILS: VOR/ILS mode is selected and ILS frequency is selected.*
- *TAC: TACAN mode is active.*
- *NAV: Navigation Computer mode is in use.*
- *MAN: Heading Mode is selected.*
- *UHF: ADF (Automatic Direction Finder) mode is active.*
- *TGT (Target): Illuminates during radar offset bombing operations.*

Navigation Input (Bearing/Distance) Selector

- *VOR/TAC: Magnetic and relative bearing to VOR station and TACAN range are displayed on HSI (Horizontal Situation Indicator).*
- *TAC: Magnetic and relative bearing and range to TACAN station is displayed on HSI.*
- *ADF/TAC: Magnetic and relative bearing to ADF (Automatic Direction Finder) station and TACAN range are is displayed on HSI.*
- *NAV COMP: Magnetic and relative bearing and range provided from navigation computer (waypoints) are displayed on HSI.*

Navigation Mode Selector (Outer Knob)

- *VOR/ILS: VHF Omnidirectional Range / Instrument Landing System.*
- *TAC: TACAN Mode.*
- *NAV COMP: Navigation Computer Mode.*
- *HDG: Heading Mode.*

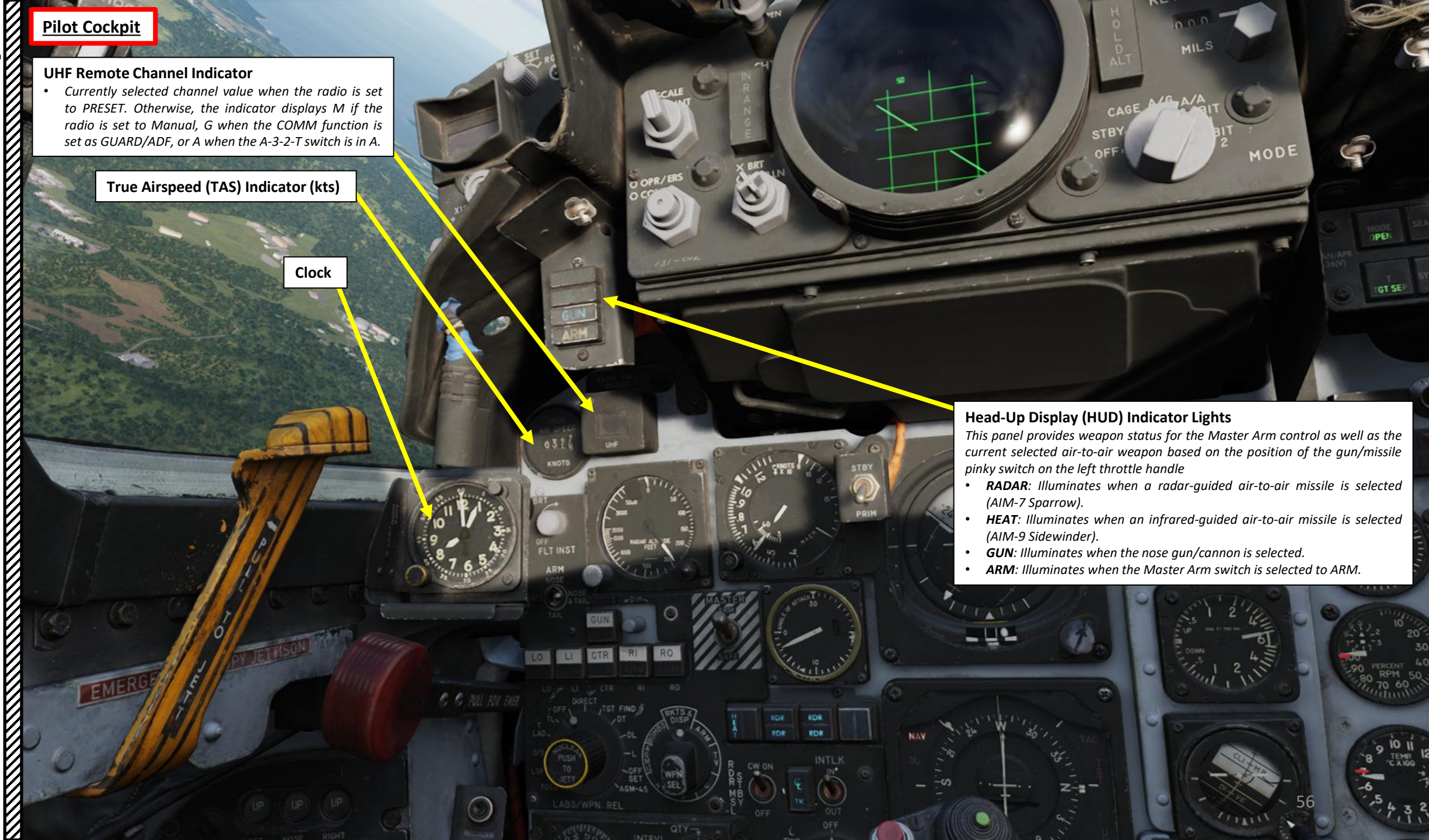
Flight Director (FD) Selector (Inner Knob)

- *Vertical FD Position: OFF*
- *Horizontal FD Position: Activates pitch and bank steering bars on the ADI (Attitude Director Indicator).*

VOR Lamp

- *Illuminates to indicate that the VOR (VHF Omnidirectional Range) system is ready and receiving.*

Pilot Cockpit



UHF Remote Channel Indicator

- *Currently selected channel value when the radio is set to PRESET. Otherwise, the indicator displays M if the radio is set to Manual, G when the COMM function is set as GUARD/ADF, or A when the A-3-2-T switch is in A.*

True Airspeed (TAS) Indicator (kts)

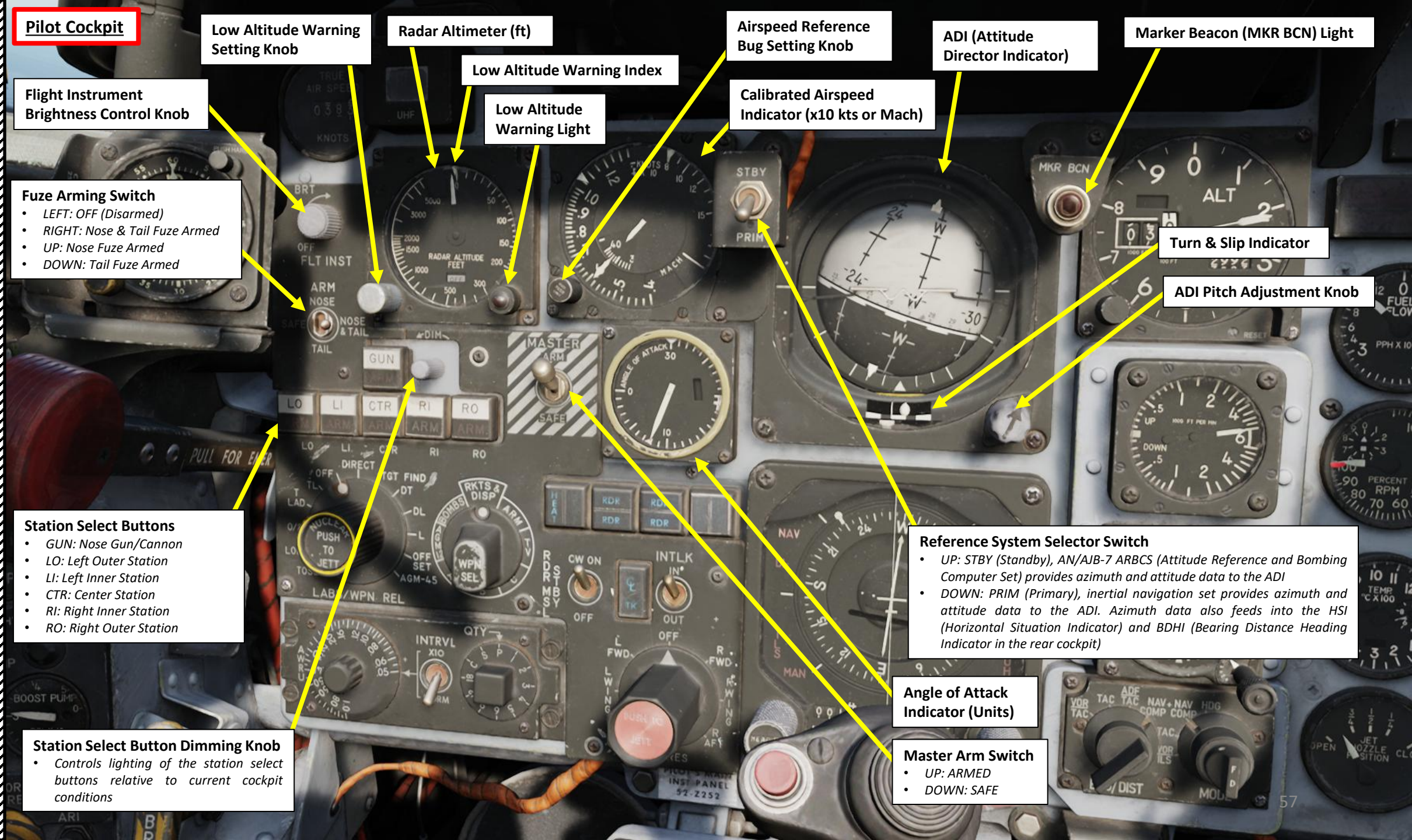
Clock

Head-Up Display (HUD) Indicator Lights

This panel provides weapon status for the Master Arm control as well as the current selected air-to-air weapon based on the position of the gun/missile pinky switch on the left throttle handle

- ***RADAR**: Illuminates when a radar-guided air-to-air missile is selected (AIM-7 Sparrow).*
- ***HEAT**: Illuminates when an infrared-guided air-to-air missile is selected (AIM-9 Sidewinder).*
- ***GUN**: Illuminates when the nose gun/cannon is selected.*
- ***ARM**: Illuminates when the Master Arm switch is selected to ARM.*

Pilot Cockpit



Low Altitude Warning Setting Knob

Radar Altimeter (ft)

Low Altitude Warning Index

Low Altitude Warning Light

Airspeed Reference Bug Setting Knob

Calibrated Airspeed Indicator (x10 kts or Mach)

ADI (Attitude Director Indicator)

Marker Beacon (MKR BCN) Light

Flight Instrument Brightness Control Knob

Fuze Arming Switch
- *LEFT: OFF (Disarmed)*
- *RIGHT: Nose & Tail Fuze Armed*
- *UP: Nose Fuze Armed*
- *DOWN: Tail Fuze Armed*

Turn & Slip Indicator

ADI Pitch Adjustment Knob

Station Select Buttons
- *GUN: Nose Gun/Cannon*
- *LO: Left Outer Station*
- *LI: Left Inner Station*
- *CTR: Center Station*
- *RI: Right Inner Station*
- *RO: Right Outer Station*

Reference System Selector Switch
- *UP: STBY (Standby), AN/AJB-7 ARBCS (Attitude Reference and Bombing Computer Set) provides azimuth and attitude data to the ADI*
- *DOWN: PRIM (Primary), inertial navigation set provides azimuth and attitude data to the ADI. Azimuth data also feeds into the HSI (Horizontal Situation Indicator) and BDHI (Bearing Distance Heading Indicator in the rear cockpit)*

Angle of Attack Indicator (Units)

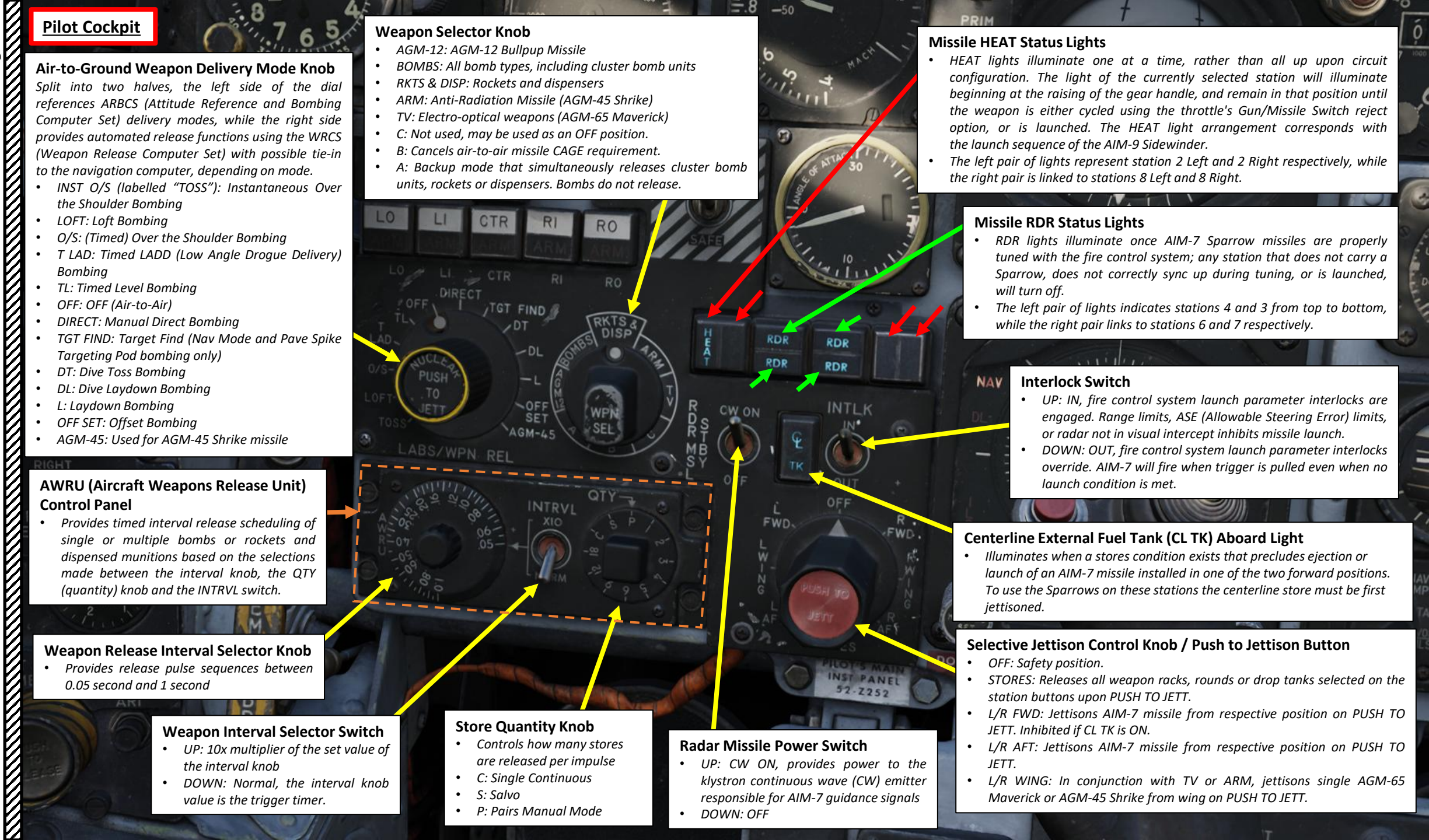
Station Select Button Dimming Knob
- *Controls lighting of the station select buttons relative to current cockpit conditions*

Master Arm Switch
- *UP: ARMED*
- *DOWN: SAFE*

F-4E PHANTOM II

PART 3 – COCKPIT & EQUIPMENT

Pilot Cockpit



Air-to-Ground Weapon Delivery Mode Knob

Split into two halves, the left side of the dial references ARBCS (Attitude Reference and Bombing Computer Set) delivery modes, while the right side provides automated release functions using the WRCS (Weapon Release Computer Set) with possible tie-in to the navigation computer, depending on mode.

- *INST O/S (labelled "TOSS"): Instantaneous Over the Shoulder Bombing*
- *LOFT: Loft Bombing*
- *O/S: (Timed) Over the Shoulder Bombing*
- *T LAD: Timed LADD (Low Angle Drogue Delivery) Bombing*
- *TL: Timed Level Bombing*
- *OFF: OFF (Air-to-Air)*
- *DIRECT: Manual Direct Bombing*
- *TGT FIND: Target Find (Nav Mode and Pave Spike Targeting Pod bombing only)*
- *DT: Dive Toss Bombing*
- *DL: Dive Laydown Bombing*
- *L: Laydown Bombing*
- *OFF SET: Offset Bombing*
- *AGM-45: Used for AGM-45 Shrike missile*

Weapon Selector Knob

- *AGM-12: AGM-12 Bullpup Missile*
- *BOMBS: All bomb types, including cluster bomb units*
- *RKTS & DISP: Rockets and dispensers*
- *ARM: Anti-Radiation Missile (AGM-45 Shrike)*
- *TV: Electro-optical weapons (AGM-65 Maverick)*
- *C: Not used, may be used as an OFF position.*
- *B: Cancels air-to-air missile CAGE requirement.*
- *A: Backup mode that simultaneously releases cluster bomb units, rockets or dispensers. Bombs do not release.*

Missile HEAT Status Lights

- *HEAT lights illuminate one at a time, rather than all up upon circuit configuration. The light of the currently selected station will illuminate beginning at the raising of the gear handle, and remain in that position until the weapon is either cycled using the throttle's Gun/Missile Switch reject option, or is launched. The HEAT light arrangement corresponds with the launch sequence of the AIM-9 Sidewinder.*
- *The left pair of lights represent station 2 Left and 2 Right respectively, while the right pair is linked to stations 8 Left and 8 Right.*

Missile RDR Status Lights

- *RDR lights illuminate once AIM-7 Sparrow missiles are properly tuned with the fire control system; any station that does not carry a Sparrow, does not correctly sync up during tuning, or is launched, will turn off.*
- *The left pair of lights indicates stations 4 and 3 from top to bottom, while the right pair links to stations 6 and 7 respectively.*

Interlock Switch

- *UP: IN, fire control system launch parameter interlocks are engaged. Range limits, ASE (Allowable Steering Error) limits, or radar not in visual intercept inhibits missile launch.*
- *DOWN: OUT, fire control system launch parameter interlocks override. AIM-7 will fire when trigger is pulled even when no launch condition is met.*

AWRU (Aircraft Weapons Release Unit) Control Panel

- *Provides timed interval release scheduling of single or multiple bombs or rockets and dispensed munitions based on the selections made between the interval knob, the QTY (quantity) knob and the INTRVL switch.*

Centerline External Fuel Tank (CL TK) Aboard Light

- *Illuminates when a stores condition exists that precludes ejection or launch of an AIM-7 missile installed in one of the two forward positions. To use the Sparrows on these stations the centerline store must be first jettisoned.*

Weapon Release Interval Selector Knob

- *Provides release pulse sequences between 0.05 second and 1 second*

Selective Jettison Control Knob / Push to Jettison Button

- *OFF: Safety position.*
- *STORES: Releases all weapon racks, rounds or drop tanks selected on the station buttons upon PUSH TO JETT.*
- *L/R FWD: Jettisons AIM-7 missile from respective position on PUSH TO JETT. Inhibited if CL TK is ON.*
- *L/R AFT: Jettisons AIM-7 missile from respective position on PUSH TO JETT.*
- *L/R WING: In conjunction with TV or ARM, jettisons single AGM-65 Maverick or AGM-45 Shrike from wing on PUSH TO JETT.*

Weapon Interval Selector Switch

- *UP: 10x multiplier of the set value of the interval knob*
- *DOWN: Normal, the interval knob value is the trigger timer.*

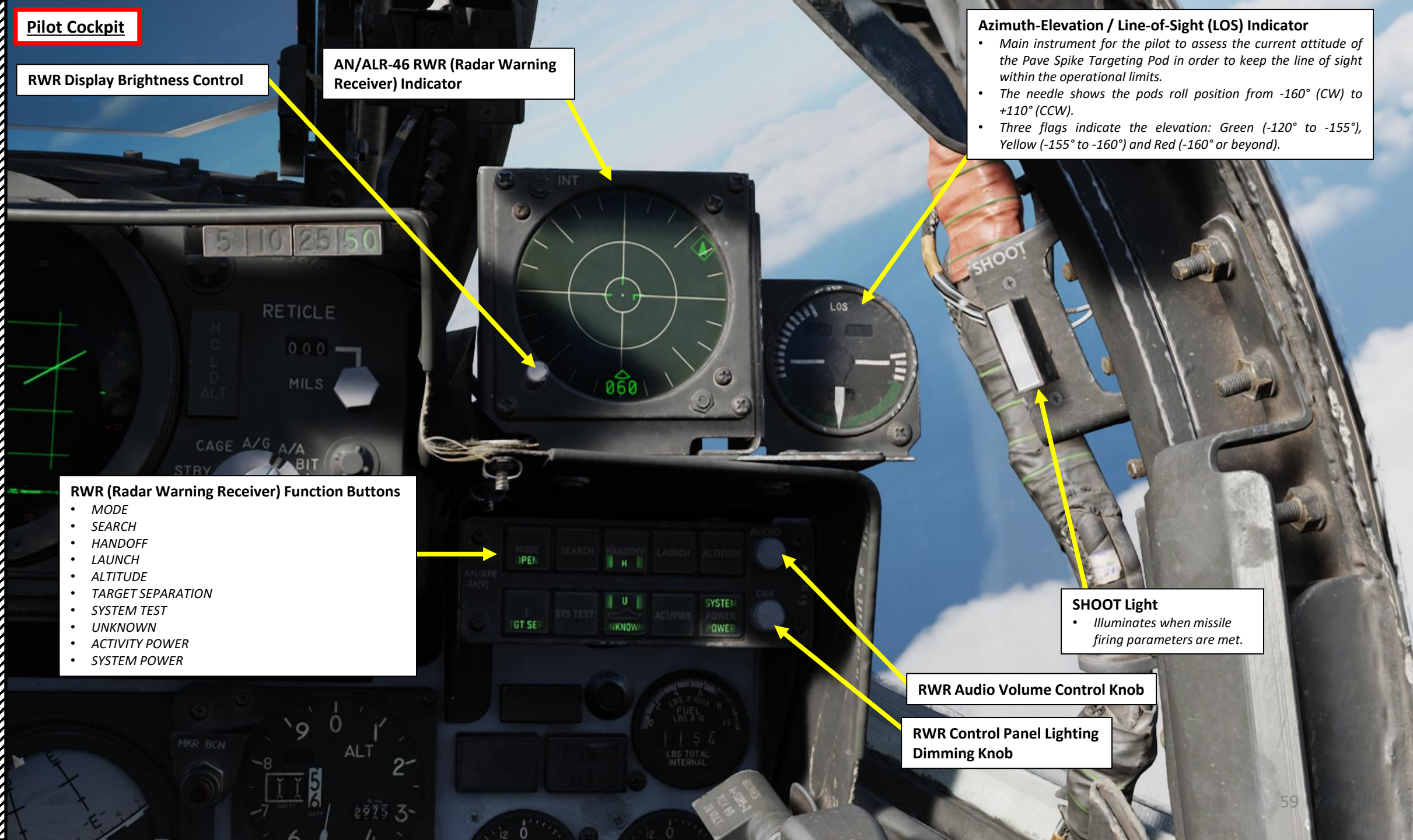
Store Quantity Knob

- *Controls how many stores are released per impulse*
- *C: Single Continuous*
- *S: Salvo*
- *P: Pairs Manual Mode*

Radar Missile Power Switch

- *UP: CW ON, provides power to the klystron continuous wave (CW) emitter responsible for AIM-7 guidance signals*
- *DOWN: OFF*

Pilot Cockpit



RWR Display Brightness Control

AN/ALR-46 RWR (Radar Warning Receiver) Indicator

Azimuth-Elevation / Line-of-Sight (LOS) Indicator

- *Main instrument for the pilot to assess the current attitude of the Pave Spike Targeting Pod in order to keep the line of sight within the operational limits.*
- *The needle shows the pods roll position from -160° (CW) to +110° (CCW).*
- *Three flags indicate the elevation: Green (-120° to -155°), Yellow (-155° to -160°) and Red (-160° or beyond).*

RWR (Radar Warning Receiver) Function Buttons

- *MODE*
- *SEARCH*
- *HANDOFF*
- *LAUNCH*
- *ALTITUDE*
- *TARGET SEPARATION*
- *SYSTEM TEST*
- *UNKNOWN*
- *ACTIVITY POWER*
- *SYSTEM POWER*

SHOOT Light

- *Illuminates when missile firing parameters are met.*

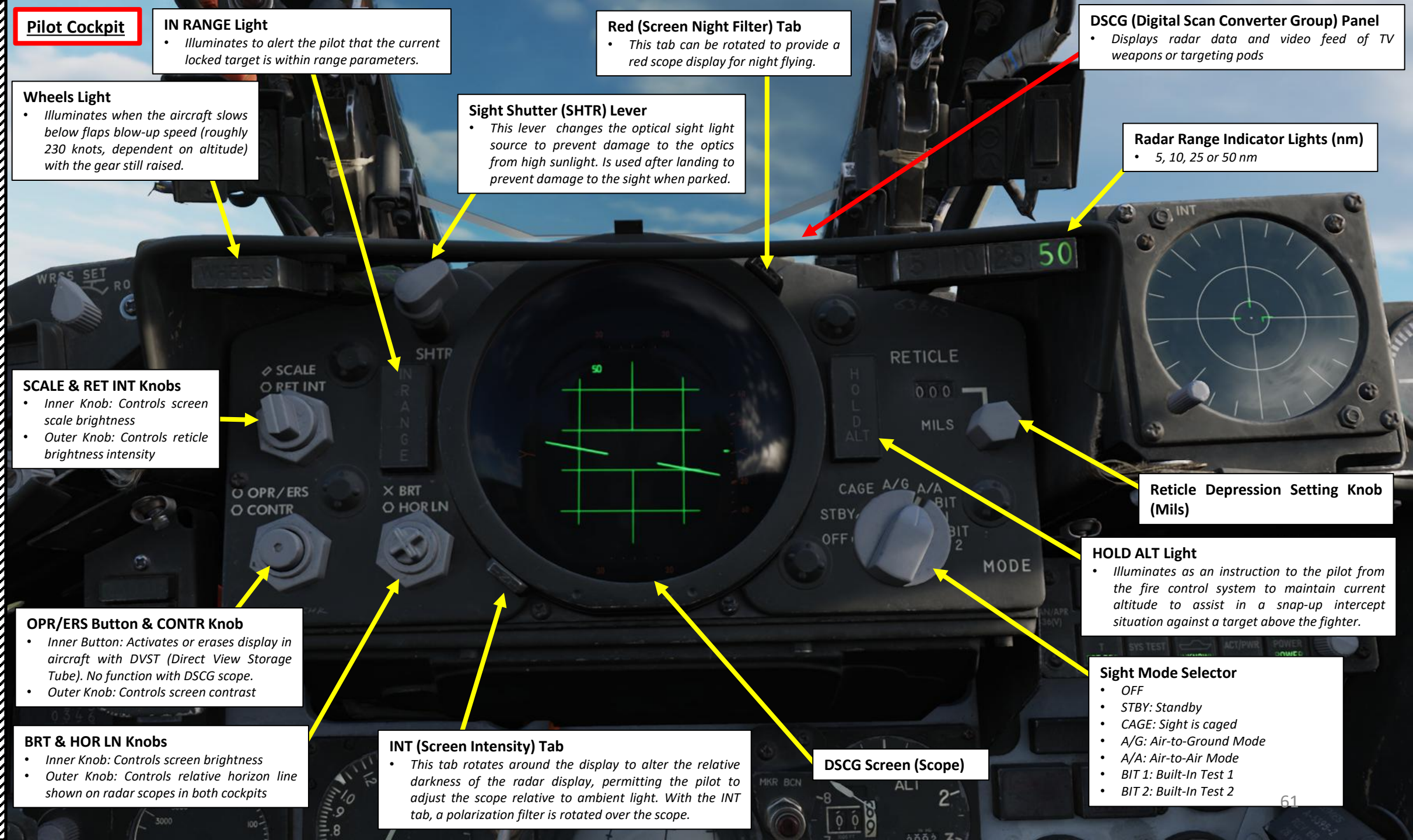
RWR Audio Volume Control Knob

RWR Control Panel Lighting Dimming Knob

Pilot Cockpit



Pilot Cockpit



IN RANGE Light
- *Illuminates to alert the pilot that the current locked target is within range parameters.*

Red (Screen Night Filter) Tab
- *This tab can be rotated to provide a red scope display for night flying.*

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

Wheels Light
- *Illuminates when the aircraft slows below flaps blow-up speed (roughly 230 knots, dependent on altitude) with the gear still raised.*

Sight Shutter (SHTR) Lever
- *This lever changes the optical sight light source to prevent damage to the optics from high sunlight. Is used after landing to prevent damage to the sight when parked.*

Radar Range Indicator Lights (nm)
- *5, 10, 25 or 50 nm*

SCALE & RET INT Knobs
- *Inner Knob: Controls screen scale brightness*
- *Outer Knob: Controls reticle brightness intensity*

Reticle Depression Setting Knob (Mils)

HOLD ALT Light
- *Illuminates as an instruction to the pilot from the fire control system to maintain current altitude to assist in a snap-up intercept situation against a target above the fighter.*

OPR/ERS Button & CONTR Knob
- *Inner Button: Activates or erases display in aircraft with DVST (Direct View Storage Tube). No function with DSCG scope.*
- *Outer Knob: Controls screen contrast*

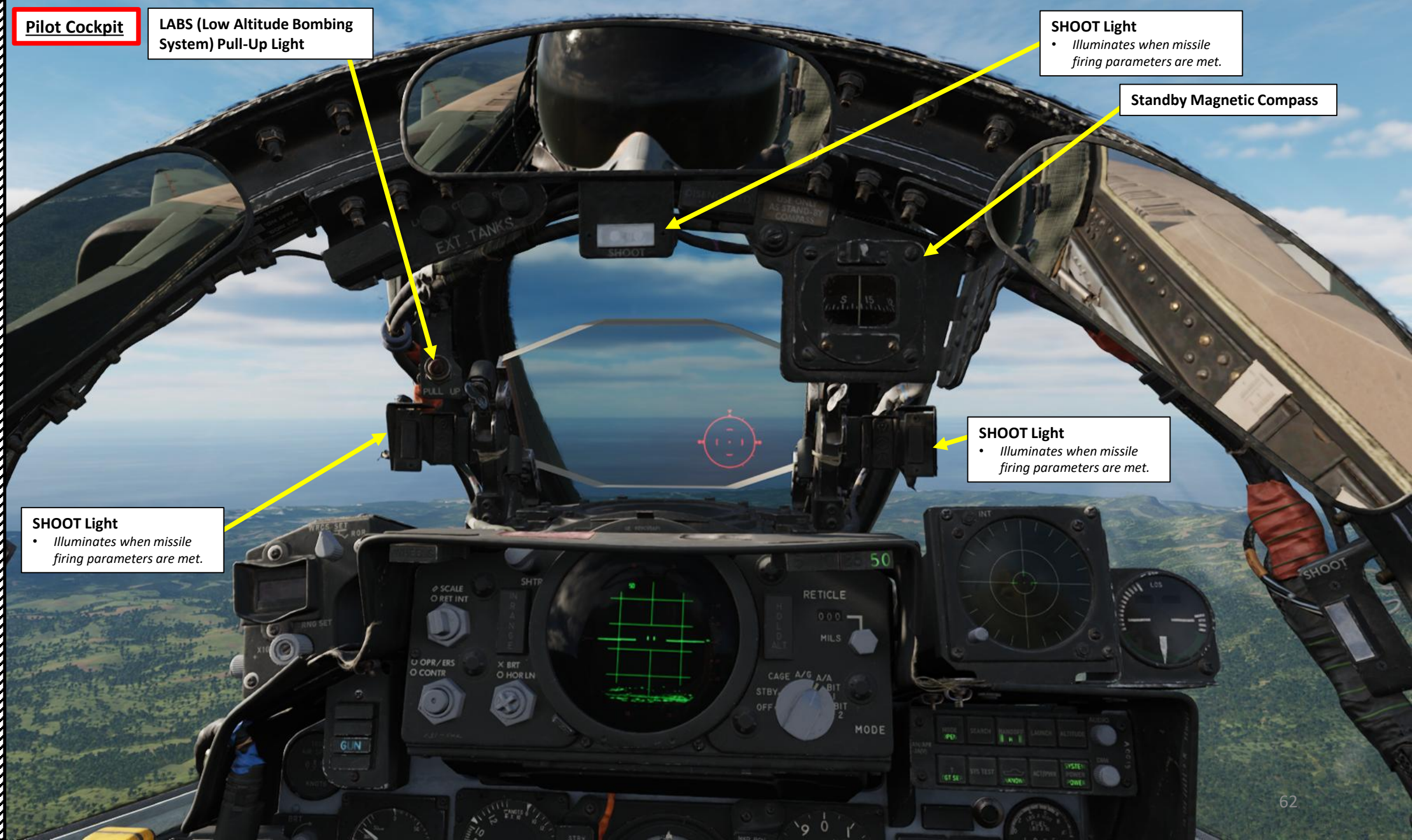
Sight Mode Selector
- *OFF*
- *STBY: Standby*
- *CAGE: Sight is caged*
- *A/G: Air-to-Ground Mode*
- *A/A: Air-to-Air Mode*
- *BIT 1: Built-In Test 1*
- *BIT 2: Built-In Test 2*

BRT & HOR LN Knobs
- *Inner Knob: Controls screen brightness*
- *Outer Knob: Controls relative horizon line shown on radar scopes in both cockpits*

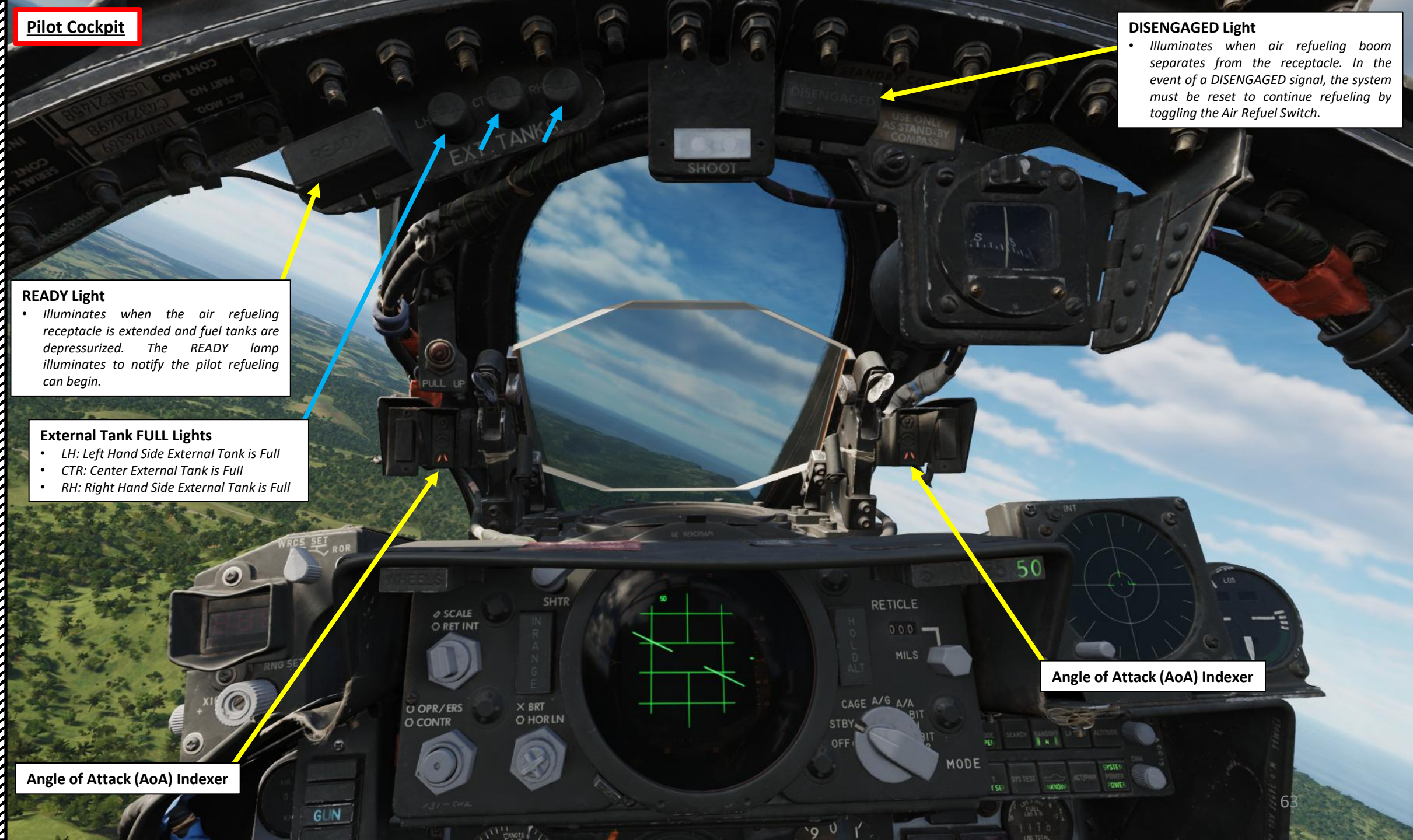
INT (Screen Intensity) Tab
- *This tab rotates around the display to alter the relative darkness of the radar display, permitting the pilot to adjust the scope relative to ambient light. With the INT tab, a polarization filter is rotated over the scope.*

DSCG Screen (Scope)

Pilot Cockpit



Pilot Cockpit



DISENGAGED Light

- *Illuminates when air refueling boom separates from the receptacle. In the event of a DISENGAGED signal, the system must be reset to continue refueling by toggling the Air Refuel Switch.*

READY Light

- *Illuminates when the air refueling receptacle is extended and fuel tanks are depressurized. The READY lamp illuminates to notify the pilot refueling can begin.*

External Tank FULL Lights

- *LH: Left Hand Side External Tank is Full*
- *CTR: Center External Tank is Full*
- *RH: Right Hand Side External Tank is Full*

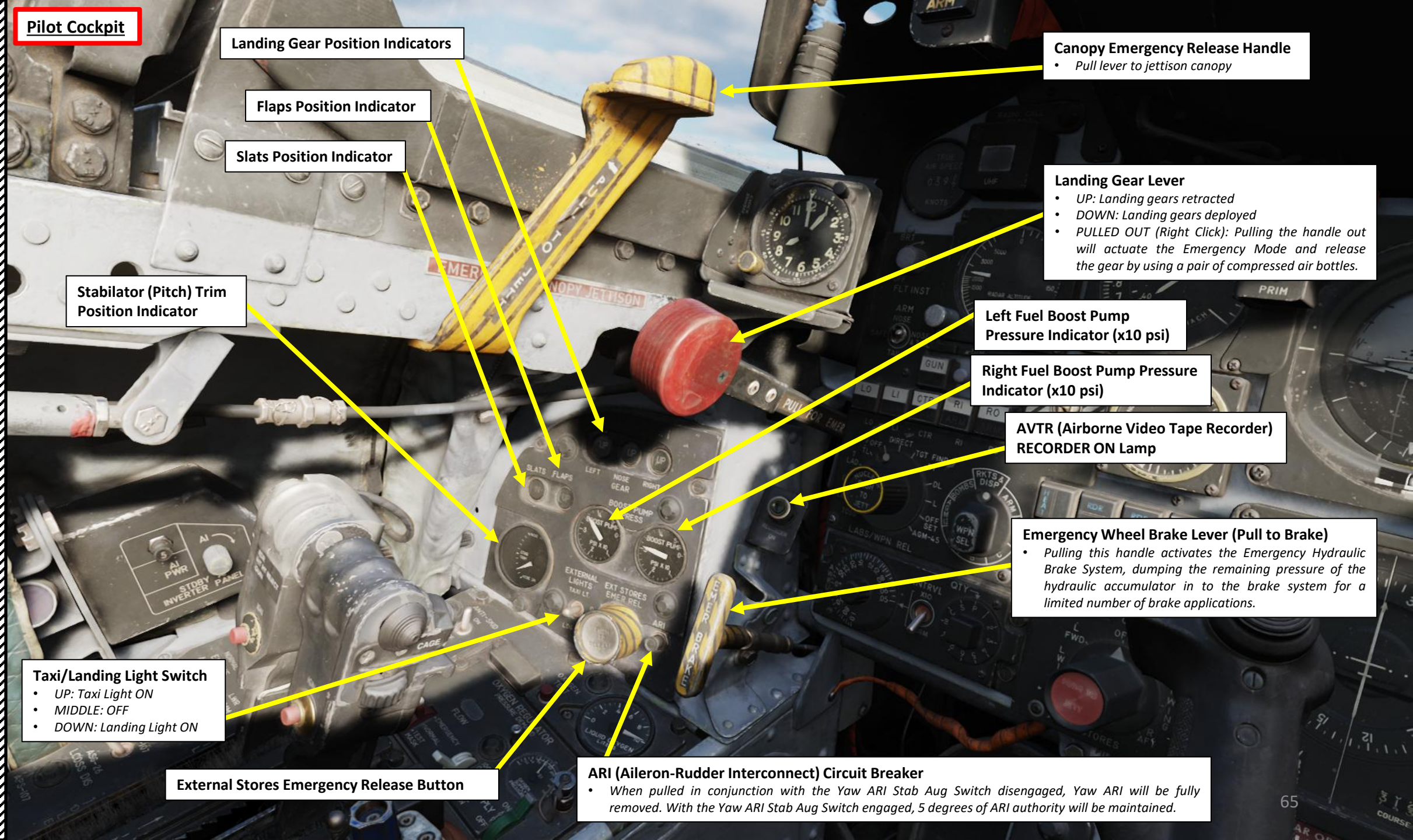
Angle of Attack (AoA) Indexer

Angle of Attack (AoA) Indexer

Pilot Cockpit



Pilot Cockpit



Landing Gear Position Indicators

Flaps Position Indicator

Slats Position Indicator

Stabilator (Pitch) Trim Position Indicator

Canopy Emergency Release Handle
- *Pull lever to jettison canopy*

Landing Gear Lever
- *UP: Landing gears retracted*
- *DOWN: Landing gears deployed*
- *PULLED OUT (Right Click): Pulling the handle out will actuate the Emergency Mode and release the gear by using a pair of compressed air bottles.*

Left Fuel Boost Pump Pressure Indicator (x10 psi)

Right Fuel Boost Pump Pressure Indicator (x10 psi)

AVTR (Airborne Video Tape Recorder) RECORDER ON Lamp

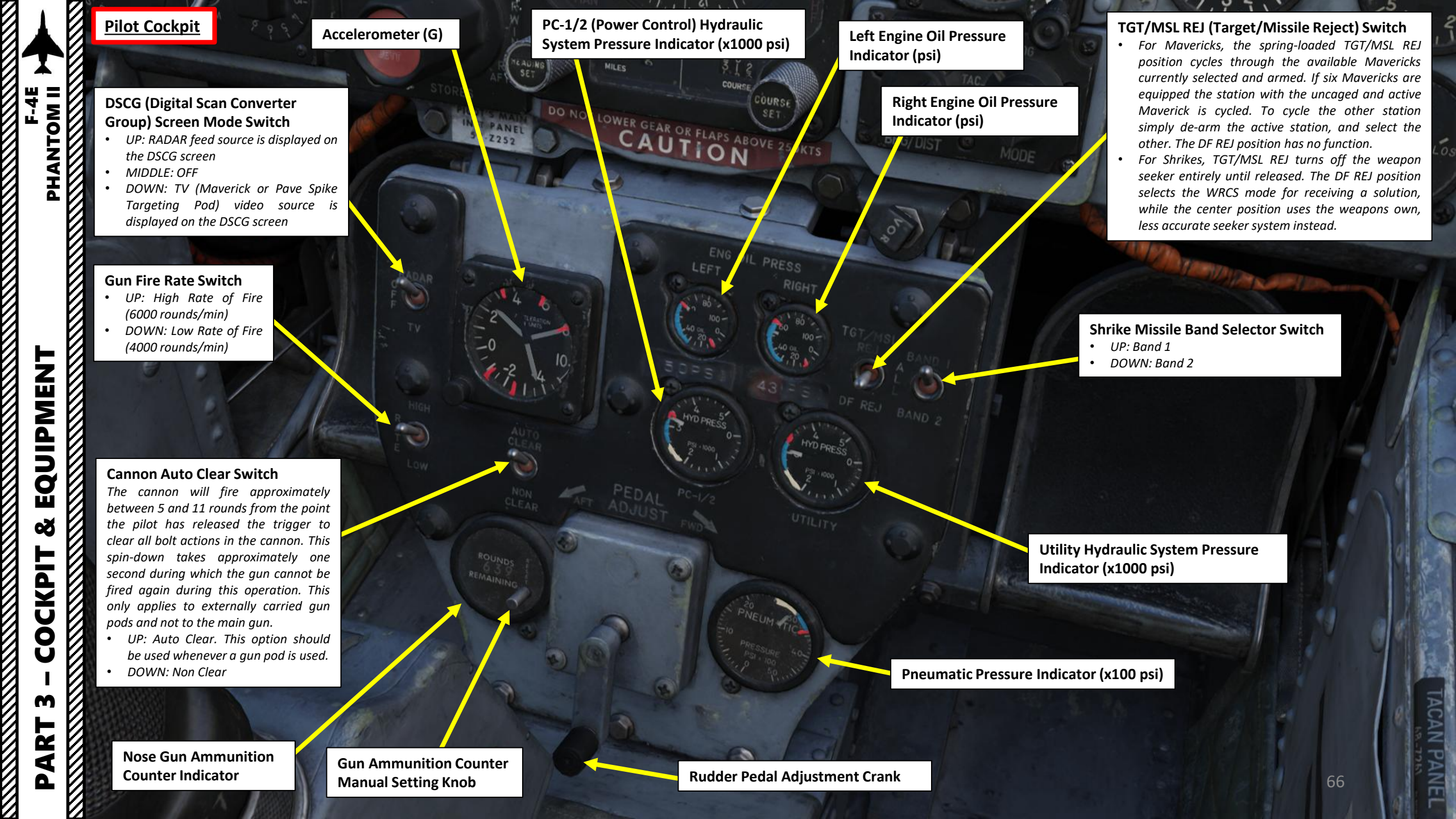
Emergency Wheel Brake Lever (Pull to Brake)
- *Pulling this handle activates the Emergency Hydraulic Brake System, dumping the remaining pressure of the hydraulic accumulator in to the brake system for a limited number of brake applications.*

Taxi/Landing Light Switch
- *UP: Taxi Light ON*
- *MIDDLE: OFF*
- *DOWN: Landing Light ON*

External Stores Emergency Release Button

ARI (Aileron-Rudder Interconnect) Circuit Breaker
- *When pulled in conjunction with the Yaw ARI Stab Aug Switch disengaged, Yaw ARI will be fully removed. With the Yaw ARI Stab Aug Switch engaged, 5 degrees of ARI authority will be maintained.*

Pilot Cockpit



Accelerometer (G)

PC-1/2 (Power Control) Hydraulic System Pressure Indicator (x1000 psi)

Left Engine Oil Pressure Indicator (psi)

Right Engine Oil Pressure Indicator (psi)

TGT/MSL REJ (Target/Missile Reject) Switch

- *For Mavericks, the spring-loaded TGT/MSL REJ position cycles through the available Mavericks currently selected and armed. If six Mavericks are equipped the station with the uncaged and active Maverick is cycled. To cycle the other station simply de-arm the active station, and select the other. The DF REJ position has no function.*
- *For Shrikes, TGT/MSL REJ turns off the weapon seeker entirely until released. The DF REJ position selects the WRCS mode for receiving a solution, while the center position uses the weapons own, less accurate seeker system instead.*

DSCG (Digital Scan Converter Group) Screen Mode Switch

- *UP: RADAR feed source is displayed on the DSCG screen*
- *MIDDLE: OFF*
- *DOWN: TV (Maverick or Pave Spike Targeting Pod) video source is displayed on the DSCG screen*

Gun Fire Rate Switch

- *UP: High Rate of Fire (6000 rounds/min)*
- *DOWN: Low Rate of Fire (4000 rounds/min)*

Shrike Missile Band Selector Switch

- *UP: Band 1*
- *DOWN: Band 2*

Cannon Auto Clear Switch

The cannon will fire approximately between 5 and 11 rounds from the point the pilot has released the trigger to clear all bolt actions in the cannon. This spin-down takes approximately one second during which the gun cannot be fired again during this operation. This only applies to externally carried gun pods and not to the main gun.

- *UP: Auto Clear. This option should be used whenever a gun pod is used.*
- *DOWN: Non Clear*

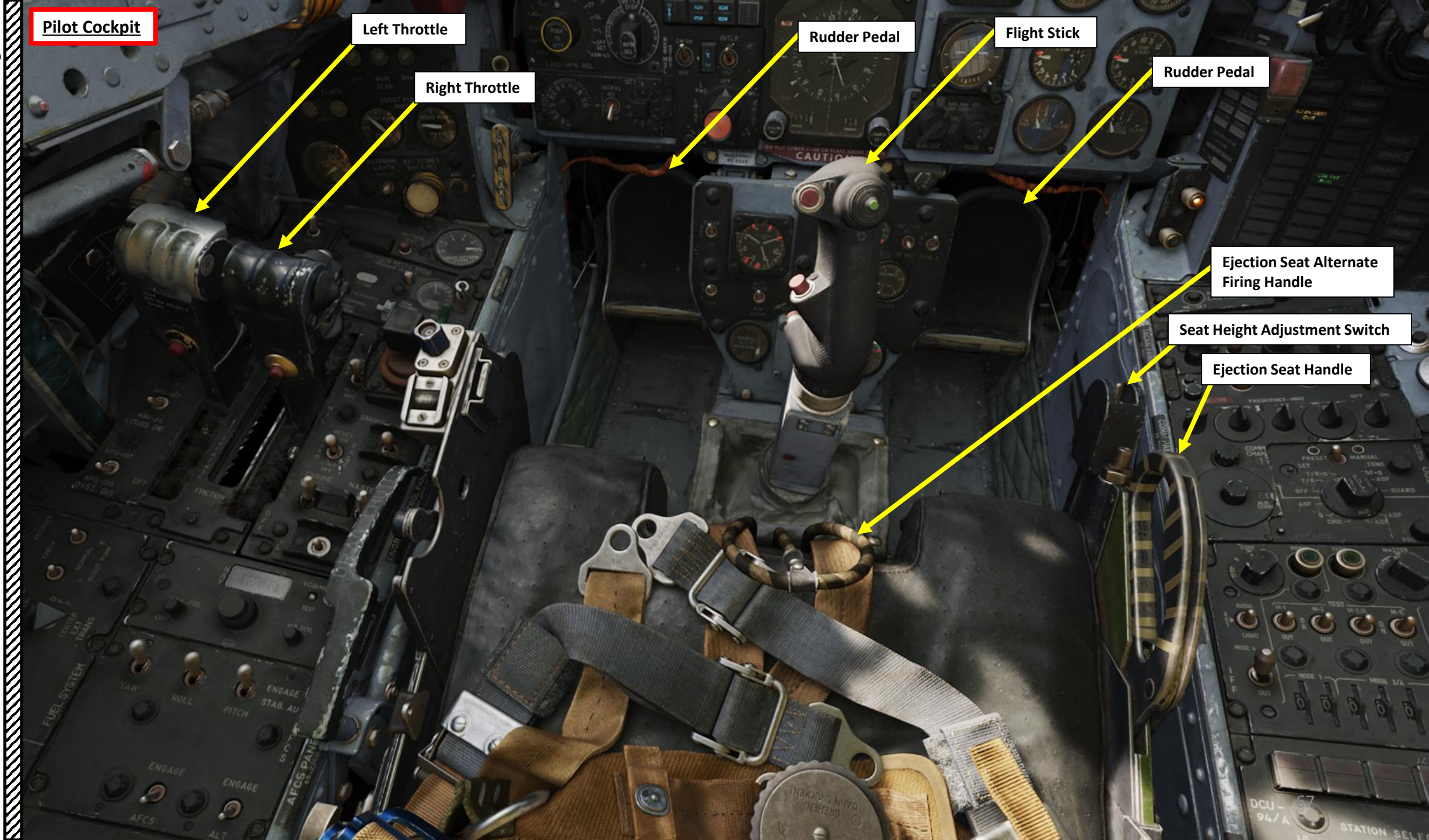
Utility Hydraulic System Pressure Indicator (x1000 psi)

Pneumatic Pressure Indicator (x100 psi)

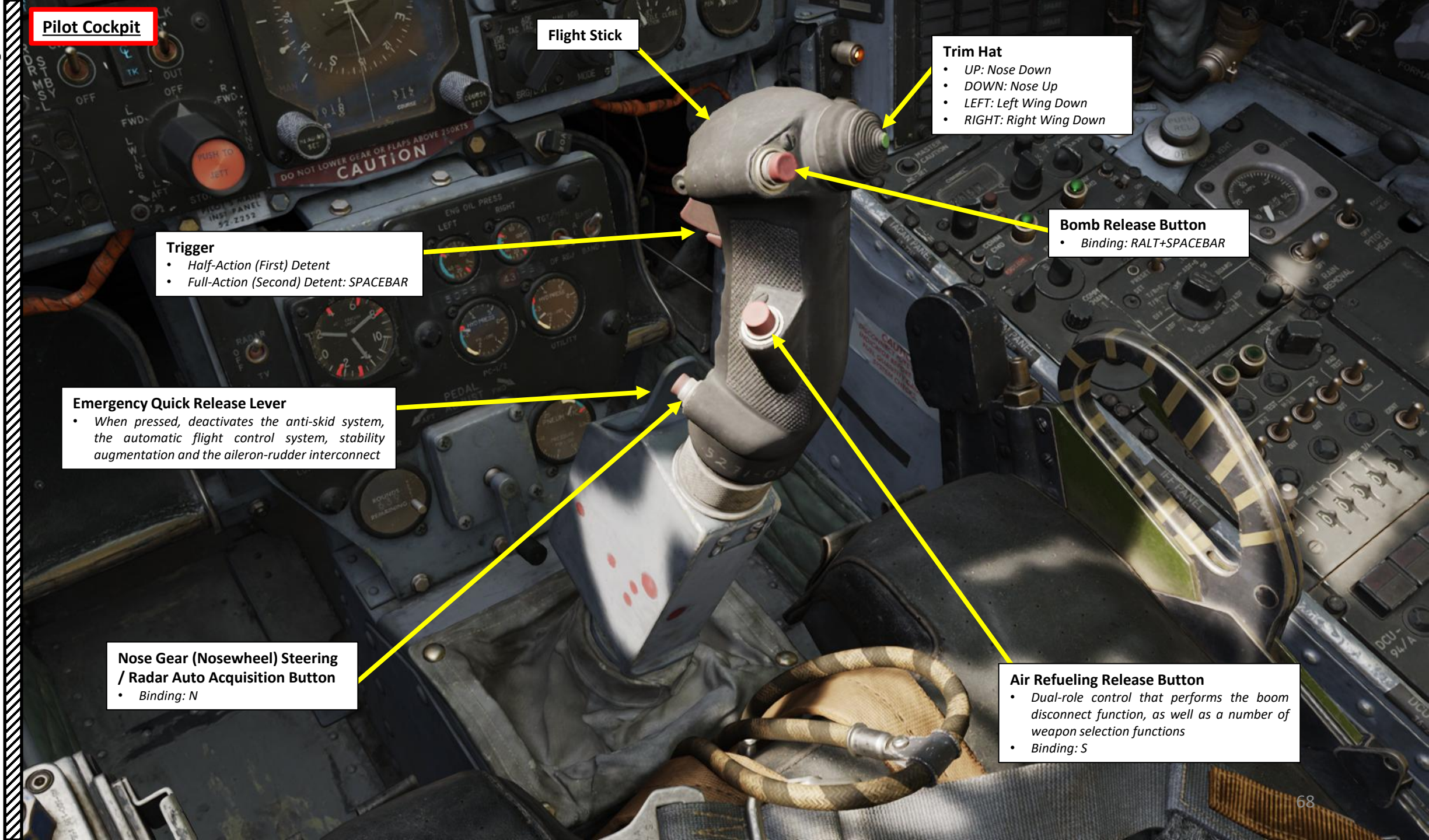
Nose Gun Ammunition Counter Indicator

Gun Ammunition Counter Manual Setting Knob

Rudder Pedal Adjustment Crank


Pilot Cockpit
Left Throttle
Right Throttle
Rudder Pedal
Flight Stick
Rudder Pedal
Ejection Seat Alternate Firing Handle
Seat Height Adjustment Switch
Ejection Seat Handle

Pilot Cockpit



Flight Stick

Trim Hat
- *UP: Nose Down*
- *DOWN: Nose Up*
- *LEFT: Left Wing Down*
- *RIGHT: Right Wing Down*

Bomb Release Button
- *Binding: RALT+SPACEBAR*

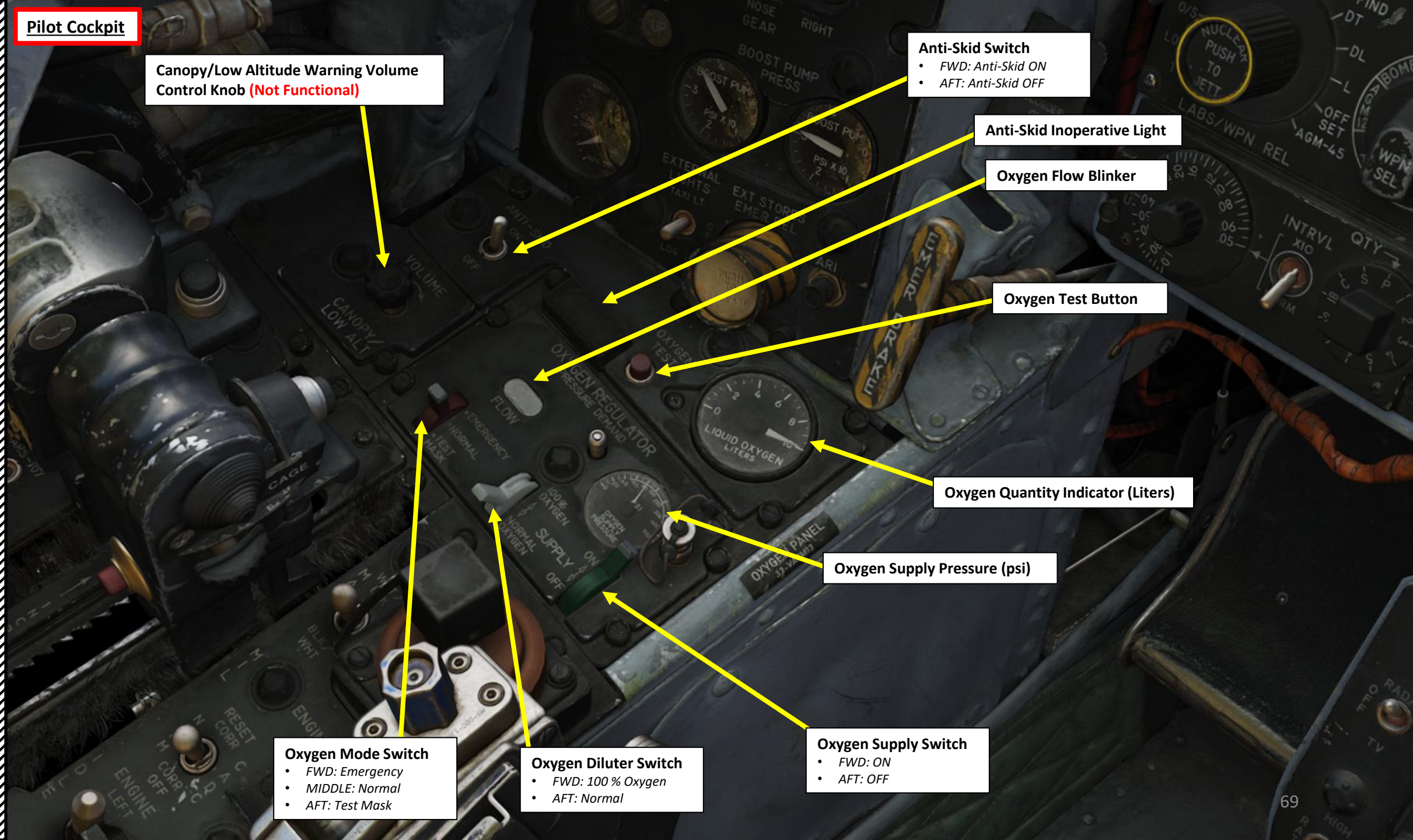
Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

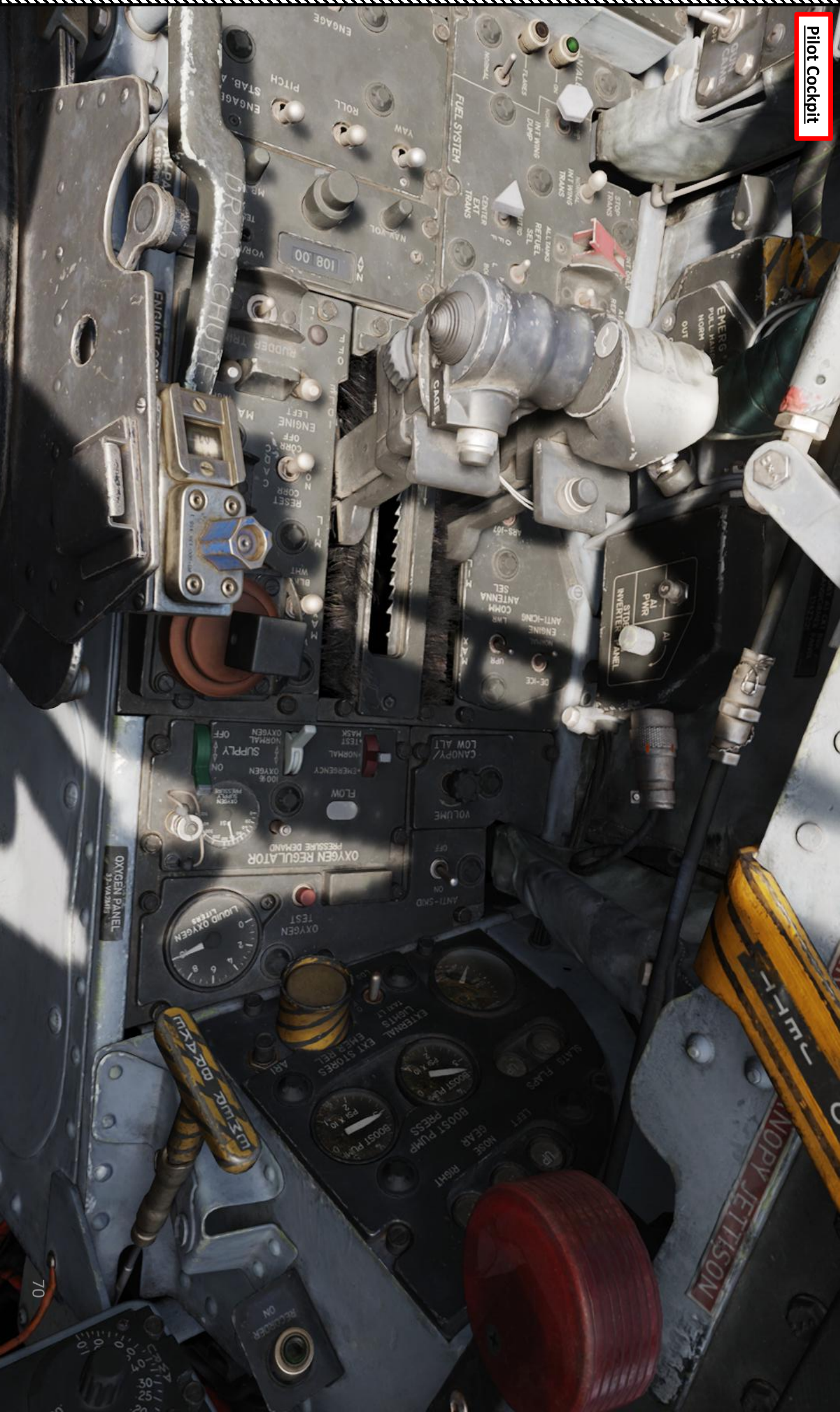
Emergency Quick Release Lever
- *When pressed, deactivates the anti-skid system, the automatic flight control system, stability augmentation and the aileron-rudder interconnect*

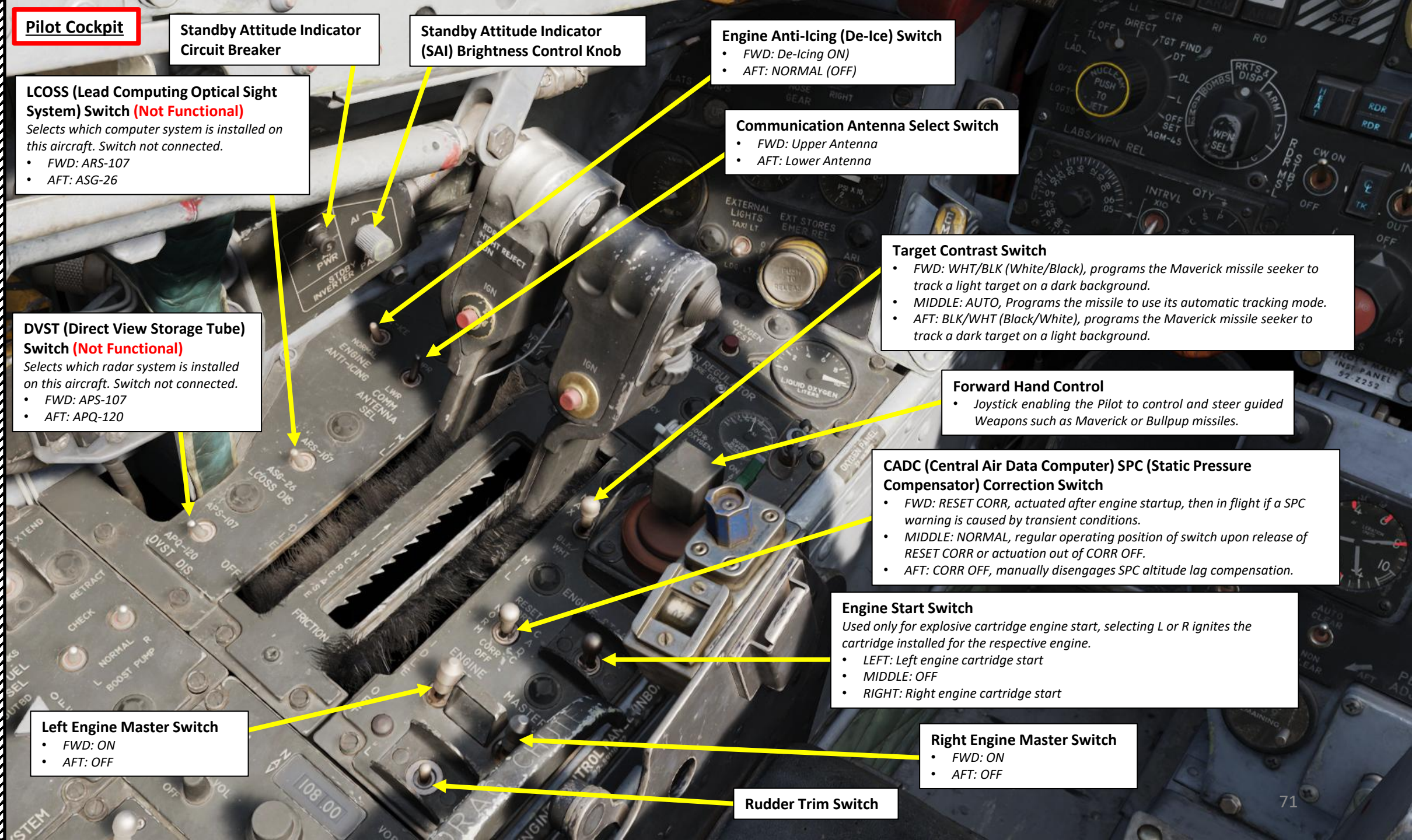
Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*

Air Refueling Release Button
- *Dual-role control that performs the boom disconnect function, as well as a number of weapon selection functions*
- *Binding: S*

Pilot Cockpit




Pilot Cockpit
FUEL SYSTEM
DRAG CHUTE
OXYGEN REGULATOR
OXYGEN PANEL
OXYGEN TEST
BOOST PUMP PRESS
EXT STORES EMER REL
EXTERNAL LIGHTS
NOSE GEAR
LEFT
RIGHT
CANOPY JETTISON
PULL



Pilot Cockpit

Standby Attitude Indicator Circuit Breaker

Standby Attitude Indicator (SAI) Brightness Control Knob

Engine Anti-Icing (De-Ice) Switch
- *FWD: De-Icing ON)*
- *AFT: NORMAL (OFF)*

LCOSS (Lead Computing Optical Sight System) Switch (Not Functional)
Selects which computer system is installed on this aircraft. Switch not connected.
- *FWD: ARS-107*
- *AFT: ASG-26*

Communication Antenna Select Switch
- *FWD: Upper Antenna*
- *AFT: Lower Antenna*

Target Contrast Switch
- *FWD: WHT/BLK (White/Black), programs the Maverick missile seeker to track a light target on a dark background.*
- *MIDDLE: AUTO, Programs the missile to use its automatic tracking mode.*
- *AFT: BLK/WHT (Black/White), programs the Maverick missile seeker to track a dark target on a light background.*

DVST (Direct View Storage Tube) Switch (Not Functional)
Selects which radar system is installed on this aircraft. Switch not connected.
- *FWD: APS-107*
- *AFT: APQ-120*

Forward Hand Control
- *Joystick enabling the Pilot to control and steer guided Weapons such as Maverick or Bullpup missiles.*

CADC (Central Air Data Computer) SPC (Static Pressure Compensator) Correction Switch
- *FWD: RESET CORR, actuated after engine startup, then in flight if a SPC warning is caused by transient conditions.*
- *MIDDLE: NORMAL, regular operating position of switch upon release of RESET CORR or actuation out of CORR OFF.*
- *AFT: CORR OFF, manually disengages SPC altitude lag compensation.*

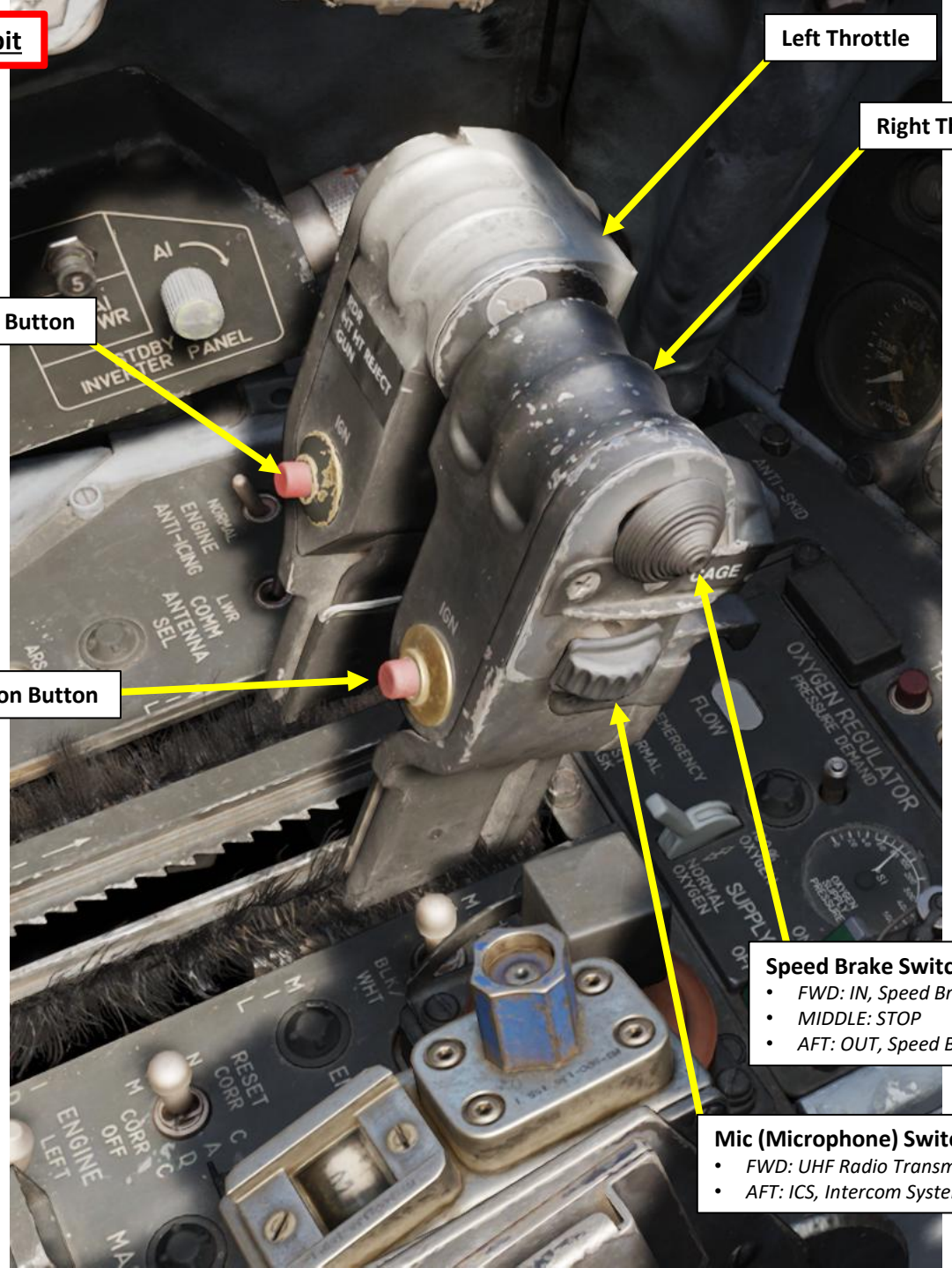
Engine Start Switch
Used only for explosive cartridge engine start, selecting L or R ignites the cartridge installed for the respective engine.
- *LEFT: Left engine cartridge start*
- *MIDDLE: OFF*
- *RIGHT: Right engine cartridge start*

Left Engine Master Switch
- *FWD: ON*
- *AFT: OFF*

Right Engine Master Switch
- *FWD: ON*
- *AFT: OFF*

Rudder Trim Switch

Pilot Cockpit

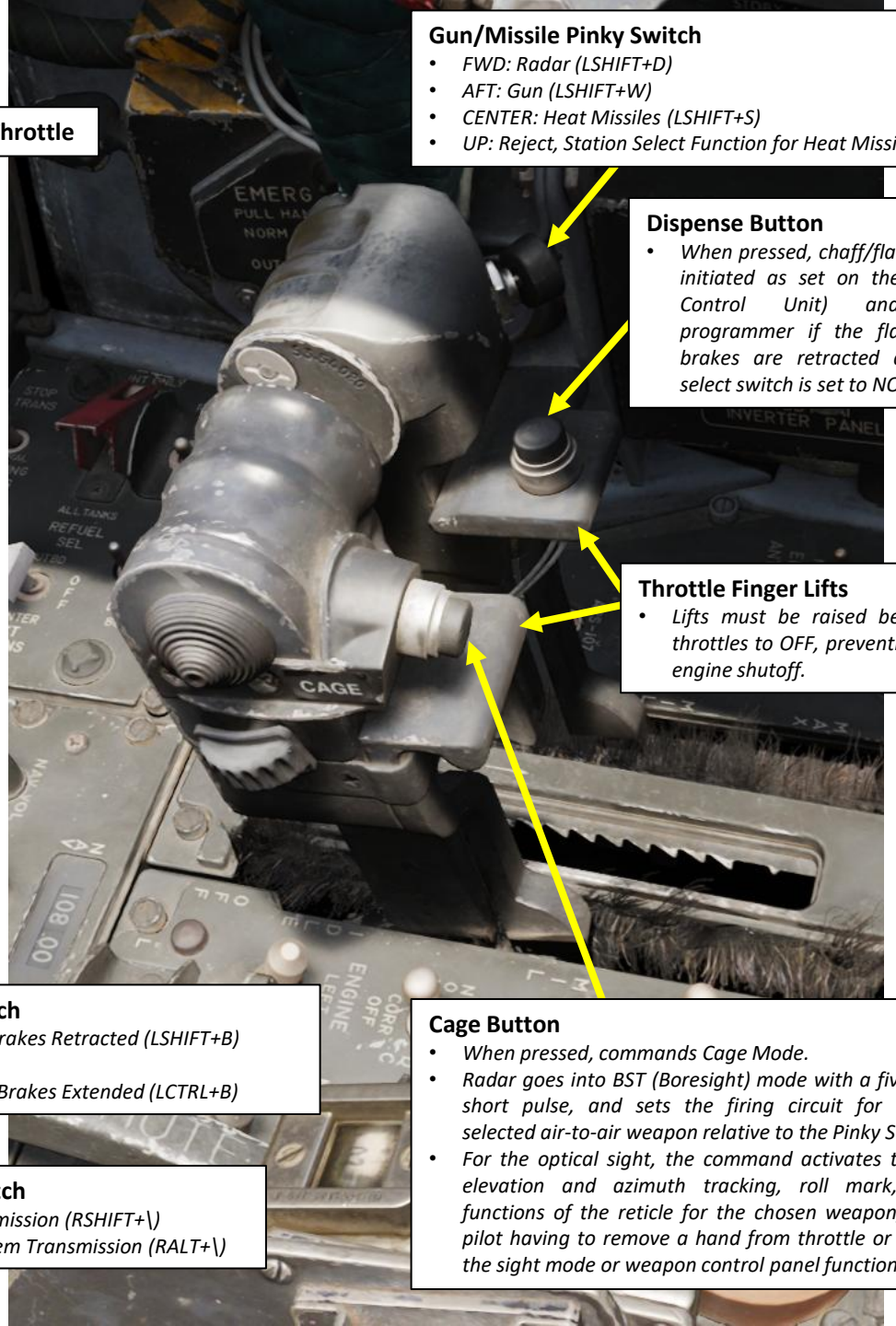


Left Throttle

Right Throttle

Left Ignition Button

Right Ignition Button



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

Dispense Button
- *When pressed, chaff/flare dispensing is initiated as set on the CCU (Cockpit Control Unit) and AN/ALE-40 programmer if the flaps and speed brakes are retracted and the flares select switch is set to NORMAL.*

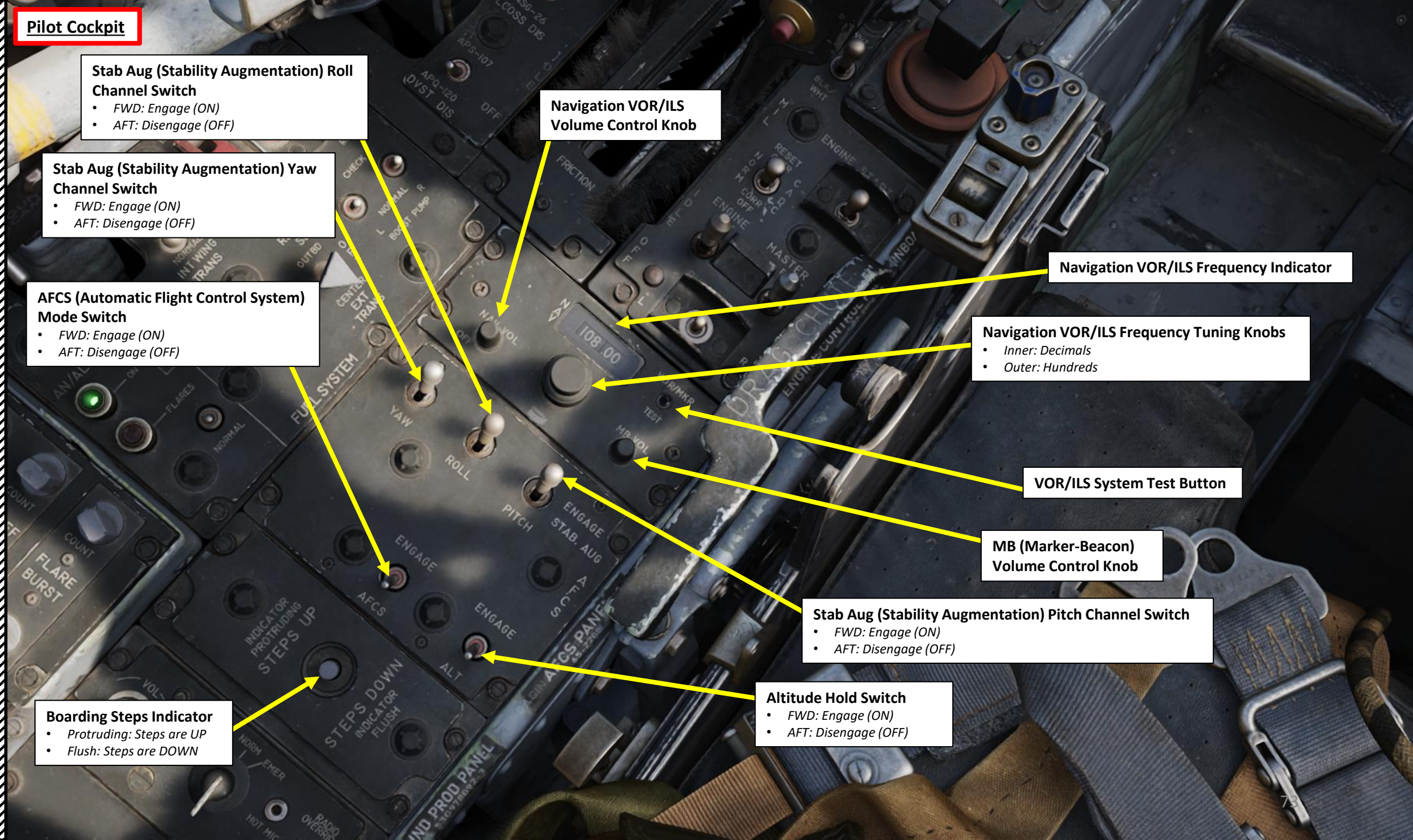
Throttle Finger Lifts
- *Lifts must be raised before retarding throttles to OFF, preventing inadvertent engine shutoff.*

Speed Brake Switch
- *FWD: IN, Speed Brakes Retracted (LSHIFT+B)*
- *MIDDLE: STOP*
- *AFT: OUT, Speed Brakes Extended (LCTRL+B)*

Mic (Microphone) Switch
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

Cage Button
- *When pressed, commands Cage Mode.*
- *Radar goes into BST (Boresight) mode with a five mile range, short pulse, and sets the firing circuit for the currently selected air-to-air weapon relative to the Pinky Switch.*
- *For the optical sight, the command activates the respective elevation and azimuth tracking, roll mark, and range functions of the reticle for the chosen weapon, without the pilot having to remove a hand from throttle or stick to swap the sight mode or weapon control panel functions.*

Pilot Cockpit



Stab Aug (Stability Augmentation) Roll Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Stab Aug (Stability Augmentation) Yaw Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

AFCS (Automatic Flight Control System) Mode Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Navigation VOR/ILS Volume Control Knob

Navigation VOR/ILS Frequency Indicator

Navigation VOR/ILS Frequency Tuning Knobs
- *Inner: Decimals*
- *Outer: Hundreds*

VOR/ILS System Test Button

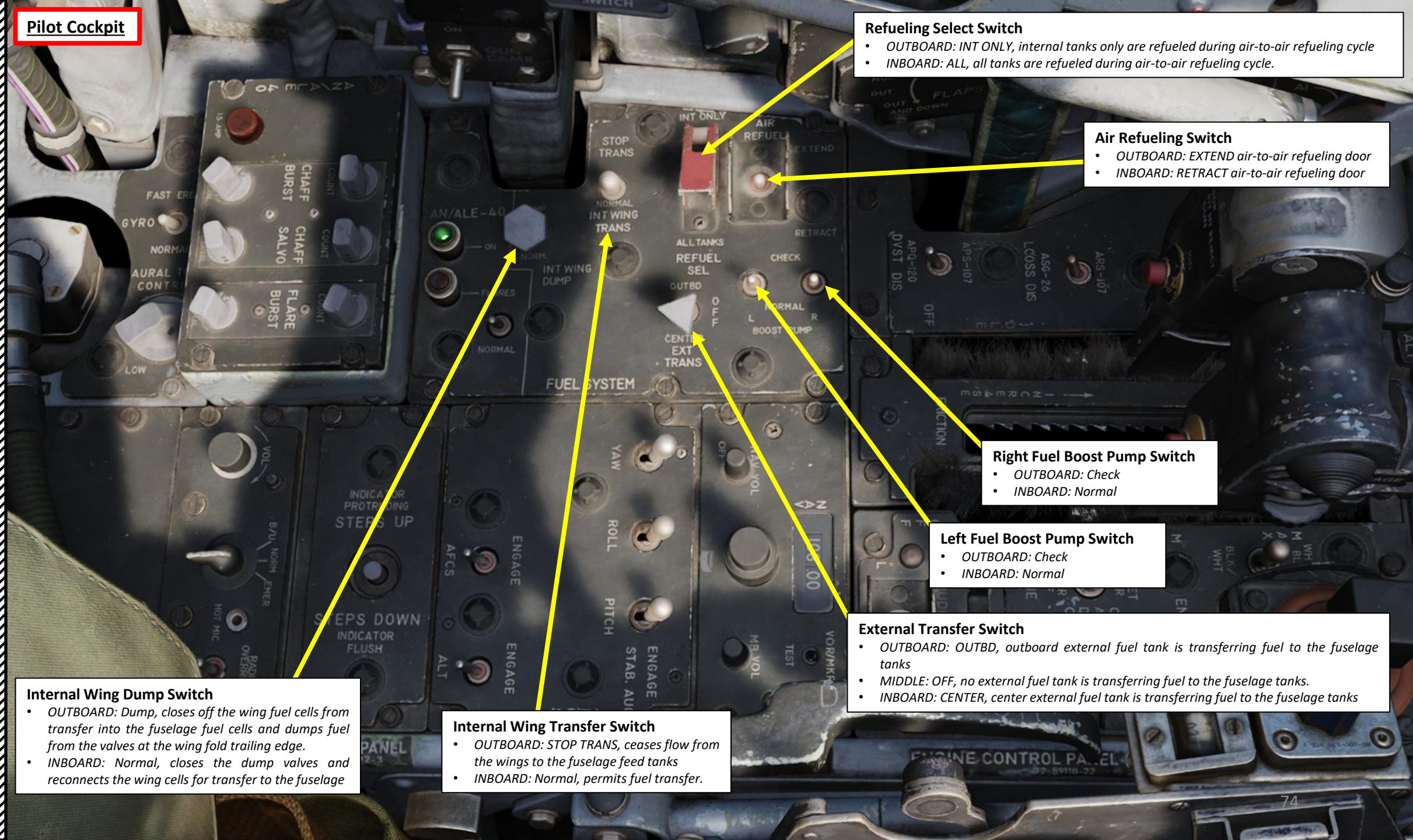
MB (Marker-Beacon) Volume Control Knob

Stab Aug (Stability Augmentation) Pitch Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Altitude Hold Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Boarding Steps Indicator
- *Protruding: Steps are UP*
- *Flush: Steps are DOWN*

Pilot Cockpit



Refueling Select Switch
- *OUTBOARD: INT ONLY, internal tanks only are refueled during air-to-air refueling cycle*
- *INBOARD: ALL, all tanks are refueled during air-to-air refueling cycle.*

Air Refueling Switch
- *OUTBOARD: EXTEND air-to-air refueling door*
- *INBOARD: RETRACT air-to-air refueling door*

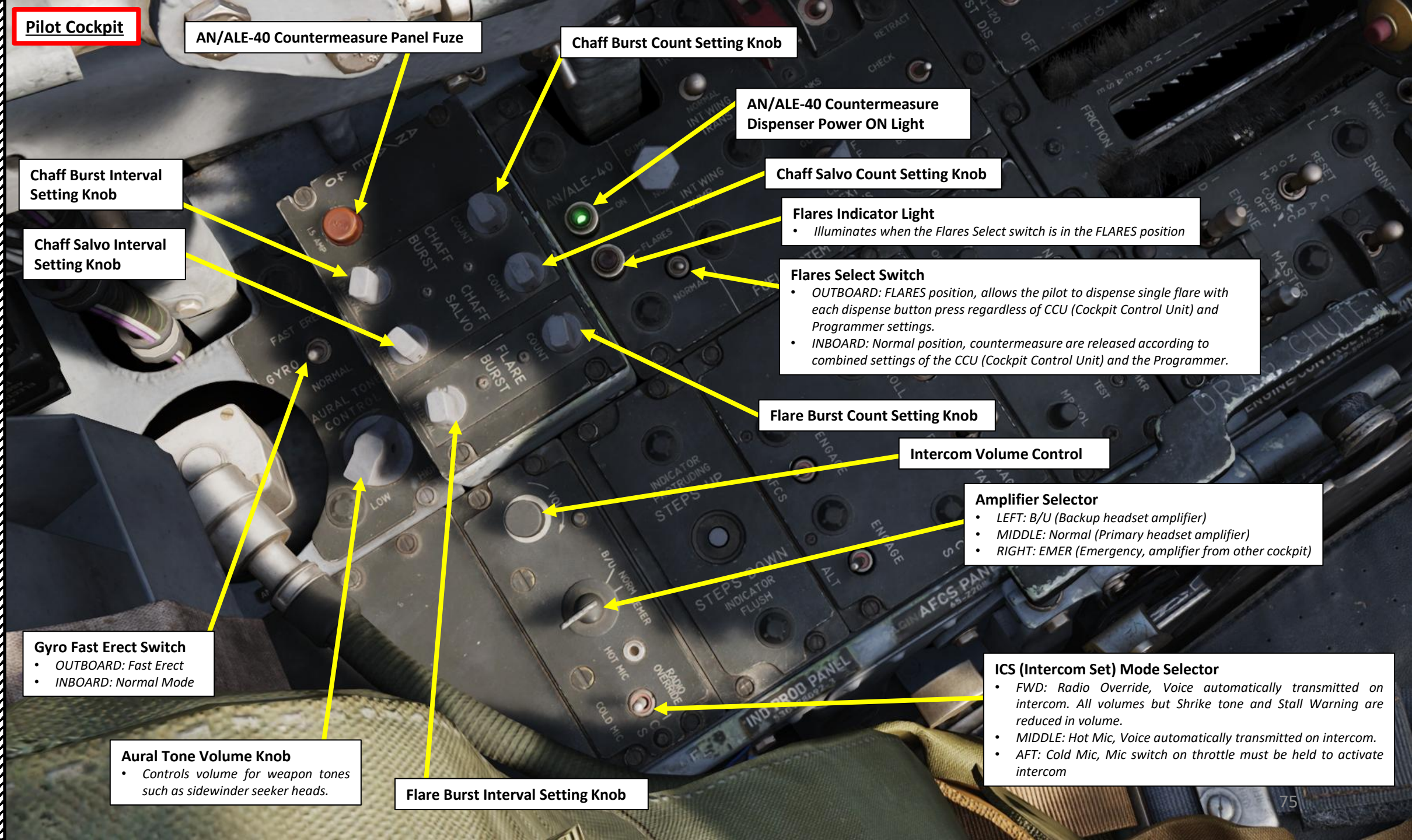
Right Fuel Boost Pump Switch
- *OUTBOARD: Check*
- *INBOARD: Normal*

Left Fuel Boost Pump Switch
- *OUTBOARD: Check*
- *INBOARD: Normal*

External Transfer Switch
- *OUTBOARD: OUTBD, outboard external fuel tank is transferring fuel to the fuselage tanks*
- *MIDDLE: OFF, no external fuel tank is transferring fuel to the fuselage tanks.*
- *INBOARD: CENTER, center external fuel tank is transferring fuel to the fuselage tanks*

Internal Wing Transfer Switch
- *OUTBOARD: STOP TRANS, ceases flow from the wings to the fuselage feed tanks*
- *INBOARD: Normal, permits fuel transfer.*

Internal Wing Dump Switch
- *OUTBOARD: Dump, closes off the wing fuel cells from transfer into the fuselage fuel cells and dumps fuel from the valves at the wing fold trailing edge.*
- *INBOARD: Normal, closes the dump valves and reconnects the wing cells for transfer to the fuselage*



Pilot Cockpit

AN/ALE-40 Countermeasure Panel Fuze

Chaff Burst Count Setting Knob

AN/ALE-40 Countermeasure Dispenser Power ON Light

Chaff Burst Interval Setting Knob

Chaff Salvo Count Setting Knob

Flares Indicator Light
- *Illuminates when the Flares Select switch is in the FLARES position*

Chaff Salvo Interval Setting Knob

Flares Select Switch
- *OUTBOARD: FLARES position, allows the pilot to dispense single flare with each dispense button press regardless of CCU (Cockpit Control Unit) and Programmer settings.*
- *INBOARD: Normal position, countermeasure are released according to combined settings of the CCU (Cockpit Control Unit) and the Programmer.*

Flare Burst Count Setting Knob

Intercom Volume Control

Amplifier Selector
- *LEFT: B/U (Backup headset amplifier)*
- *MIDDLE: Normal (Primary headset amplifier)*
- *RIGHT: EMER (Emergency, amplifier from other cockpit)*

Gyro Fast Erect Switch
- *OUTBOARD: Fast Erect*
- *INBOARD: Normal Mode*

ICS (Intercom Set) Mode Selector
- *FWD: Radio Override, Voice automatically transmitted on intercom. All volumes but Shrike tone and Stall Warning are reduced in volume.*
- *MIDDLE: Hot Mic, Voice automatically transmitted on intercom.*
- *AFT: Cold Mic, Mic switch on throttle must be held to activate intercom*

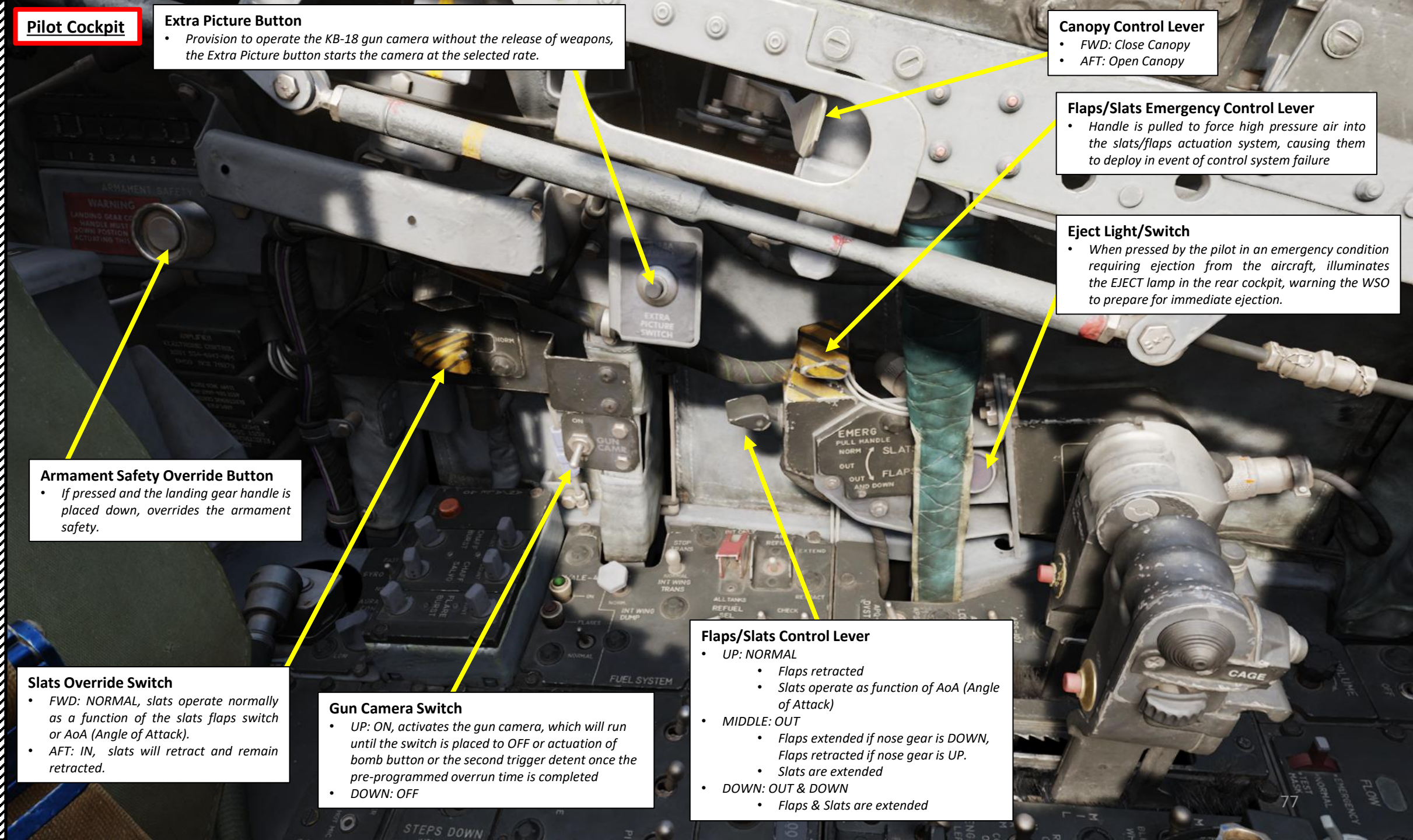
Aural Tone Volume Knob
- *Controls volume for weapon tones such as sidewinder seeker heads.*

Flare Burst Interval Setting Knob

Pilot Cockpit



Pilot Cockpit



Extra Picture Button
- *Provision to operate the KB-18 gun camera without the release of weapons, the Extra Picture button starts the camera at the selected rate.*

Canopy Control Lever
- *FWD: Close Canopy*
- *AFT: Open Canopy*

Flaps/Slats Emergency Control Lever
- *Handle is pulled to force high pressure air into the slats/flaps actuation system, causing them to deploy in event of control system failure*

Eject Light/Switch
- *When pressed by the pilot in an emergency condition requiring ejection from the aircraft, illuminates the EJECT lamp in the rear cockpit, warning the WSO to prepare for immediate ejection.*

Armament Safety Override Button
- *If pressed and the landing gear handle is placed down, overrides the armament safety.*

Slats Override Switch
- *FWD: NORMAL, slats operate normally as a function of the slats flaps switch or AoA (Angle of Attack).*
- *AFT: IN, slats will retract and remain retracted.*

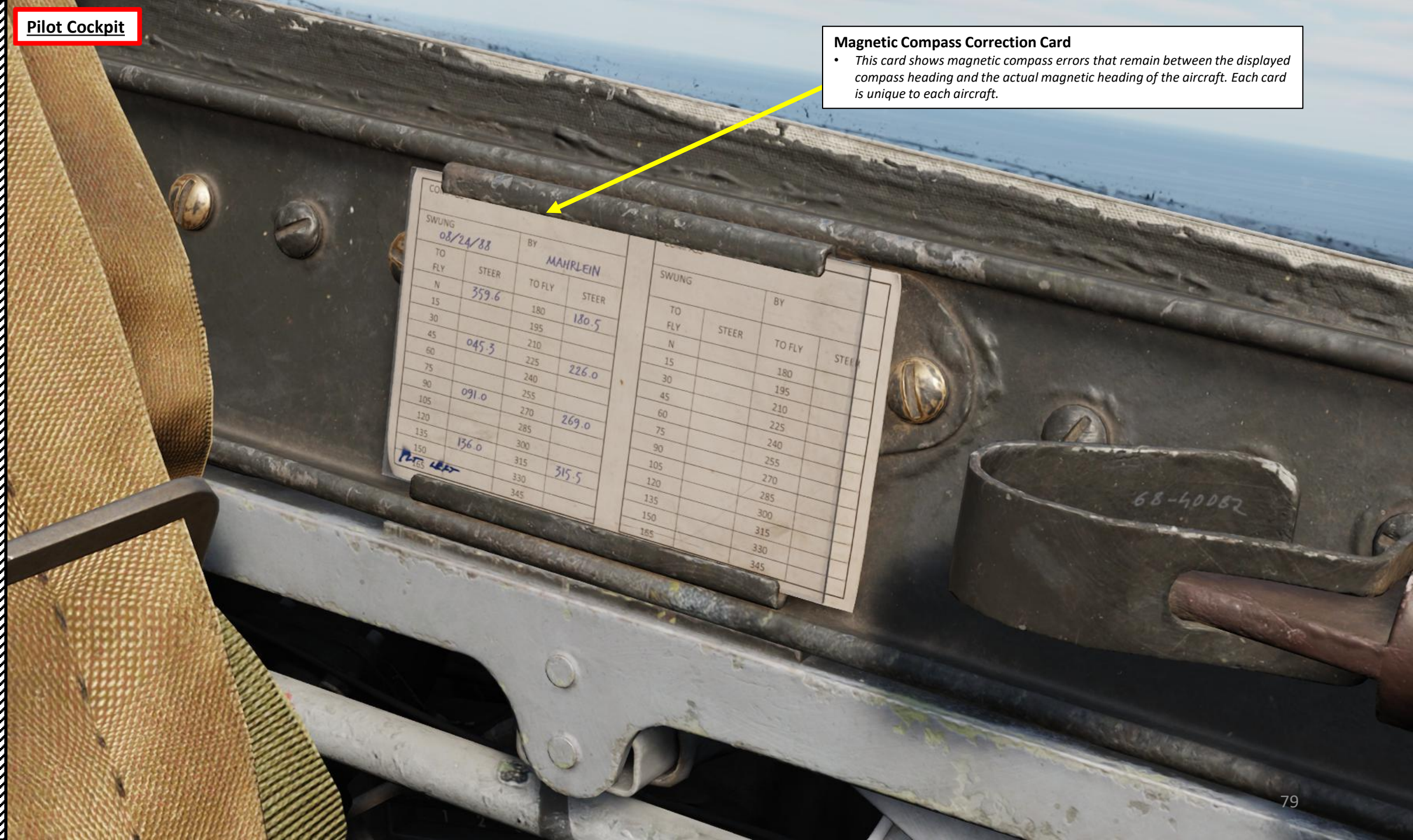
Gun Camera Switch
- *UP: ON, activates the gun camera, which will run until the switch is placed to OFF or actuation of bomb button or the second trigger detent once the pre-programmed overrun time is completed*
- *DOWN: OFF*

Flaps/Slats Control Lever
- *UP: NORMAL*
  - *Flaps retracted*
  - *Slats operate as function of AoA (Angle of Attack)*
- *MIDDLE: OUT*
  - *Flaps extended if nose gear is DOWN, Flaps retracted if nose gear is UP.*
  - *Slats are extended*
- *DOWN: OUT & DOWN*
  - *Flaps & Slats are extended*

Pilot Cockpit



Pilot Cockpit



Pilot Cockpit



Pilot Cockpit



Flashlight Control
- ON/OFF: LALT + L

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Tip: WSO body can be toggled on/off by using the “First Person Pilot Body - Toggle” binding. Recommended binding: “LSHIFT+P”.

WSO (Weapon Systems Officer) Cockpit



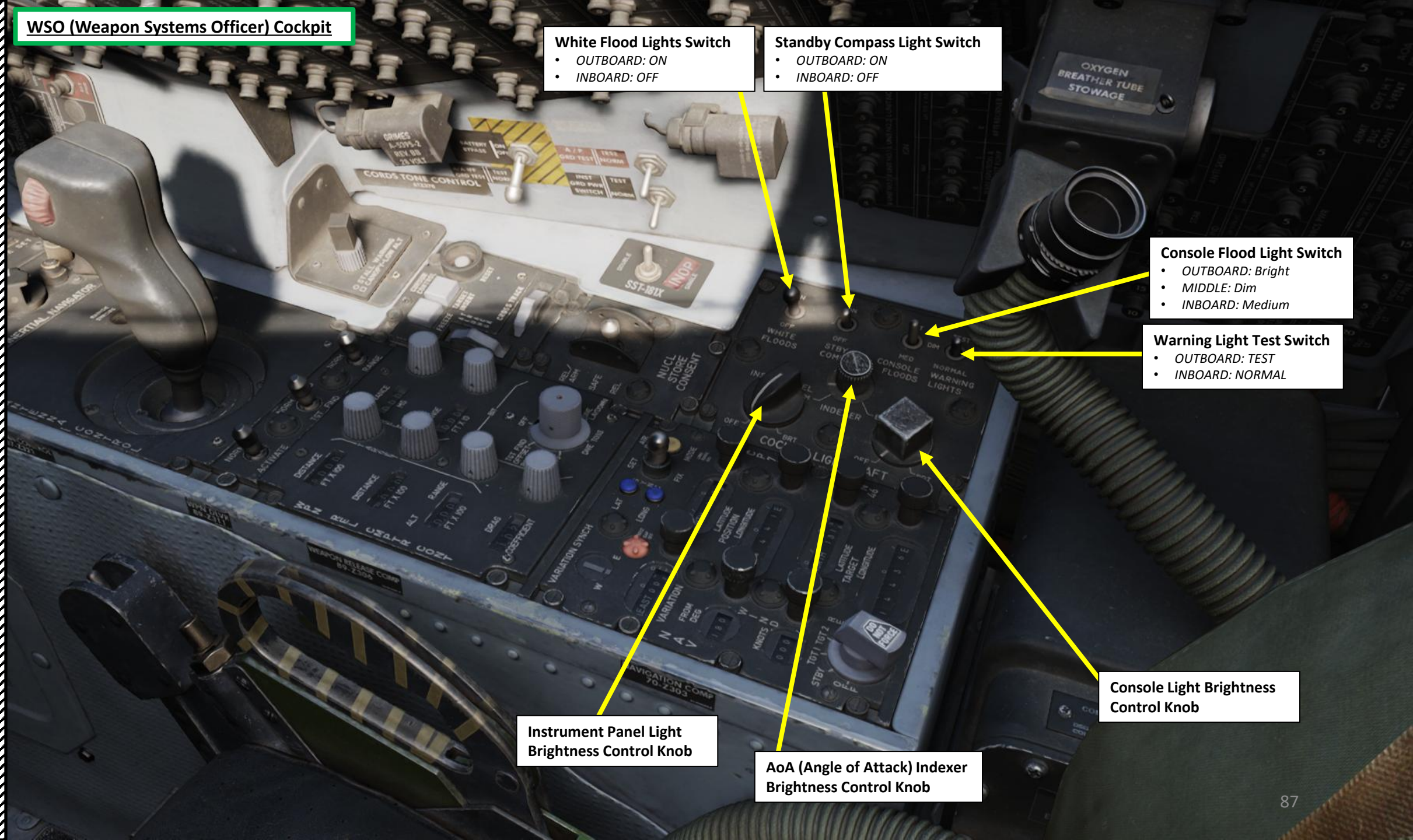
WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



White Flood Lights Switch
- *OUTBOARD: ON*
- *INBOARD: OFF*

Standby Compass Light Switch
- *OUTBOARD: ON*
- *INBOARD: OFF*

Console Flood Light Switch
- *OUTBOARD: Bright*
- *MIDDLE: Dim*
- *INBOARD: Medium*

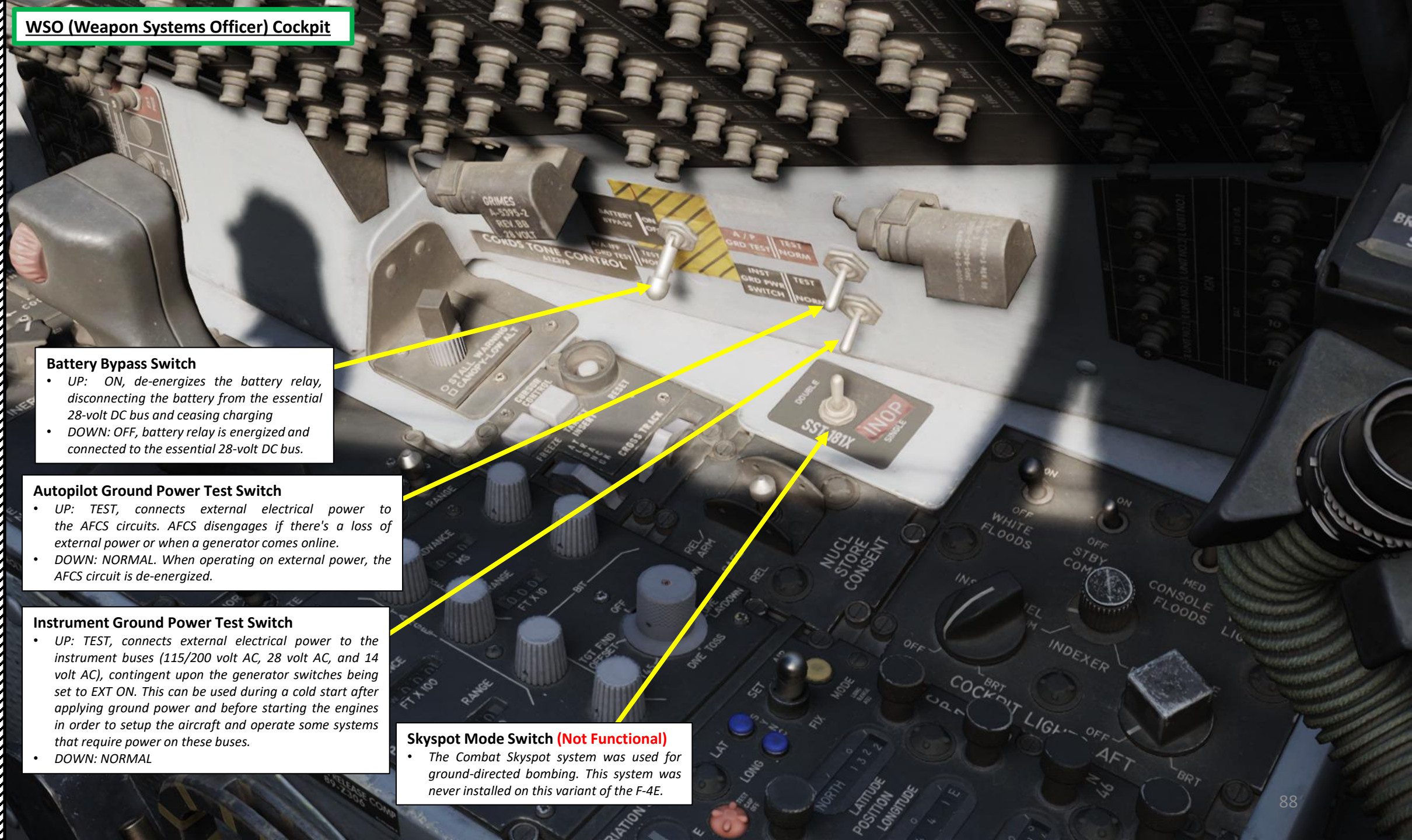
Warning Light Test Switch
- *OUTBOARD: TEST*
- *INBOARD: NORMAL*

Instrument Panel Light Brightness Control Knob

AoA (Angle of Attack) Indexer Brightness Control Knob

Console Light Brightness Control Knob

WSO (Weapon Systems Officer) Cockpit



Battery Bypass Switch

- *UP: ON, de-energizes the battery relay, disconnecting the battery from the essential 28-volt DC bus and ceasing charging*
- *DOWN: OFF, battery relay is energized and connected to the essential 28-volt DC bus.*

Autopilot Ground Power Test Switch

- *UP: TEST, connects external electrical power to the AFCS circuits. AFCS disengages if there's a loss of external power or when a generator comes online.*
- *DOWN: NORMAL. When operating on external power, the AFCS circuit is de-energized.*

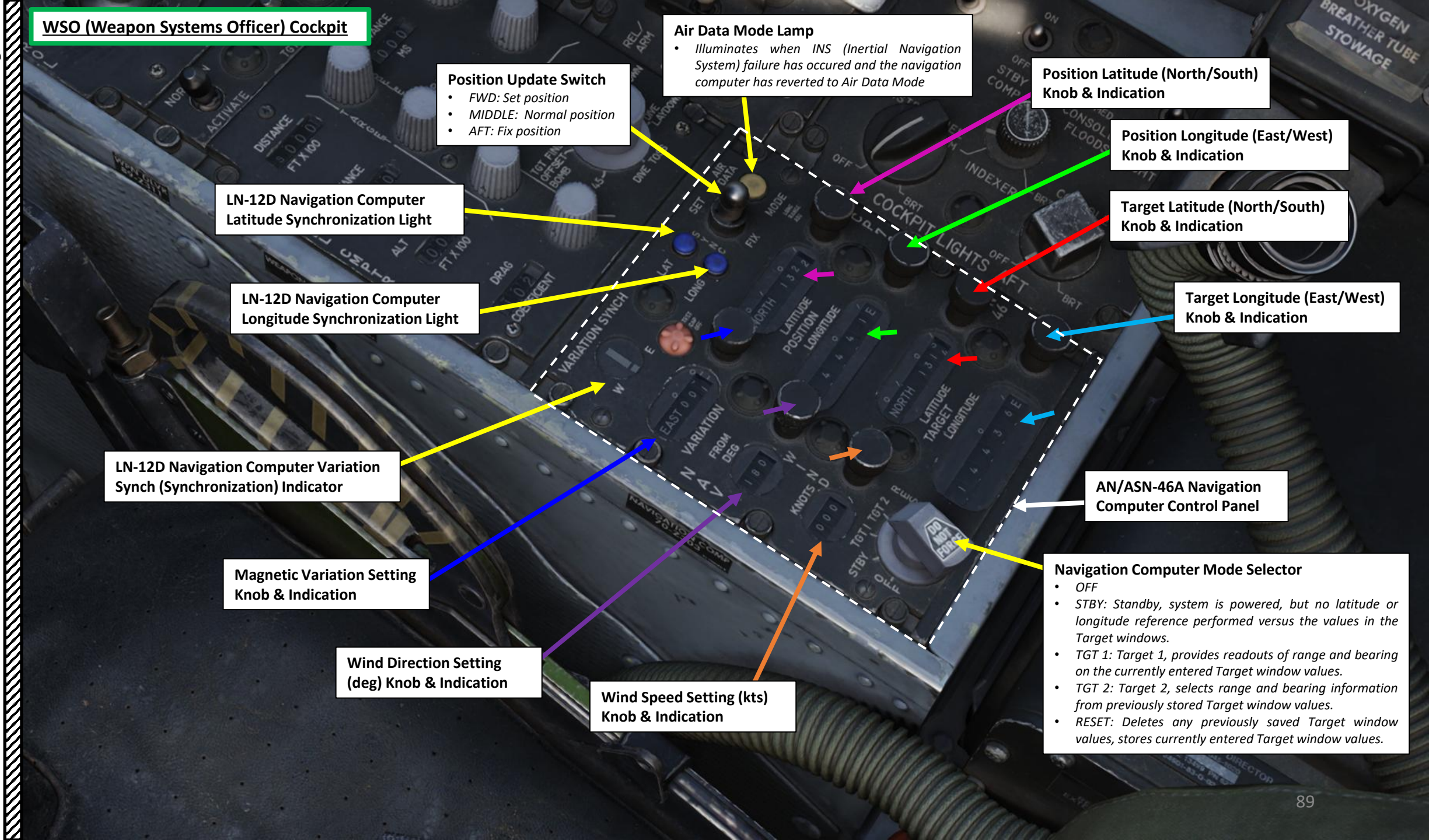
Instrument Ground Power Test Switch

- *UP: TEST, connects external electrical power to the instrument buses (115/200 volt AC, 28 volt AC, and 14 volt AC), contingent upon the generator switches being set to EXT ON. This can be used during a cold start after applying ground power and before starting the engines in order to setup the aircraft and operate some systems that require power on these buses.*
- *DOWN: NORMAL*

Skyspot Mode Switch (Not Functional)

- *The Combat Skyspot system was used for ground-directed bombing. This system was never installed on this variant of the F-4E.*

WSO (Weapon Systems Officer) Cockpit



Air Data Mode Lamp
- *Illuminates when INS (Inertial Navigation System) failure has occured and the navigation computer has reverted to Air Data Mode*

Position Update Switch
- *FWD: Set position*
- *MIDDLE: Normal position*
- *AFT: Fix position*

Position Latitude (North/South) Knob & Indication

Position Longitude (East/West) Knob & Indication

LN-12D Navigation Computer Latitude Synchronization Light

Target Latitude (North/South) Knob & Indication

LN-12D Navigation Computer Longitude Synchronization Light

Target Longitude (East/West) Knob & Indication

LN-12D Navigation Computer Variation Synch (Synchronization) Indicator

AN/ASN-46A Navigation Computer Control Panel

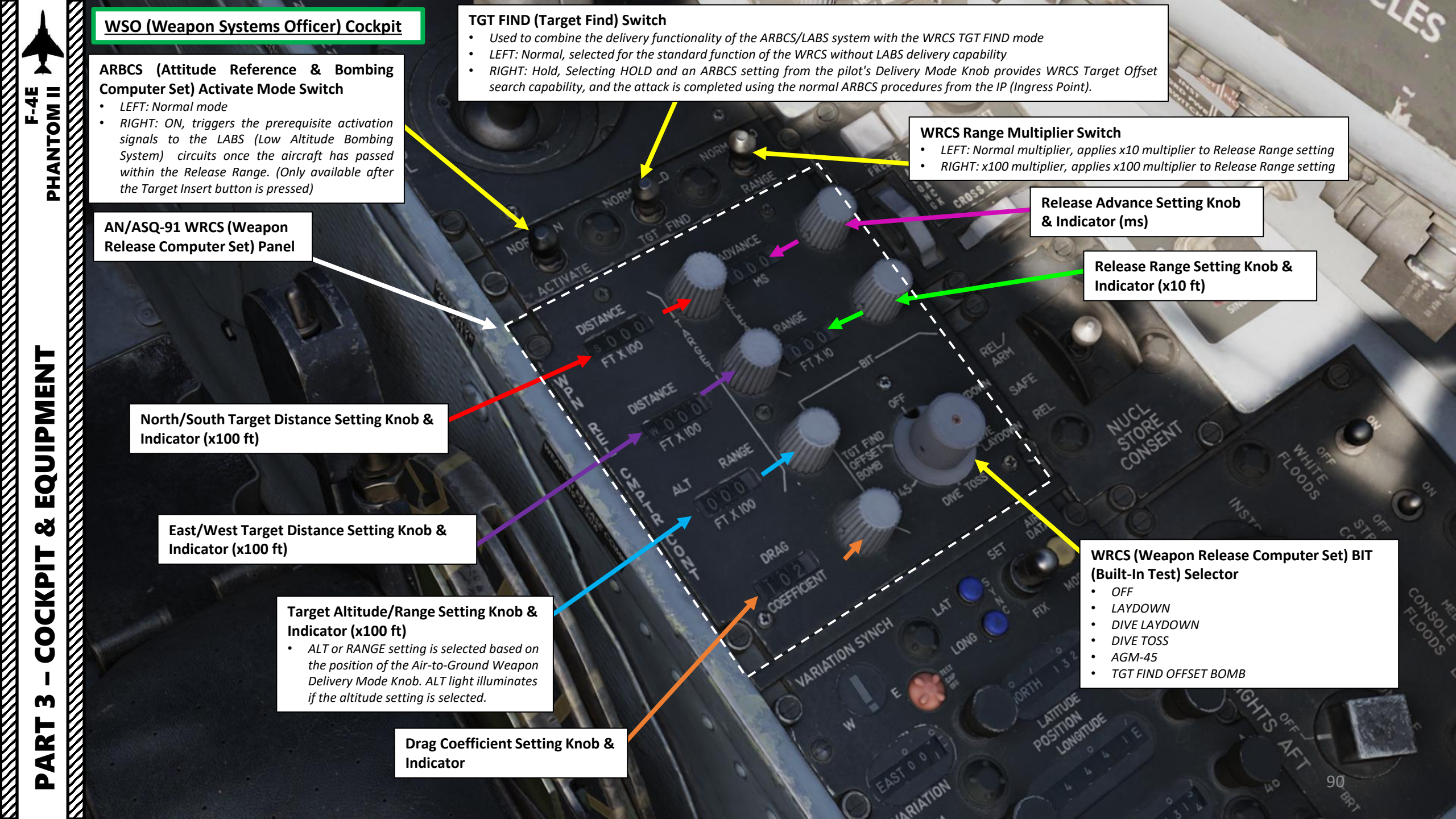
Magnetic Variation Setting Knob & Indication

Navigation Computer Mode Selector
- *OFF*
- *STBY: Standby, system is powered, but no latitude or longitude reference performed versus the values in the Target windows.*
- *TGT 1: Target 1, provides readouts of range and bearing on the currently entered Target window values.*
- *TGT 2: Target 2, selects range and bearing information from previously stored Target window values.*
- *RESET: Deletes any previously saved Target window values, stores currently entered Target window values.*

Wind Direction Setting (deg) Knob & Indication

Wind Speed Setting (kts) Knob & Indication

WSO (Weapon Systems Officer) Cockpit



ARBCS (Attitude Reference & Bombing Computer Set) Activate Mode Switch
- *LEFT: Normal mode*
- *RIGHT: ON, triggers the prerequisite activation signals to the LABS (Low Altitude Bombing System) circuits once the aircraft has passed within the Release Range. (Only available after the Target Insert button is pressed)*

TGT FIND (Target Find) Switch
- *Used to combine the delivery functionality of the ARBCS/LABS system with the WRCS TGT FIND mode*
- *LEFT: Normal, selected for the standard function of the WRCS without LABS delivery capability*
- *RIGHT: Hold, Selecting HOLD and an ARBCS setting from the pilot's Delivery Mode Knob provides WRCS Target Offset search capability, and the attack is completed using the normal ARBCS procedures from the IP (Ingress Point).*

WRCS Range Multiplier Switch
- *LEFT: Normal multiplier, applies x10 multiplier to Release Range setting*
- *RIGHT: x100 multiplier, applies x100 multiplier to Release Range setting*

Release Advance Setting Knob & Indicator (ms)

AN/ASQ-91 WRCS (Weapon Release Computer Set) Panel

Release Range Setting Knob & Indicator (x10 ft)

North/South Target Distance Setting Knob & Indicator (x100 ft)

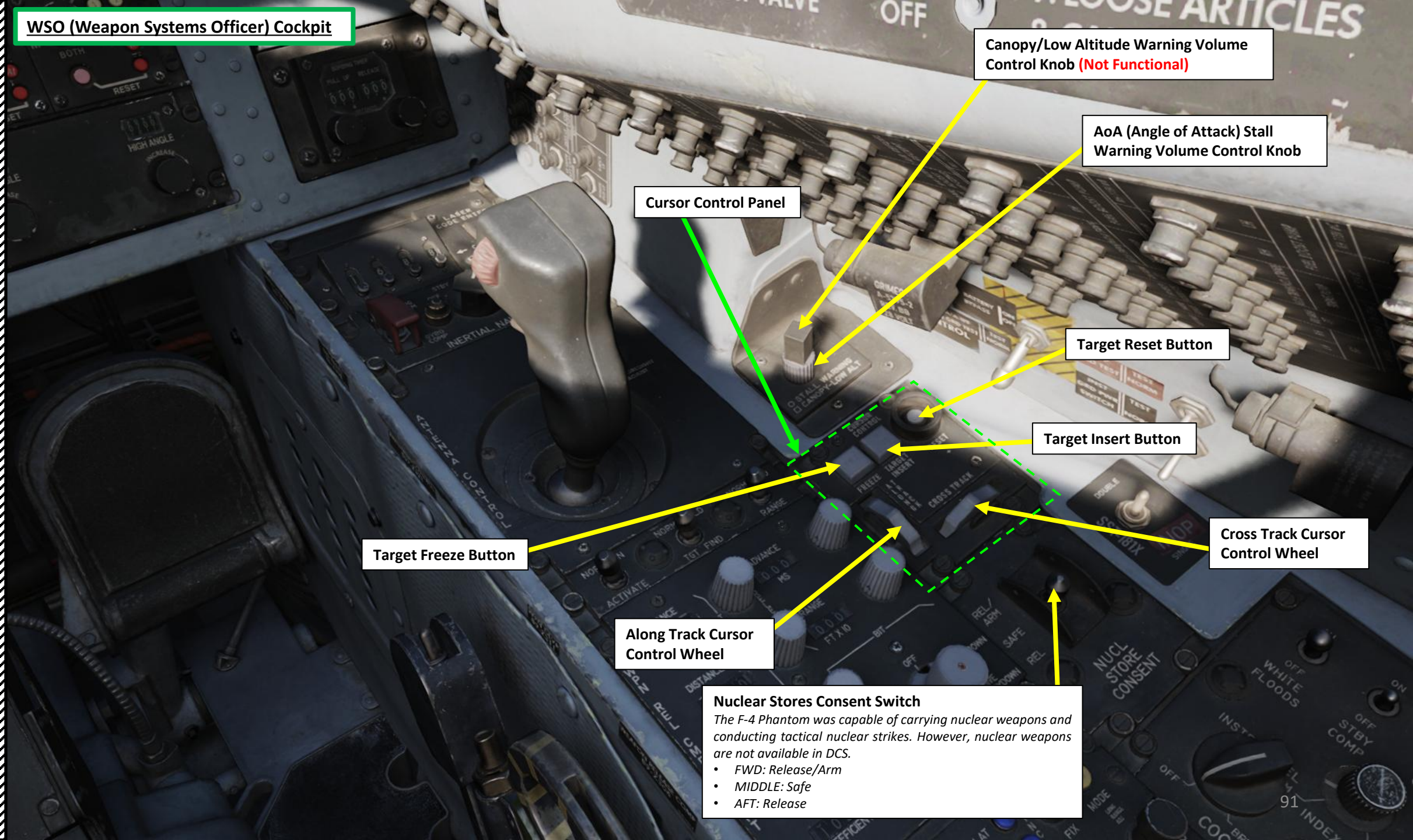
East/West Target Distance Setting Knob & Indicator (x100 ft)

Target Altitude/Range Setting Knob & Indicator (x100 ft)
- *ALT or RANGE setting is selected based on the position of the Air-to-Ground Weapon Delivery Mode Knob. ALT light illuminates if the altitude setting is selected.*

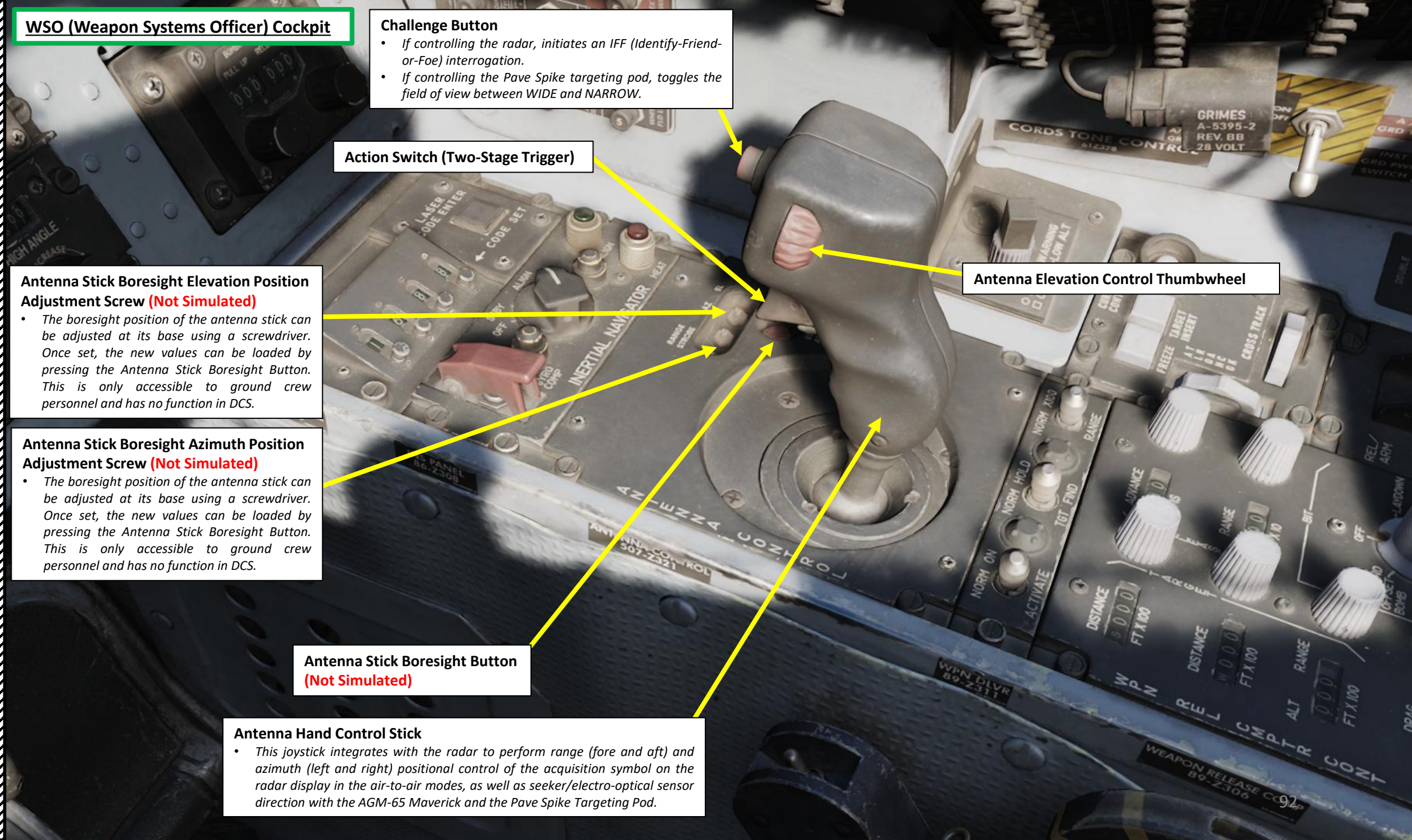
Drag Coefficient Setting Knob & Indicator

WRCS (Weapon Release Computer Set) BIT (Built-In Test) Selector
- *OFF*
- *LAYDOWN*
- *DIVE LAYDOWN*
- *DIVE TOSS*
- *AGM-45*
- *TGT FIND OFFSET BOMB*

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*

Action Switch (Two-Stage Trigger)

Antenna Elevation Control Thumbwheel

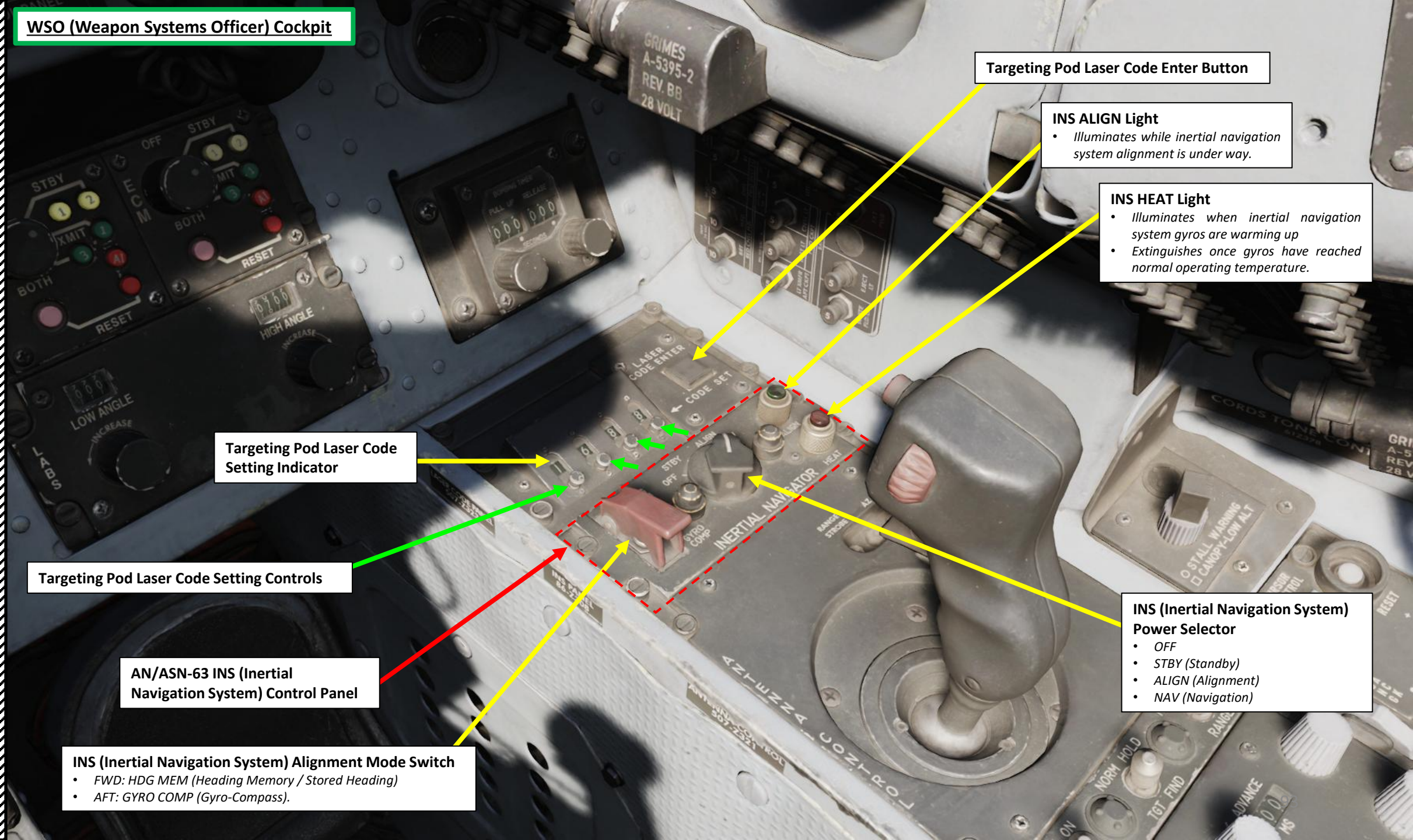
Antenna Stick Boresight Elevation Position Adjustment Screw (Not Simulated)
- *The boresight position of the antenna stick can be adjusted at its base using a screwdriver. Once set, the new values can be loaded by pressing the Antenna Stick Boresight Button. This is only accessible to ground crew personnel and has no function in DCS.*

Antenna Stick Boresight Azimuth Position Adjustment Screw (Not Simulated)
- *The boresight position of the antenna stick can be adjusted at its base using a screwdriver. Once set, the new values can be loaded by pressing the Antenna Stick Boresight Button. This is only accessible to ground crew personnel and has no function in DCS.*

Antenna Stick Boresight Button (Not Simulated)

Antenna Hand Control Stick
- *This joystick integrates with the radar to perform range (fore and aft) and azimuth (left and right) positional control of the acquisition symbol on the radar display in the air-to-air modes, as well as seeker/electro-optical sensor direction with the AGM-65 Maverick and the Pave Spike Targeting Pod.*

WSO (Weapon Systems Officer) Cockpit



Targeting Pod Laser Code Enter Button

INS ALIGN Light
- *Illuminates while inertial navigation system alignment is under way.*

INS HEAT Light
- *Illuminates when inertial navigation system gyros are warming up*
- *Extinguishes once gyros have reached normal operating temperature.*

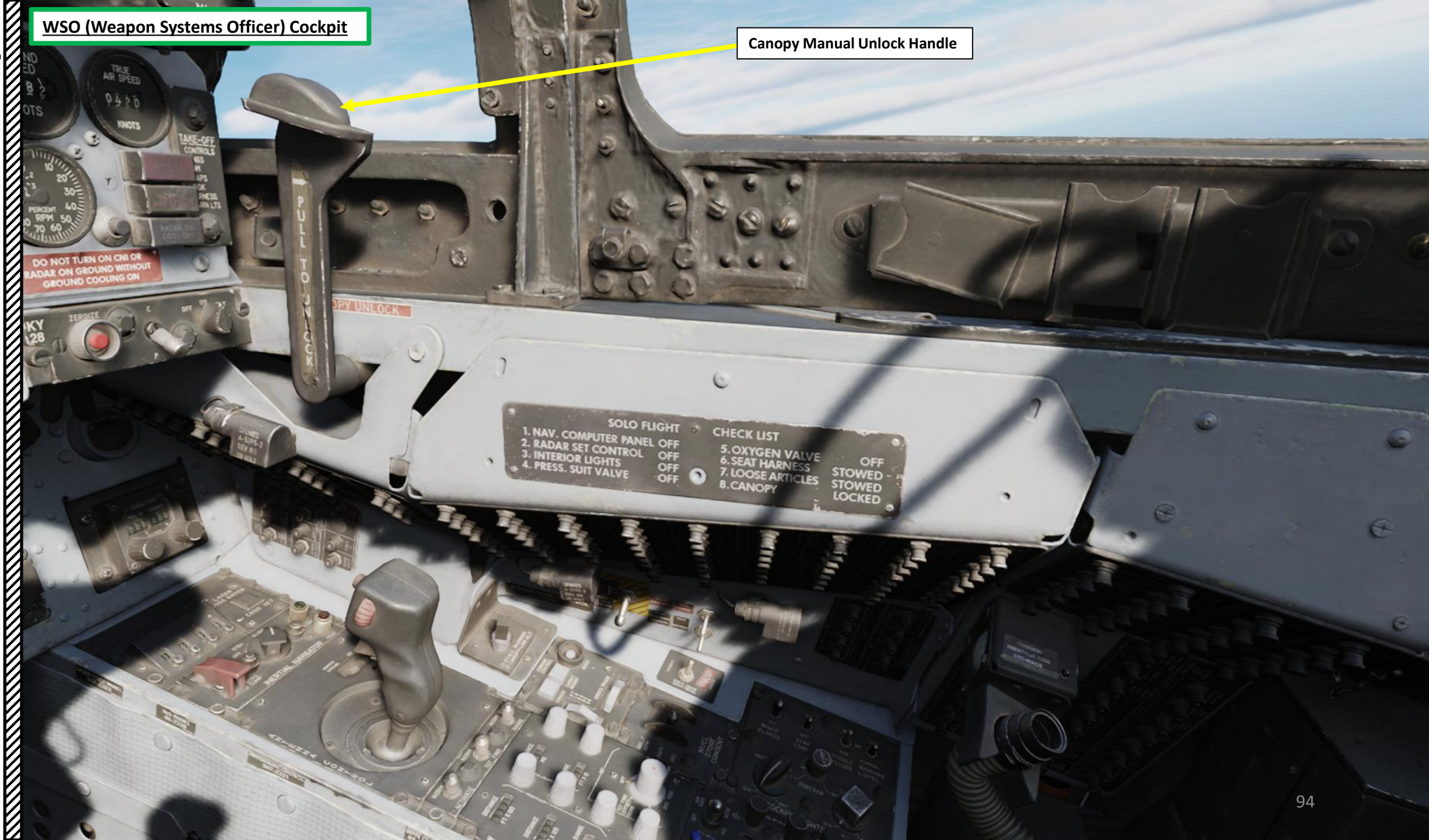
Targeting Pod Laser Code Setting Indicator

Targeting Pod Laser Code Setting Controls

AN/ASN-63 INS (Inertial Navigation System) Control Panel

INS (Inertial Navigation System) Alignment Mode Switch
- *FWD: HDG MEM (Heading Memory / Stored Heading)*
- *AFT: GYRO COMP (Gyro-Compass).*

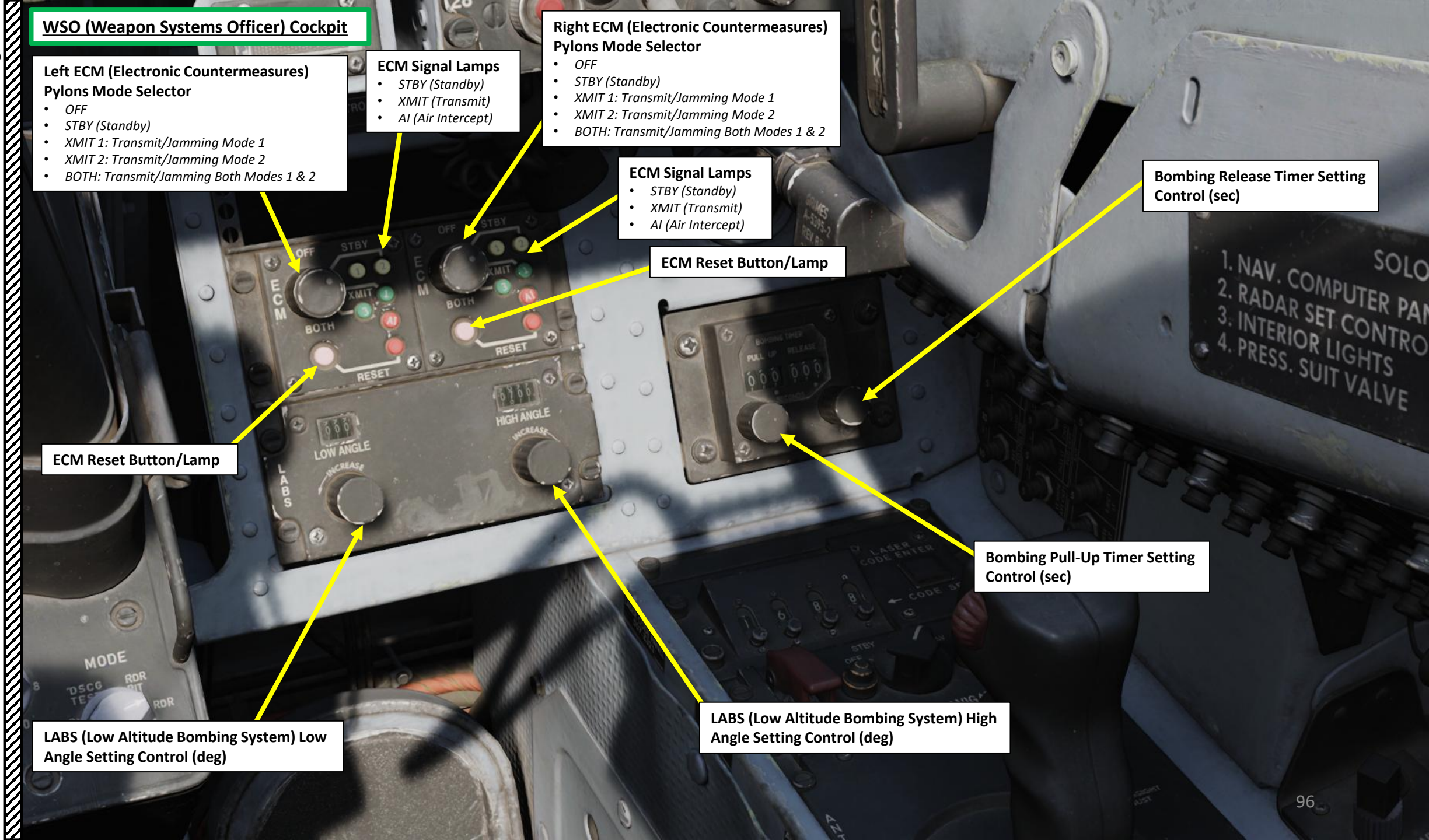
INS (Inertial Navigation System) Power Selector
- *OFF*
- *STBY (Standby)*
- *ALIGN (Alignment)*
- *NAV (Navigation)*


WSO (Weapon Systems Officer) Cockpit
Canopy Manual Unlock Handle
PULL TO UNLOCK
SOLO FLIGHT CHECK LIST
1. NAV. COMPUTER PANEL OFF
2. RADAR SET CONTROL OFF
3. INTERIOR LIGHTS OFF
4. PRESS. SUIT VALVE OFF
5. OXYGEN VALVE OFF
6. SEAT HARNESS STOWED
7. LOOSE ARTICLES STOWED
8. CANOPY LOCKED
DO NOT TURN ON CNI OR RADAR ON GROUND WITHOUT GROUND COOLING ON
TRUE AIR SPEED
KNOTS
TAKE-OFF CONTROLS

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Left ECM (Electronic Countermeasures) Pylons Mode Selector
- *OFF*
- *STBY (Standby)*
- *XMIT 1: Transmit/Jamming Mode 1*
- *XMIT 2: Transmit/Jamming Mode 2*
- *BOTH: Transmit/Jamming Both Modes 1 & 2*

ECM Signal Lamps
- *STBY (Standby)*
- *XMIT (Transmit)*
- *AI (Air Intercept)*

Right ECM (Electronic Countermeasures) Pylons Mode Selector
- *OFF*
- *STBY (Standby)*
- *XMIT 1: Transmit/Jamming Mode 1*
- *XMIT 2: Transmit/Jamming Mode 2*
- *BOTH: Transmit/Jamming Both Modes 1 & 2*

ECM Signal Lamps
- *STBY (Standby)*
- *XMIT (Transmit)*
- *AI (Air Intercept)*

ECM Reset Button/Lamp

Bombing Release Timer Setting Control (sec)

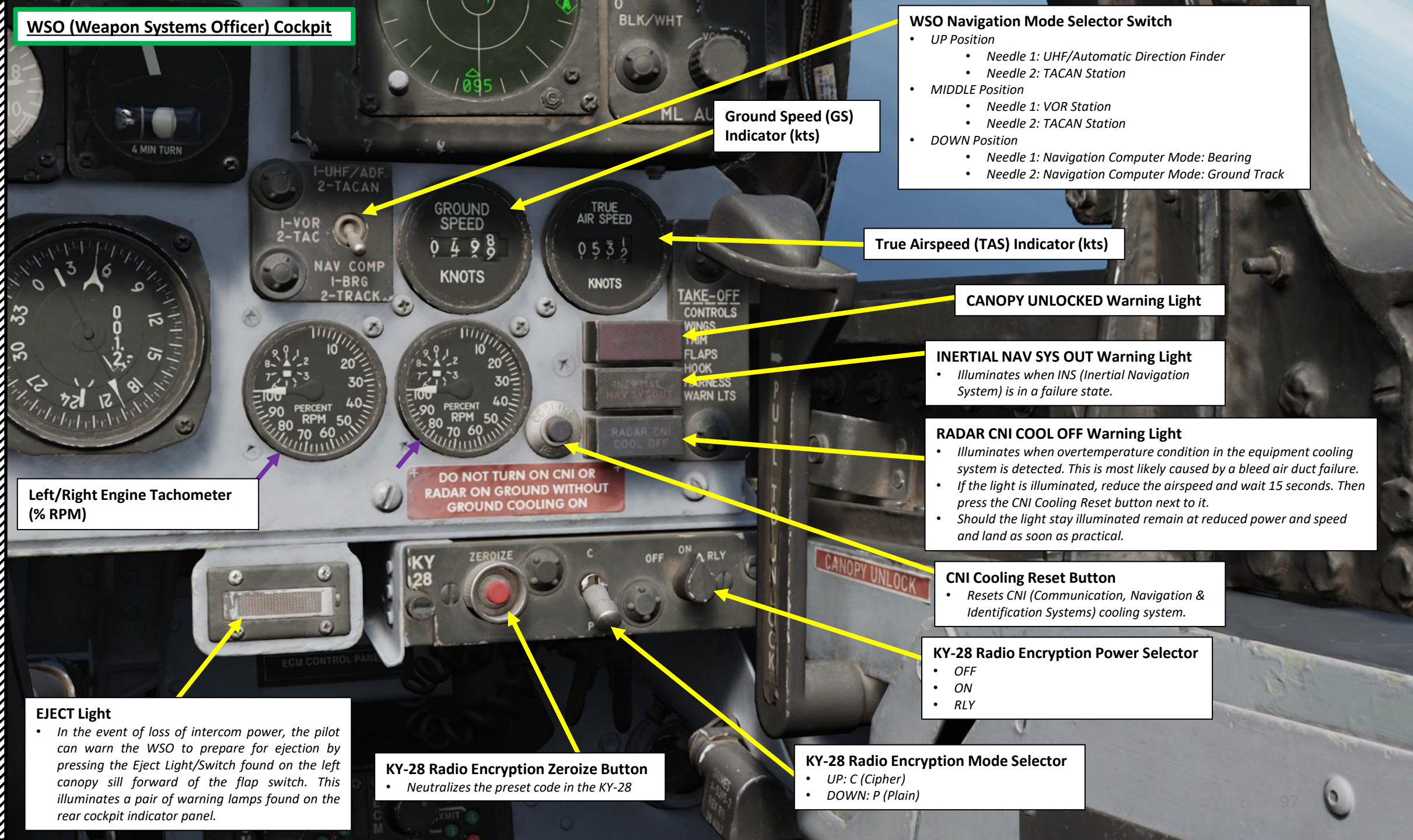
ECM Reset Button/Lamp

Bombing Pull-Up Timer Setting Control (sec)

LABS (Low Altitude Bombing System) Low Angle Setting Control (deg)

LABS (Low Altitude Bombing System) High Angle Setting Control (deg)

WSO (Weapon Systems Officer) Cockpit



WSO Navigation Mode Selector Switch
- *UP Position*
  - *Needle 1: UHF/Automatic Direction Finder*
  - *Needle 2: TACAN Station*
- *MIDDLE Position*
  - *Needle 1: VOR Station*
  - *Needle 2: TACAN Station*
- *DOWN Position*
  - *Needle 1: Navigation Computer Mode: Bearing*
  - *Needle 2: Navigation Computer Mode: Ground Track*

Ground Speed (GS) Indicator (kts)

True Airspeed (TAS) Indicator (kts)

CANOPY UNLOCKED Warning Light

INERTIAL NAV SYS OUT Warning Light
- *Illuminates when INS (Inertial Navigation System) is in a failure state.*

RADAR CNI COOL OFF Warning Light
- *Illuminates when overtemperature condition in the equipment cooling system is detected. This is most likely caused by a bleed air duct failure.*
- *If the light is illuminated, reduce the airspeed and wait 15 seconds. Then press the CNI Cooling Reset button next to it.*
- *Should the light stay illuminated remain at reduced power and speed and land as soon as practical.*

Left/Right Engine Tachometer (% RPM)

CNI Cooling Reset Button
- *Resets CNI (Communication, Navigation & Identification Systems) cooling system.*

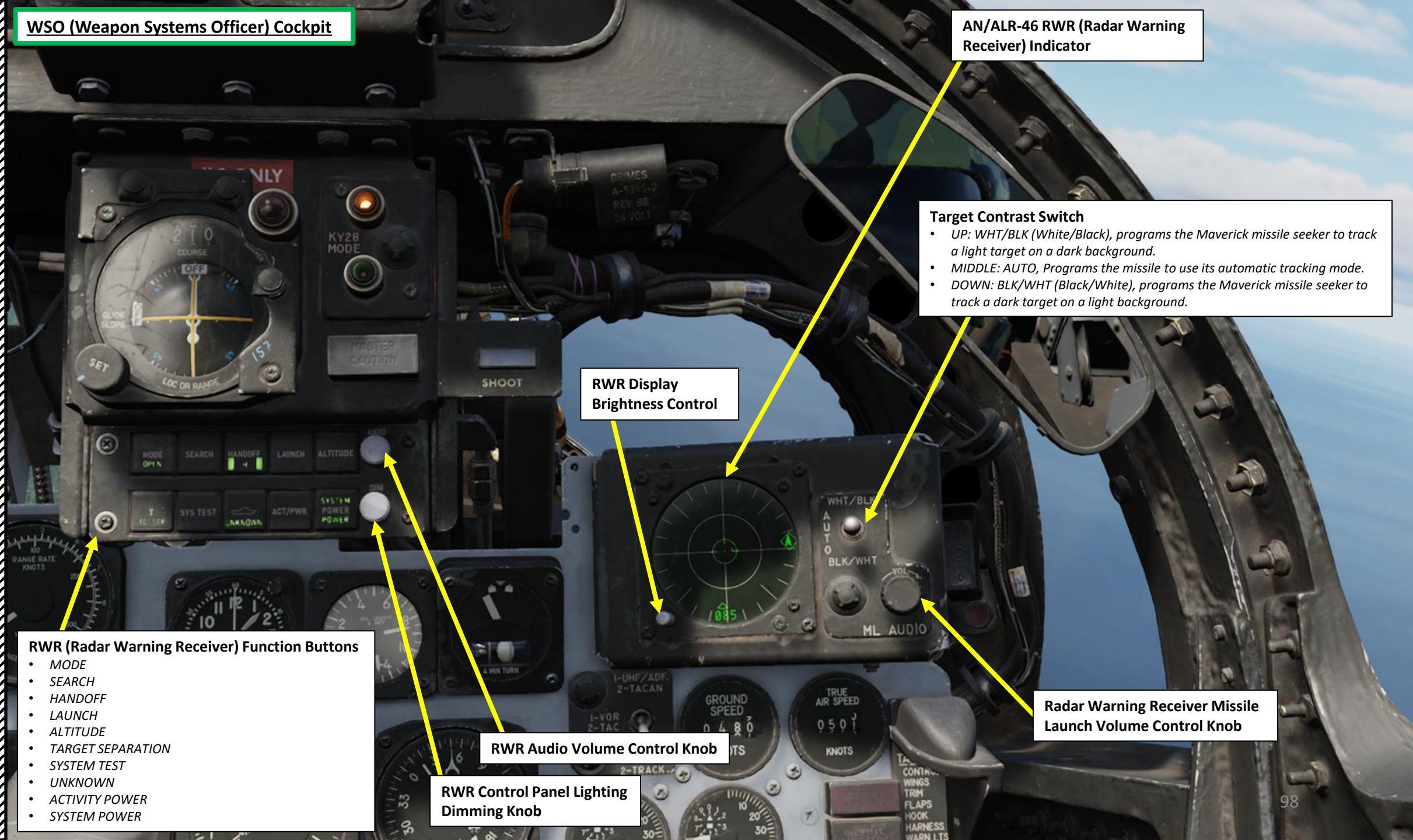
KY-28 Radio Encryption Power Selector
- *OFF*
- *ON*
- *RLY*

EJECT Light
- *In the event of loss of intercom power, the pilot can warn the WSO to prepare for ejection by pressing the Eject Light/Switch found on the left canopy sill forward of the flap switch. This illuminates a pair of warning lamps found on the rear cockpit indicator panel.*

KY-28 Radio Encryption Zeroize Button
- *Neutralizes the preset code in the KY-28*

KY-28 Radio Encryption Mode Selector
- *UP: C (Cipher)*
- *DOWN: P (Plain)*

WSO (Weapon Systems Officer) Cockpit



AN/ALR-46 RWR (Radar Warning Receiver) Indicator

Target Contrast Switch

- *UP: WHT/BLK (White/Black), programs the Maverick missile seeker to track a light target on a dark background.*
- *MIDDLE: AUTO, Programs the missile to use its automatic tracking mode.*
- *DOWN: BLK/WHT (Black/White), programs the Maverick missile seeker to track a dark target on a light background.*

RWR Display Brightness Control

RWR (Radar Warning Receiver) Function Buttons

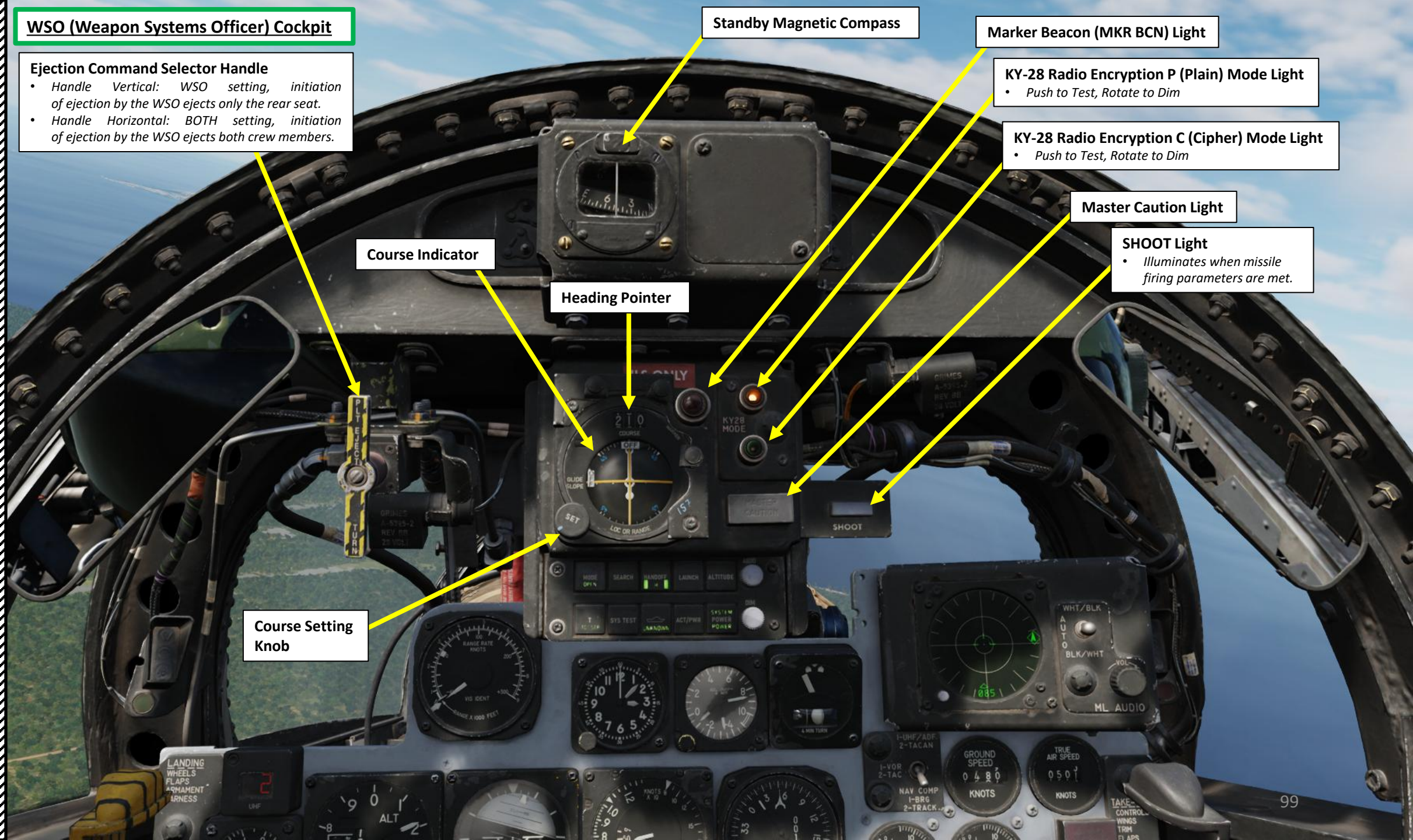
- *MODE*
- *SEARCH*
- *HANDOFF*
- *LAUNCH*
- *ALTITUDE*
- *TARGET SEPARATION*
- *SYSTEM TEST*
- *UNKNOWN*
- *ACTIVITY POWER*
- *SYSTEM POWER*

RWR Audio Volume Control Knob

RWR Control Panel Lighting Dimming Knob

Radar Warning Receiver Missile Launch Volume Control Knob

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



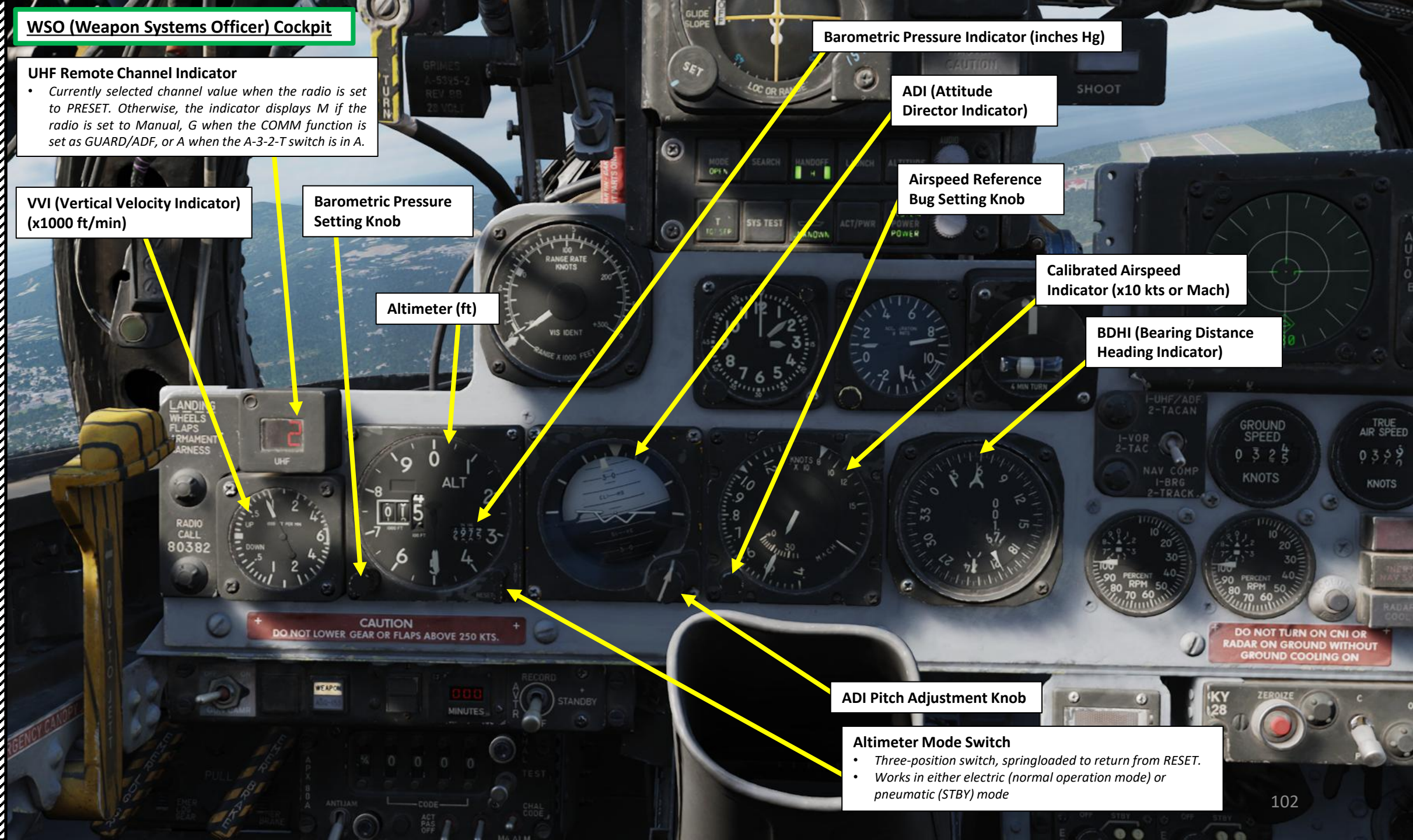
WSO (Weapon Systems Officer) Cockpit



Radar Range VISIDENT (Visual Identification) Indicator

- *Used for close range VID (visual identification) intercept profiles, providing range information out to two miles and range rate information from inside of 9000'. The information is confirmed as radar-accurate once the range indicator jumps to 9.*
- *The gauge functions in the VI, B NAR, and B WIDE display modes*
- *The gauge does not function in air to ground modes.*

WSO (Weapon Systems Officer) Cockpit



UHF Remote Channel Indicator
- *Currently selected channel value when the radio is set to PRESET. Otherwise, the indicator displays M if the radio is set to Manual, G when the COMM function is set as GUARD/ADF, or A when the A-3-2-T switch is in A.*

VVI (Vertical Velocity Indicator) (x1000 ft/min)

Barometric Pressure Setting Knob

Altimeter (ft)

Barometric Pressure Indicator (inches Hg)

ADI (Attitude Director Indicator)

Airspeed Reference Bug Setting Knob

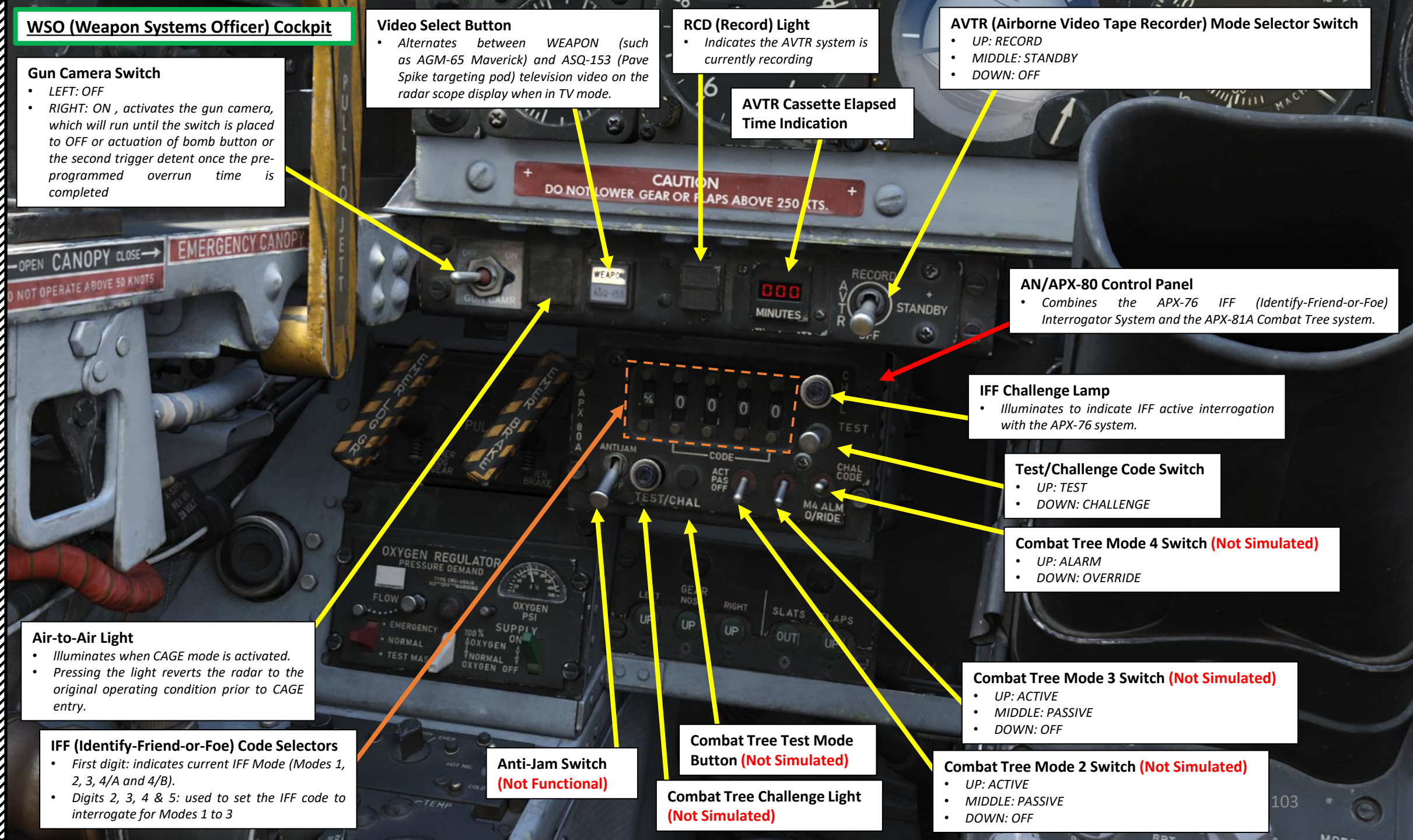
Calibrated Airspeed Indicator (x10 kts or Mach)

BDHI (Bearing Distance Heading Indicator)

ADI Pitch Adjustment Knob

Altimeter Mode Switch
- *Three-position switch, springloaded to return from RESET.*
- *Works in either electric (normal operation mode) or pneumatic (STBY) mode*

WSO (Weapon Systems Officer) Cockpit



Gun Camera Switch
- *LEFT: OFF*
- *RIGHT: ON , activates the gun camera, which will run until the switch is placed to OFF or actuation of bomb button or the second trigger detent once the pre-programmed overrun time is completed*

Video Select Button
- *Alternates between WEAPON (such as AGM-65 Maverick) and ASQ-153 (Pave Spike targeting pod) television video on the radar scope display when in TV mode.*

RCD (Record) Light
- *Indicates the AVTR system is currently recording*

AVTR Cassette Elapsed Time Indication

AVTR (Airborne Video Tape Recorder) Mode Selector Switch
- *UP: RECORD*
- *MIDDLE: STANDBY*
- *DOWN: OFF*

AN/APX-80 Control Panel
- *Combines the APX-76 IFF (Identify-Friend-or-Foe) Interrogator System and the APX-81A Combat Tree system.*

IFF Challenge Lamp
- *Illuminates to indicate IFF active interrogation with the APX-76 system.*

Test/Challenge Code Switch
- *UP: TEST*
- *DOWN: CHALLENGE*

Combat Tree Mode 4 Switch (Not Simulated)
- *UP: ALARM*
- *DOWN: OVERRIDE*

Combat Tree Mode 3 Switch (Not Simulated)
- *UP: ACTIVE*
- *MIDDLE: PASSIVE*
- *DOWN: OFF*

Combat Tree Mode 2 Switch (Not Simulated)
- *UP: ACTIVE*
- *MIDDLE: PASSIVE*
- *DOWN: OFF*

Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

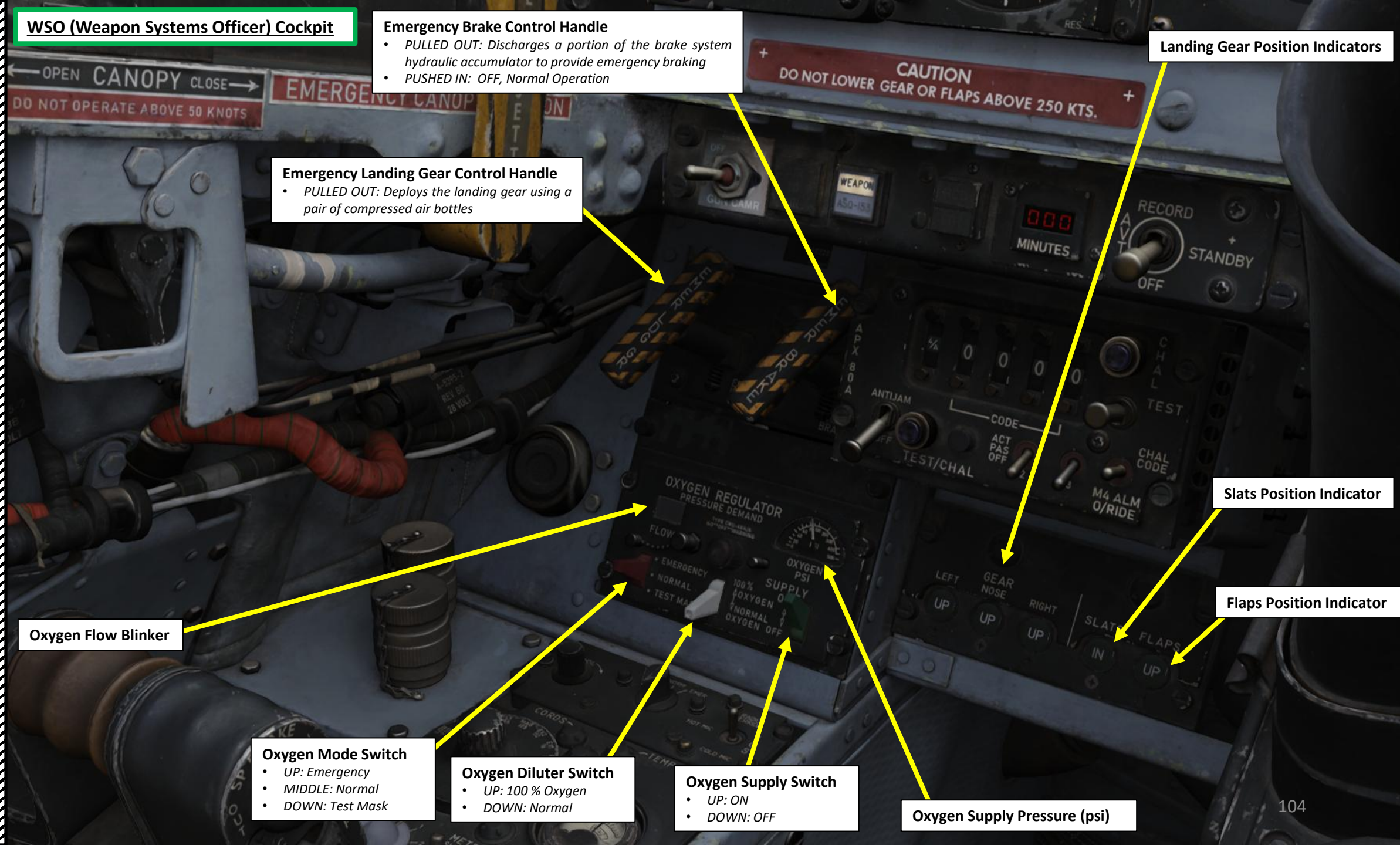
IFF (Identify-Friend-or-Foe) Code Selectors
- *First digit: indicates current IFF Mode (Modes 1, 2, 3, 4/A and 4/B).*
- *Digits 2, 3, 4 & 5: used to set the IFF code to interrogate for Modes 1 to 3*

Anti-Jam Switch (Not Functional)

Combat Tree Test Mode Button (Not Simulated)

Combat Tree Challenge Light (Not Simulated)

WSO (Weapon Systems Officer) Cockpit



Emergency Brake Control Handle
- *PULLED OUT: Discharges a portion of the brake system hydraulic accumulator to provide emergency braking*
- *PUSHED IN: OFF, Normal Operation*

Emergency Landing Gear Control Handle
- *PULLED OUT: Deploys the landing gear using a pair of compressed air bottles*

Landing Gear Position Indicators

Slats Position Indicator

Flaps Position Indicator

Oxygen Flow Blinker

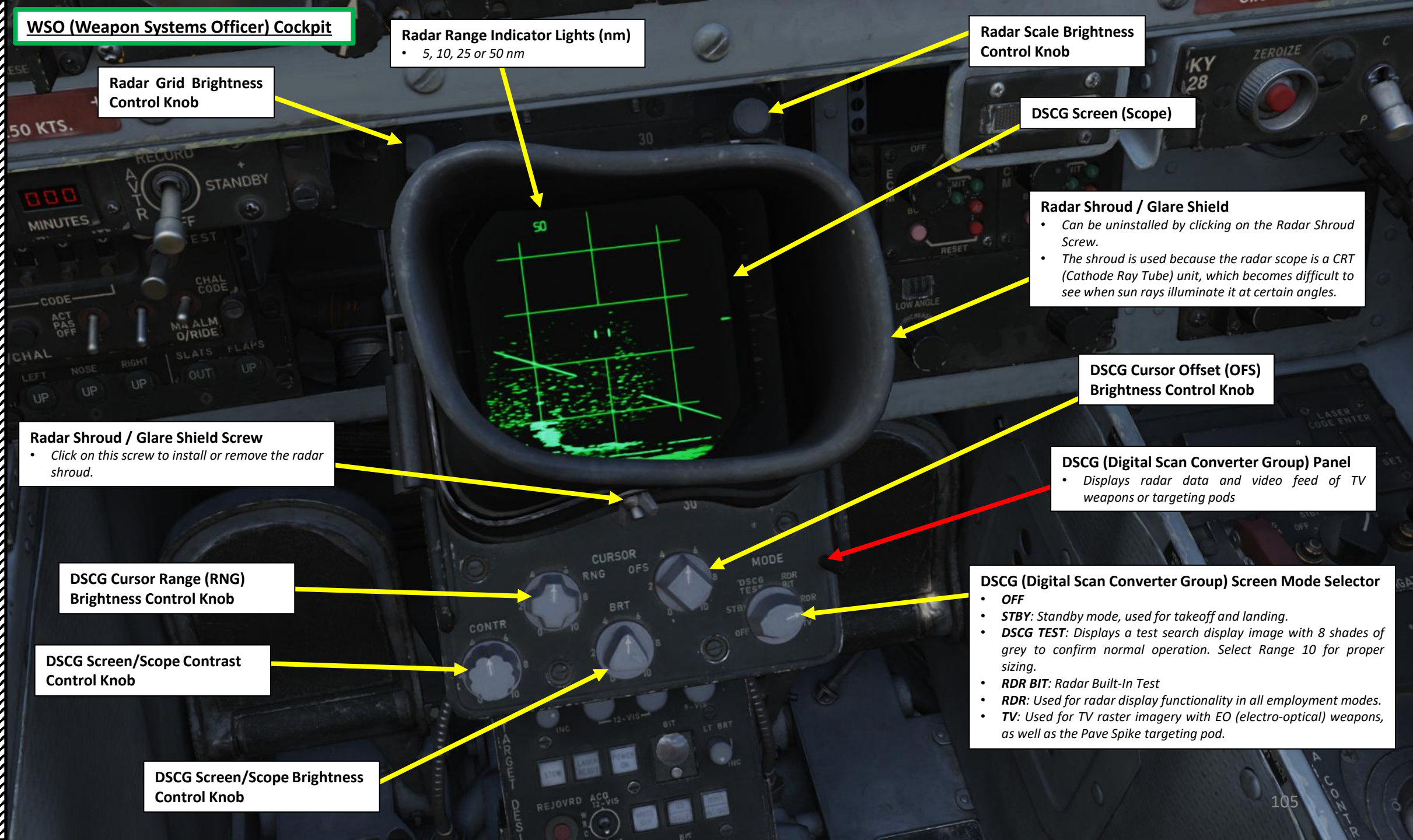
Oxygen Mode Switch
- *UP: Emergency*
- *MIDDLE: Normal*
- *DOWN: Test Mask*

Oxygen Diluter Switch
- *UP: 100 % Oxygen*
- *DOWN: Normal*

Oxygen Supply Switch
- *UP: ON*
- *DOWN: OFF*

Oxygen Supply Pressure (psi)

WSO (Weapon Systems Officer) Cockpit



Radar Range Indicator Lights (nm)
- *5, 10, 25 or 50 nm*

Radar Scale Brightness Control Knob

Radar Grid Brightness Control Knob

DSCG Screen (Scope)

Radar Shroud / Glare Shield
- *Can be uninstalled by clicking on the Radar Shroud Screw.*
- *The shroud is used because the radar scope is a CRT (Cathode Ray Tube) unit, which becomes difficult to see when sun rays illuminate it at certain angles.*

DSCG Cursor Offset (OFS) Brightness Control Knob

Radar Shroud / Glare Shield Screw
- *Click on this screw to install or remove the radar shroud.*

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

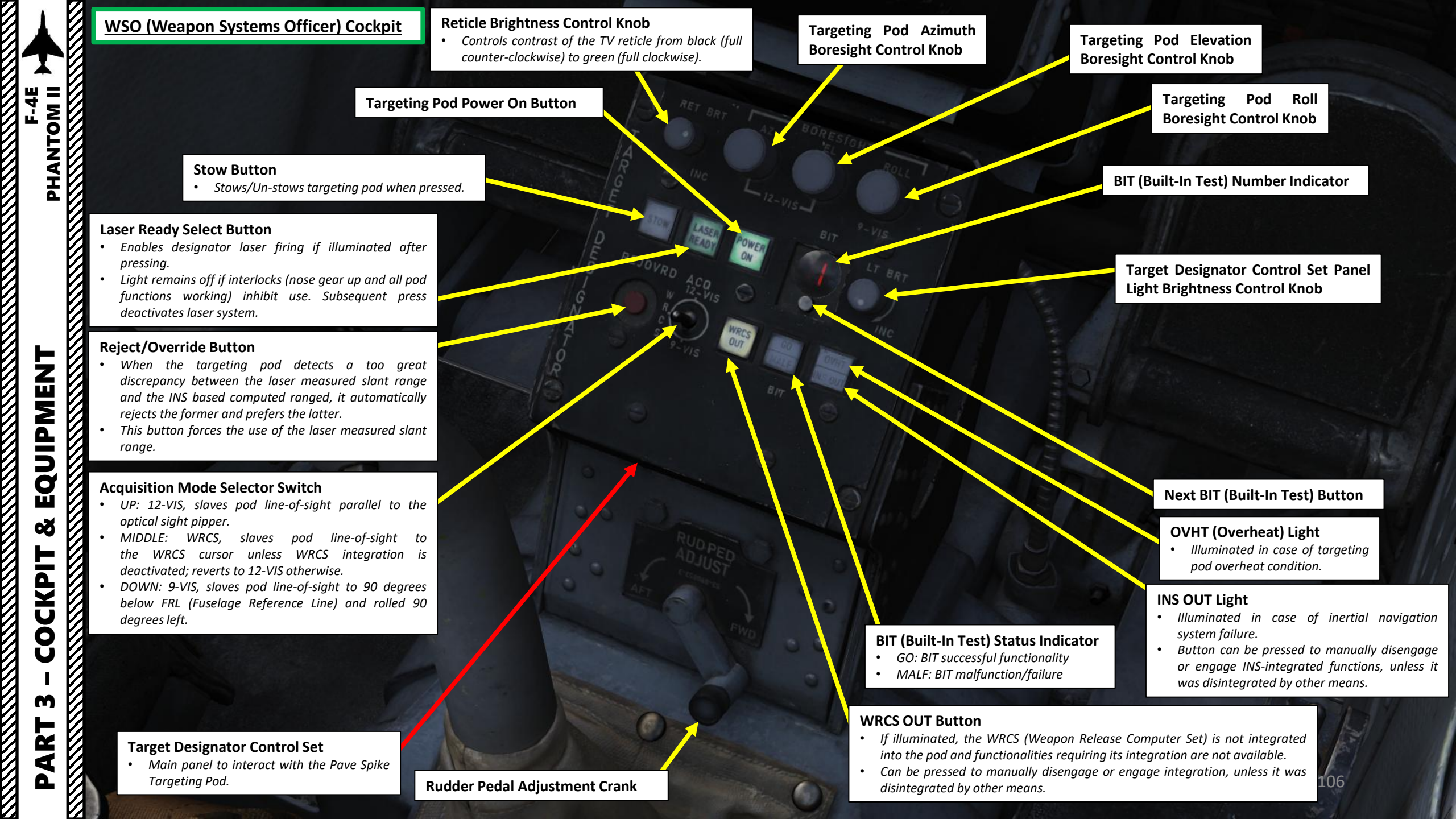
DSCG Cursor Range (RNG) Brightness Control Knob

DSCG (Digital Scan Converter Group) Screen Mode Selector
- ***OFF***
- ***STBY****: Standby mode, used for takeoff and landing.*
- ***DSCG TEST****: Displays a test search display image with 8 shades of grey to confirm normal operation. Select Range 10 for proper sizing.*
- ***RDR BIT****: Radar Built-In Test*
- ***RDR****: Used for radar display functionality in all employment modes.*
- ***TV****: Used for TV raster imagery with EO (electro-optical) weapons, as well as the Pave Spike targeting pod.*

DSCG Screen/Scope Contrast Control Knob

DSCG Screen/Scope Brightness Control Knob

WSO (Weapon Systems Officer) Cockpit



Reticle Brightness Control Knob
- *Controls contrast of the TV reticle from black (full counter-clockwise) to green (full clockwise).*

Targeting Pod Azimuth Boresight Control Knob

Targeting Pod Elevation Boresight Control Knob

Targeting Pod Power On Button

Targeting Pod Roll Boresight Control Knob

Stow Button
- *Stows/Un-stows targeting pod when pressed.*

BIT (Built-In Test) Number Indicator

Laser Ready Select Button
- *Enables designator laser firing if illuminated after pressing.*
- *Light remains off if interlocks (nose gear up and all pod functions working) inhibit use. Subsequent press deactivates laser system.*

Target Designator Control Set Panel Light Brightness Control Knob

Reject/Override Button
- *When the targeting pod detects a too great discrepancy between the laser measured slant range and the INS based computed ranged, it automatically rejects the former and prefers the latter.*
- *This button forces the use of the laser measured slant range.*

Next BIT (Built-In Test) Button

OVHT (Overheat) Light
- *Illuminated in case of targeting pod overheat condition.*

Acquisition Mode Selector Switch
- *UP: 12-VIS, slaves pod line-of-sight parallel to the optical sight pipper.*
- *MIDDLE: WRCS, slaves pod line-of-sight to the WRCS cursor unless WRCS integration is deactivated; reverts to 12-VIS otherwise.*
- *DOWN: 9-VIS, slaves pod line-of-sight to 90 degrees below FRL (Fuselage Reference Line) and rolled 90 degrees left.*

INS OUT Light
- *Illuminated in case of inertial navigation system failure.*
- *Button can be pressed to manually disengage or engage INS-integrated functions, unless it was disintegrated by other means.*

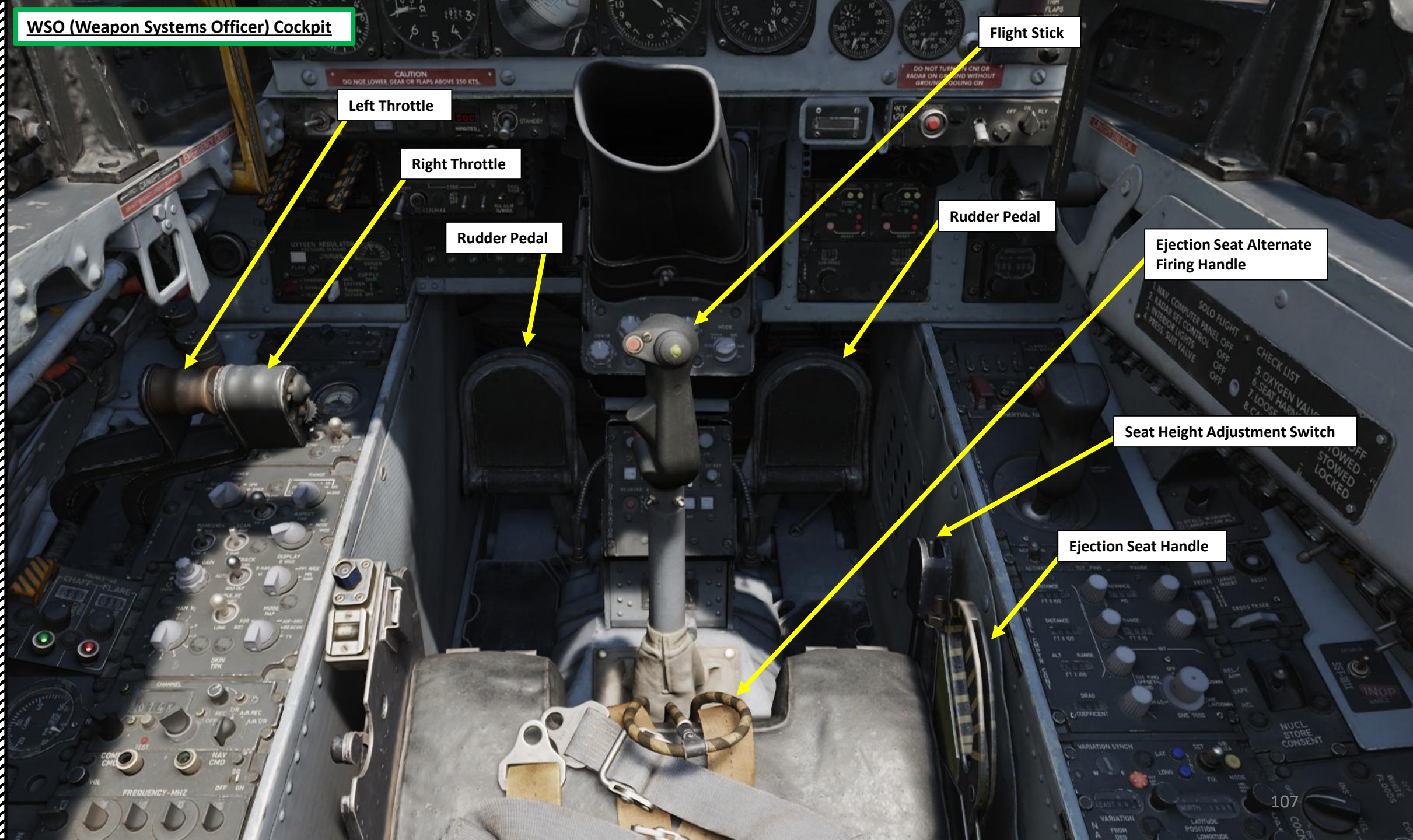
BIT (Built-In Test) Status Indicator
- *GO: BIT successful functionality*
- *MALF: BIT malfunction/failure*

WRCS OUT Button
- *If illuminated, the WRCS (Weapon Release Computer Set) is not integrated into the pod and functionalities requiring its integration are not available.*
- *Can be pressed to manually disengage or engage integration, unless it was disintegrated by other means.*

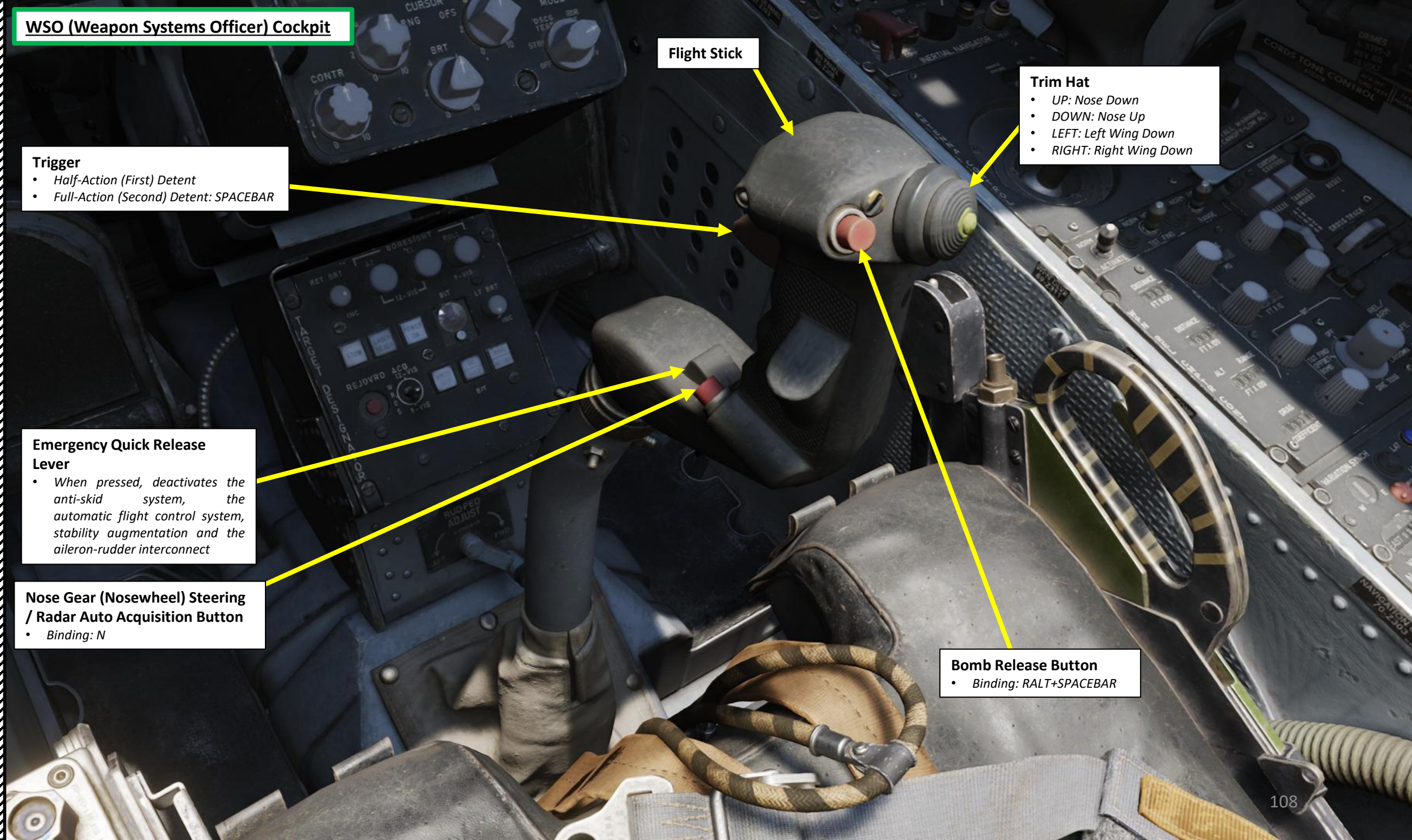
Target Designator Control Set
- *Main panel to interact with the Pave Spike Targeting Pod.*

Rudder Pedal Adjustment Crank

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Flight Stick

Trim Hat
- *UP: Nose Down*
- *DOWN: Nose Up*
- *LEFT: Left Wing Down*
- *RIGHT: Right Wing Down*

Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

Emergency Quick Release Lever
- *When pressed, deactivates the anti-skid system, the automatic flight control system, stability augmentation and the aileron-rudder interconnect*

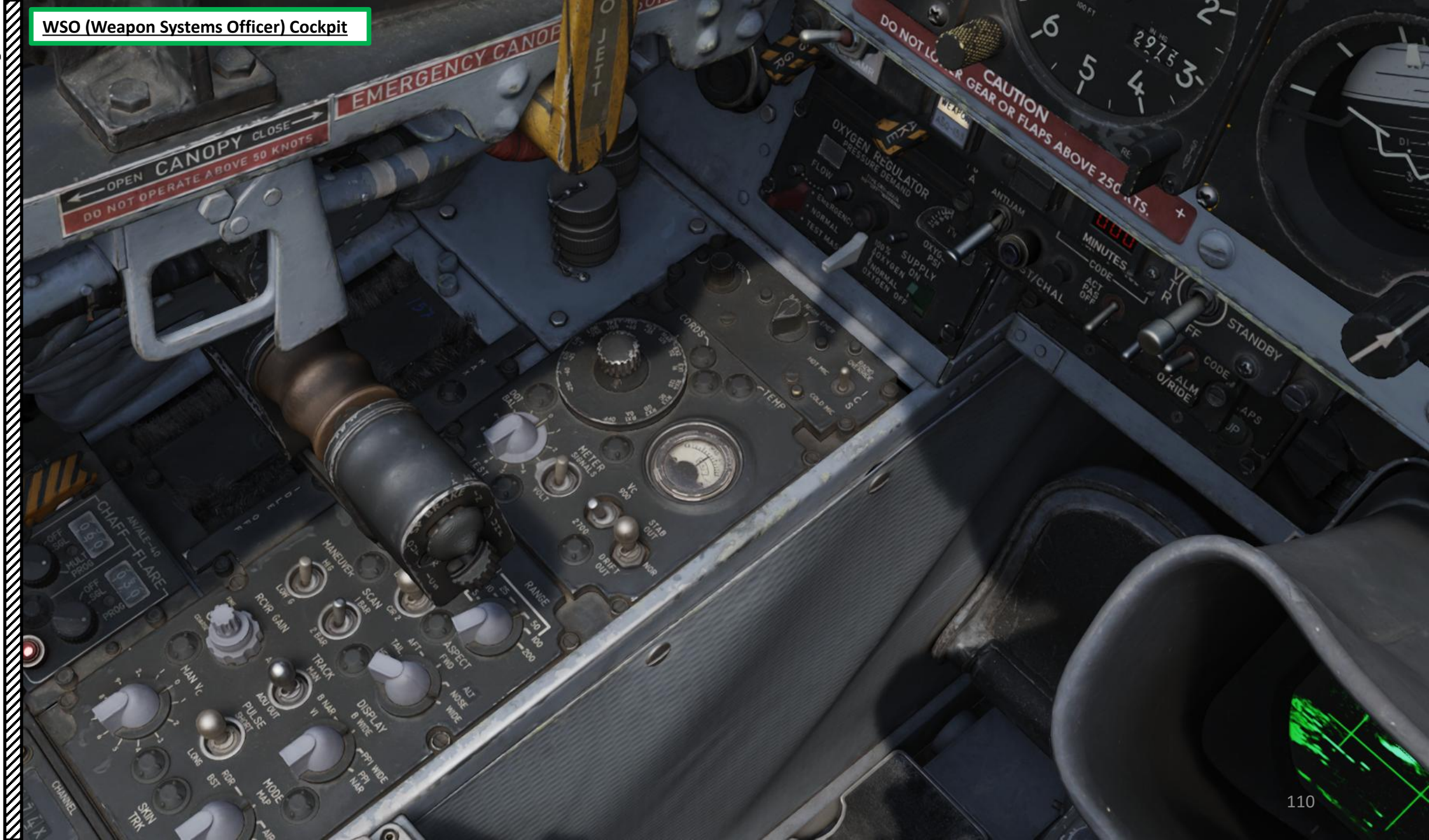
Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*

Bomb Release Button
- *Binding: RALT+SPACEBAR*

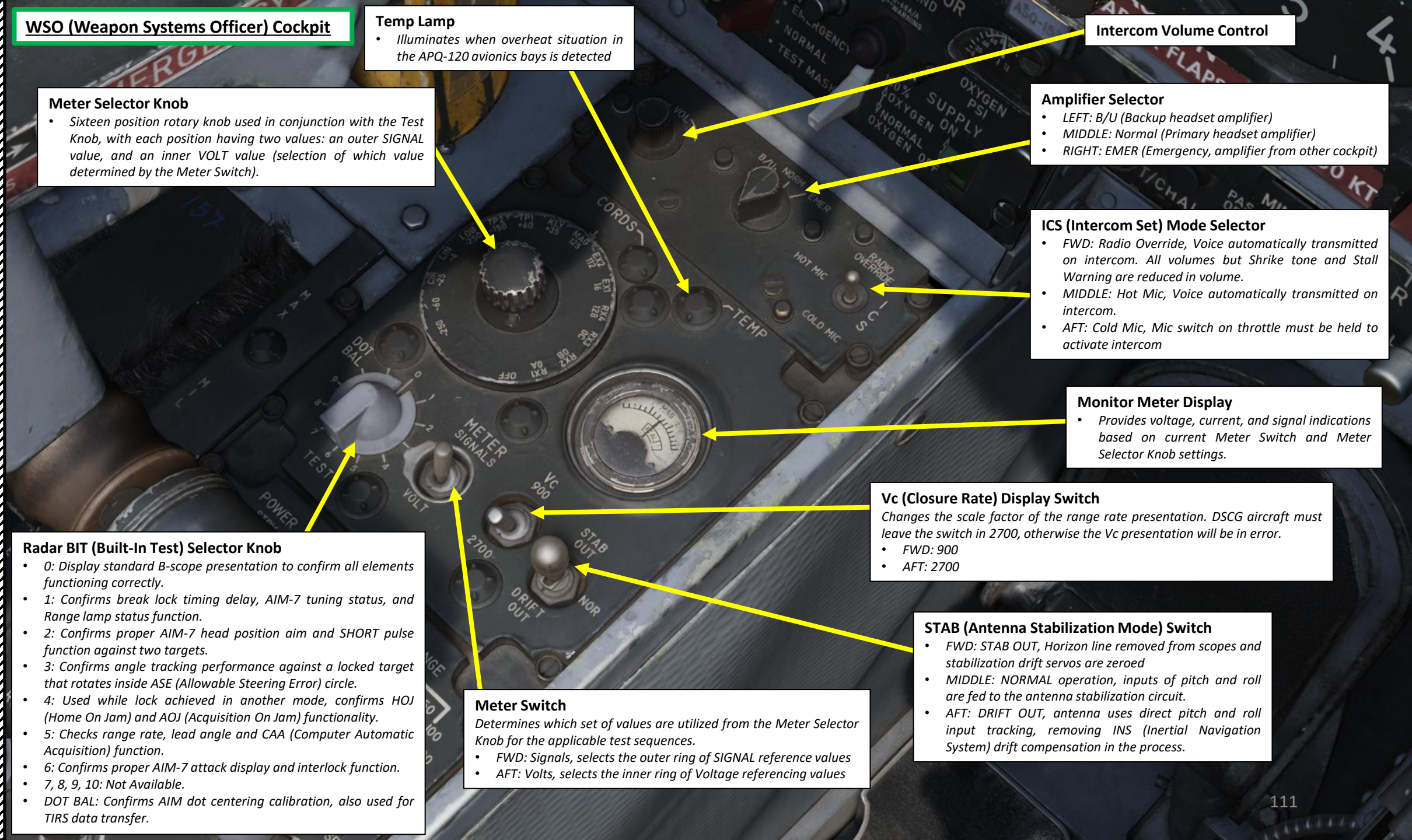
WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Temp Lamp
- *Illuminates when overheat situation in the APQ-120 avionics bays is detected*

Intercom Volume Control

Meter Selector Knob
- *Sixteen position rotary knob used in conjunction with the Test Knob, with each position having two values: an outer SIGNAL value, and an inner VOLT value (selection of which value determined by the Meter Switch).*

Amplifier Selector
- *LEFT: B/U (Backup headset amplifier)*
- *MIDDLE: Normal (Primary headset amplifier)*
- *RIGHT: EMER (Emergency, amplifier from other cockpit)*

ICS (Intercom Set) Mode Selector
- *FWD: Radio Override, Voice automatically transmitted on intercom. All volumes but Shrike tone and Stall Warning are reduced in volume.*
- *MIDDLE: Hot Mic, Voice automatically transmitted on intercom.*
- *AFT: Cold Mic, Mic switch on throttle must be held to activate intercom*

Monitor Meter Display
- *Provides voltage, current, and signal indications based on current Meter Switch and Meter Selector Knob settings.*

Vc (Closure Rate) Display Switch

Changes the scale factor of the range rate presentation. DSCG aircraft must leave the switch in 2700, otherwise the Vc presentation will be in error.
- *FWD: 900*
- *AFT: 2700*

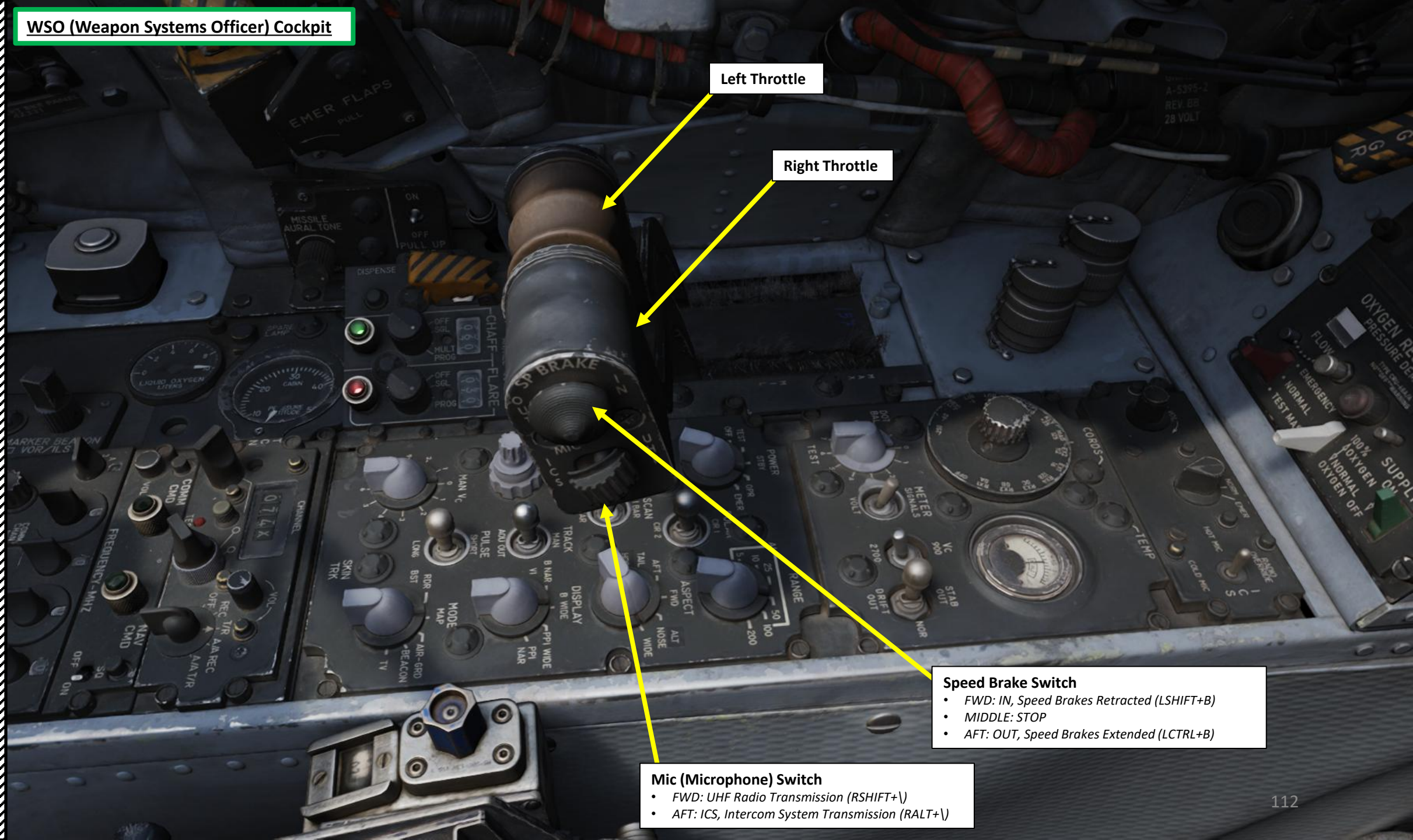
Radar BIT (Built-In Test) Selector Knob
- *0: Display standard B-scope presentation to confirm all elements functioning correctly.*
- *1: Confirms break lock timing delay, AIM-7 tuning status, and Range lamp status function.*
- *2: Confirms proper AIM-7 head position aim and SHORT pulse function against two targets.*
- *3: Confirms angle tracking performance against a locked target that rotates inside ASE (Allowable Steering Error) circle.*
- *4: Used while lock achieved in another mode, confirms HOJ (Home On Jam) and AOJ (Acquisition On Jam) functionality.*
- *5: Checks range rate, lead angle and CAA (Computer Automatic Acquisition) function.*
- *6: Confirms proper AIM-7 attack display and interlock function.*
- *7, 8, 9, 10: Not Available.*
- *DOT BAL: Confirms AIM dot centering calibration, also used for TIRS data transfer.*

Meter Switch

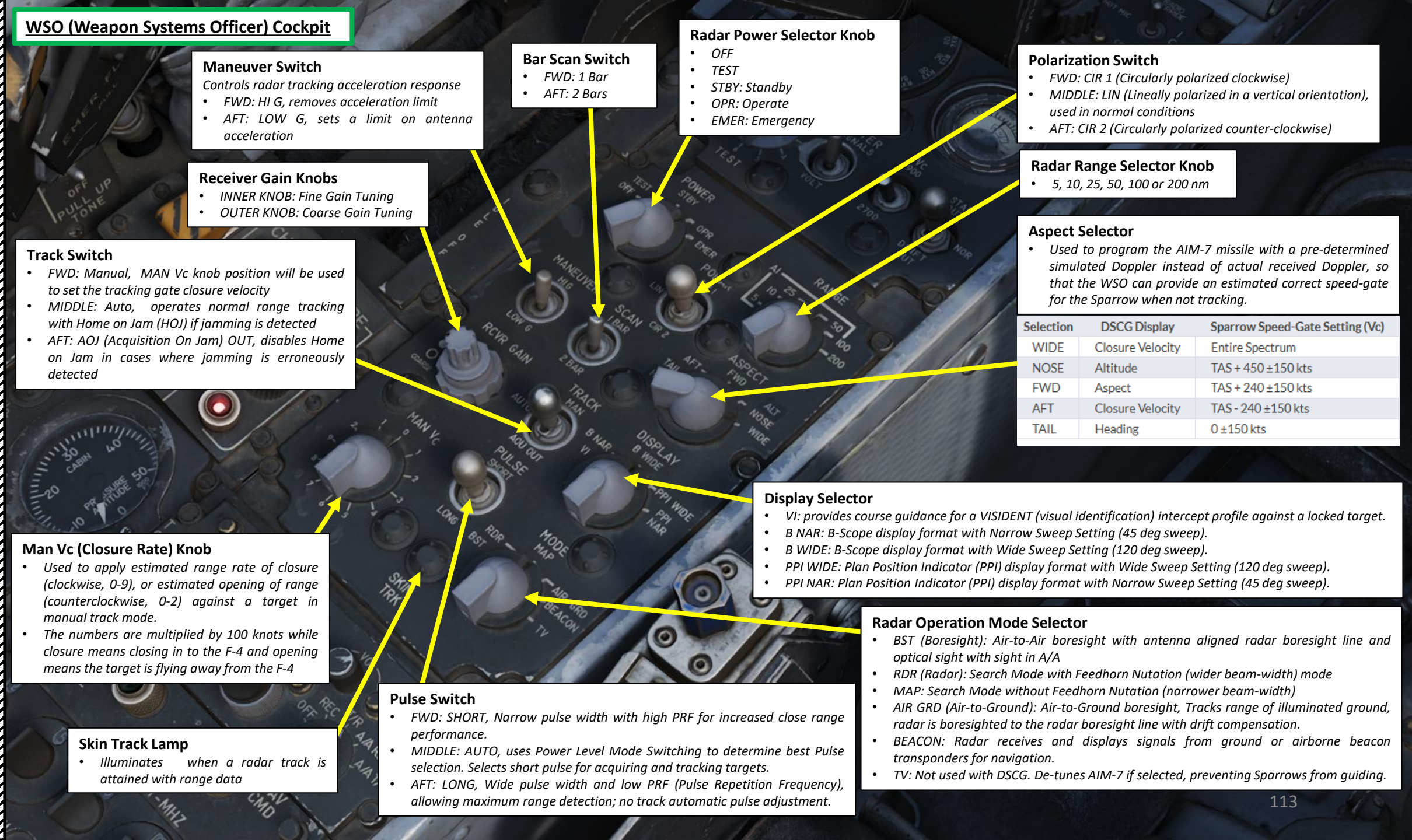
Determines which set of values are utilized from the Meter Selector Knob for the applicable test sequences.
- *FWD: Signals, selects the outer ring of SIGNAL reference values*
- *AFT: Volts, selects the inner ring of Voltage referencing values*

STAB (Antenna Stabilization Mode) Switch
- *FWD: STAB OUT, Horizon line removed from scopes and stabilization drift servos are zeroed*
- *MIDDLE: NORMAL operation, inputs of pitch and roll are fed to the antenna stabilization circuit.*
- *AFT: DRIFT OUT, antenna uses direct pitch and roll input tracking, removing INS (Inertial Navigation System) drift compensation in the process.*

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



Maneuver Switch
Controls radar tracking acceleration response
- *FWD: HI G, removes acceleration limit*
- *AFT: LOW G, sets a limit on antenna acceleration*

Bar Scan Switch
- *FWD: 1 Bar*
- *AFT: 2 Bars*

Radar Power Selector Knob
- *OFF*
- *TEST*
- *STBY: Standby*
- *OPR: Operate*
- *EMER: Emergency*

Polarization Switch
- *FWD: CIR 1 (Circularly polarized clockwise)*
- *MIDDLE: LIN (Lineally polarized in a vertical orientation), used in normal conditions*
- *AFT: CIR 2 (Circularly polarized counter-clockwise)*

Radar Range Selector Knob
- *5, 10, 25, 50, 100 or 200 nm*

Receiver Gain Knobs
- *INNER KNOB: Fine Gain Tuning*
- *OUTER KNOB: Coarse Gain Tuning*

Track Switch
- *FWD: Manual, MAN Vc knob position will be used to set the tracking gate closure velocity*
- *MIDDLE: Auto, operates normal range tracking with Home on Jam (HOJ) if jamming is detected*
- *AFT: AOJ (Acquisition On Jam) OUT, disables Home on Jam in cases where jamming is erroneously detected*

Aspect Selector
- *Used to program the AIM-7 missile with a pre-determined simulated Doppler instead of actual received Doppler, so that the WSO can provide an estimated correct speed-gate for the Sparrow when not tracking.*

Selection	DSCG Display	Sparrow Speed-Gate Setting (Vc)
WIDE	Closure Velocity	Entire Spectrum
NOSE	Altitude	TAS + 450 ±150 kts
FWD	Aspect	TAS + 240 ±150 kts
AFT	Closure Velocity	TAS - 240 ±150 kts
TAIL	Heading	0 ±150 kts

Display Selector
- *VI: provides course guidance for a VISIDENT (visual identification) intercept profile against a locked target.*
- *B NAR: B-Scope display format with Narrow Sweep Setting (45 deg sweep).*
- *B WIDE: B-Scope display format with Wide Sweep Setting (120 deg sweep).*
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*

Man Vc (Closure Rate) Knob
- *Used to apply estimated range rate of closure (clockwise, 0-9), or estimated opening of range (counterclockwise, 0-2) against a target in manual track mode.*
- *The numbers are multiplied by 100 knots while closure means closing in to the F-4 and opening means the target is flying away from the F-4*

Radar Operation Mode Selector
- *BST (Boresight): Air-to-Air boresight with antenna aligned radar boresight line and optical sight with sight in A/A*
- *RDR (Radar): Search Mode with Feedhorn Nutation (wider beam-width) mode*
- *MAP: Search Mode without Feedhorn Nutation (narrower beam-width)*
- *AIR GRD (Air-to-Ground): Air-to-Ground boresight, Tracks range of illuminated ground, radar is boresighted to the radar boresight line with drift compensation.*
- *BEACON: Radar receives and displays signals from ground or airborne beacon transponders for navigation.*
- *TV: Not used with DSCG. De-tunes AIM-7 if selected, preventing Sparrows from guiding.*

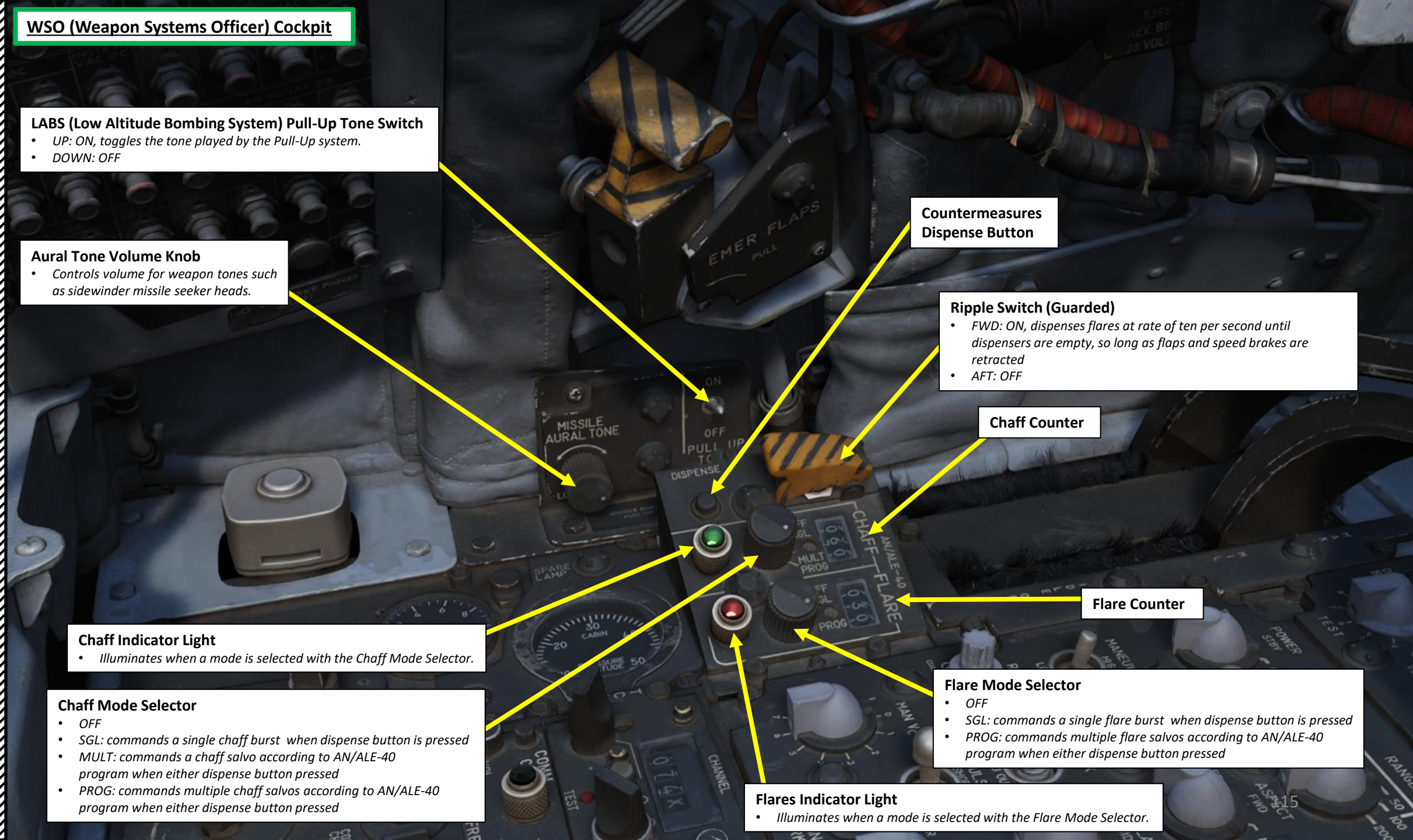
Skin Track Lamp
- *Illuminates when a radar track is attained with range data*

Pulse Switch
- *FWD: SHORT, Narrow pulse width with high PRF for increased close range performance.*
- *MIDDLE: AUTO, uses Power Level Mode Switching to determine best Pulse selection. Selects short pulse for acquiring and tracking targets.*
- *AFT: LONG, Wide pulse width and low PRF (Pulse Repetition Frequency), allowing maximum range detection; no track automatic pulse adjustment.*

WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



LABS (Low Altitude Bombing System) Pull-Up Tone Switch
- *UP: ON, toggles the tone played by the Pull-Up system.*
- *DOWN: OFF*

Aural Tone Volume Knob
- *Controls volume for weapon tones such as sidewinder missile seeker heads.*

Countermeasures Dispense Button

Ripple Switch (Guarded)
- *FWD: ON, dispenses flares at rate of ten per second until dispensers are empty, so long as flaps and speed brakes are retracted*
- *AFT: OFF*

Chaff Counter

Flare Counter

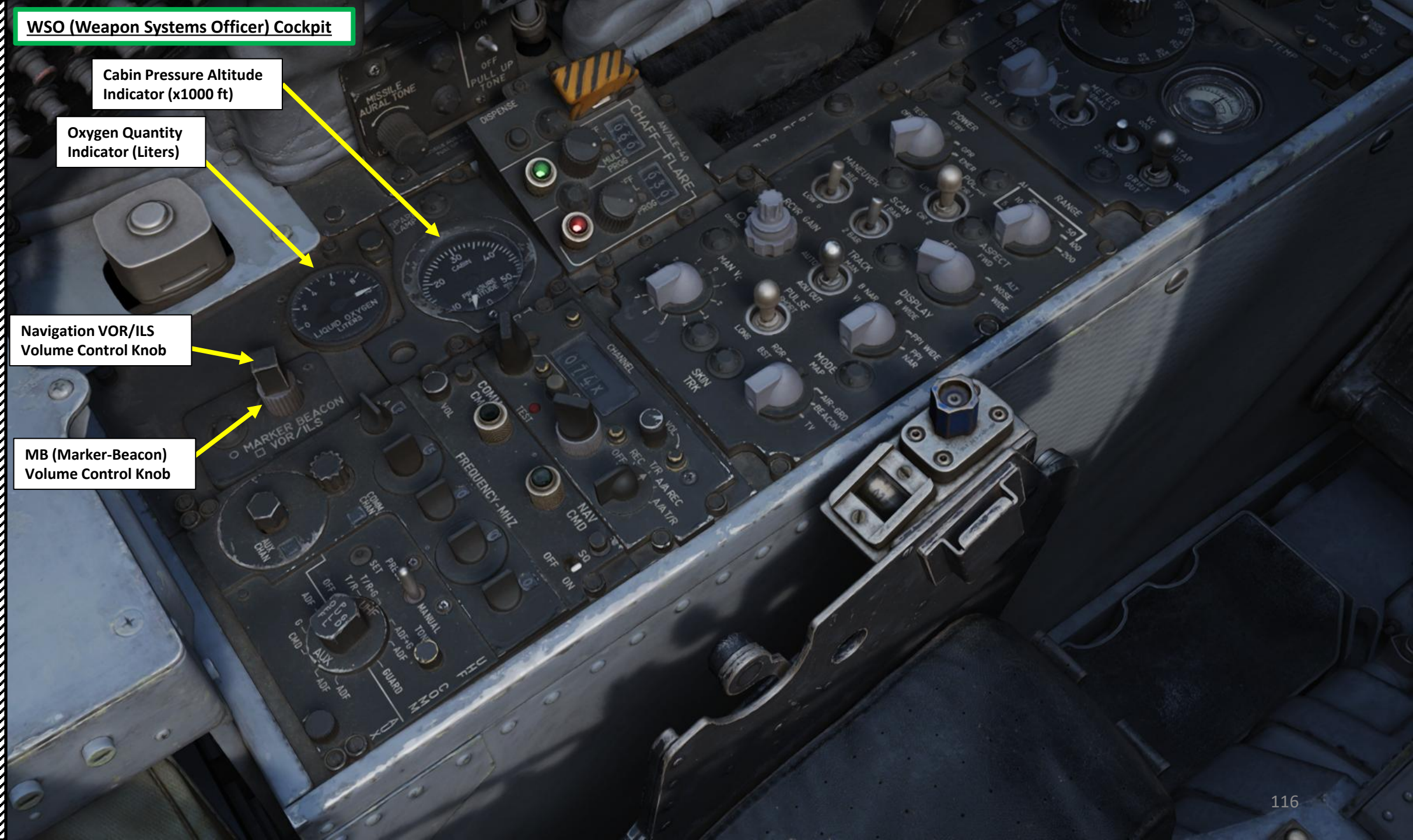
Chaff Indicator Light
- *Illuminates when a mode is selected with the Chaff Mode Selector.*

Chaff Mode Selector
- *OFF*
- *SGL: commands a single chaff burst when dispense button is pressed*
- *MULT: commands a chaff salvo according to AN/ALE-40 program when either dispense button pressed*
- *PROG: commands multiple chaff salvos according to AN/ALE-40 program when either dispense button pressed*

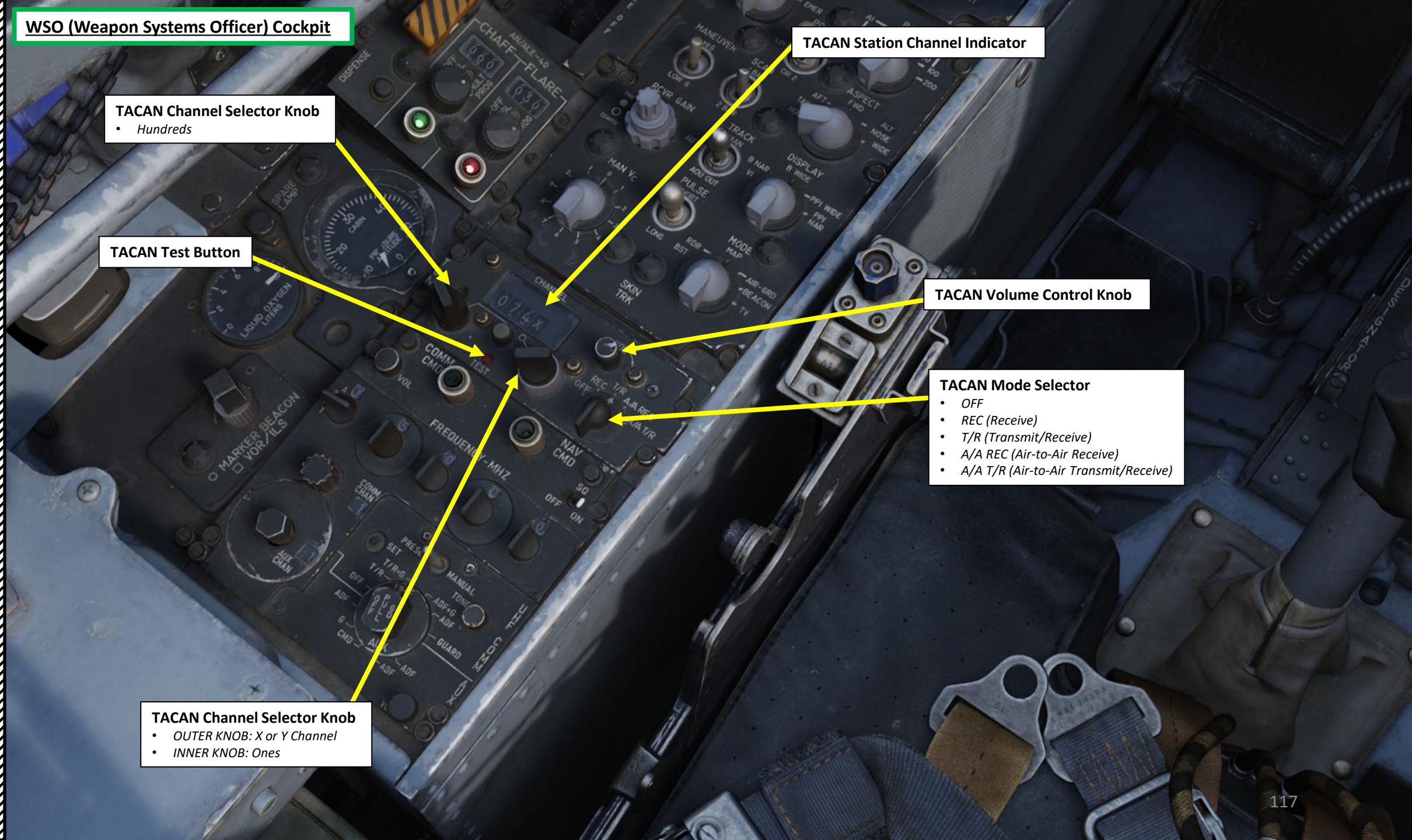
Flare Mode Selector
- *OFF*
- *SGL: commands a single flare burst when dispense button is pressed*
- *PROG: commands multiple flare salvos according to AN/ALE-40 program when either dispense button pressed*

Flares Indicator Light
- *Illuminates when a mode is selected with the Flare Mode Selector.*

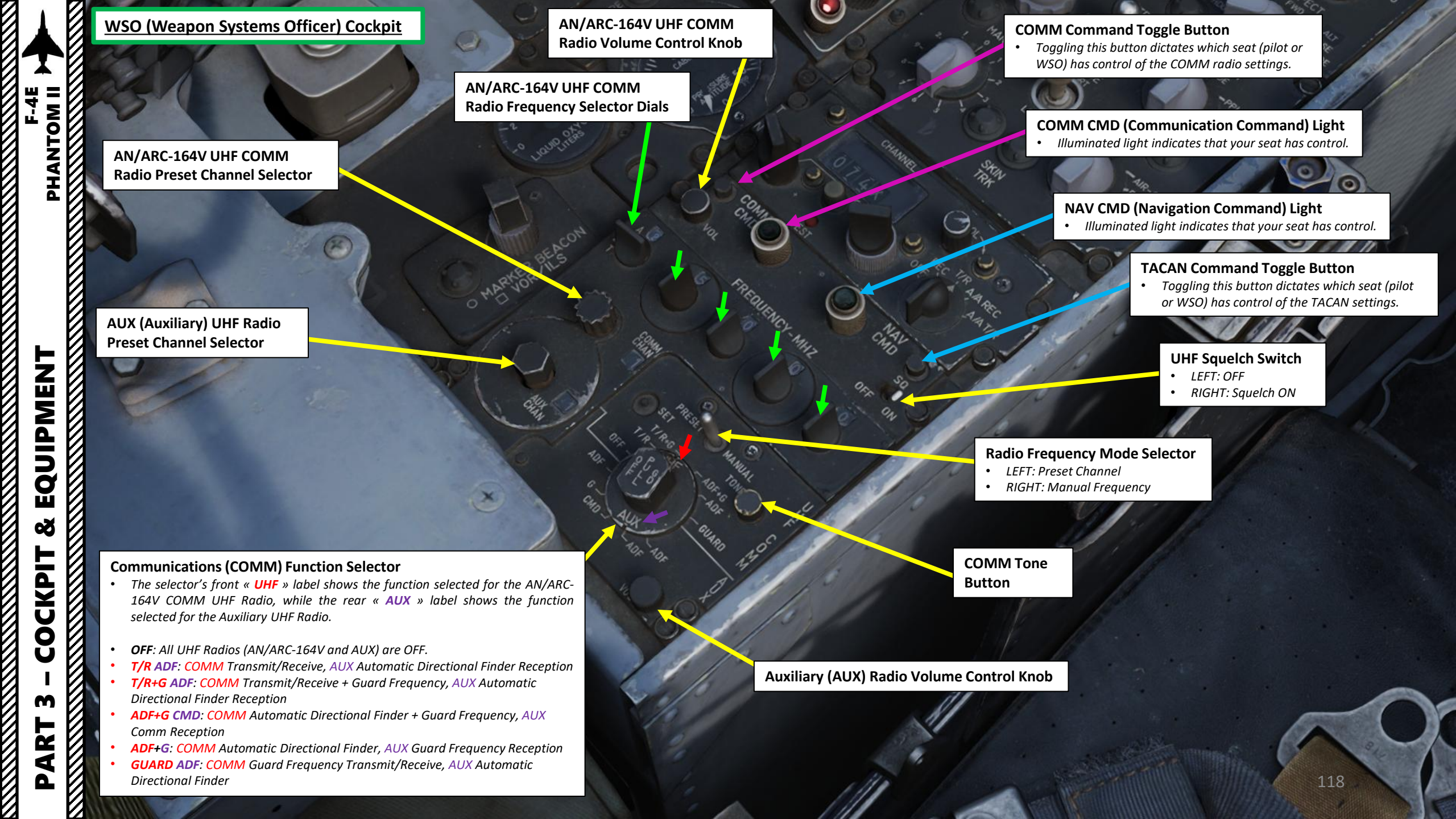
WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit



AN/ARC-164V UHF COMM Radio Volume Control Knob

AN/ARC-164V UHF COMM Radio Frequency Selector Dials

AN/ARC-164V UHF COMM Radio Preset Channel Selector

AUX (Auxiliary) UHF Radio Preset Channel Selector

COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*

COMM CMD (Communication Command) Light
- *Illuminated light indicates that your seat has control.*

NAV CMD (Navigation Command) Light
- *Illuminated light indicates that your seat has control.*

TACAN Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the TACAN settings.*

UHF Squelch Switch
- *LEFT: OFF*
- *RIGHT: Squelch ON*

Radio Frequency Mode Selector
- *LEFT: Preset Channel*
- *RIGHT: Manual Frequency*

COMM Tone Button

Auxiliary (AUX) Radio Volume Control Knob

Communications (COMM) Function Selector
- *The selector's front « **UHF** » label shows the function selected for the AN/ARC-164V COMM UHF Radio, while the rear « **AUX** » label shows the function selected for the Auxiliary UHF Radio.*

- ***OFF**: All UHF Radios (AN/ARC-164V and AUX) are OFF.*
- ***T/R ADF**: COMM Transmit/Receive, AUX Automatic Directional Finder Reception*
- ***T/R+G ADF**: COMM Transmit/Receive + Guard Frequency, AUX Automatic Directional Finder Reception*
- ***ADF+G CMD**: COMM Automatic Directional Finder + Guard Frequency, AUX Comm Reception*
- ***ADF+G**: COMM Automatic Directional Finder, AUX Guard Frequency Reception*
- ***GUARD ADF**: COMM Guard Frequency Transmit/Receive, AUX Automatic Directional Finder*

WSO (Weapon Systems Officer) Cockpit

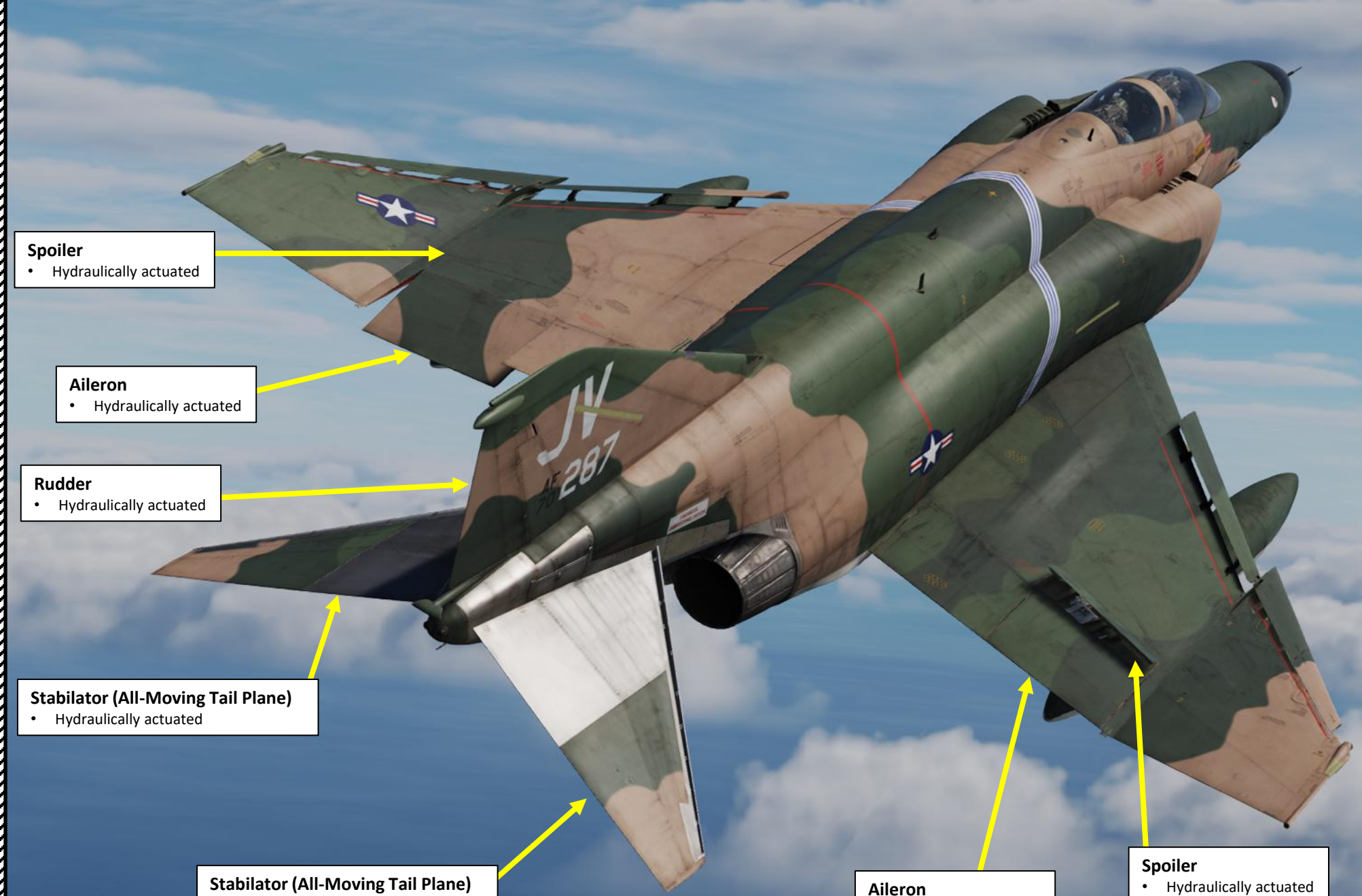


WSO (Weapon Systems Officer) Cockpit



WSO (Weapon Systems Officer) Cockpit





Spoiler
- Hydraulically actuated

Aileron
- Hydraulically actuated

Rudder
- Hydraulically actuated

Stabilator (All-Moving Tail Plane)
- Hydraulically actuated

Stabilator (All-Moving Tail Plane)
- Hydraulically actuated

Aileron
- Hydraulically actuated

Spoiler
- Hydraulically actuated

Flaps/Slats Control Lever

- *UP: NORMAL*
  - *Flaps retracted*
  - *Slats operate as function of AoA (Angle of Attack)*
- *MIDDLE: OUT*
  - *Flaps extended if nose gear is DOWN, Flaps retracted if nose gear is UP.*
  - *Slats are extended*
- *DOWN: OUT & DOWN*
  - *Flaps & Slats are extended*





Slats Position Indicator

Flaps Position Indicator

Inboard Slats
- Hydraulically actuated

Outboard Slats
- Hydraulically actuated

Flap
- Hydraulically actuated







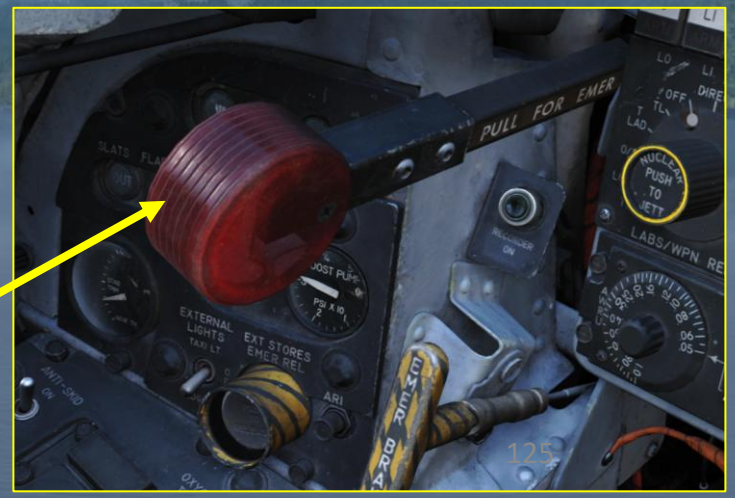
Landing Gear Position Indicators

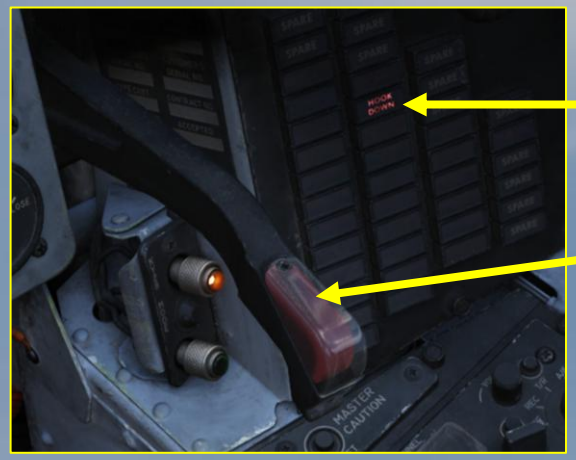
Nose Landing Gear
- Hydraulically actuated

Main Landing Gear
- Hydraulically actuated

Main Landing Gear
- Hydraulically actuated

Landing Gear Lever
- *UP: Landing gears retracted*
- *DOWN: Landing gears deployed*
- *PULLED OUT (Right Click): Pulling the handle out will actuate the Emergency Mode and release the gear by using a pair of compressed air bottles.*





HOOK DOWN Light

Arresting Hook Handle
- *UP: Hook Retracted*
- *DOWN: Hook Deployed*

Arresting Hook
- *The hook is used to achieve rapid deceleration during routine landings during emergency landings or aborted takeoffs at airports equipped with an arresting wire/cable.*



Speed Brake Switch
- *FWD: IN, Speed Brakes Retracted (LSHIFT+B)*
- *MIDDLE: STOP*
- *AFT: OUT, Speed Brakes Extended (LCTRL+B)*

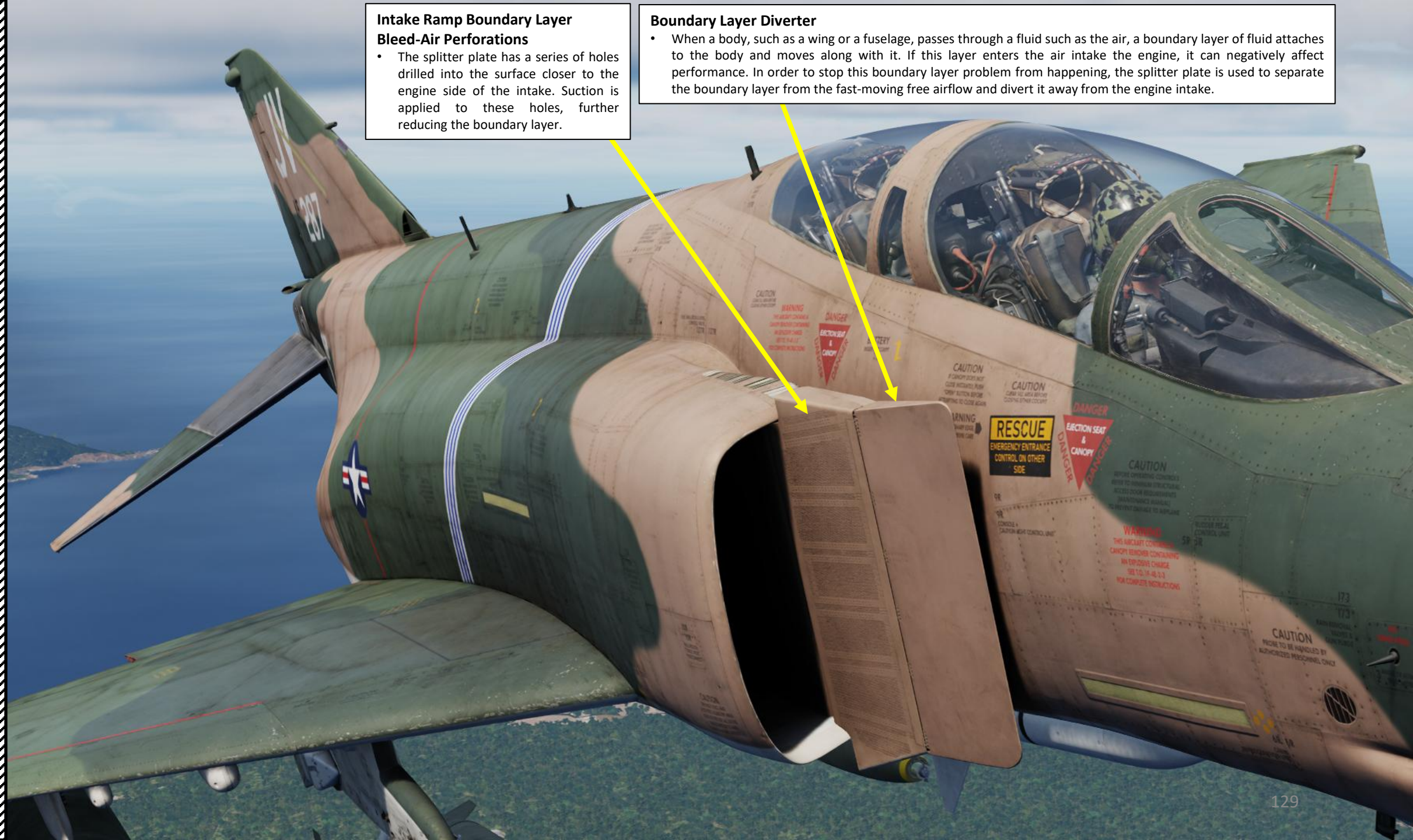


SPEEDBRAKE OUT Light

Speed Brake
- Hydraulically actuated

Speed Brake
- Hydraulically actuated


RESCUE
Air Conditioning System Ram-Air Heat Exchanger Intake



Intake Ramp Boundary Layer Bleed-Air Perforations

- The splitter plate has a series of holes drilled into the surface closer to the engine side of the intake. Suction is applied to these holes, further reducing the boundary layer.

Boundary Layer Diverter

- When a body, such as a wing or a fuselage, passes through a fluid such as the air, a boundary layer of fluid attaches to the body and moves along with it. If this layer enters the air intake the engine, it can negatively affect performance. In order to stop this boundary layer problem from happening, the splitter plate is used to separate the boundary layer from the fast-moving free airflow and divert it away from the engine intake.


AN/APQ-120 Radar Radome

Wing Position Light (Green)

Wingtip Join-Up Light (Green)

Tail Position Light (White)

Exterior Lights Flasher Mode Switch
- *Applicable to Tail, Anti-Collision and Fuselage Lights.*
- *OUTER: Flash*
- *MIDDLE: OFF*
- *INNER: Steady*



Wingtip Join-Up Lights & Wing Position Lights Control Switch
- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Tail Position Light Control Switch
- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Wingtip Join-Up Light (Red)

Wing Position Light (Red)

Anti-Collision Light (Red)

Anti-Collision Light (White)

Anti-Collision Light (White)

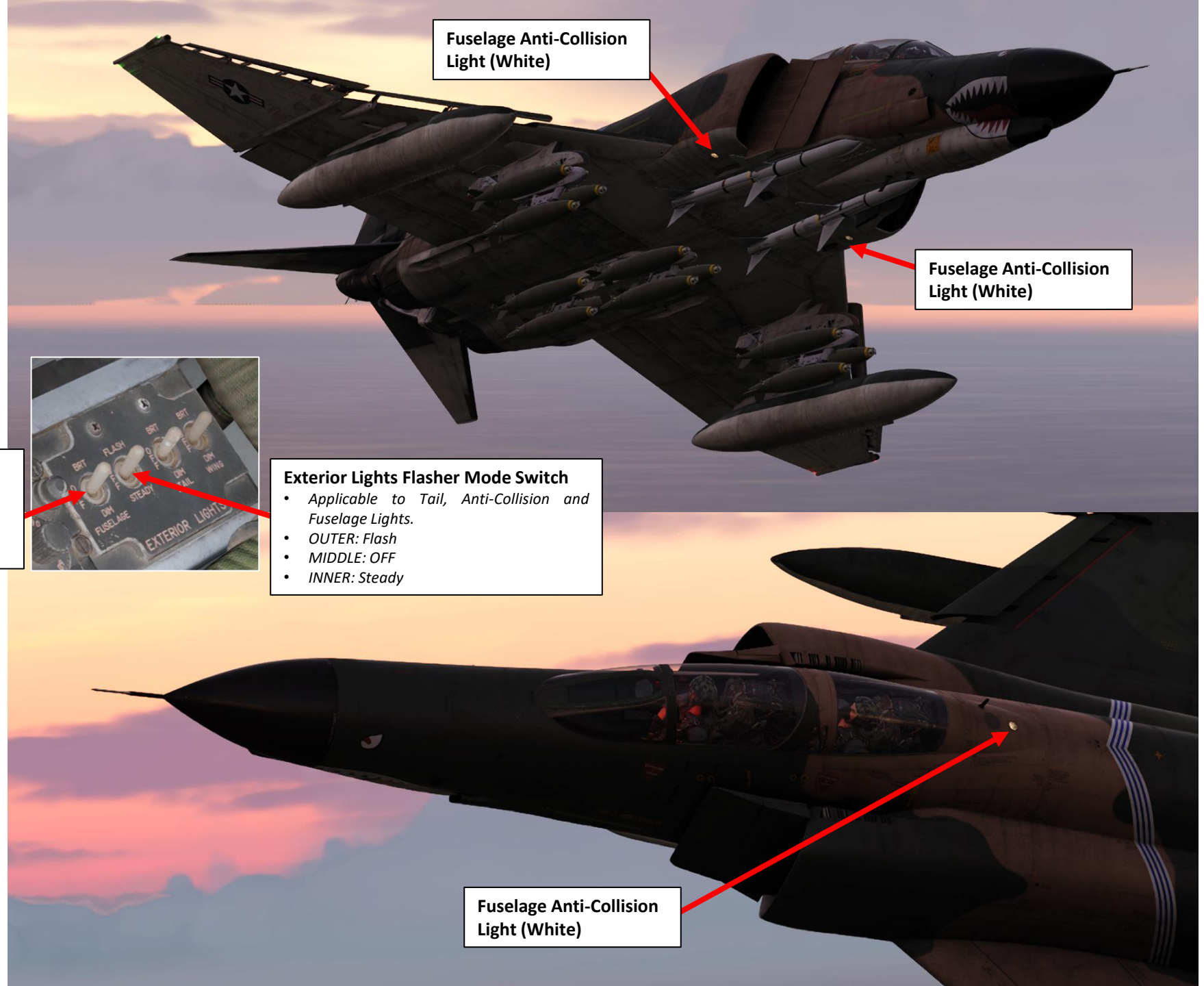


Fuselage Anti-Collision Lights Control Switch

- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Exterior Lights Flasher Mode Switch

- *Applicable to Tail, Anti-Collision and Fuselage Lights.*
- *OUTER: Flash*
- *MIDDLE: OFF*
- *INNER: Steady*



Fuselage Anti-Collision Lights Control Switch
- *OUTER: BRT (Bright)*
- *MIDDLE: OFF*
- *INNER: DIM*

Exterior Lights Flasher Mode Switch
- *Applicable to Tail, Anti-Collision and Fuselage Lights.*
- *OUTER: Flash*
- *MIDDLE: OFF*
- *INNER: Steady*

Formation Light

Formation Light

Formation Light

Formation Light

Formation Light



Formation Lights Mode Switch
- *UP: ON*
- *MIDDLE: OFF*
- *DOWN: MOM (Momentary)*

Formation Lights Control Knob

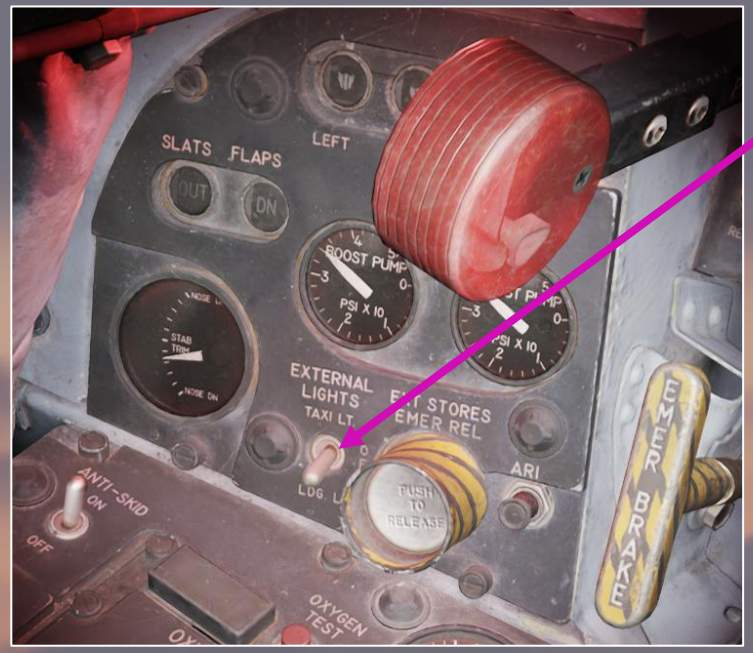
Air Refuel Switch

- *OUTER: ON/EXTEND, in-flight refueling receptacle is powered ON and extended.*
- *INNER: OFF, in-flight refueling receptacle is unpowered and lowered/stowed*



In-Flight Refueling (IFR) Light

- *Light illuminating the IFR receptacle powers on when the Air Refuel Switch is set to EXTEND*



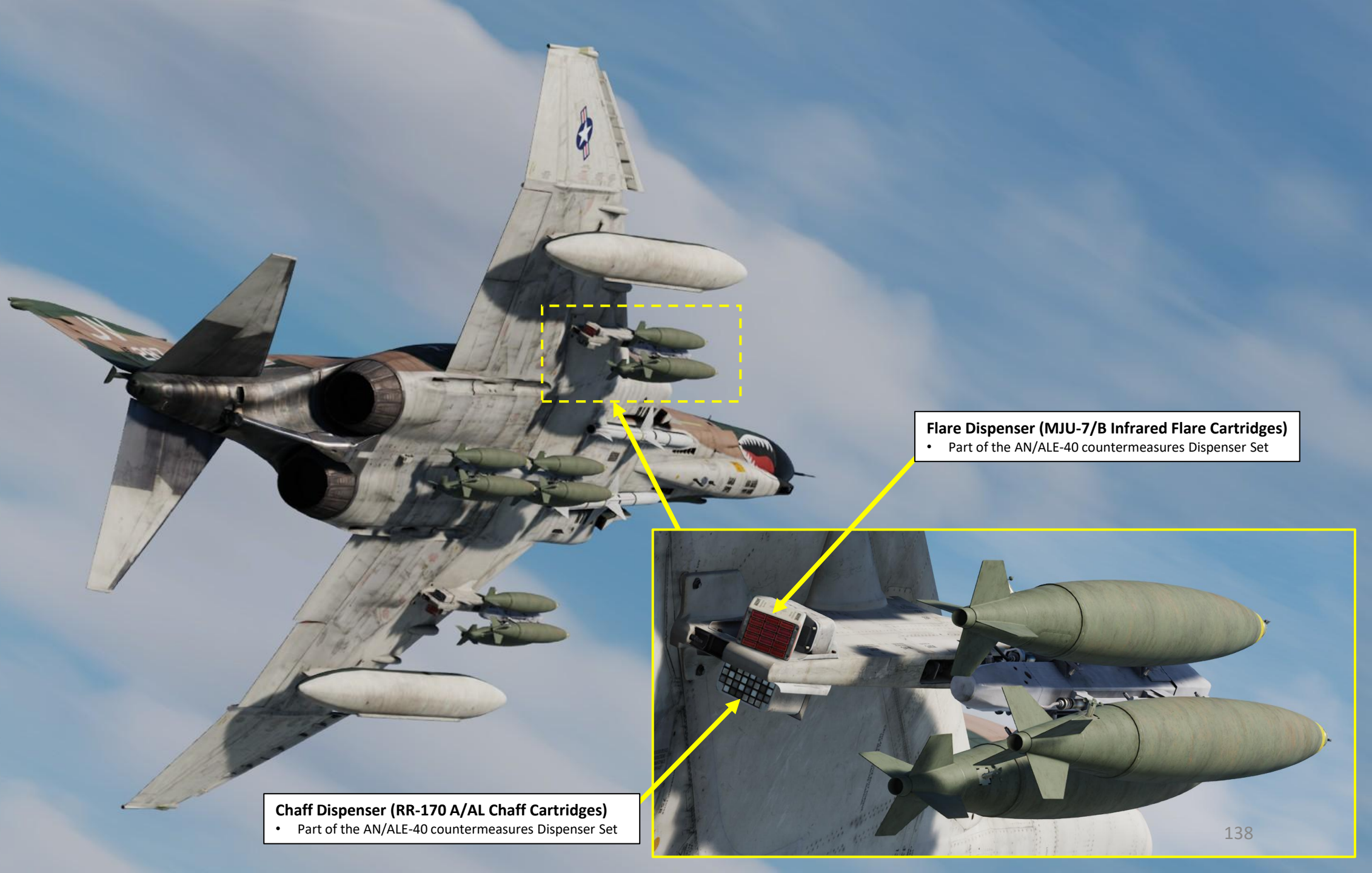
Taxi/Landing Light Switch

- *UP: Taxi Light ON*
- *MIDDLE: OFF*
- *DOWN: Landing Light ON*

Taxi Light

Landing Light


M61A1 Vulcan Cannon (20 mm)



Flare Dispenser (MJU-7/B Infrared Flare Cartridges)
- Part of the AN/ALE-40 countermeasures Dispenser Set

Chaff Dispenser (RR-170 A/AL Chaff Cartridges)
- Part of the AN/ALE-40 countermeasures Dispenser Set


AN/AVQ-23 Pave Spike Targeting Pod


Fuselage Fuel Tank Jettison Outlet
Drag Chute Door Handle
287
DANGER ARRESTING HOOK

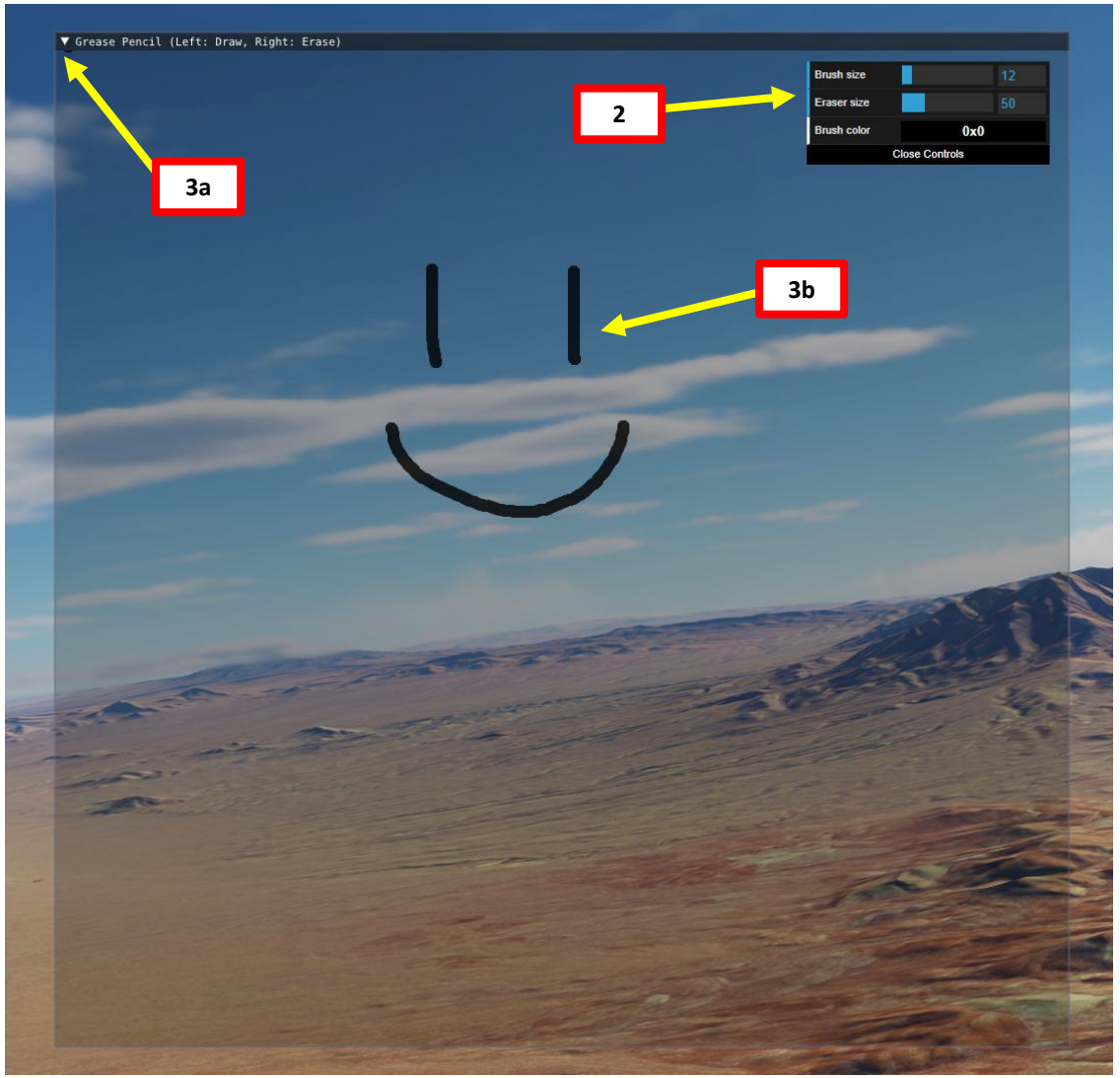




The Grease Pencil

Both crew members can use a grease pencil to draw on the side of their canopy.

1. The interface can be opened by clicking on the corresponding spot on the right front side of the canopy.
2. Brush size, eraser size and brush color settings can be selected as desired on the Grease Pencil interface.
3. Holding down left click allows drawing, while right click will use the eraser.
4. After closing the window by clicking on the canopy spot again, the results are rendered on the canopy.



The Spotting Circle

- *To aid in crew coordination, during startup and planning, a commonly employed technique is to select a static object at distance, such as a building, vehicle or tree, and drawing a circle around it.*
- *The circle drawn by the Pilot and the WSO should roughly point in the same direction and, once in air, can be used to enhance coordination.*
- *For example, if the Pilot spots a target, he can tell the WSO: "There is a target 100 meters right to the circle."*













A/M32-60B External Ground Power Cart
- Also known as “Dash Sixty”, or “Huffer”

PART 4 – START-UP PROCEDURE



COLD START PROCEDURE OVERVIEW

- A – Before Start-Up
- B – Engine Start
- C – INS (Inertial Navigation System) Alignment
- D – Before Taxi (Pilot)
- E – Before Taxi (WSO)

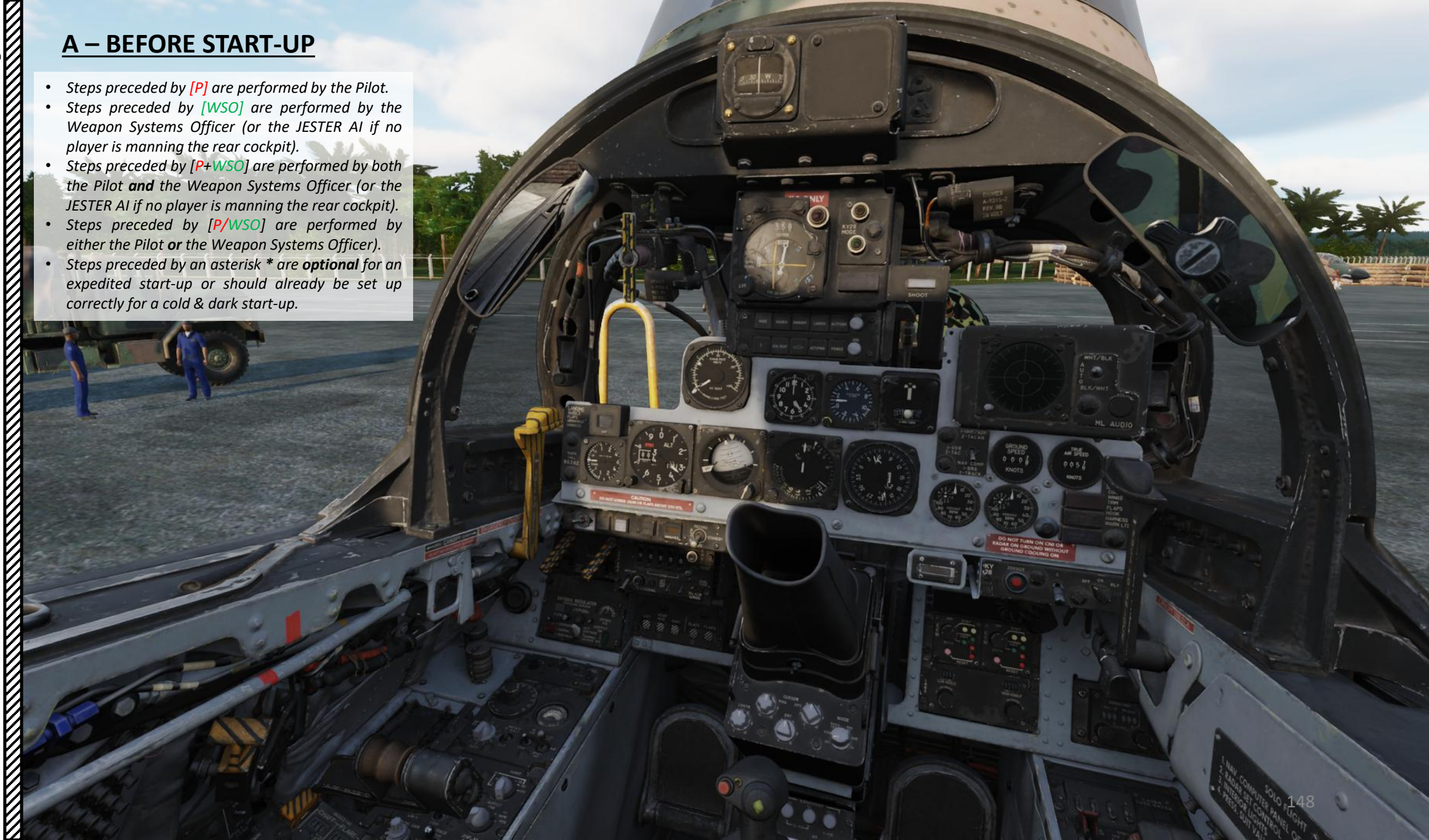


A – BEFORE START-UP



A – BEFORE START-UP

- *Steps preceded by [P] are performed by the Pilot.*
- *Steps preceded by [WSO] are performed by the Weapon Systems Officer (or the JESTER AI if no player is manning the rear cockpit).*
- *Steps preceded by [P+WSO] are performed by both the Pilot **and** the Weapon Systems Officer (or the JESTER AI if no player is manning the rear cockpit).*
- *Steps preceded by [P/WSO] are performed by either the Pilot **or** the Weapon Systems Officer).*
- *Steps preceded by an asterisk ***** are **optional** for an expedited start-up or should already be set up correctly for a cold & dark start-up.*



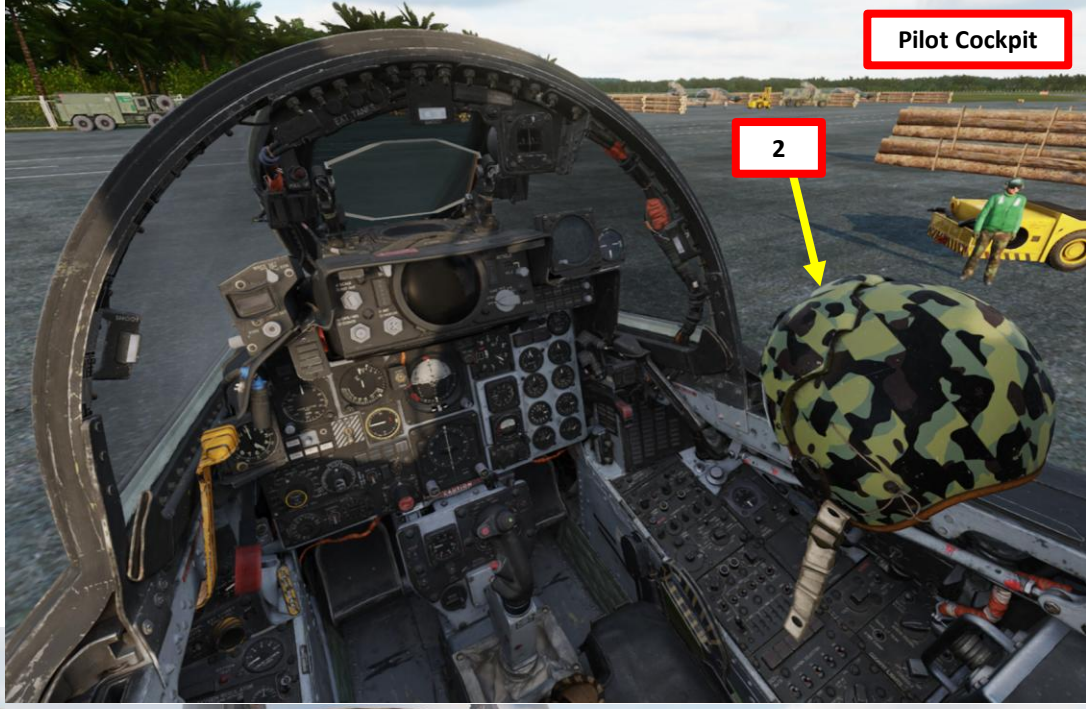
A – BEFORE START-UP

- *Note: Some steps will be omitted to keep the procedure concise and practical. We will assume that the jet is in pristine condition and that the ground crew did their job properly.*
- *If operating during night, you can use the flashlight by using the "LALT+L" control.*

1. *[P+WSO]* Embark on the aircraft using the steps or the boarding ladder.
2. *[P+WSO]* Put on helmet by clicking on it. Ground crew will then remove ladder after a short delay.

See Part 20 – REFERENCE MATERIAL for Abbreviated Checklists.

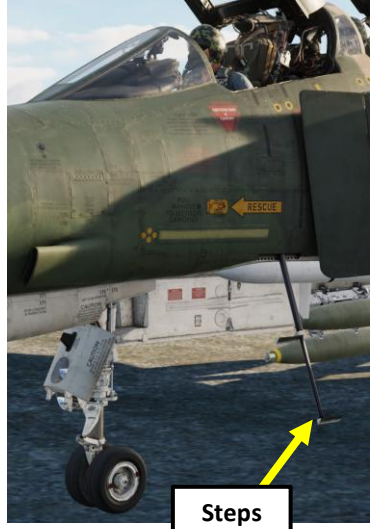


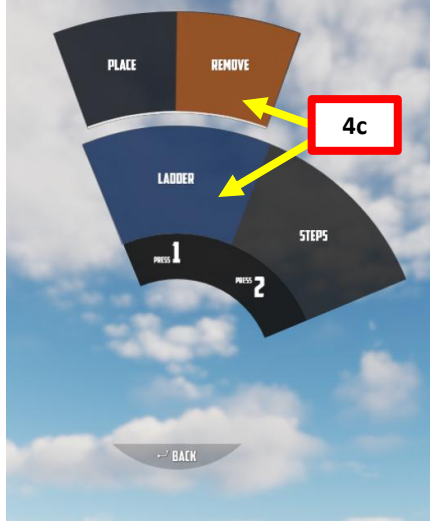


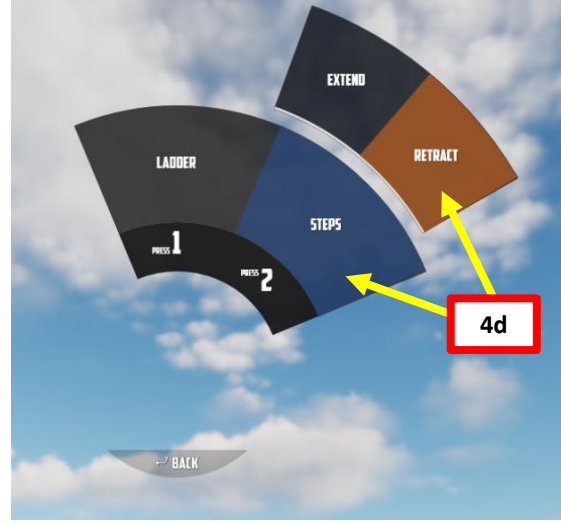


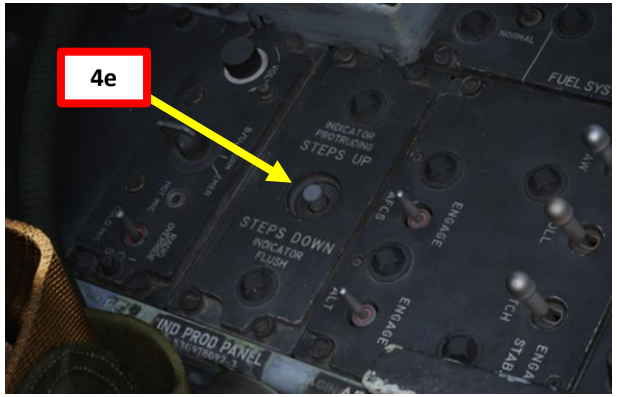
A – BEFORE START-UP

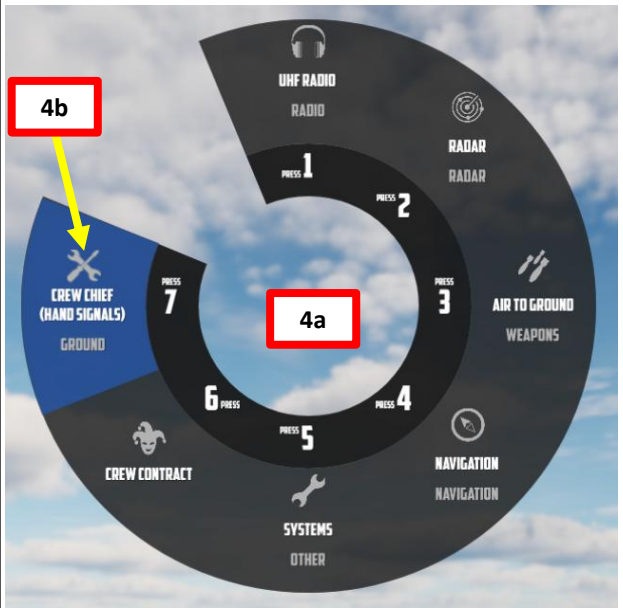
3. There is no parking brake in the Phantom. Wheel chocks should already be placed by default.
4. *[P]* If installed, remove boarding ladder or retract steps.
   a) Open JESTER AI wheel by short-pressing “A”.
   b) Click on CREW CHIEF (HAND SIGNALS)
   c) To remove boarding ladder, click on LADDER, then REMOVE.
   d) To remove steps, click on STEPS, then RETRACT.
   e) Check that boarding steps position Indicator is protruding, indicating the steps are in the RETRACTED position.
   f) Close JESTER AI wheel by long-pressing “A”.

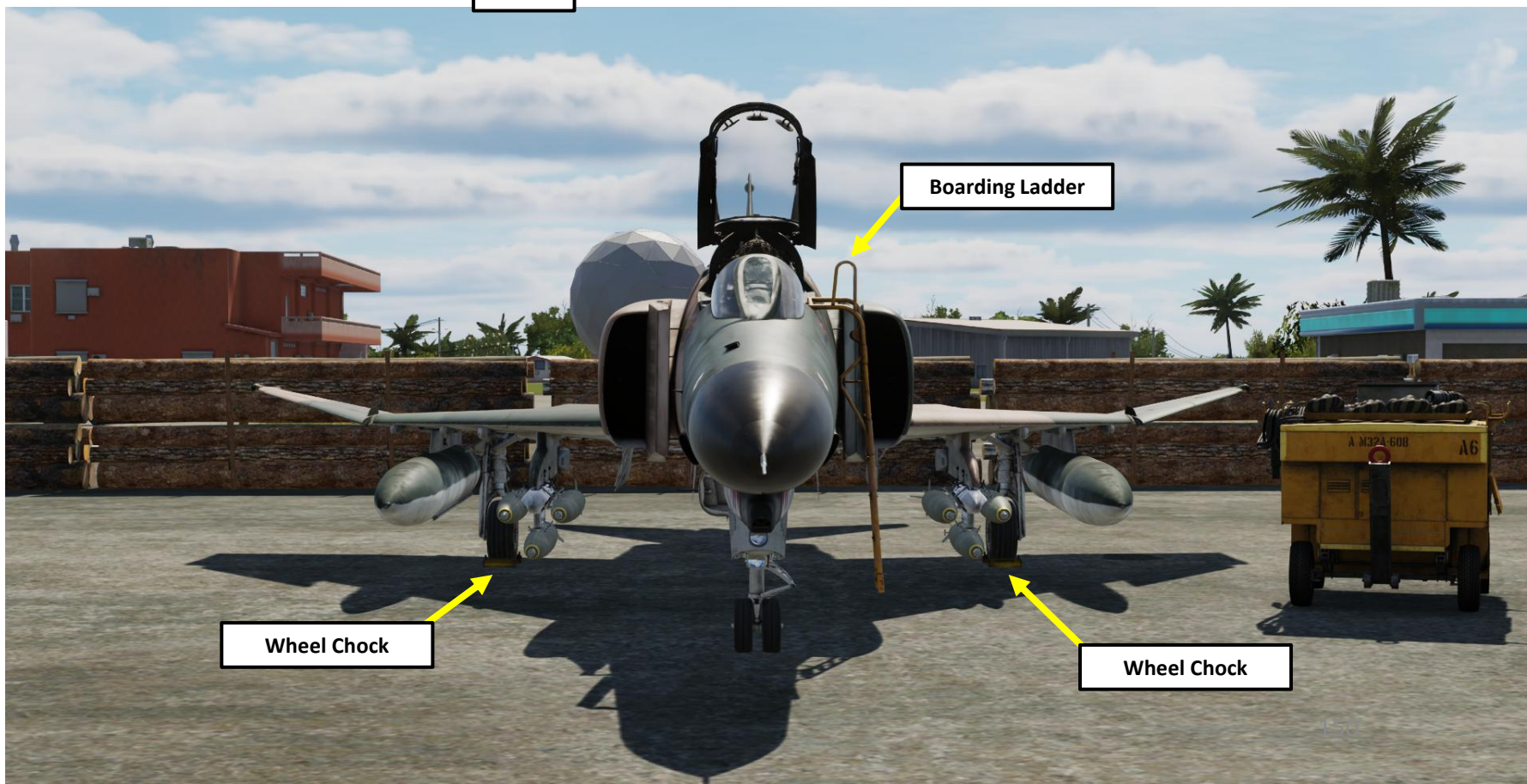








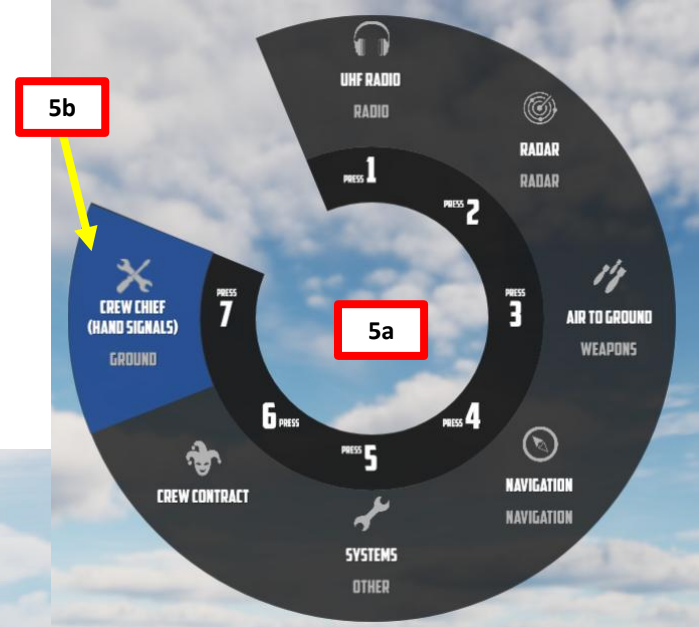




A – BEFORE START-UP

5. *[P]* Request ground crew to connect the aircraft with the A/M32-60B External Ground Power Cart (also known as “Dash Sixty”, or “Huffer”).
   a) Open JESTER AI wheel by short-pressing “A”.
   b) Click on CREW CHIEF (HAND SIGNALS)
   c) Click on EXTERNAL POWER, then CONNECT
   d) Close JESTER AI wheel by long-pressing “A”.

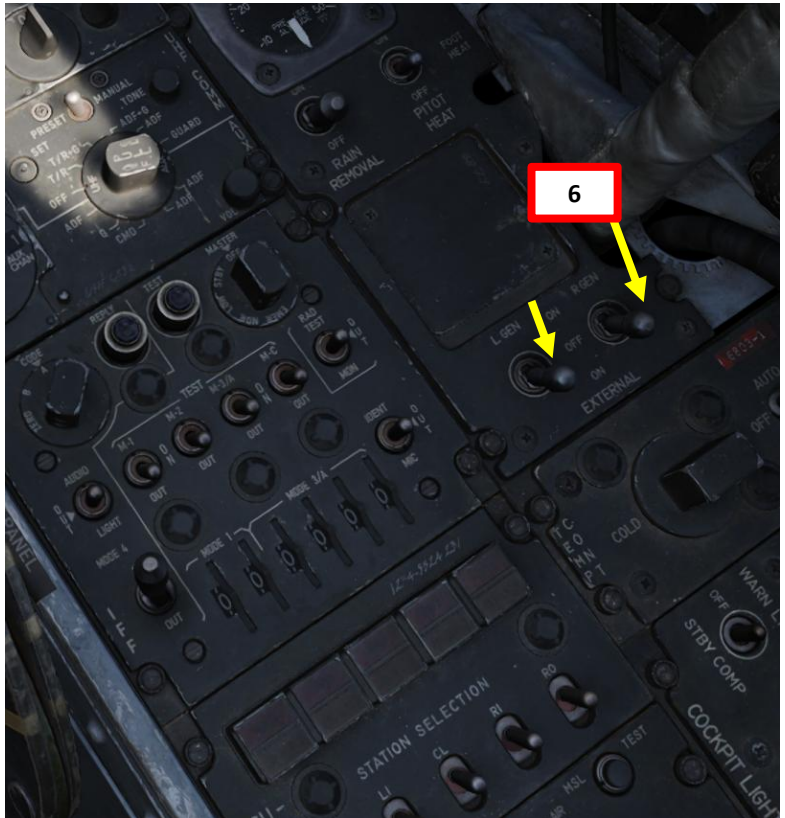


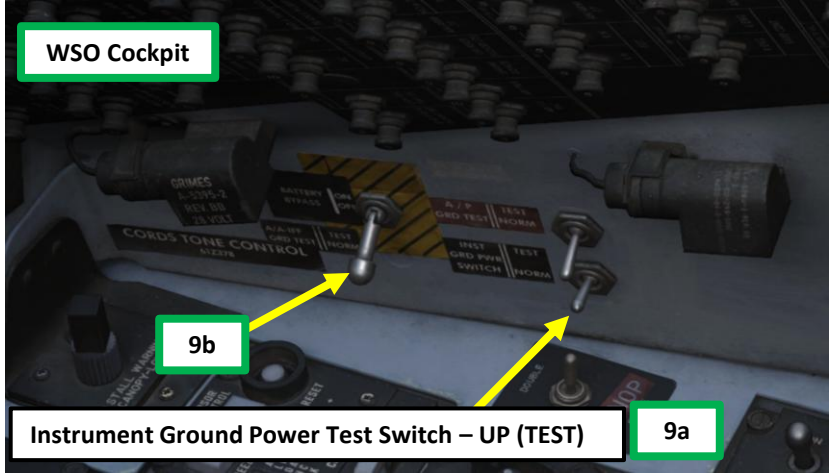




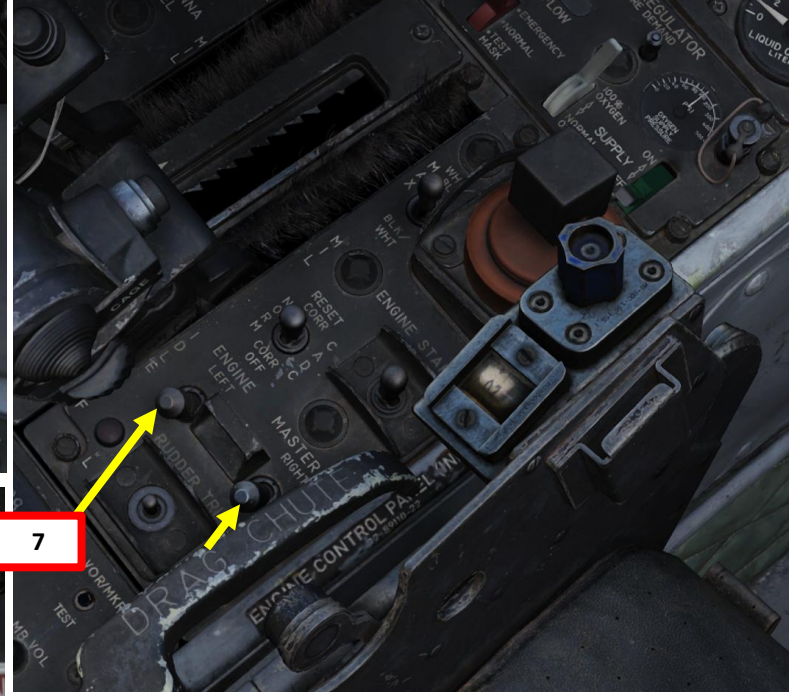
A – BEFORE START-UP

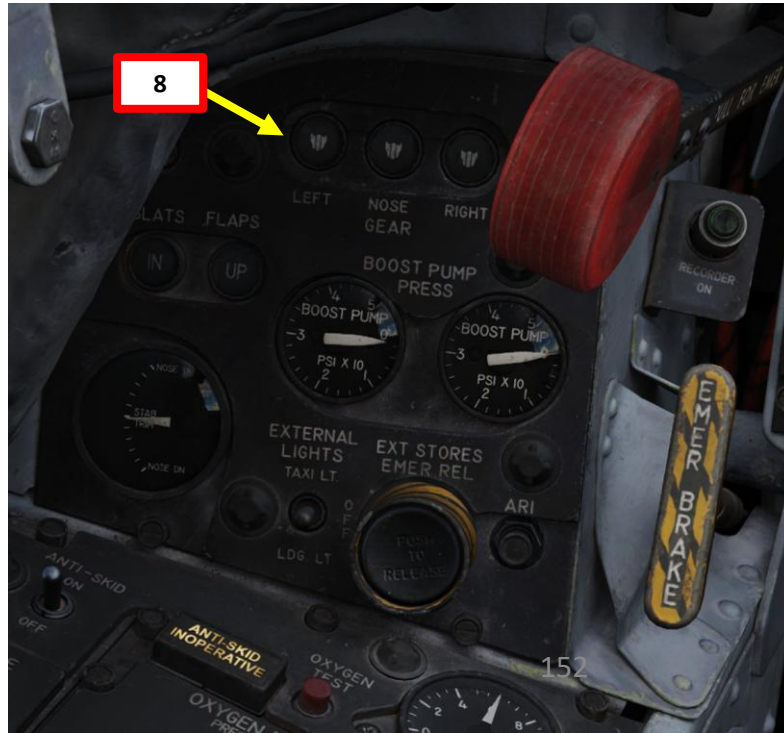
6. *[P]* Once ground power is connected, set Left & Right Generator Switches – EXTERNAL ON (AFT).
7. *[P]* Check Left & Right Engine Master Switches – OFF (AFT)
8. **[P]* Check TR (Transformer Rectifier) Units.
    - Both TR units operate correctly if the Landing Gear Indicators are energized and indicate GEAR DOWN.
9. *[WSO]* Once ground power is connected, the WSO (Weapon Systems Officer) can proceed with his own start-up procedure (INS pre-heat).
    a) Set Instrument Ground Power Test Switch – TEST (UP). This will power up the rear cockpit even if engines are not running.
    b) Check Battery Bypass Switch is set to OFF (DOWN).







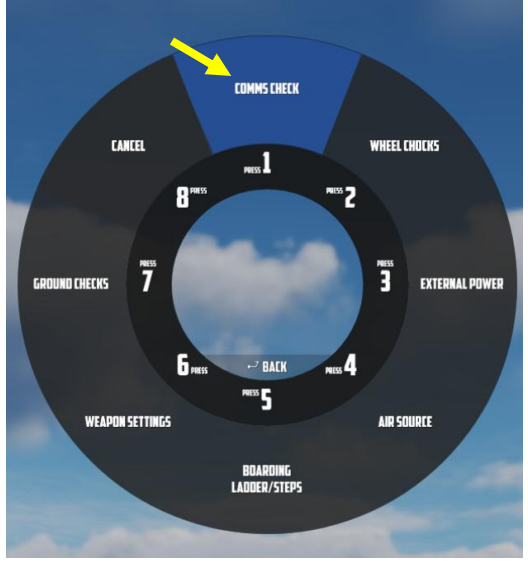


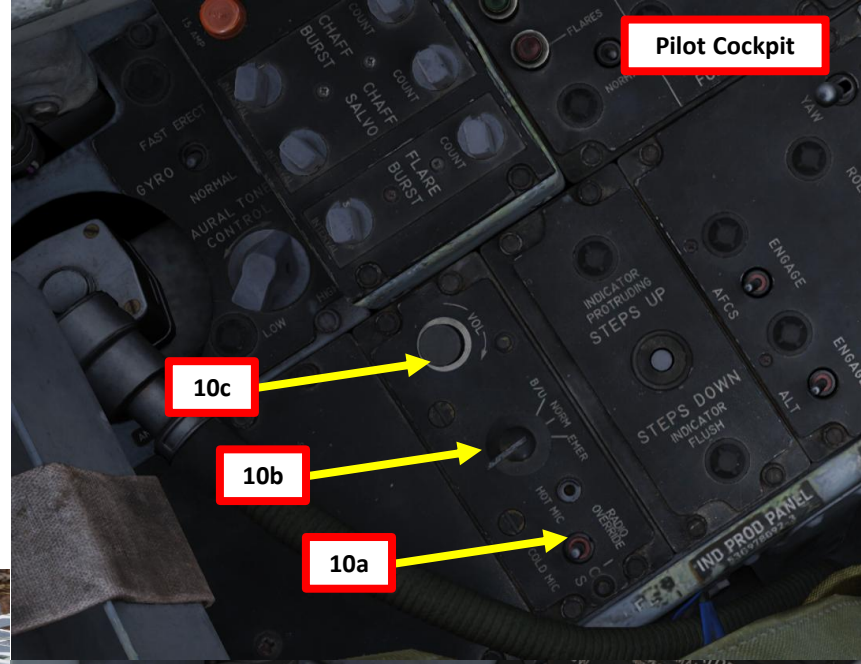


A – BEFORE START-UP

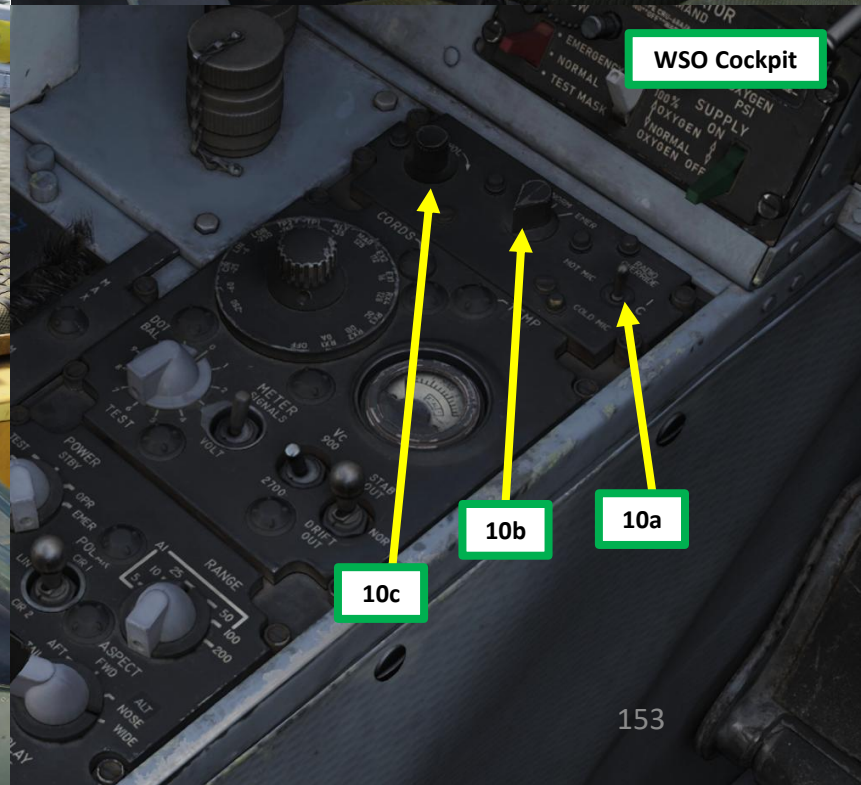
10. *[P+WSO]* Set ICS (Intercom Set). This will allow communication between the pilot, WSO (Weapon Systems Officer) and crew chief with the intercom once aircraft power is provided.
    a) Set ICS Switch – HOT MIC (MIDDLE).
    b) Set Amplifier Selector – NORM
    c) Set Intercom Volume – As desired.

- Note: from the JESTER AI "CREW CHIEF" menu, you can do a "Comms Check" to verify radios are working correctly.



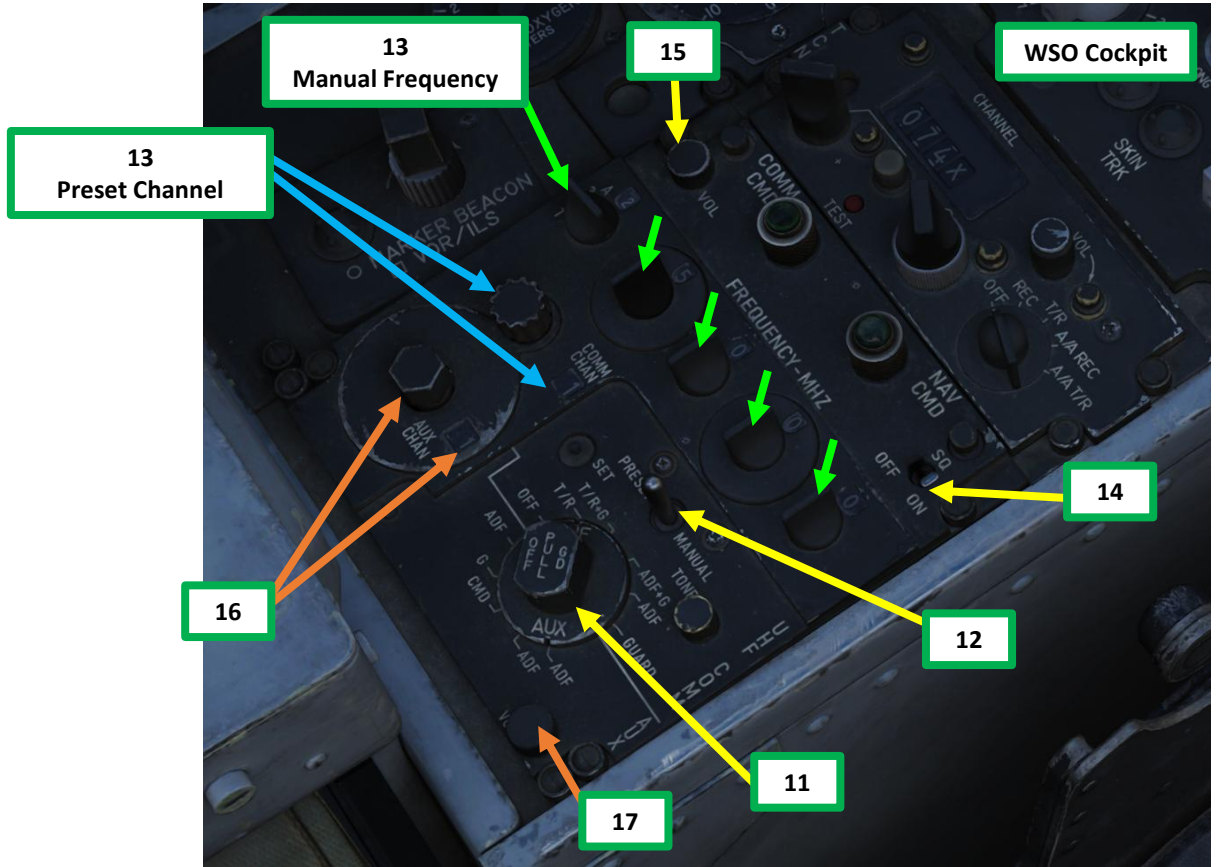


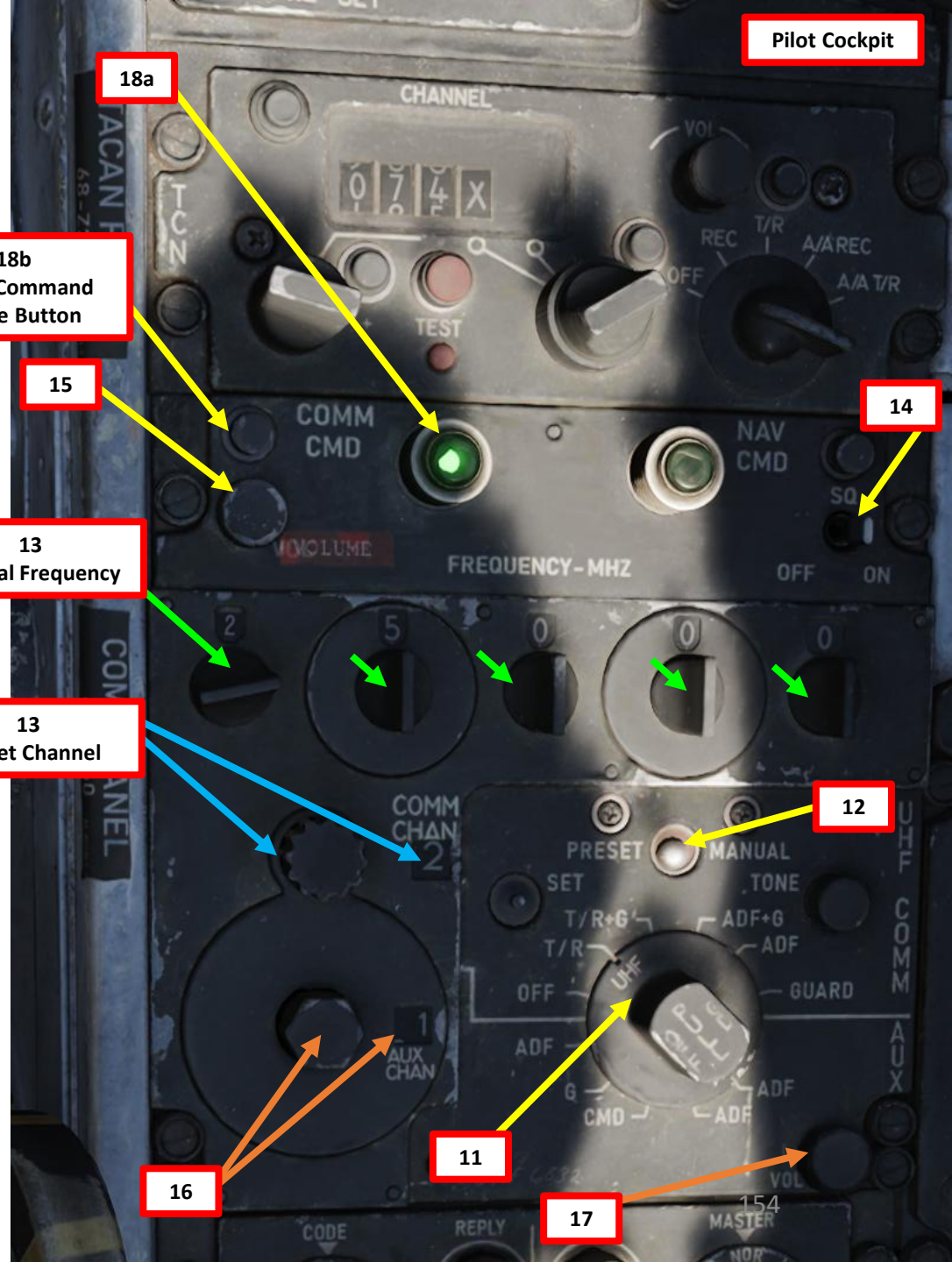




A – BEFORE START-UP

11. *[P+WSO]* Set UHF Radio Mode Selector – T/R (Transmit/Receive) or T/R+G.
12. *[P+WSO]* Set UHF Radio Frequency Mode Selector – As desired (Preset or Manual).
13. *[P+WSO]* Set UHF Radio Frequency – As required.
    - Use Frequency Tuning knobs for Manual Frequencies
    - Use COMM CHAN selector for Preset Channels
14. *[P+WSO]* Set Radio Squelch Switch – ON (OUTBOARD).
15. *[P+WSO]* Set UHF Radio Volume – As desired.
16. *[P+WSO]* Set AUX Radio Channel – As required.
17. *[P+WSO]* Set AUX Radio Volume – As desired.
18. *[P]* Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to the pilot's cockpit.

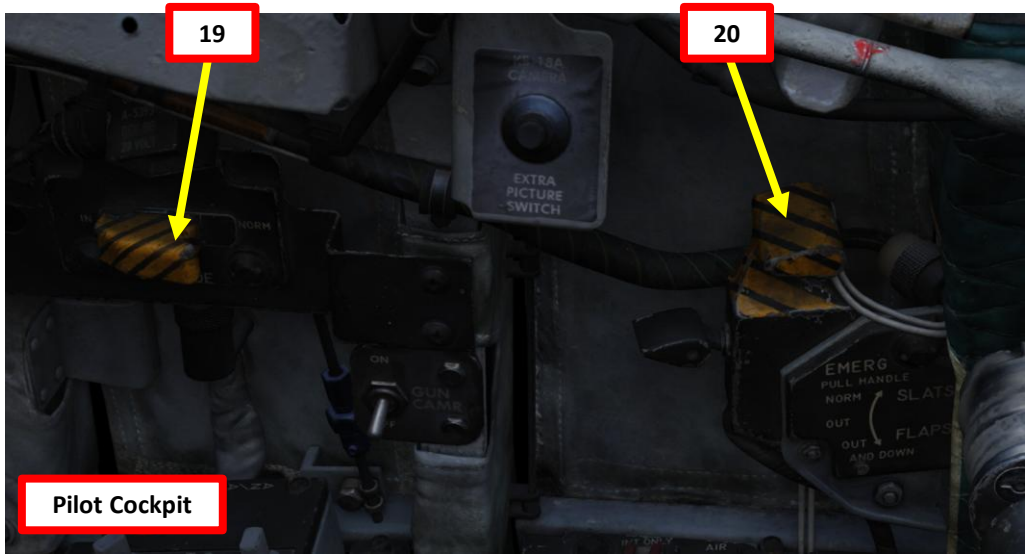


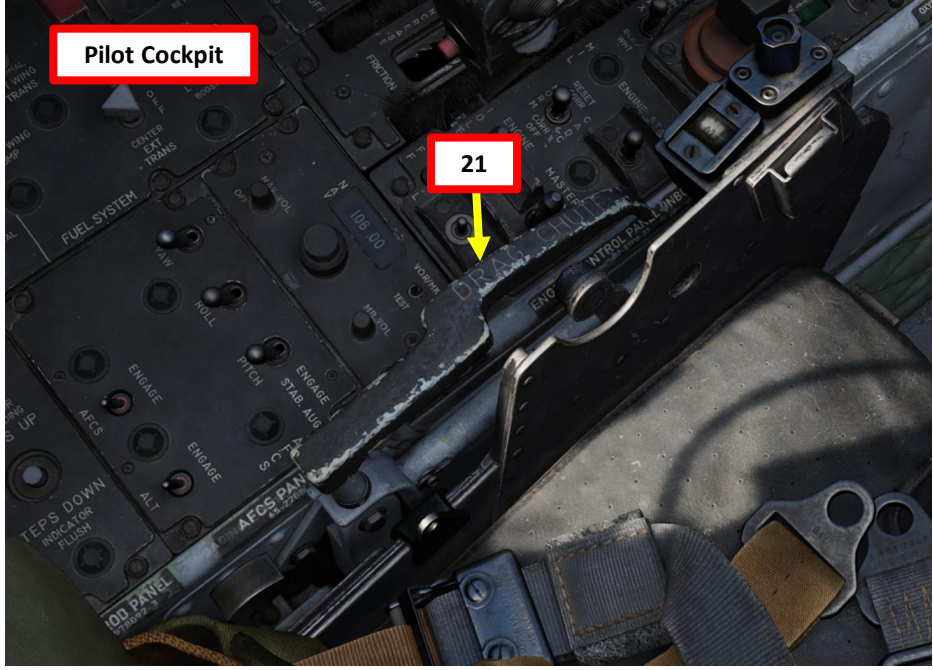


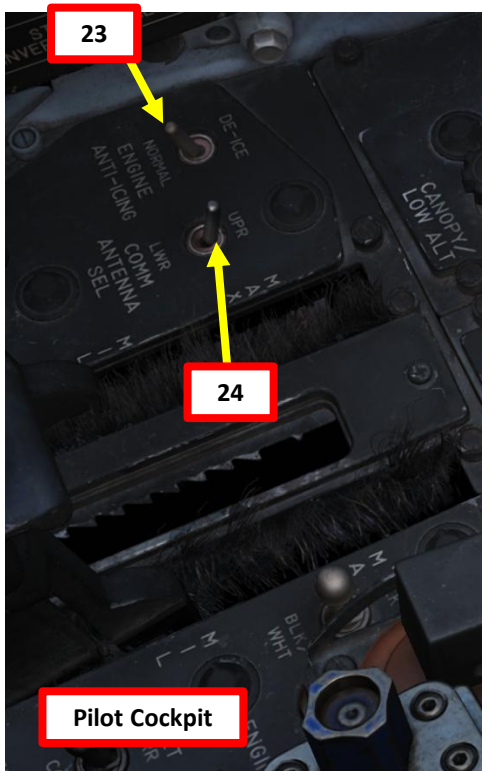
A – BEFORE START-UP

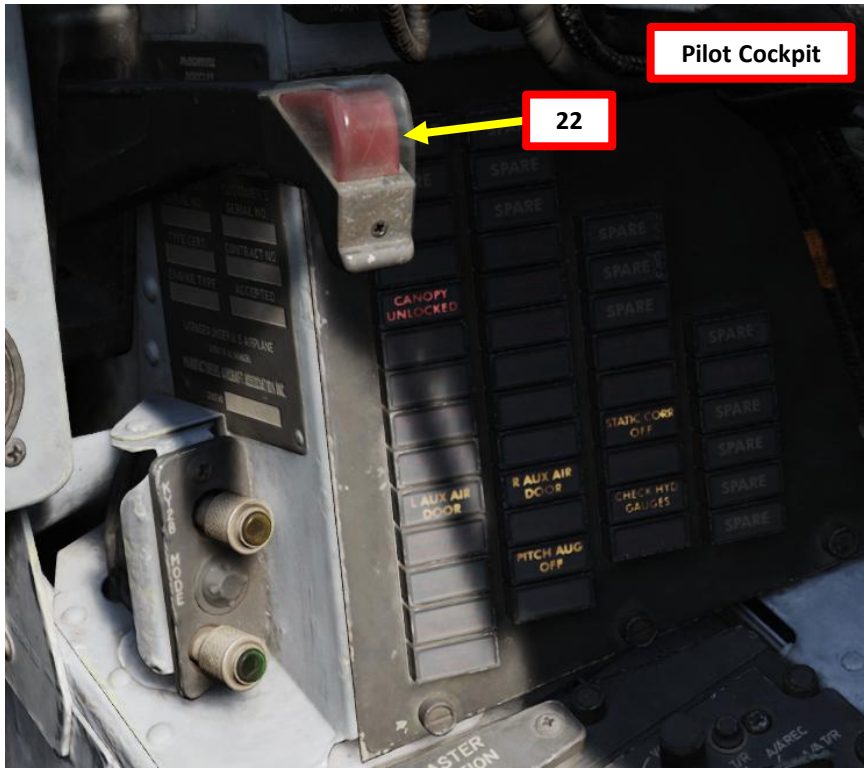
19. *[P]* Set Slats Override Switch – NORMAL & Guarded (FWD)
20. *[P+WSO]* Check Emergency Slats/Flaps Handle – FWD (as shown)
21. *[P]* Check Drag Chute Control Handle – DOWN & SECURE
22. *[P]* Check Arresting Hook Control Handle – RETRACTED (UP)
23. *[P]* Set Engine Anti-Icing (De-Ice) Switch – NORMAL (AFT)
24. *[P]* Set Communication Antenna Select Switch – UPR.
    - Note: Anti-Skid and nosewheel steering may malfunction while transmitting on the lower antenna due to electromagnetic interference.





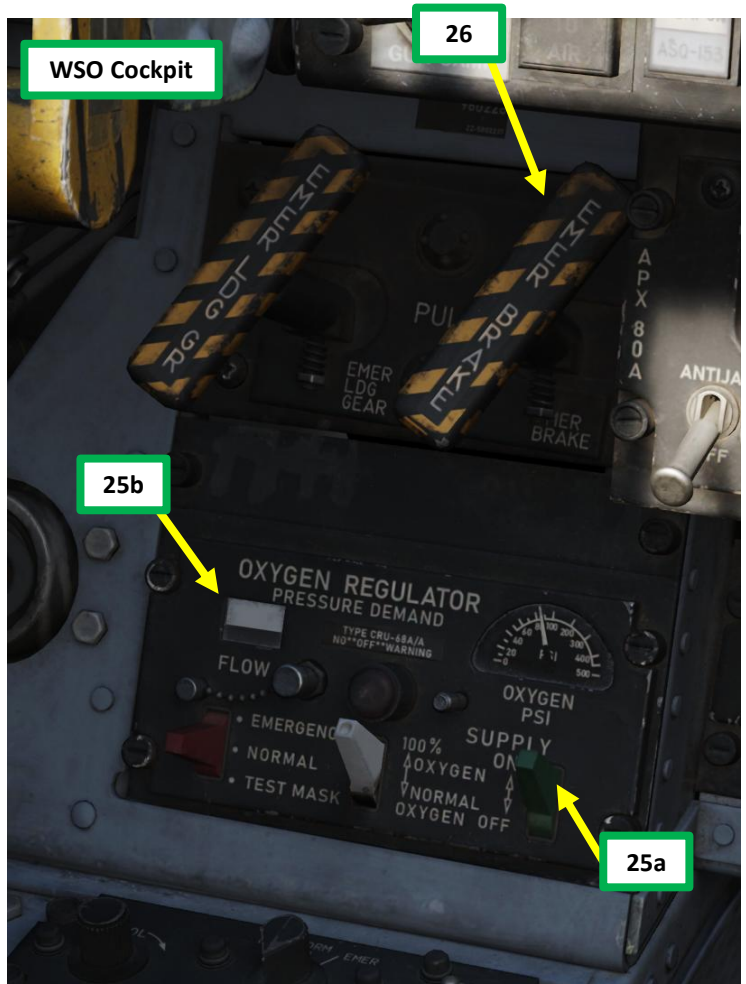


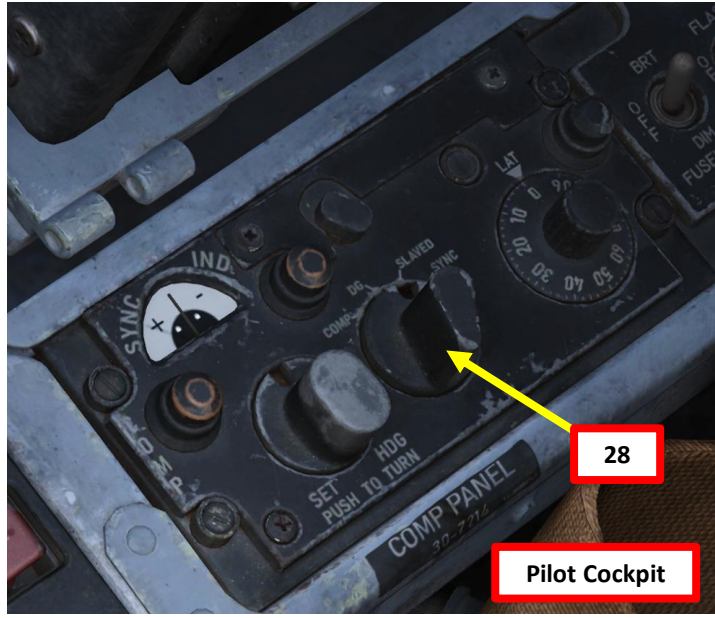


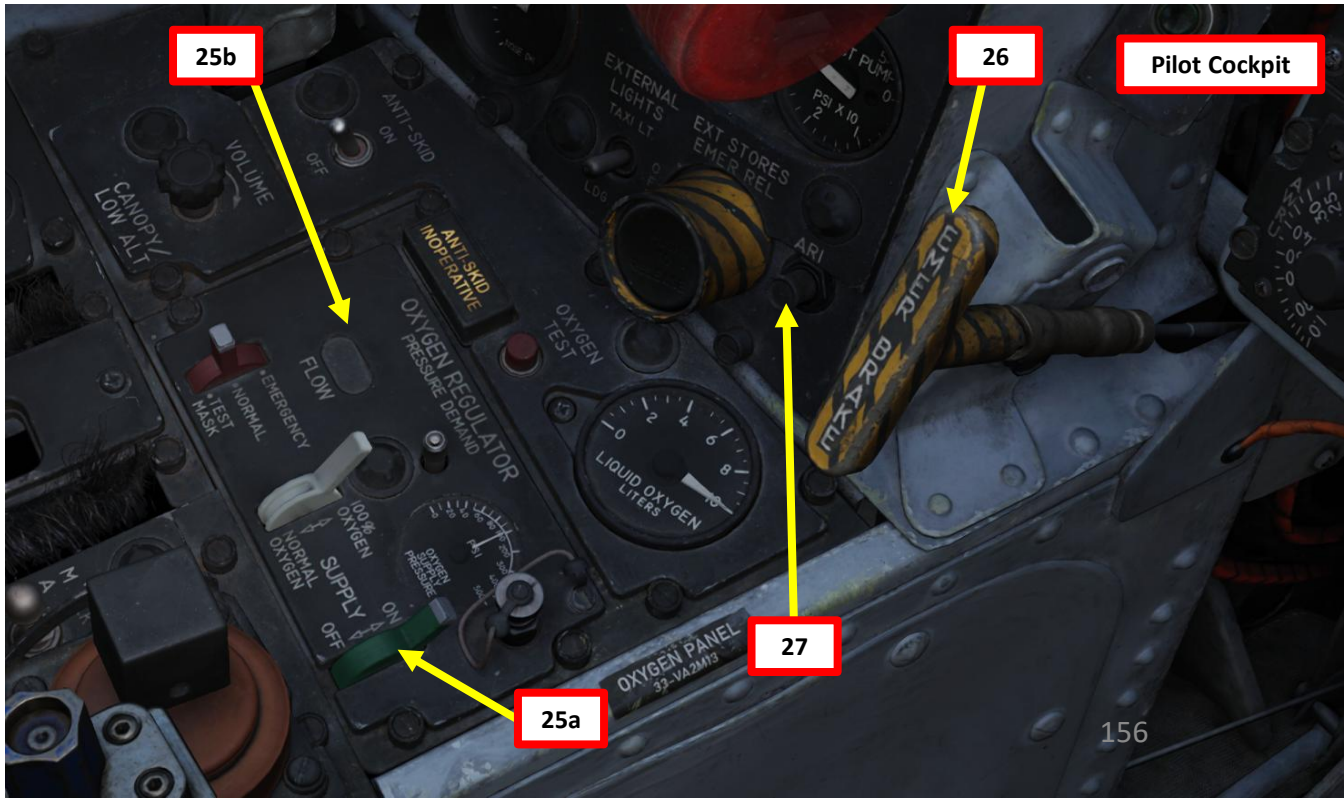


A – BEFORE START-UP

25. *[P+WSO]* Set Oxygen Supply Switch – ON (FWD). Confirm Oxygen Flow Blinker is operating.
26. *[P+WSO]* Check Emergency Brake Control Handle – IN & SECURE.
27. *[P]* Check ARI (Aileron-Rudder Interconnect) Circuit Breaker – IN.
28. *[P]* Set Compass Mode Selector – Slaved.





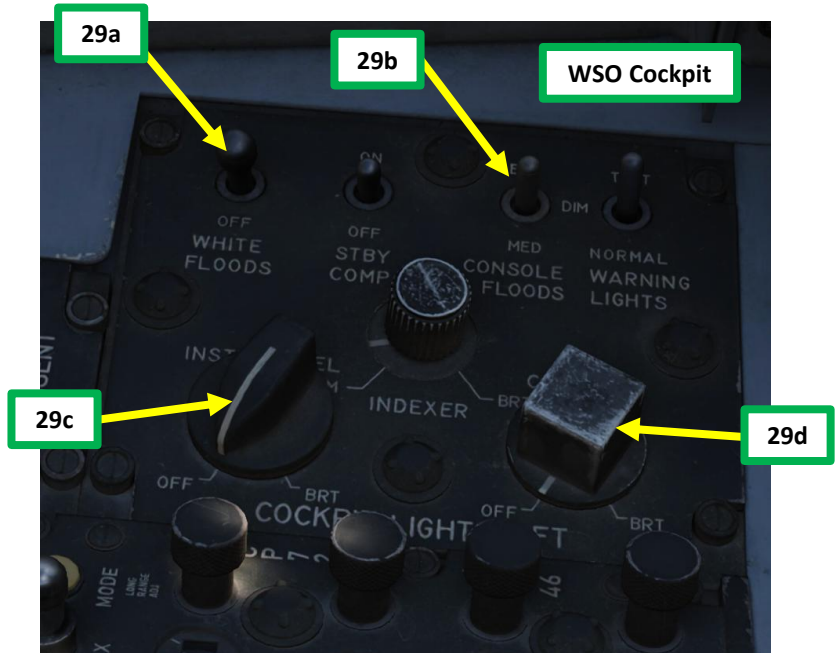


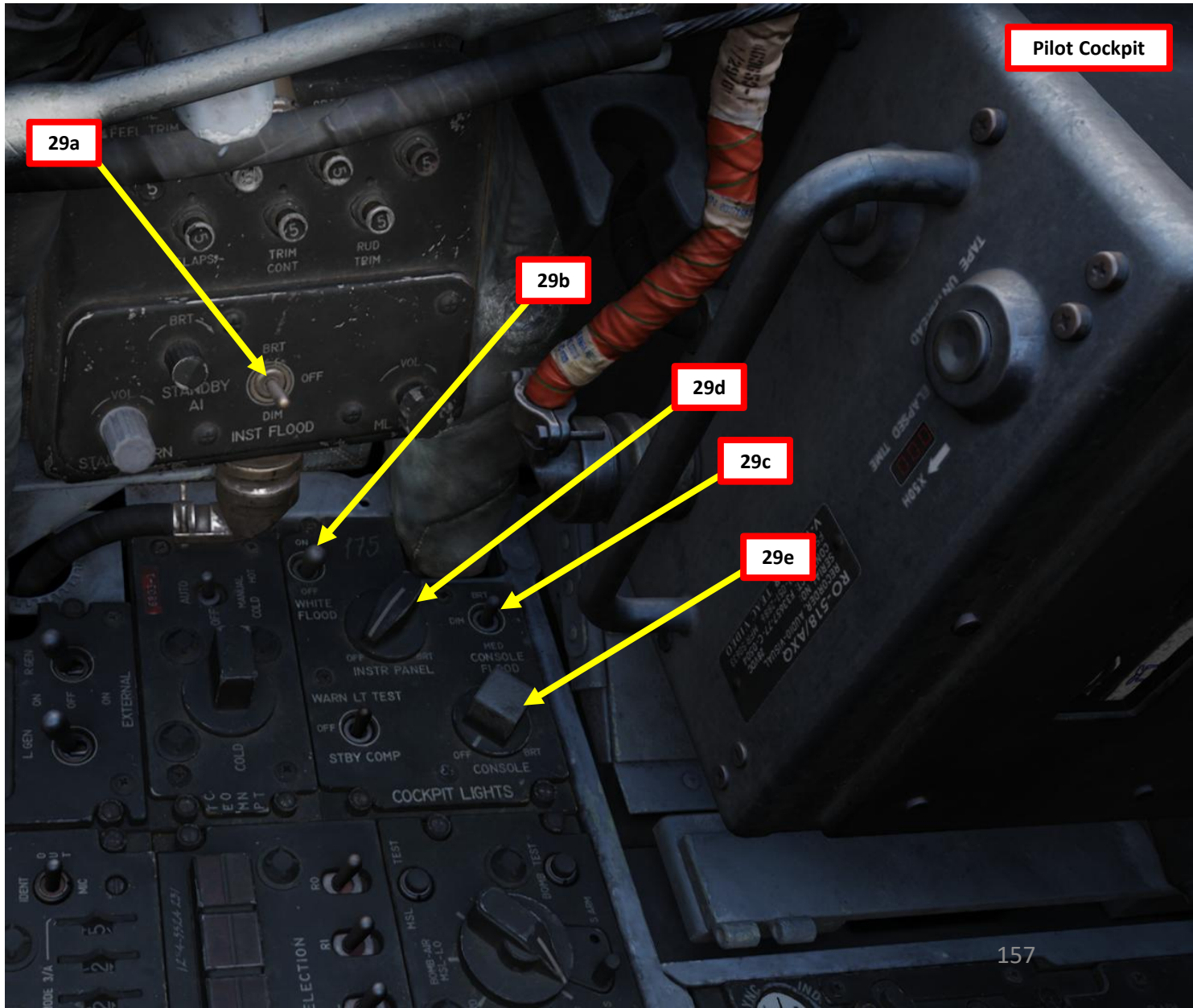
A – BEFORE START-UP

29. [P+WSO] Set Interior Lights – As required.

- Pilot:
  a) Instrument Panel Red Flood Light Switch
     - BRT (UP) / OFF (MIDDLE) / DIM (DOWN)
  b) Instrument Panel White Flood Light Switch
     - BRT (OUTBOARD) / OFF (INBOARD)
  c) Console Red Flood Light Switch
     - BRT (OUTBOARD) / OFF (MIDDLE) / DIM (INBOARD)
  d) Instrument Panel Light Brightness Control
  e) Console Light Brightness Control

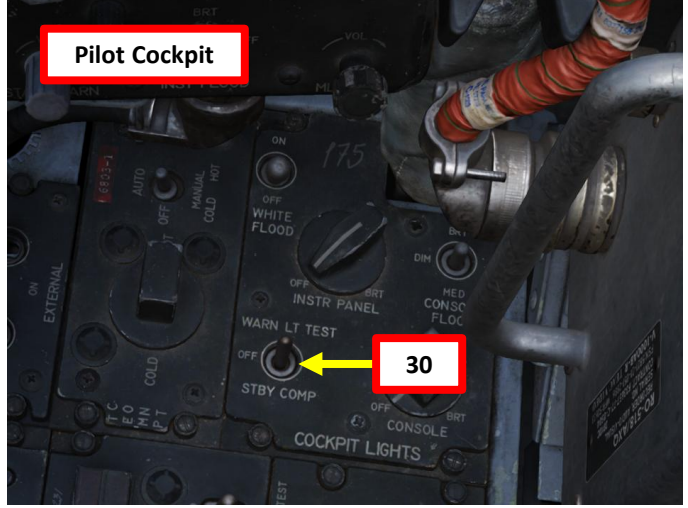
- WSO:
  a) Instrument Panel White Flood Light Switch
     - BRT (OUTBOARD) / OFF (INBOARD)
  b) Console Red Flood Light Switch
     - BRT (OUTBOARD) / OFF (MIDDLE) / DIM (INBOARD)
  c) Instrument Panel Light Brightness Control
  d) Console Light Brightness Control





A – BEFORE START-UP

30. *[P+WSO]* Set Warning Light Test / Standby Compass Light Switch – TEST (OUTBOARD) momentarily and check annunciator lights illuminate correctly. Then, release the Set Warning Light Test / Standby Compass Light Switch back to the OFF (MIDDLE) position.











A – BEFORE START-UP

31. [P] Set Exterior Lights – As required.

a) Formation Lights Mode Switch
   - ON (UP) / OFF (MIDDLE) / MOMENTARY (DOWN)

b) Formation Lights Brightness Knob – As required.

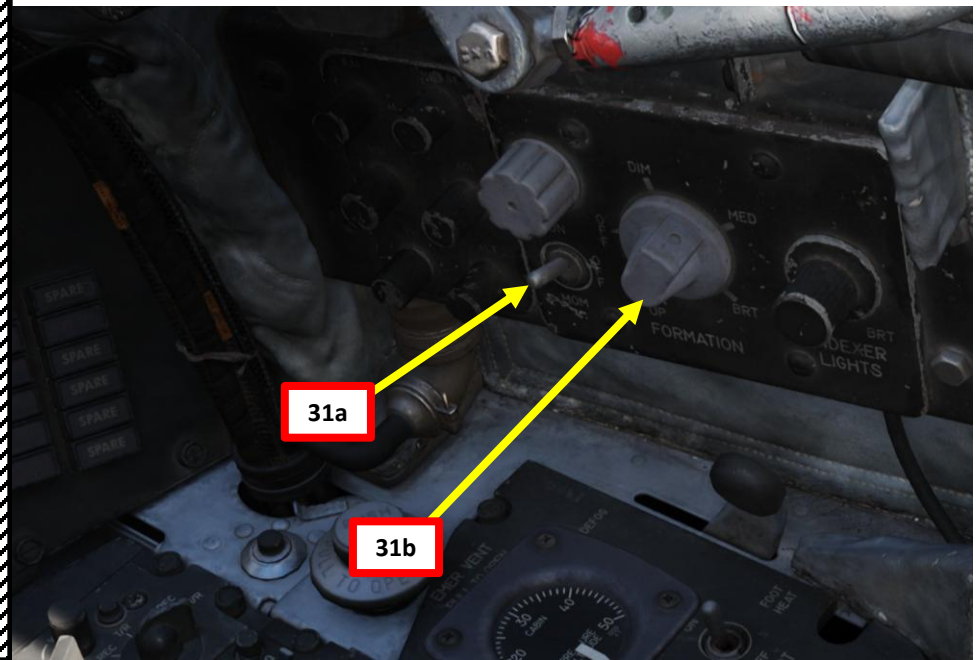
c) Fuselage & Anti-Collision Brightness Switch
   - BRT (OUTBOARD) / OFF (MIDDLE) / DIM (INBOARD)

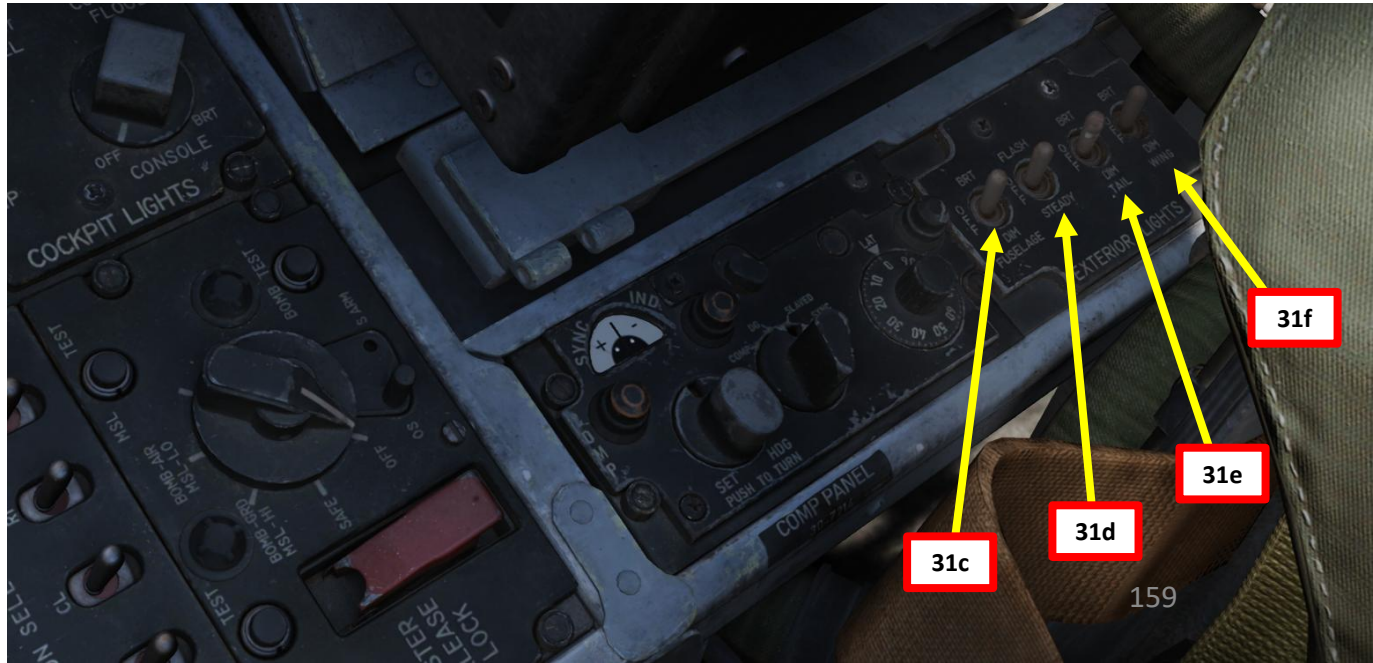
d) Flasher Mode Switch
   - FLASH (OUTBOARD) / OFF (MIDDLE) / STEADY (INBOARD)
   - Only applicable for Tail, Anti-Collision & Fuselage lights

e) Tail Position Light Switch
   - BRT (OUTBOARD) / OFF (MIDDLE) / DIM (INBOARD)

f) Wing Position & Join-Up Light Switch
   - BRT (OUTBOARD) / OFF (MIDDLE) / DIM (INBOARD)

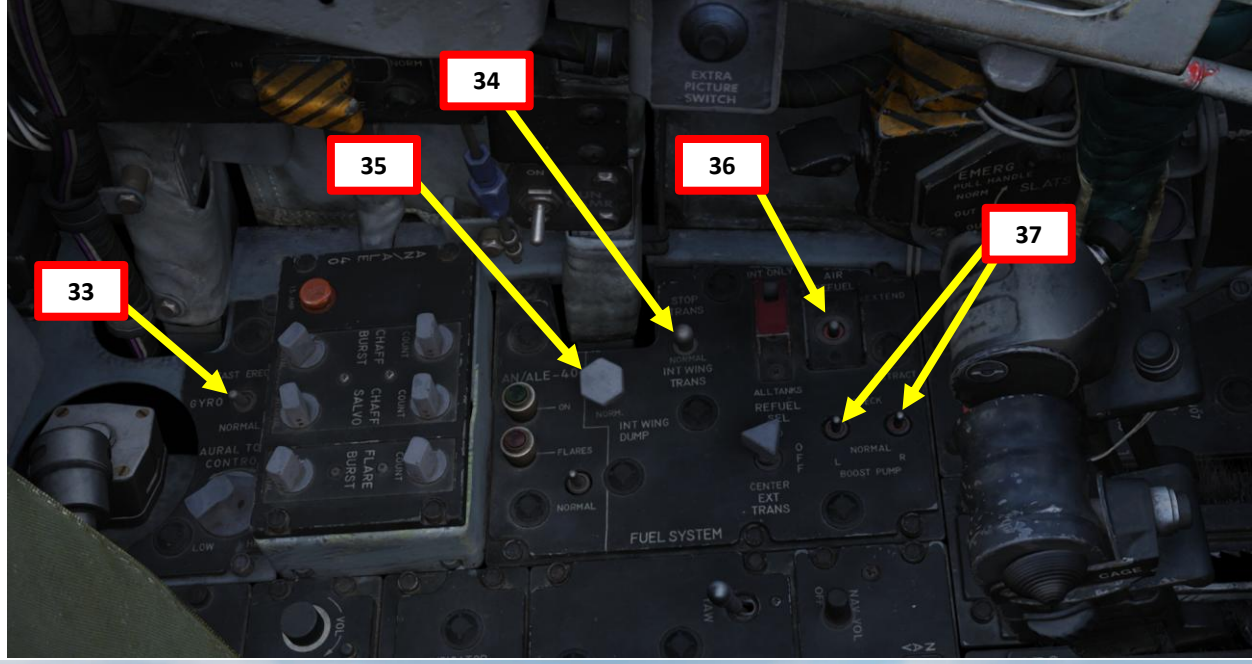


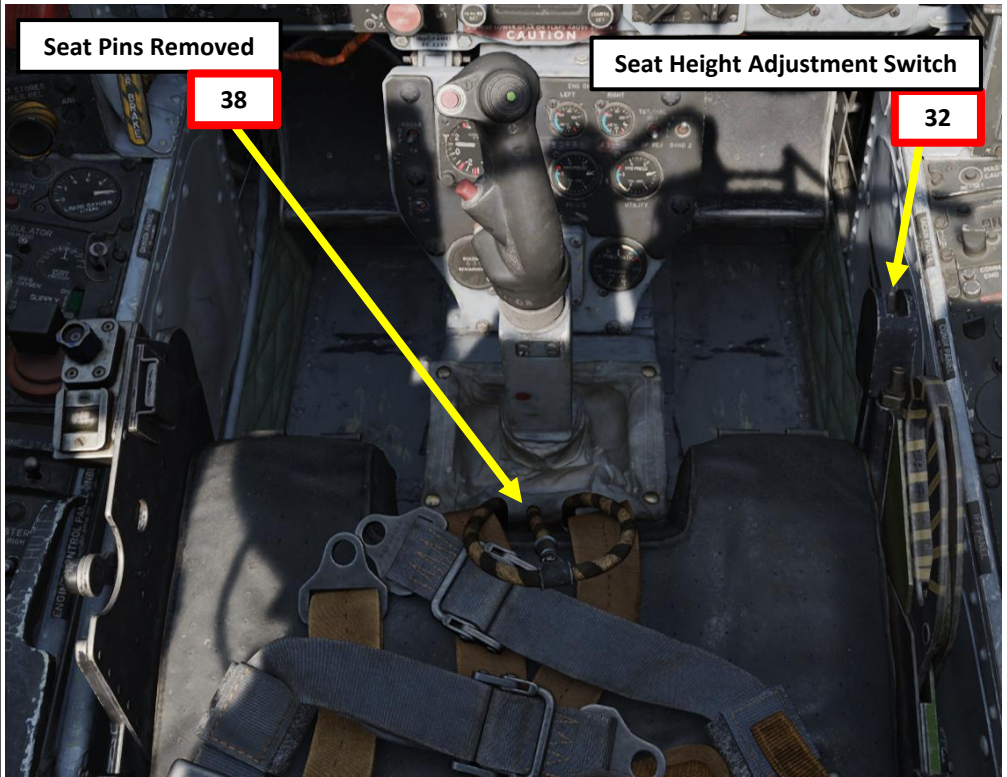


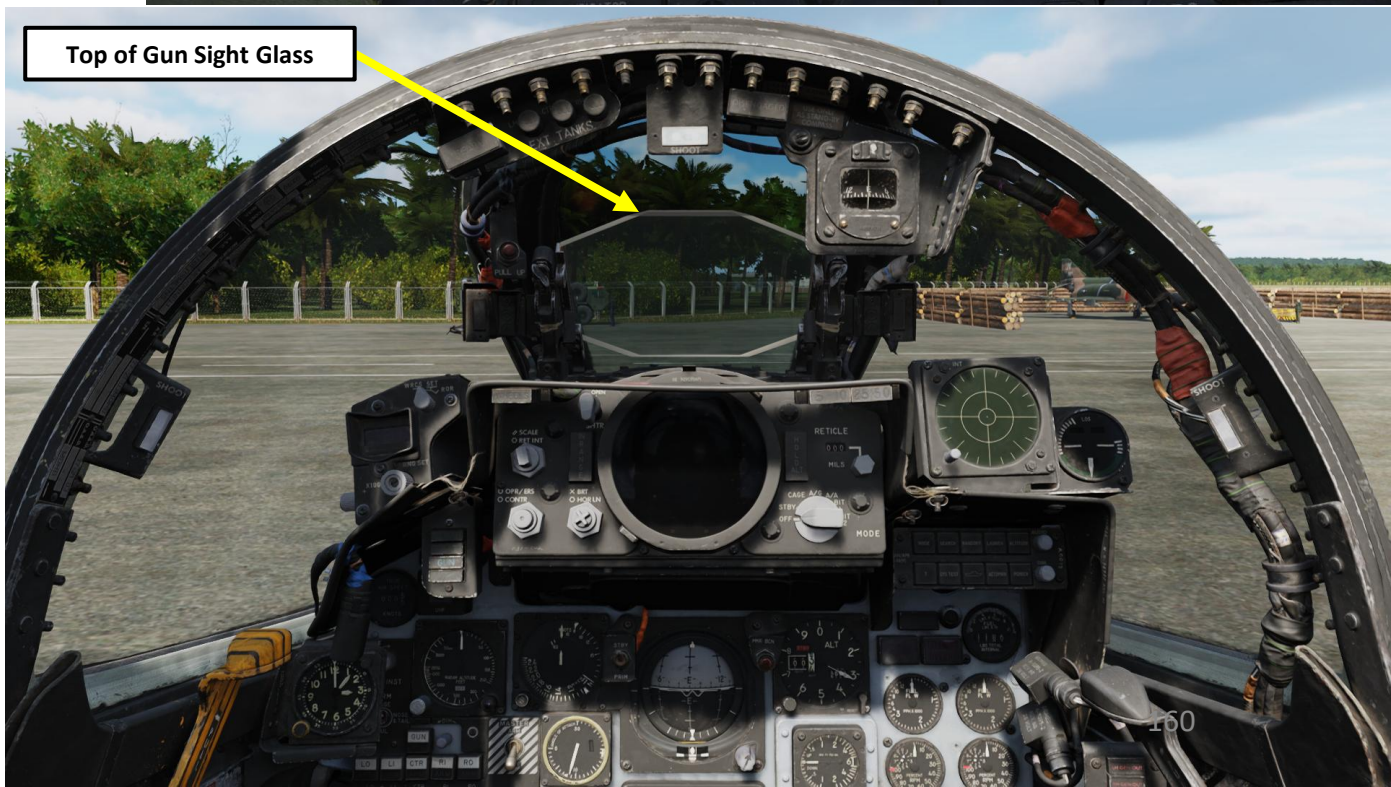


A – BEFORE START-UP

32. *[P+WSO]* Adjust Seat Height – As required.
    - For the pilot, your eyes should be lined up with the top of the gun sight glass.
33. *[P]* Set Gyro Switch – NORMAL (INBOARD).
34. *[P]* Check Internal Wing Transfer Switch – NORMAL (INBOARD position).
35. *[P]* Check Internal Wing Dump Switch – NORMAL (INBOARD position)
36. *[P]* Check Air Refuel Switch – RETRACT (INBOARD position).
37. *[P]* Check Left & Fuel Boost Pumps are in the NORMAL (INBOARD) position.
38. *[P]* Check Seat Pins – REMOVED & STOWED.
39. *[P+WSO]* Check fore and aft areas are cleared.



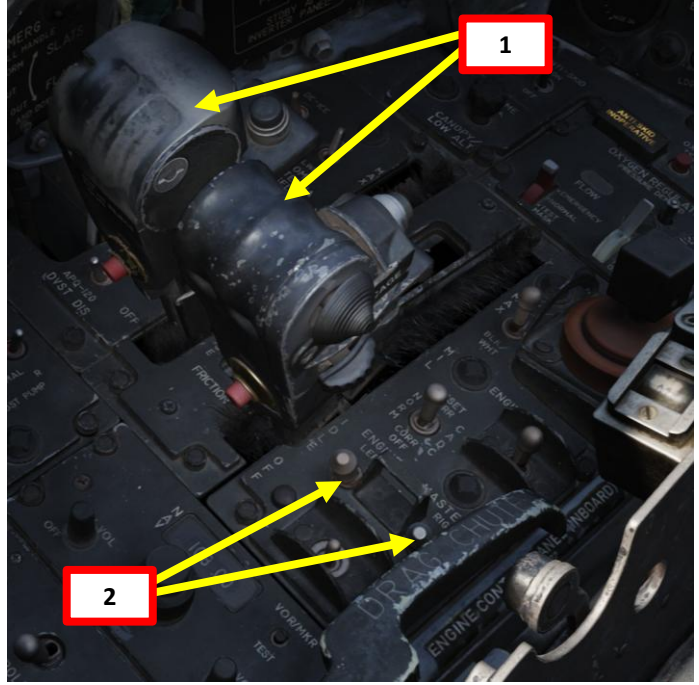


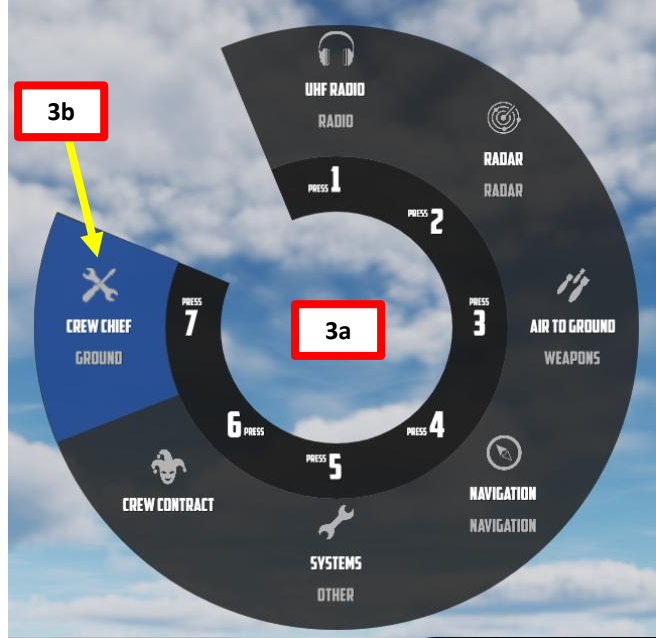


B – ENGINE START

***Note**: The F-4 does not have a battery switch nor an APU (Auxiliary Power Unit) – its electrical systems run strictly on either engine generator power or an external power source. General Electric J79-GE-17A/F engines have pneumatic starters and require an external air pressure source, which can be provided by contacting the Ground Crew.*

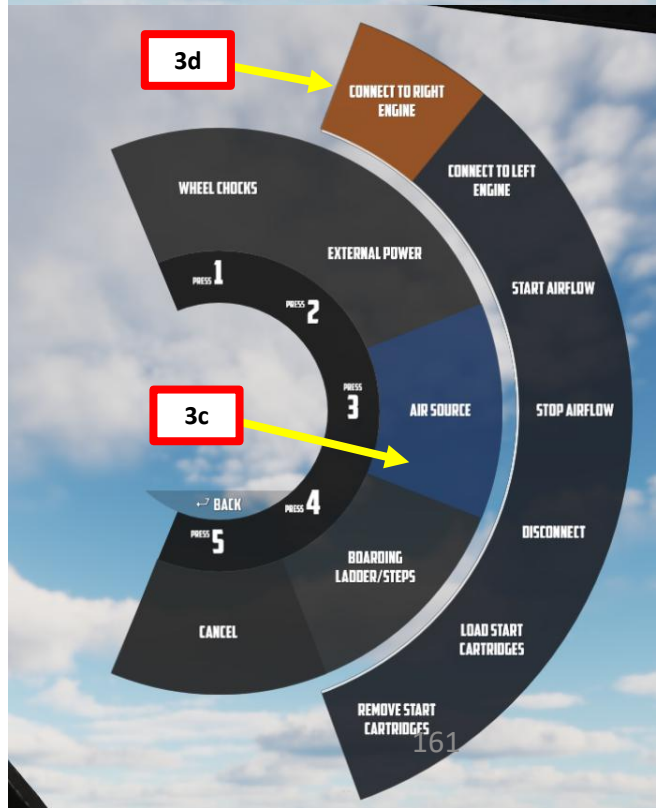
1. *[P+WSO]* Verify throttles are set to OFF detent. Attempting to start the engines with throttles out of the OFF detent will result in fuel puddling and the possibility of a hot start (or even… engine fire!).
    - Left Throttle OFF/IDLE Toggle: "RALT+END" binding.
    - Right Throttle OFF/IDLE Toggle : "RCTRL+END" binding.
2. *[P]* Verify Left & Right Engine Master Switches are set to OFF (AFT)
3. *[P]* Call ground crew to connect compressed air supply unit to the right engine:
    a) Open JESTER AI wheel by short-pressing "A".
    b) Click on CREW CHIEF
    c) Click on AIR SOURCE, then CONNECT TO RIGHT ENGINE
    d) Close JESTER AI wheel by long-pressing "A".
    e) Once connected, the ground crew will call out "Connected to the Right".







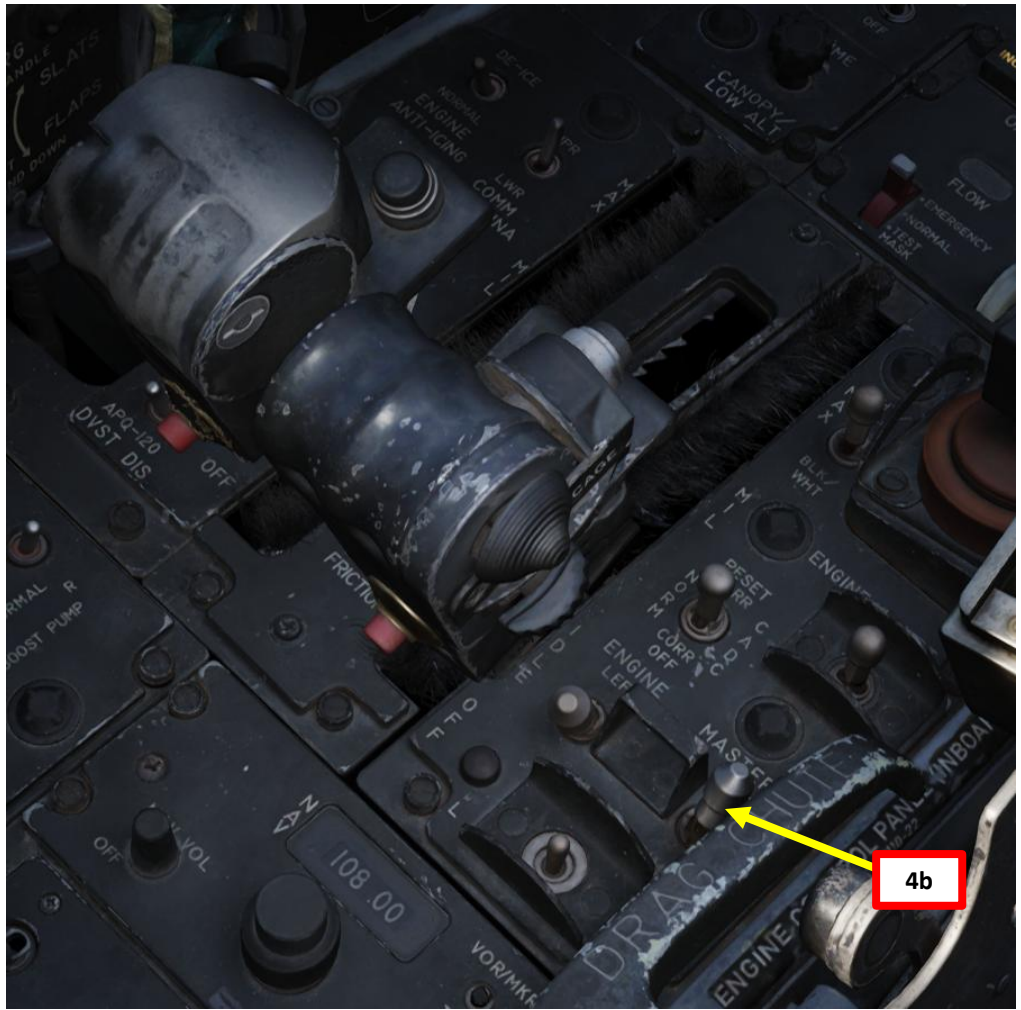
Note: To perform an engine start without the air supply unit, you can alternatively use explosive cartridges instead. These cartridges are installed by the ground crew.

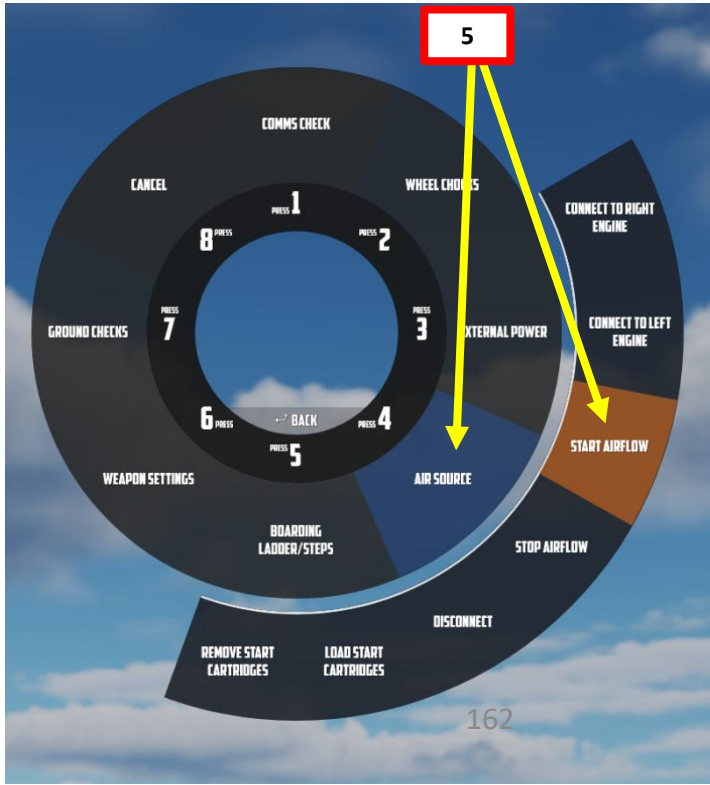


B – ENGINE START

4. *[P]* Check right engine RPM is at 0 %, then set Right Engine Master Switch – ON (FWD).
5. *[P]* Request the crew chief to apply air supply pressure to drive the right engine starter (motoring).
    - From JESTER AI wheel AIR SOURCE sub-menu, click START AIRFLOW.

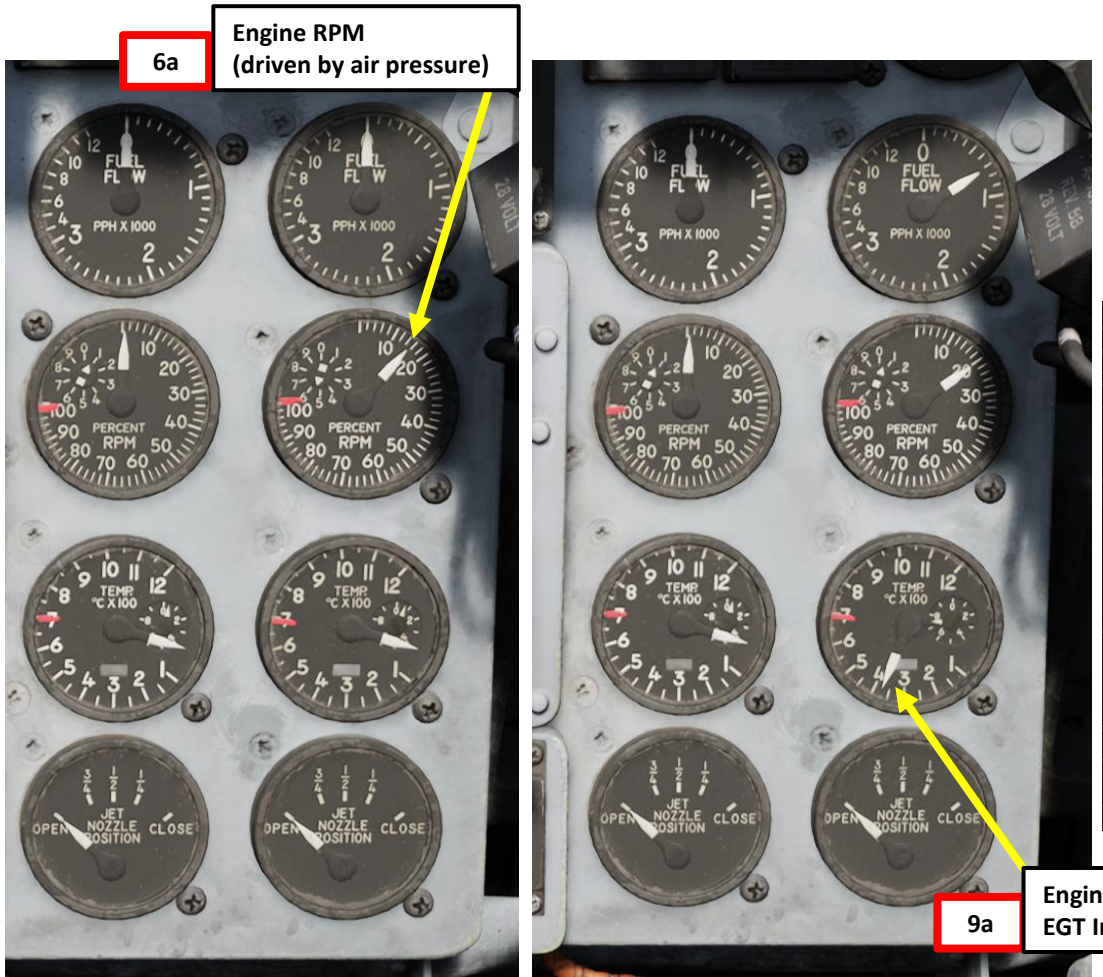




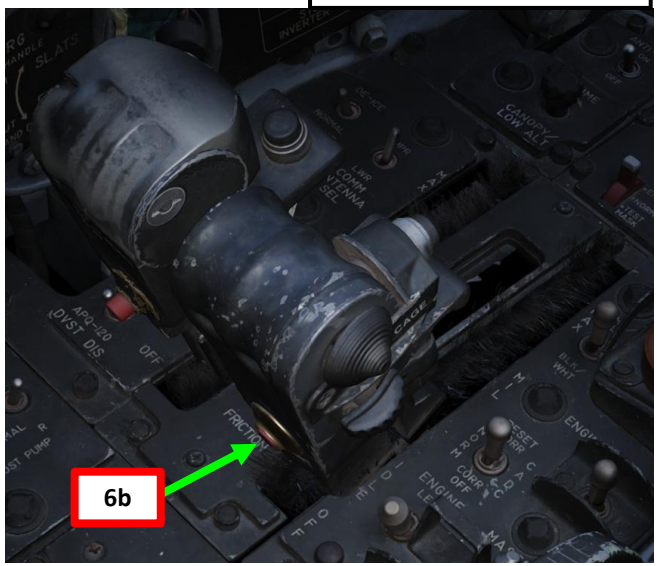


B – ENGINE START

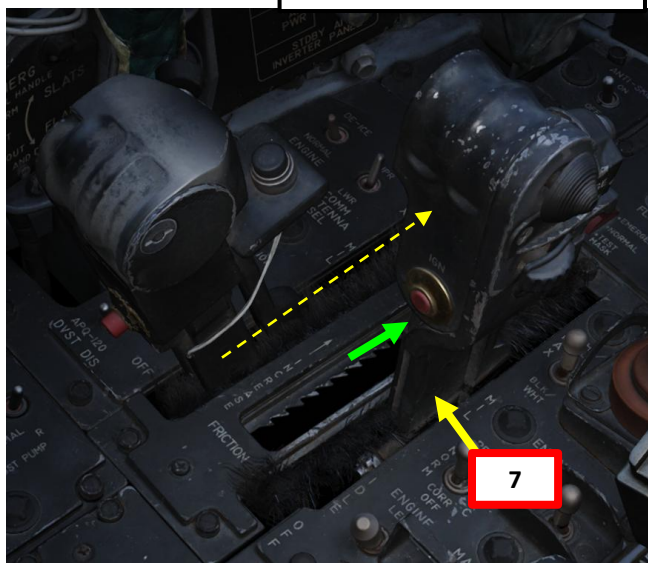
6. *[P]* Right engine RPM will gradually increase, its starter being driven by the airflow supply. When Engine RPM reaches 10 %, press and hold the Right Ignition Button. I recommend clicking and holding the button.
    - Right Throttle Ignition Button: "RCTRL+HOME" binding.
7. *[P]* Move Right Throttle out of the OFF detent halfway forward. Keep Right Ignition Button PRESSED.
    - Right Throttle OFF/IDLE Toggle : "RCTRL+END" binding.
8. *[P]* Move Right Throttle back to IDLE detent. Keep Right Ignition Button PRESSED.
9. *[P]* Confirm right engine lightoff occurs by checking for EGT (Exhaust Gas Temperature) increase, then release Right Ignition Button.



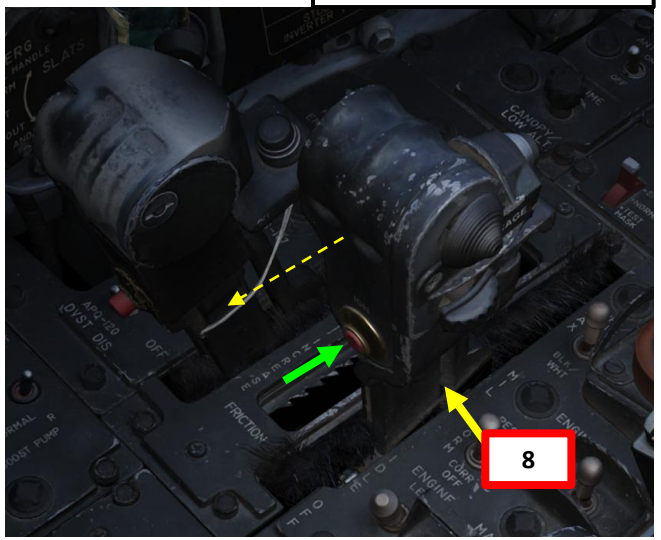
Throttle – OFF
Ignition Button – PRESSED



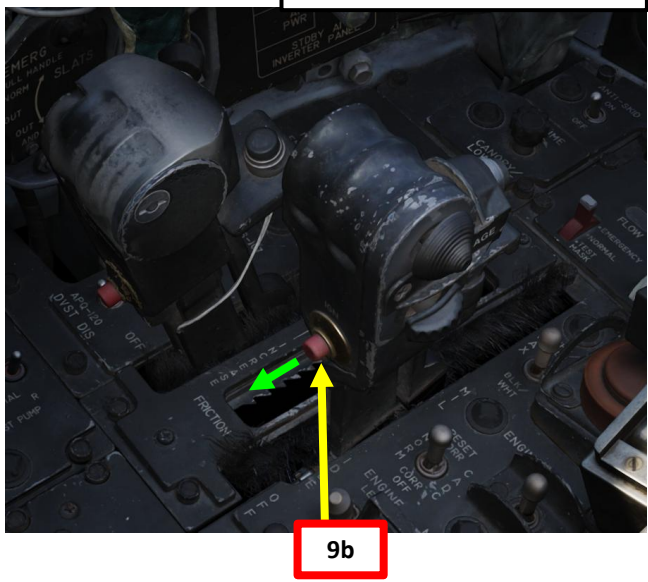
Throttle – Halfway
Ignition Button – PRESSED



Throttle – IDLE
Ignition Button – PRESSED

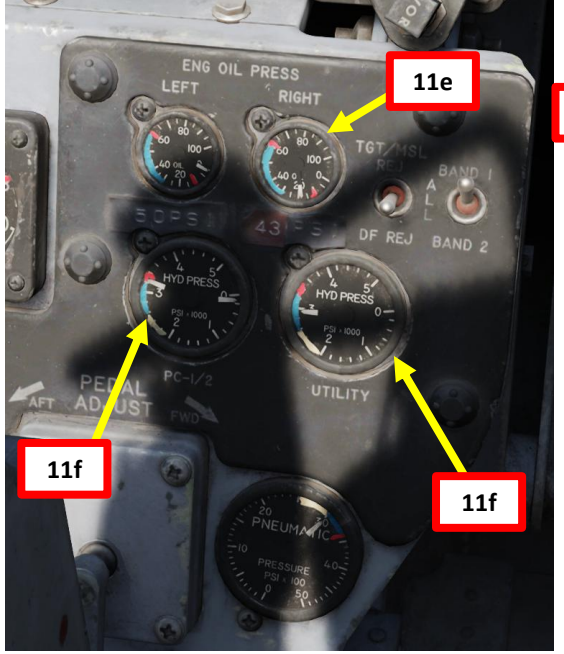


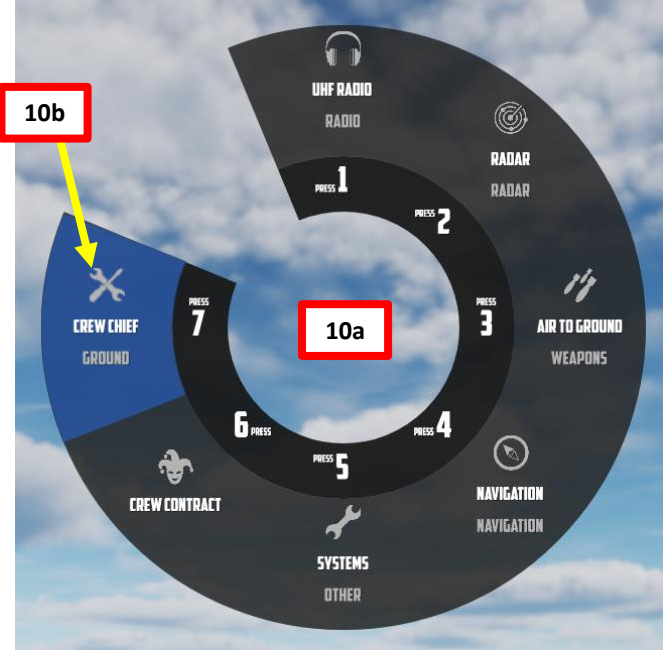
Throttle – IDLE
Ignition Button – RELEASED

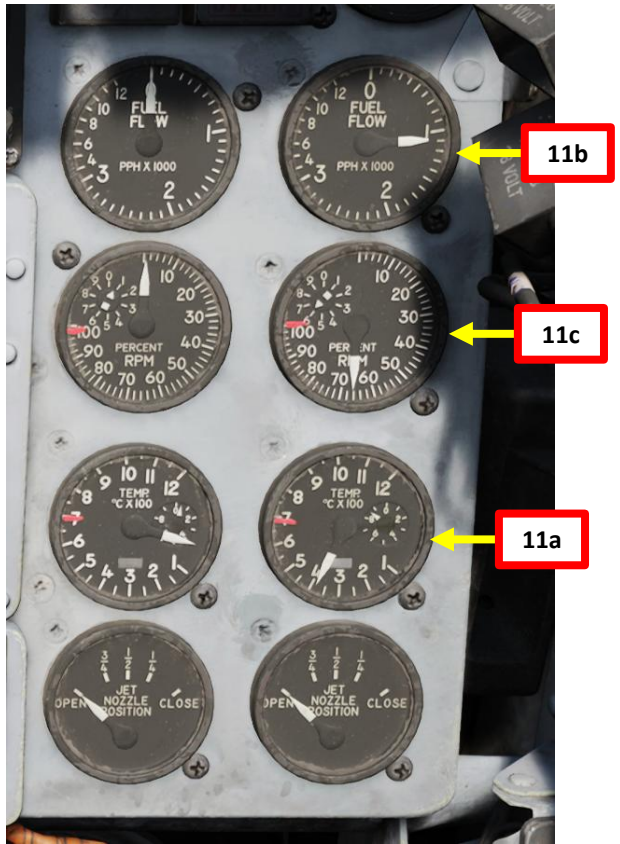


B – ENGINE START

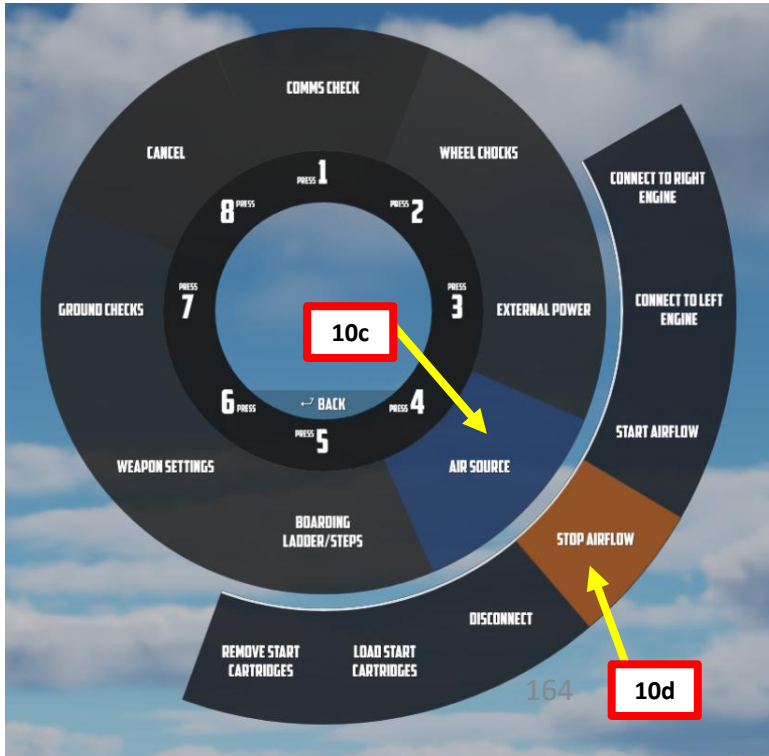
10. *[P]* At 45% Engine RPM, external air flow is no longer needed. Request the crew chief to stop airflow.
    a) Open JESTER AI wheel by short-pressing “A”.
    b) Click on CREW CHIEF
    c) Click on AIR SOURCE, then STOP AIRFLOW
    d) Close JESTER AI wheel by long-pressing “A”.
11. *[P]* Wait for engine parameters to stabilize, then check parameters are within nominal ranges.
    a) Exhaust Gas Temperature: 220 to 420 deg C
    b) Fuel Flow Indicator: 800 to 1400 lbs/hour (pph)
    c) Idle RPM: 65 %
    d) Fuel Boost Pump Pressure: 30 (+/- 5) psi
    e) Engine Oil Pressure: 12 to 50 psi
    f) Hydraulic Pressure – Within Limits
        - PC-2 Hydraulic Pressure: 3000 (+/- 250) psi
        - Utility Hydraulic Pressure: 2755 (+/- 255) psi









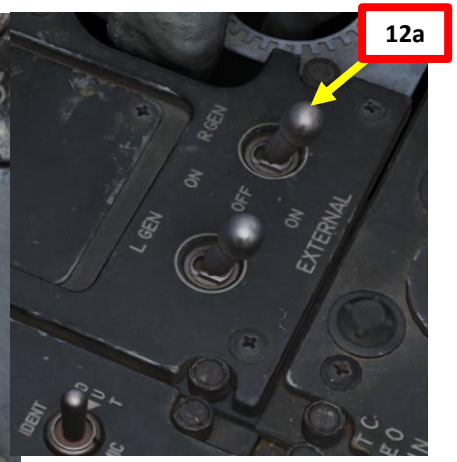


B – ENGINE START

12. *[P]* Set Right Generator Switch – ON (FWD)
13. *[P]* Confirm that RH GEN OUT light extinguishes once right engine generator power comes online.

Note for the WSO: *To avoid electrical power interruption which could result in an INS NO-GO indication, ensure Inertial Navigation System is not in the ALIGN mode when generator switches are placed to ON. If a power interruption does occur, switch the INS power control knob to OFF. When power is restored, go from OFF to ALIGN pausing momentarily at STBY.*









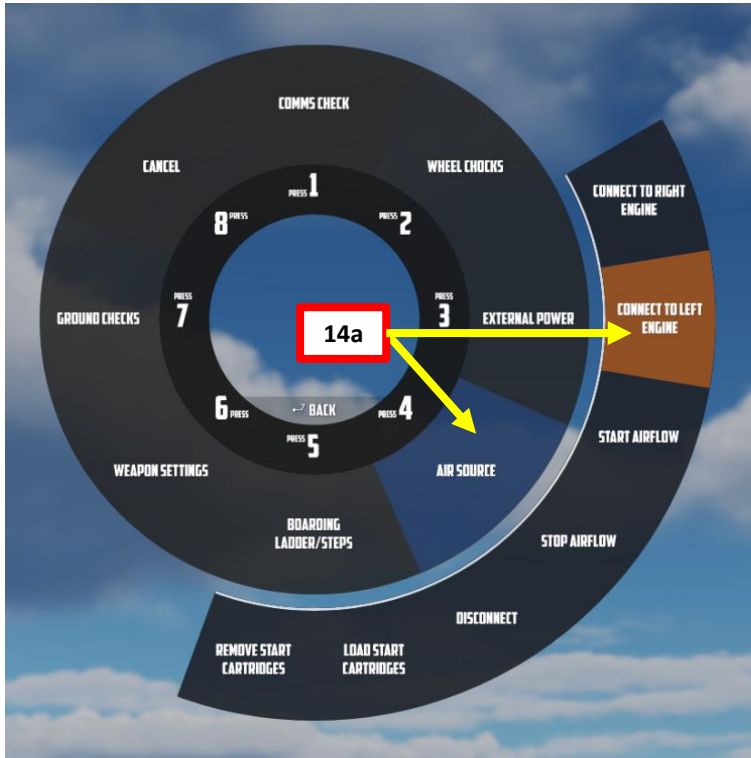
B – ENGINE START

14. [P] Call ground crew to connect compressed air supply unit to the left engine:

a) From JESTER AI wheel AIR SOURCE sub-menu, click CONNECT TO LEFT ENGINE

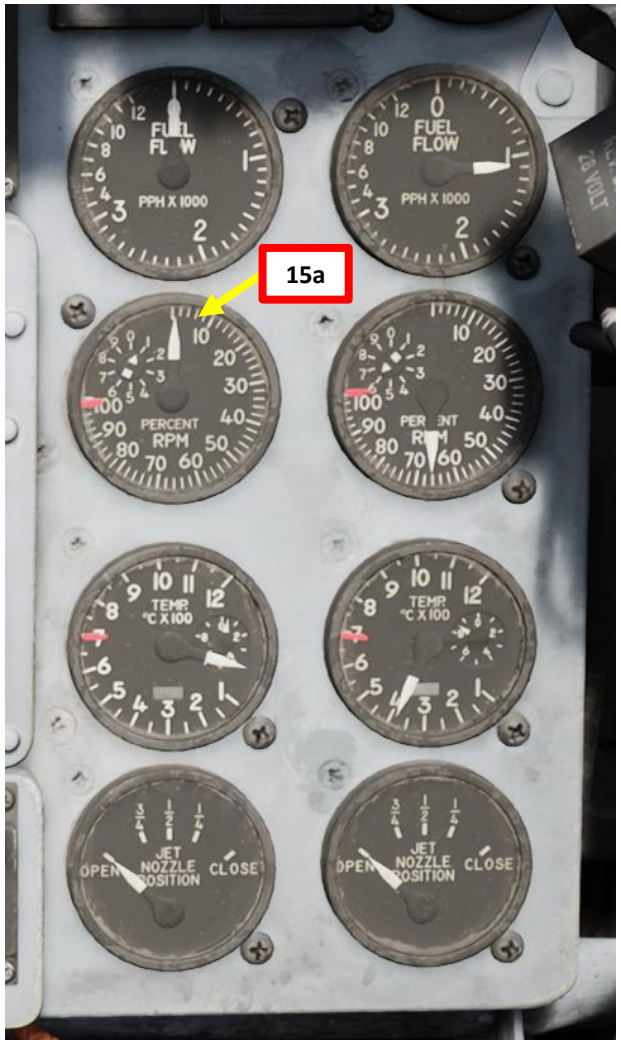
b) Once connected, the ground crew will call out “Connected to the Left”.

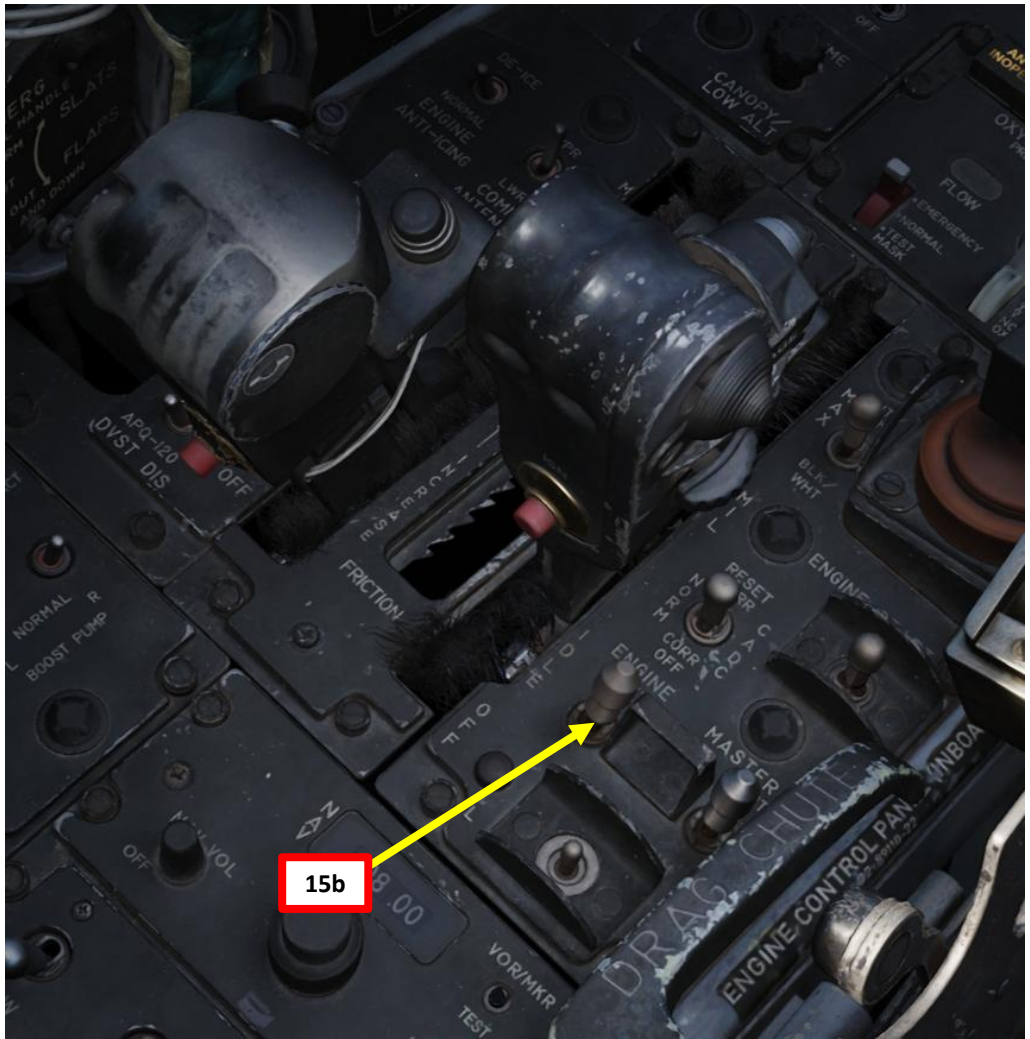


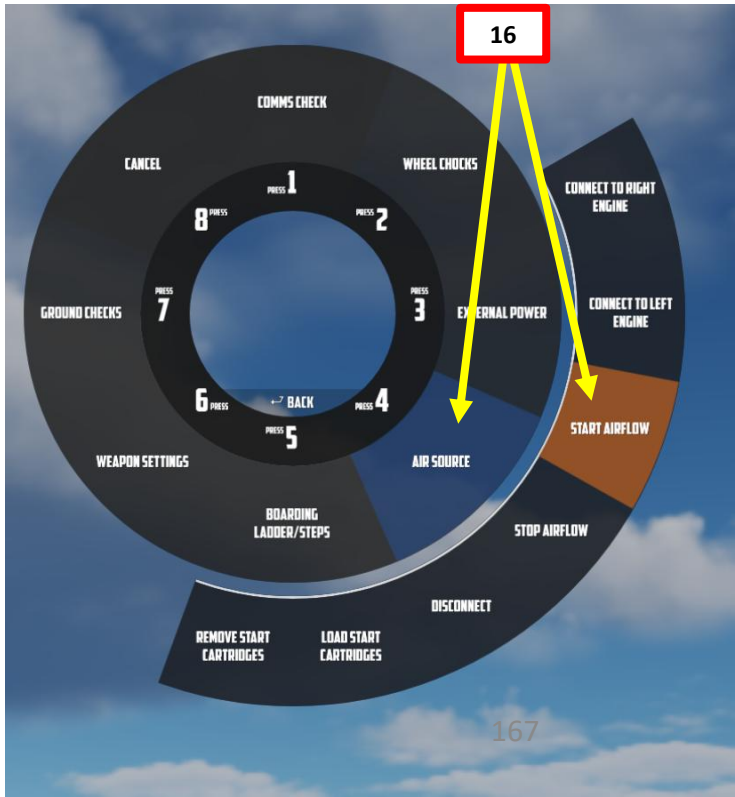


B – ENGINE START

15. *[P]* Check left engine RPM is at 0 %, then set Left Engine Master Switch – ON (FWD).
16. *[P]* Request the crew chief to apply air supply pressure to drive the left engine starter (motoring).
    - From JESTER AI wheel AIR SOURCE sub-menu, click START AIRFLOW.





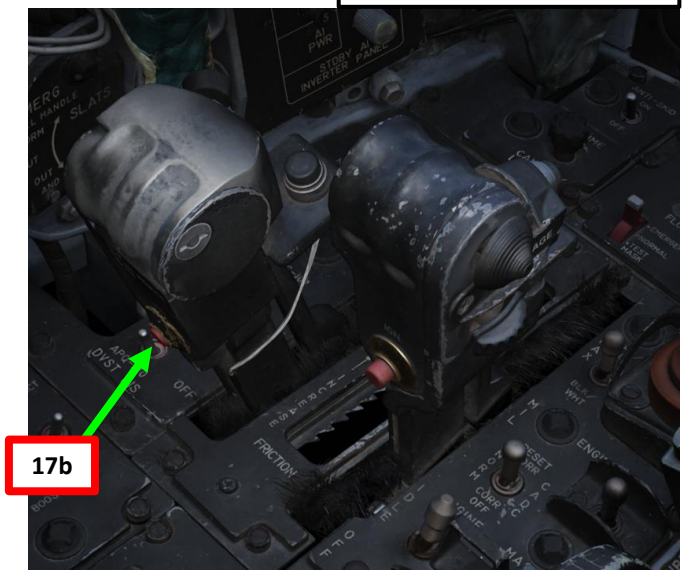


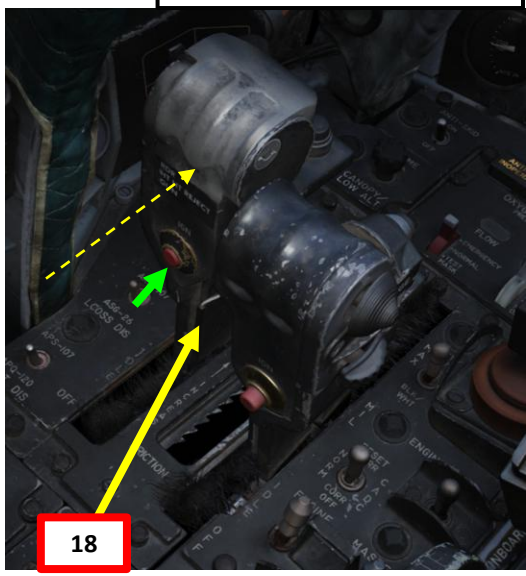
B – ENGINE START

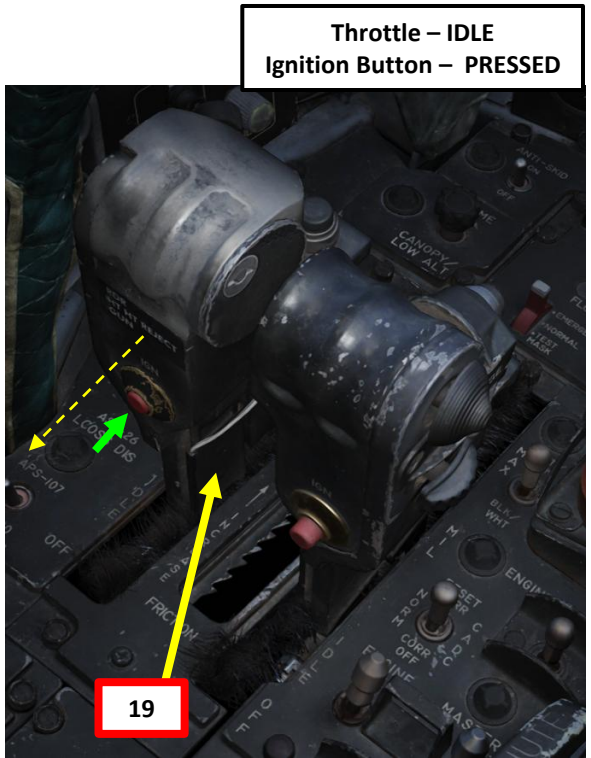
17. *[P]* Left engine RPM will gradually increase, its starter being driven by the airflow supply. When Engine RPM reaches 10 %, press and hold the Left Ignition Button. I recommend clicking and holding the button.
    - Left Throttle Ignition Button: “RALT+HOME” binding.
18. *[P]* Move Left Throttle out of the OFF detent halfway forward. Keep Left Ignition Button PRESSED.
    - Left Throttle OFF/IDLE Toggle: “RALT+END” binding.
19. *[P]* Move Left Throttle back to IDLE detent. Keep Left Ignition Button PRESSED.
20. *[P]* Confirm left engine lightoff occurs by checking for EGT (Exhaust Gas Temperature) increase, then release Left Ignition Button.

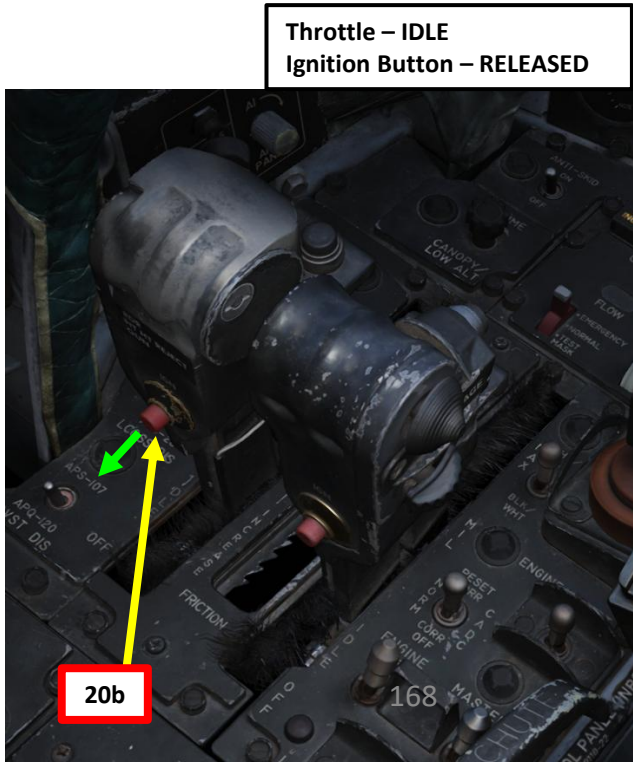








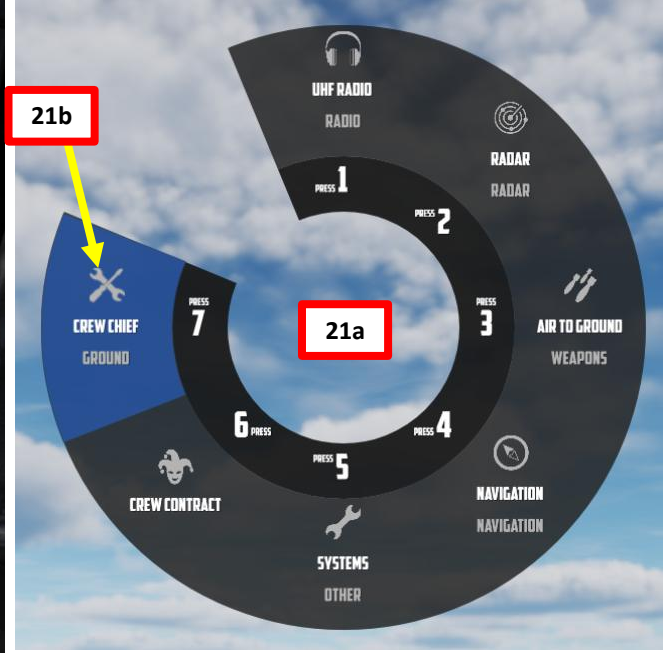


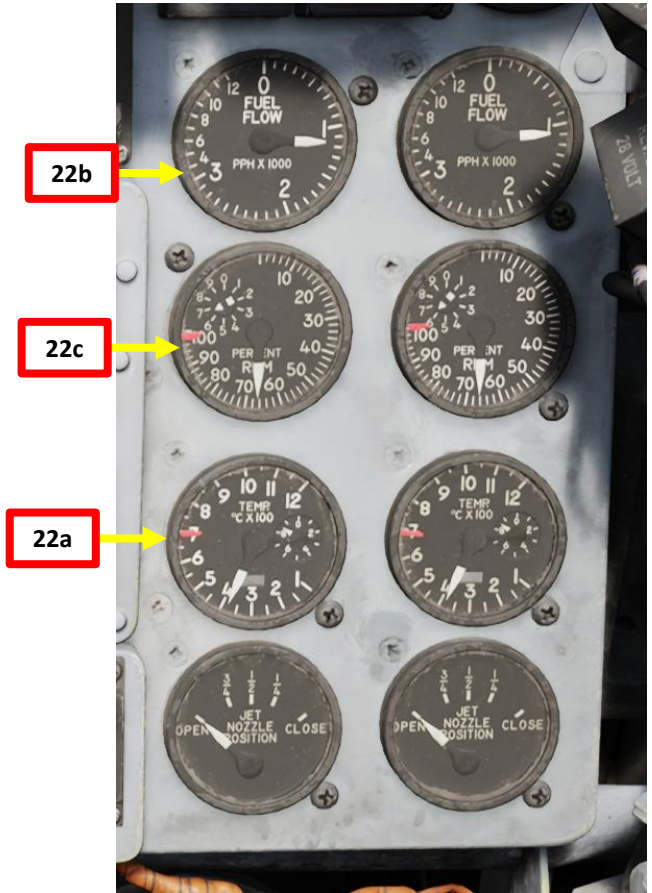


B – ENGINE START

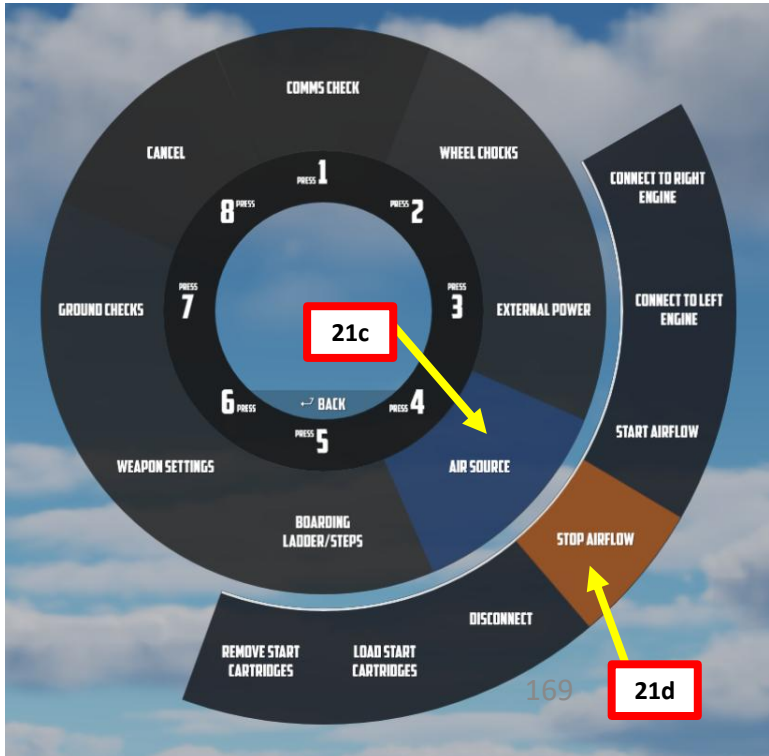
21. *[P]* At 45% Engine RPM, external air flow is no longer needed. Request the crew chief to stop airflow.
    a) Open JESTER AI wheel by short-pressing “A”.
    b) Click on CREW CHIEF
    c) Click on AIR SOURCE, then STOP AIRFLOW
    d) Close JESTER AI wheel by long-pressing “A”.
22. *[P]* Wait for engine parameters to stabilize, then check parameters are within nominal ranges.
    a) Exhaust Gas Temperature: 220 to 420 deg C
    b) Fuel Flow Indicator: 800 to 1400 lbs/hour (pph)
    c) Idle RPM: 65 %
    d) Fuel Boost Pump Pressure: 30 (+/- 5) psi
    e) Engine Oil Pressure: 12 to 50 psi









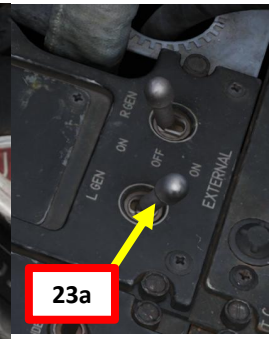


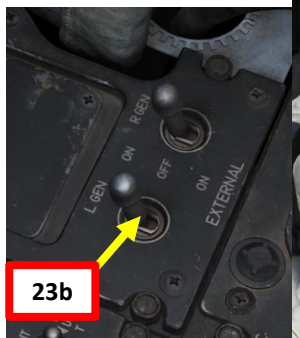
B – ENGINE START

23. *[P]* Set Left Generator Switch – ON (FWD)
24. *[P]* Confirm that LH GEN OUT light extinguishes once left engine generator power comes online.
25. *[P]* Set Right Generator Switch to OFF (MIDDLE) position, then back to ON. Once generator has been cycled ON and OFF, check that BUS TIE OPEN LIGHT is extinguished.

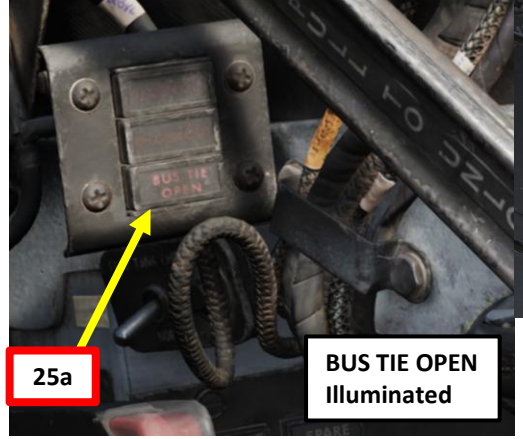
Note for the WSO: *To avoid electrical power interruption which could result in an INS NO-GO indication, ensure Inertial Navigation System is not in the ALIGN mode when generator switches are placed to ON. If a power interruption does occur, switch the INS power control knob to OFF. When power is restored, go from OFF to ALIGN pausing momentarily at STBY.*

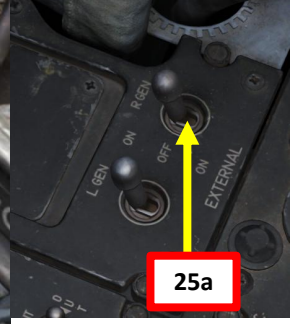


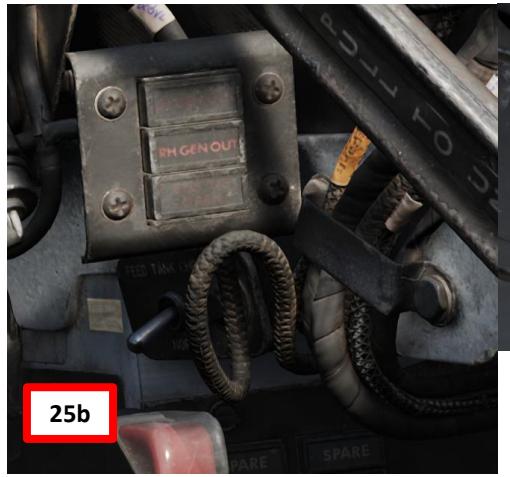


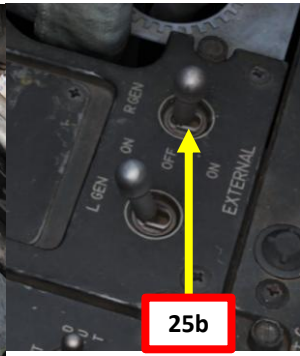


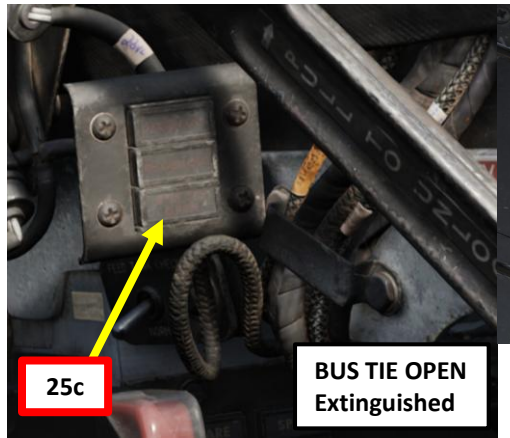


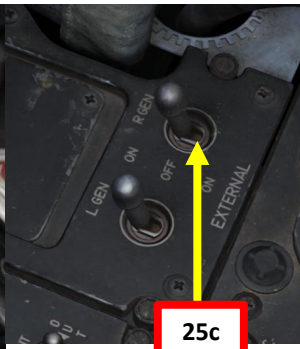








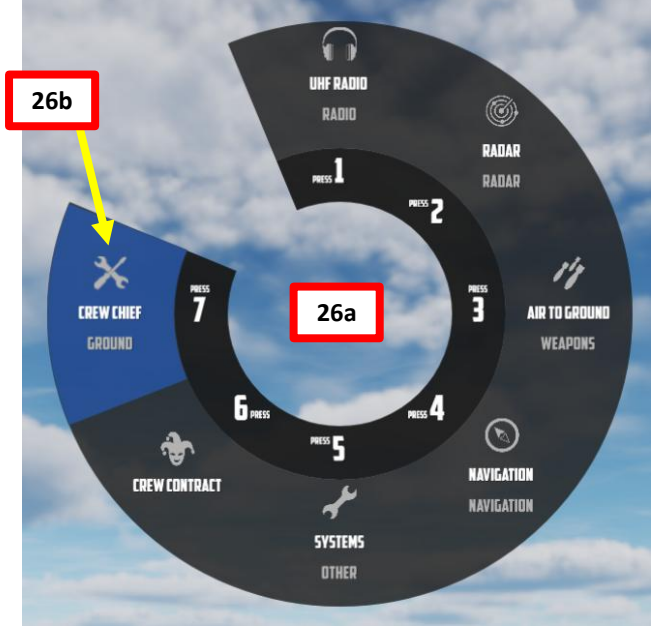


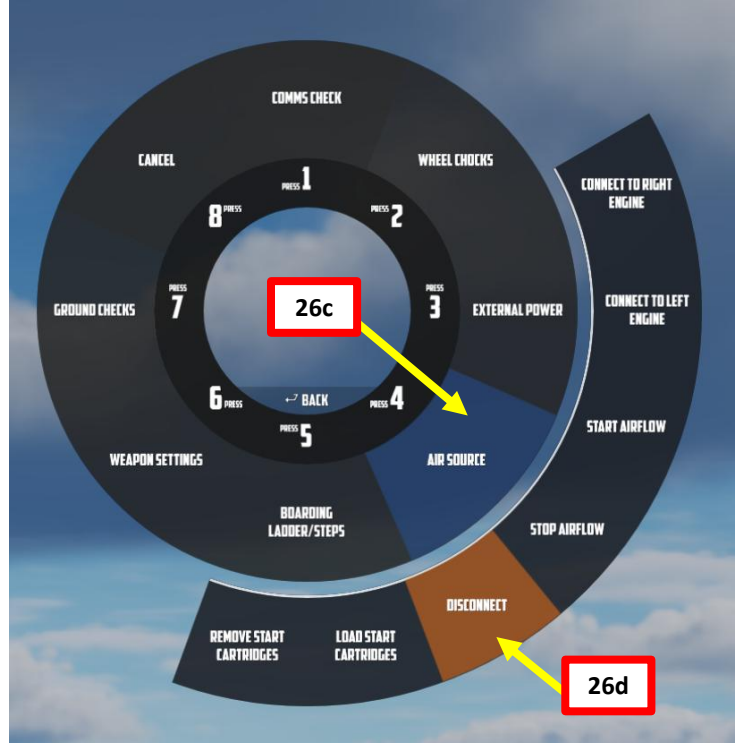


B – ENGINE START

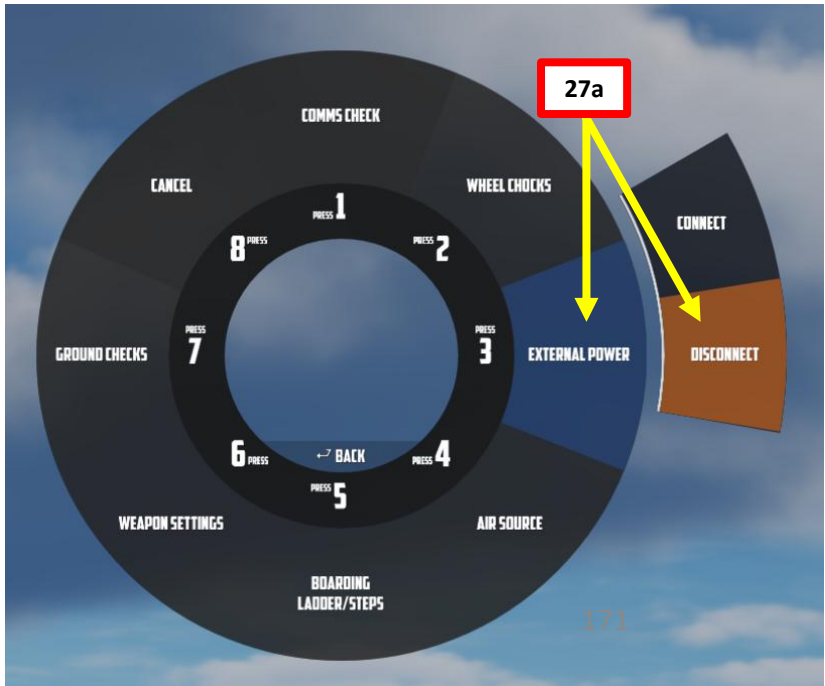
26. [P] Call ground crew to disconnect compressed air supply unit:
- a) Open JESTER AI wheel by short-pressing “A”.
- b) Click on CREW CHIEF
- c) Click on AIR SOURCE, then DISCONNECT
- d) Once disconnected, the ground crew will call out “Disconnected”.

27. [P] Request ground crew to disconnect the aircraft with the External Ground Power Cart.
- a) Click on EXTERNAL POWER, then DISCONNECT
- b) Close JESTER AI wheel by long-pressing “A”.









C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT

Basics & Alignment Types

The LN-12D Navigational Computer and the AN/ASN-63 INS (Inertial Navigation System) require position alignment. There are three primary methods to perform this alignment on the ground:

Option A – Full Gyrocompass Alignment:

- This process takes approximately between **8 minutes to 12 minutes**, but alignment time varies based on temperature and BATH alignment accuracy. The initial **aircraft position** (Latitude/Longitude) and **magnetic variation** (MAGVAR) are both required for this alignment, which can be obtained from the kneeboard TURNPOINTS page.
- This alignment offers a relative CEP (Circular Error Probability) of **3 nm per hour** (think of this is the INS drift/position error accumulating over time).

Option B – Fast BATH (Best Available True Heading) Alignment:

- This process takes approximately **2 minutes 15 seconds**. This method minimizes alignment time but can potentially be inaccurate if the available true heading does not match the actual aircraft heading (which is why Stored Heading can be set via the Mission Editor to prevent this issue).
- Once in BATH, the INS is accurate to a CEP (Circular Error Probability) of roughly **5.5 nm per hour**, although higher inaccuracies can be seen.

Option C – Stored Heading (HDG MEM) Alignment:

- This process takes approximately **2 minutes 15 seconds**. This method minimizes alignment time while providing a reasonably accurate position.
- Once in HDG MEM, the INS offers a relative CEP (Circular Error Probability) at the optimal end of BATH (**5.5 nm per hour**), or even Gyrocompass Alignment (**3 nm per hour**) if the previous alignment occurred within the last 2 hours.
- This option is only available if a previously stored alignment has been done and the aircraft has remained stationary. Stored Heading is enabled via the Mission Editor in the Aircraft Additional Properties tab. “INS REFERENCE ALIGNMENT STORED” option checkbox needs to be ticked.

AN/ASN-63 INS Control Panel



AN/ASN-46A Navigation Computer Control Panel



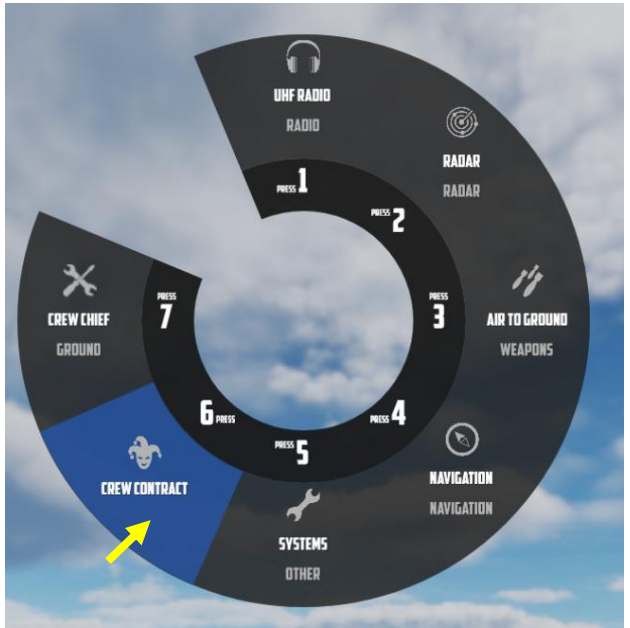


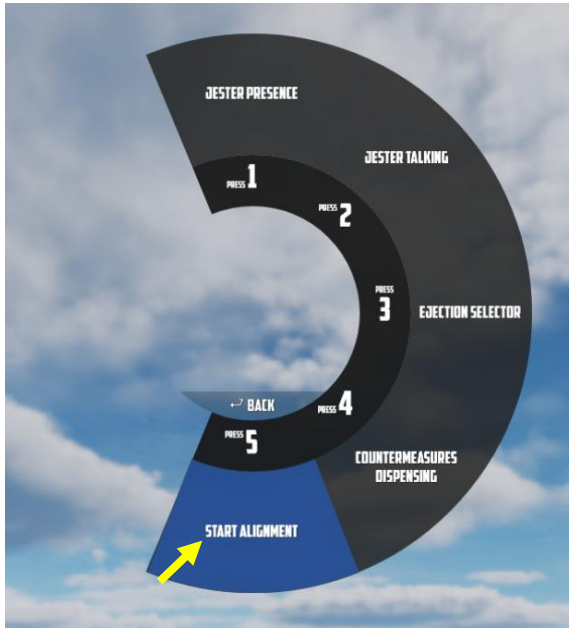
C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (PILOT)

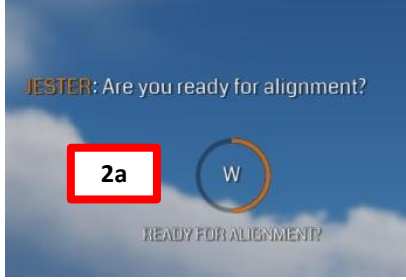
Alignment with JESTER AI

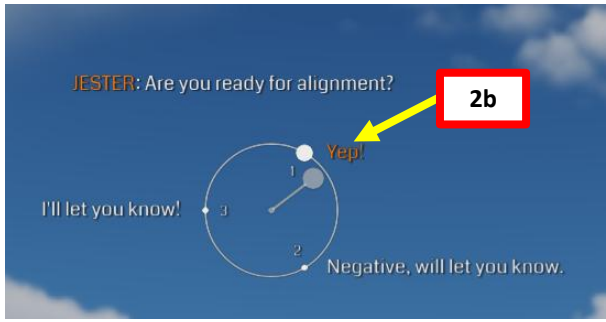
1. *[WSO]* Now that the engines are started and aircraft is running on generator power, the WSO (Weapon Systems Officer) can proceed with setting up the rear cockpit (including navigation, radar and targeting pod systems). In this case, JESTER AI will set up the following systems for us:
   - INS (Inertial Navigation System) alignment
   - AN/APQ-120 Fire Control Radar Setup **(see section E)**
   - DSCG (Digital Scan Converter Group) setup, which displays radar, weapon and targeting pod video footage **(see section E)**
   - WRCS (Weapon Release Computer Set) setup **(see section E)**
   - AN/AVQ-23 Pave Spike Targeting Pod setup if equipped **(see section E)**
2. *[WSO]* When JESTER asks: "Are you ready for alignment?" Press "W" to select dialog option, then click on "Yep".
3. *[WSO]* When JESTER asks: "What alignment do you want?" Press "W" to select dialog option, then click on desired INS alignment mode. We will use BATH alignment for this tutorial for an expedited start-up.
   - **Full Alignment**: Takes between 8 to 12 minutes. Most precise but longest form of alignment.
   - **BATH (Best Available True Heading) Alignment**: Takes 2 minutes 15 seconds. Offers quick alignment with reasonable precision if Stored Heading is not available.
   - **HDG Memory Alignment**: Takes 2 minutes 15 seconds. Offers better precision vs alignment time than BATH. Only available if Stored Heading option is enabled via Mission Editor.
4. *[WSO]* JESTER will also automatically enter Waypoint and Target Point coordinates of your flight plan. A player-controlled WSO will have to enter all this data manually. Once INS alignment is complete, JESTER will call out that "Alignment is done, ready to taxi".

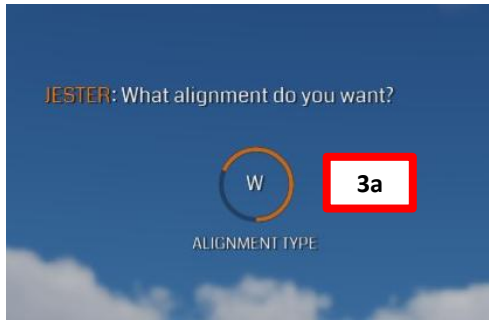
- Note: If you miss the dialog option, open JESTER AI wheel by short-pressing "A", click on CREW CONTRACT, then START ALIGNMENT. JESTER will then ask you what alignment type you want (step 3).









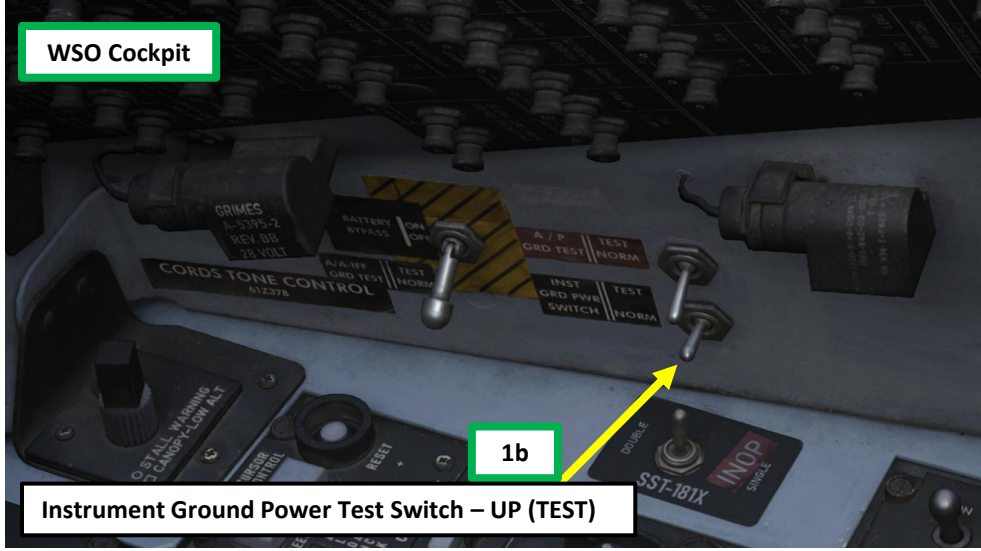


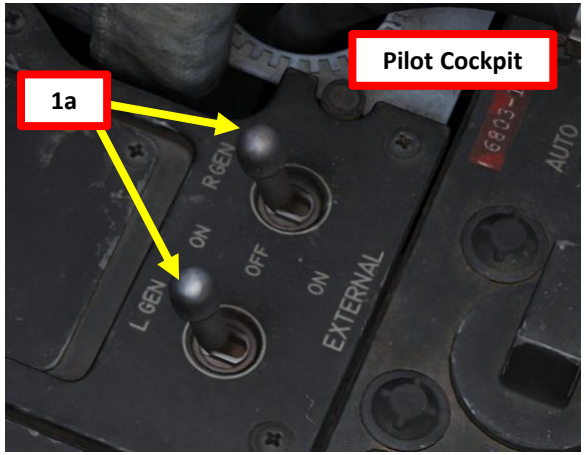


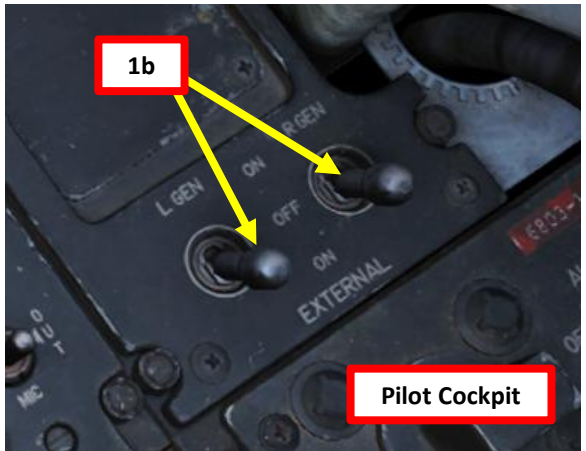
C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

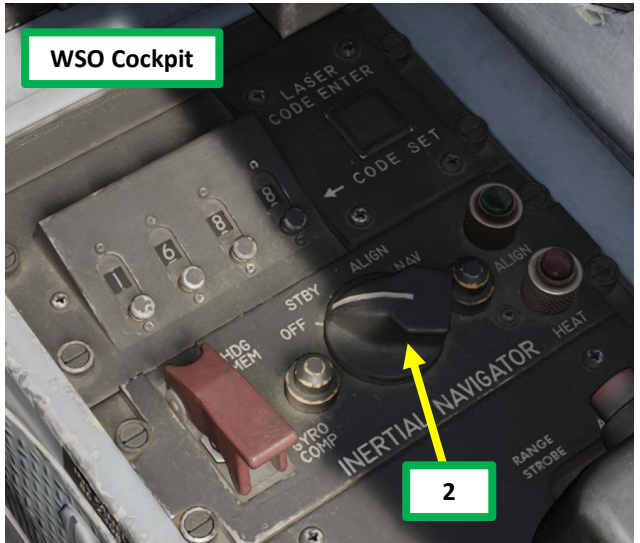
Before Starting INS Alignment: Power Considerations

1. *[WSO]* **Very Important**: Before starting INS alignment, check with the pilot the power state of the aircraft.
   a) If aircraft **engines are running** and **generator** switches are set to **ON** (FWD), set Instrument Ground Power Test Switch – NORM (DOWN).
   b) If aircraft is powered by **external ground power** and **generator** switches are set to **EXTERNAL ON** (AFT), set Instrument Ground Power Test Switch – TEST (UP). This will power up the rear cockpit even if engines are not running.
   - Note: To avoid an "INS NO-GO" indication, check that the INS Power Knob is not in the ALIGN position if power interruptions occur (as an example, transitioning from ground power to engine generator power).
2. *[WSO]* Check INS Power Selector – OFF
3. *[WSO]* Check Navigation Computer Mode Selector – OFF







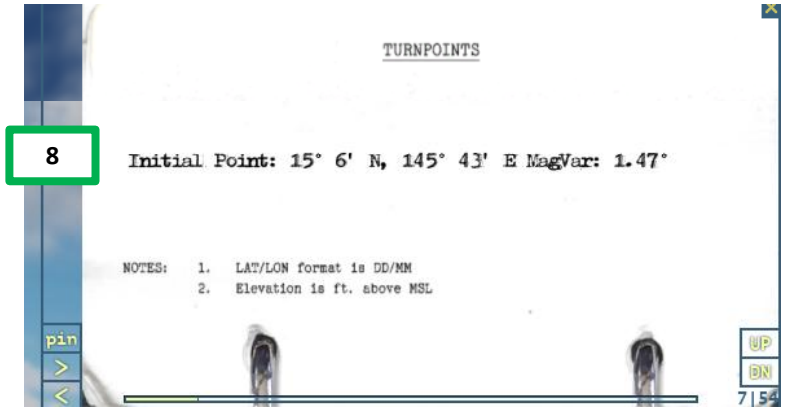


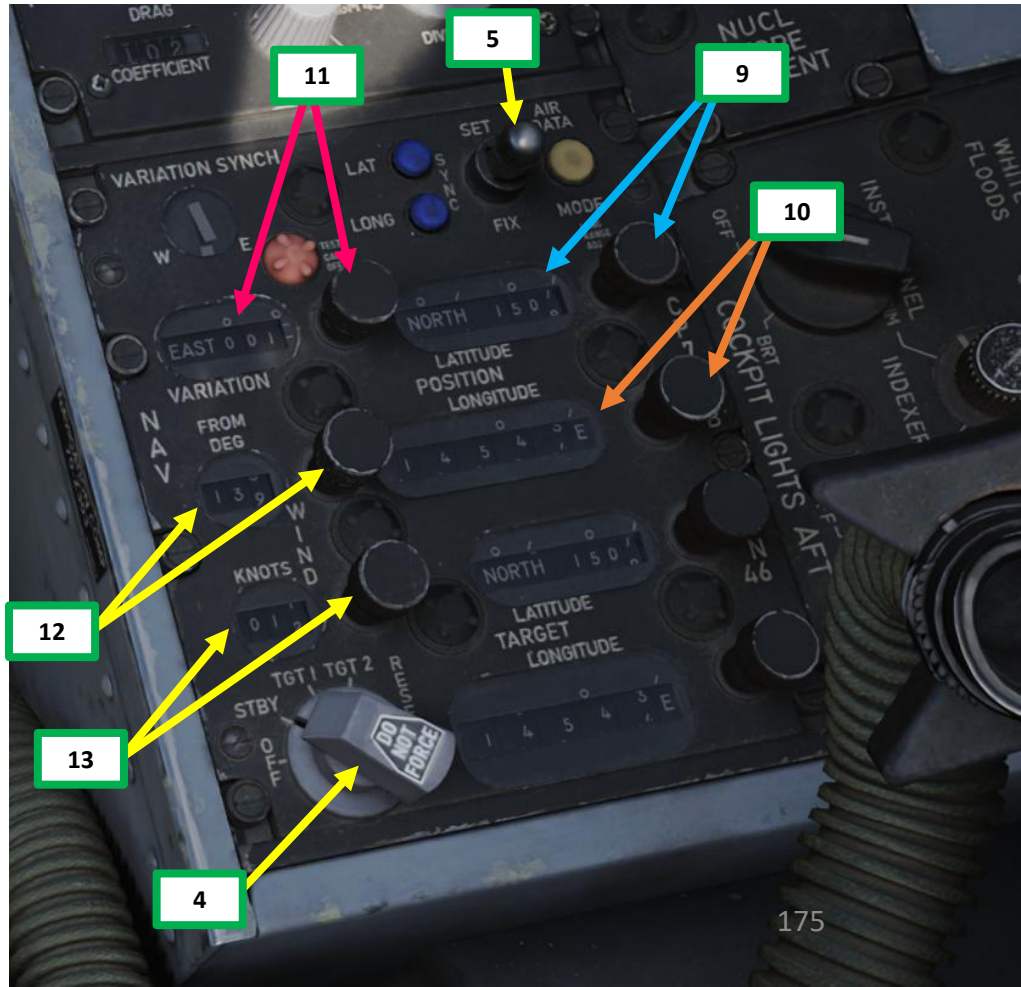


C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

Option A: Full Gyrocompass Alignment

4. *[WSO]* Set Navigation Computer Mode Selector – STBY (Standby)
5. *[WSO]* Set Position Update Switch – NORMAL (Middle position)
6. *[WSO]* Open up your kneeboard using "RSHIFT+K".
7. *[WSO]* Cycle through pages using the "[" and "]" (kneeboard previous/next page bindings) until reaching Initial Point section.
8. *[WSO]* Initial Point Data:
   - LATITUDE : **15 deg 06 minutes North**
   - LONGITUDE: **145 deg 43 minutes East**
   - MAGVAR (Magnetic Variation): **1.47 deg**
9. *[WSO]* Press and hold **LATITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Latitude to **15 deg 06 minutes North**. Release knob (OUT) when correct value is set.
10. *[WSO]* Press and hold **LONGITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Longitude to **145 deg 43 minutes East**. Release knob (OUT) when correct value is set.
11. *[WSO]* Press and hold **VARIATION** knob IN (left click and hold), then rotate (scroll mousewheel) to set MAGVAR to **1.47 deg**. Release knob (OUT) when correct value is set.
12. **[WSO]* If wind direction is available from mission briefing: press and hold **WIND FROM** knob IN (left click and hold), then rotate (scroll mousewheel) to set the direction the wind is coming from (as an example, 139 is for a wind coming from the South East). Release knob (OUT) when correct value is set. *This step will be omitted for simplicity since the INS does not require this value for alignment.*
13. **[WSO]* If wind speed is available from mission briefing: press and hold **WIND KNOTS** knob IN (left click and hold), then rotate (scroll mousewheel) to set the wind speed (as an example, 12 knots). Release knob (OUT) when correct value is set. *This step will be omitted for simplicity since the INS does not require this value for alignment.*

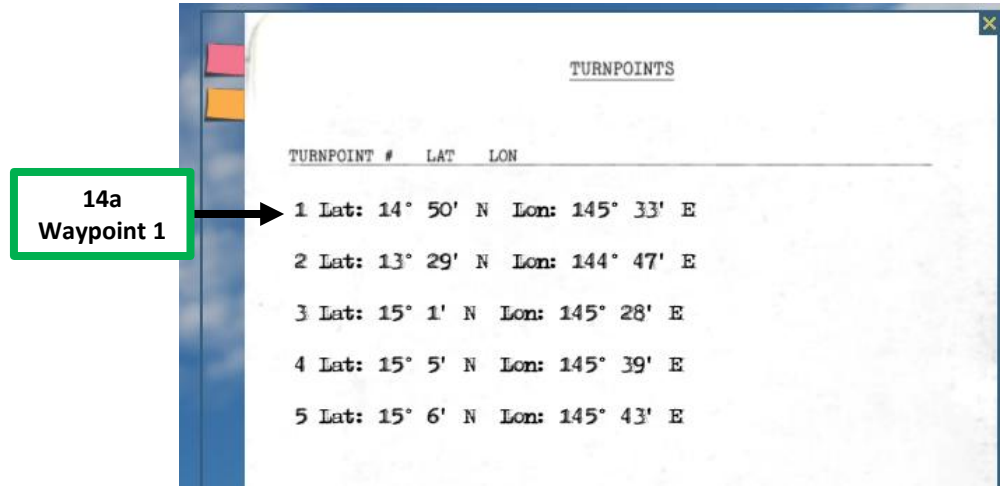


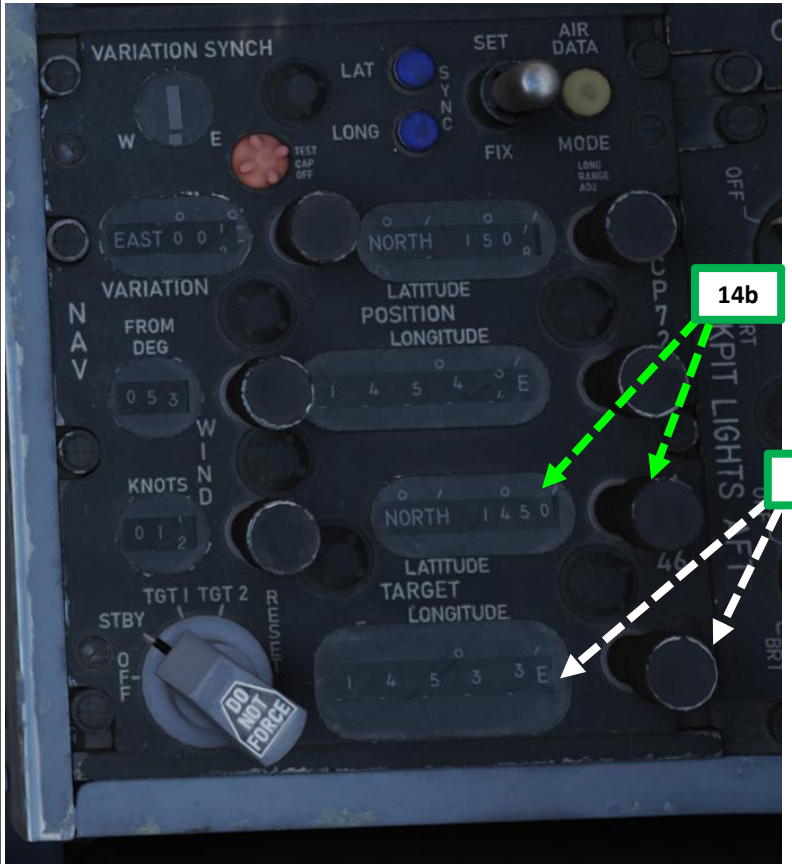


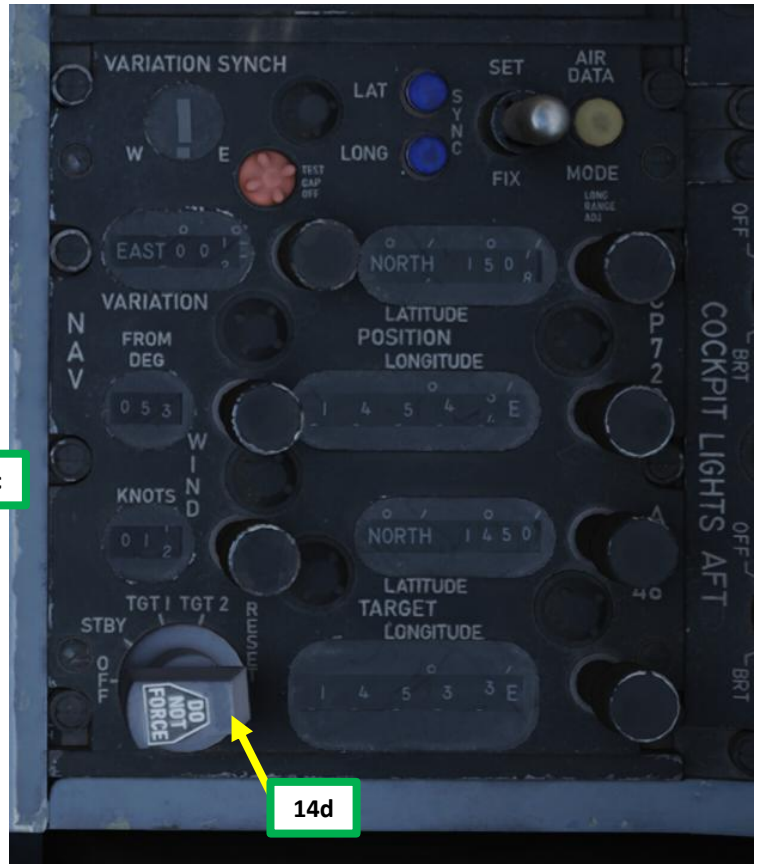
C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

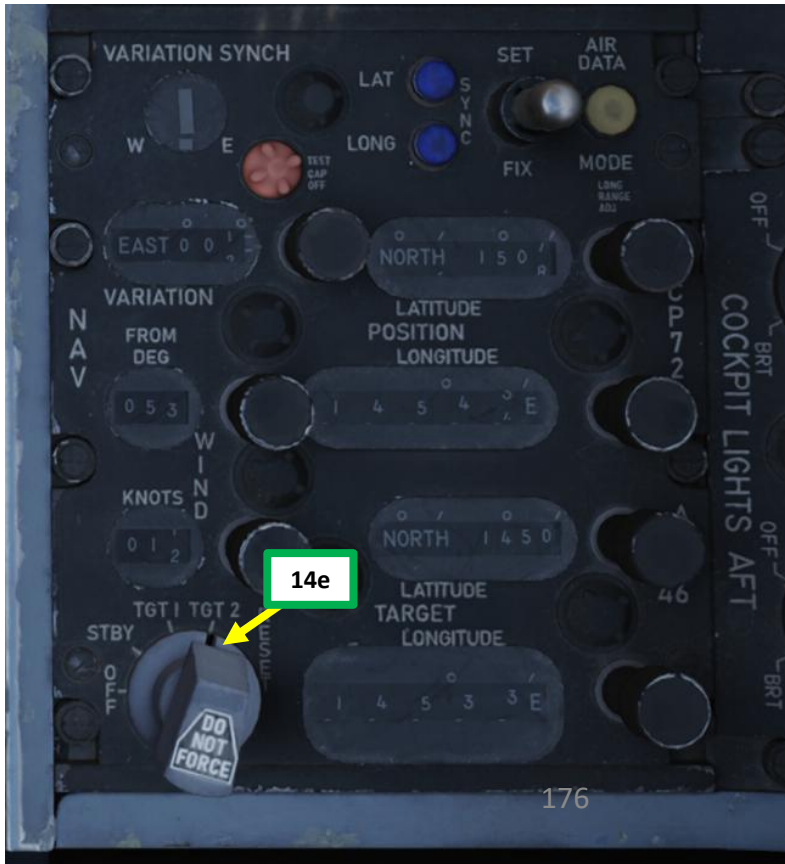
Option A: Full Gyrocompass Alignment

14. *[WSO] Set Target 2 (TGT 2) Mode Latitude & Longitude for the first waypoint in the flight plan. *This step can be omitted for simplicity*.
    a) As an example, if **Waypoint 1 coordinates** are **14 deg 50 min North / 145 deg 33 min East**.
    b) Rotate TARGET LATITUDE position knob (scroll mousewheel) to **14 deg 50 min North**.
    c) Rotate TARGET LONGITUDE position knob (scroll mousewheel) to **145 deg 33 min East**.
    d) Set Navigation Computer Mode Selector – RESET position.
    e) Set Navigation Computer Mode Selector – TGT 2 position.
    f) Waypoint 1 Coordinates are now memorized/stored in the Inertial Navigation System.





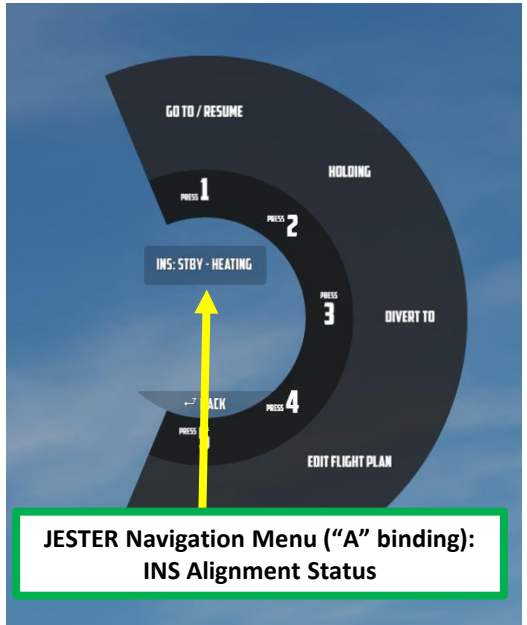




C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

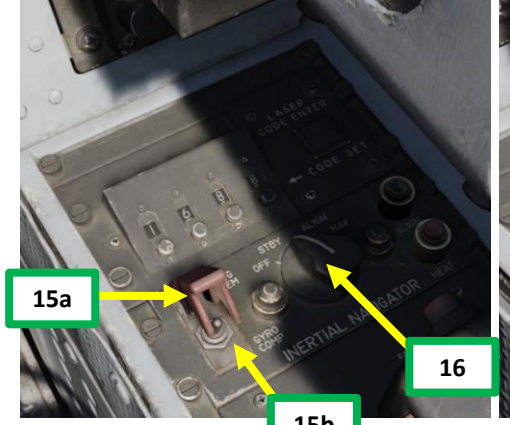
Option A: Full Gyrocompass Alignment

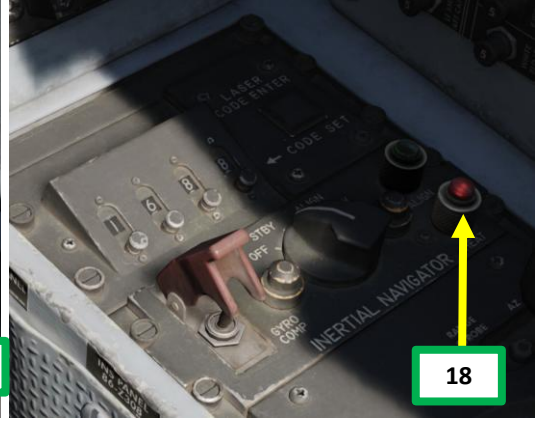
15. *[WSO]* Flip INS Alignment Mode Switch guard UP, then check INS Alignment Mode Switch is set to AFT to GYRO COMP (Gyrocompass). Take note that GYRO COMP is the default (guard down) position.
16. *[WSO]* Set INS Power Selector – STBY (Standby).
17. *[WSO]* Power is applied to the INS heaters and temperature control system and initiates Coarse alignment.
18. *[WSO]* Confirm HEAT lamp illuminates. This means the INS pre-heat sequence is ongoing and operational temperature has not been reached yet.
19. *[WSO]* Wait until HEAT lamp extinguishes (approximately **6 minutes**).
    - When the system heats up to an operational temperature of 160 deg F (which takes about 5 minutes), the HEAT lamp will take another 50 seconds to extinguish, indicating that the INS is ready for alignment.
20. *[WSO]* Set INS Power Selector – ALIGN.
21. *[WSO]* Wait until ALIGN lamp illuminates steadily (approximately **75 seconds**). This indicates the completion of the initial BATH (Best Available True Heading) or "Fine" alignment, initiating the gyro-compassing process.
    - When ALIGN lamp is illuminated, you can set INS Power Selector to NAV mode at any time, but optimal accuracy is not attained until ALIGN lamp is flashing.
22. *[WSO]* Wait until ALIGN lamp flashes (approximately **5 minutes**), indicating the gyro-compassing process is complete and optimal accuracy is attained.
23. *[WSO]* Set INS Power Selector – NAV.
24. *[WSO]* Confirm ALIGN light extinguishes.
25. *[WSO]* Flip INS Alignment Mode guard DOWN. This will ensure INS Alignment Mode stays to GYRO COMP.

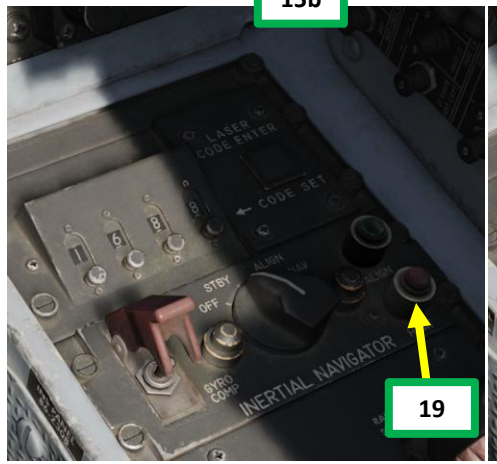


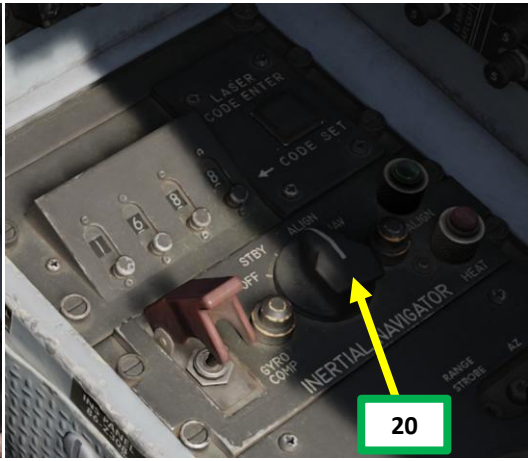
JESTER Navigation Menu ("A" binding): INS Alignment Status

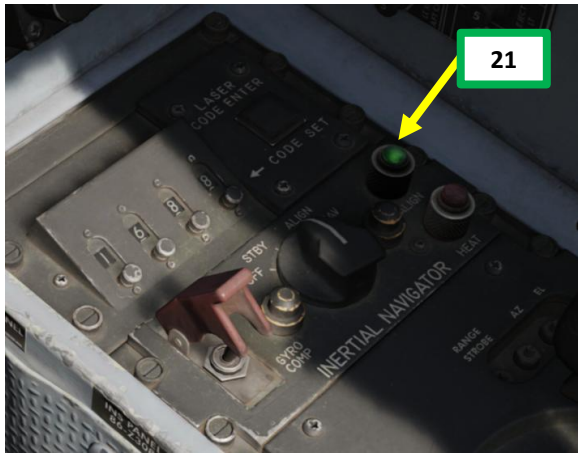


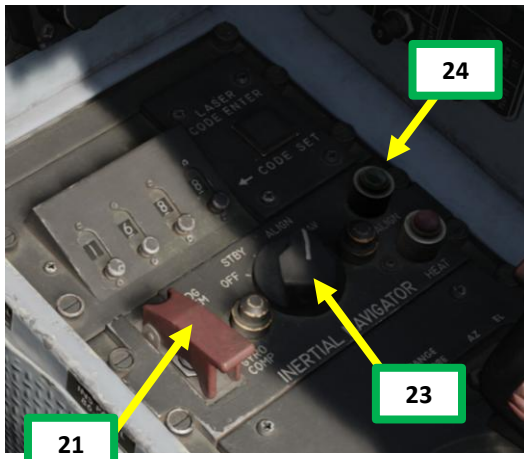








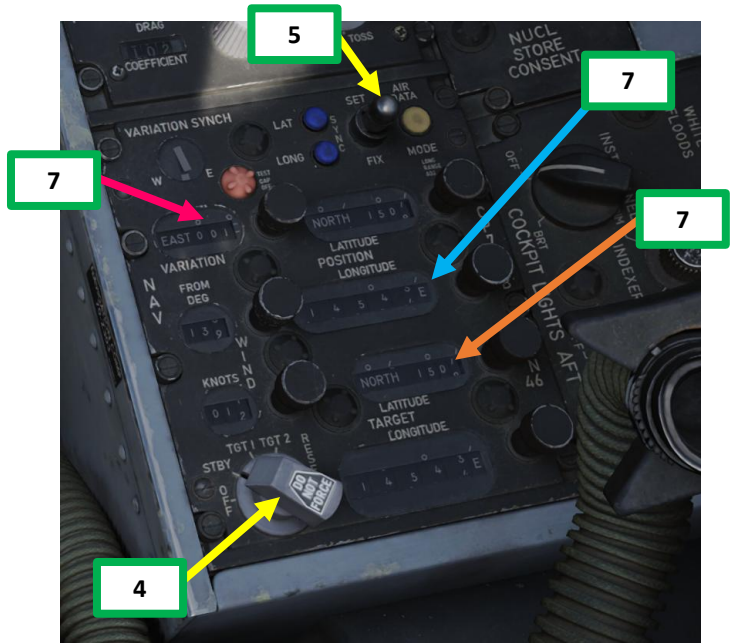


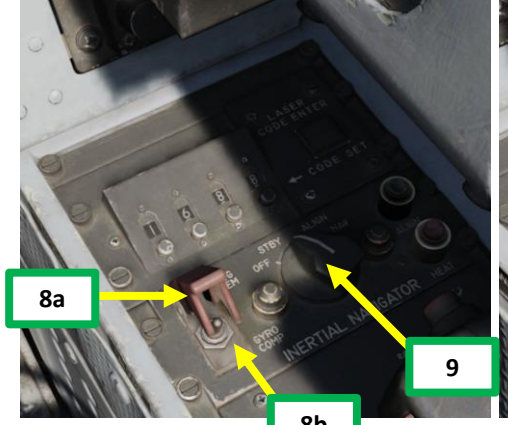


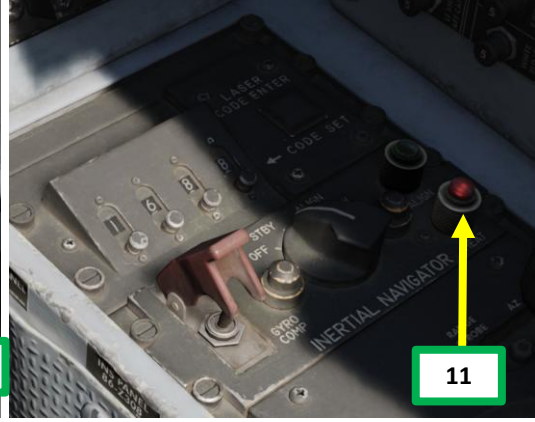
C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

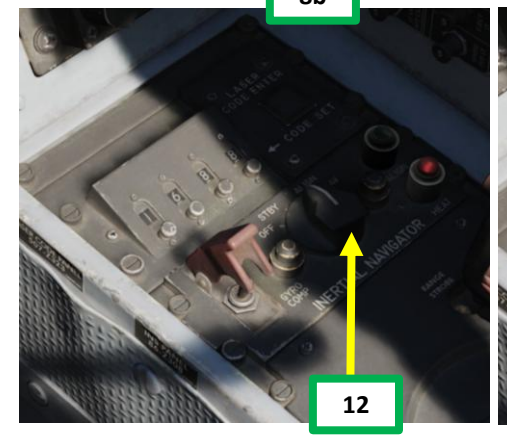
Option B: Fast BATH (Best Available True Heading) Alignment

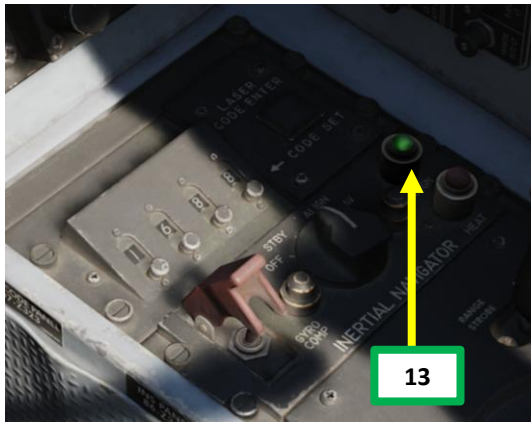
4. *[WSO]* Set Navigation Computer Mode Selector – STBY (Standby)
5. *[WSO]* Set Position Update Switch – NORMAL (Middle position)
6. *[WSO]* Initial Point Data:
   - LATITUDE : **15 deg 06 minutes North**
   - LONGITUDE: **145 deg 43 minutes East**
   - MAGVAR (Magnetic Variation): **1.47 deg**
7. *[WSO]* We will assume latitude, longitude and MAGVAR values have all been entered correctly in the Navigation Computer already.
8. *[WSO]* Flip INS Alignment Mode Switch guard UP, then check INS Alignment Mode Switch is set to AFT to GYRO COMP (Gyrocompass). Take note that GYRO COMP is the default (guard down) position.
9. *[WSO]* Set INS Power Selector – STBY (Standby).
10. *[WSO]* Power is applied to the INS heaters and temperature control system and initiates Coarse alignment.
11. *[WSO]* For BATH alignment, we will disregard the status of the HEAT lamp.
12. *[WSO]* Set INS Power Selector – ALIGN.
13. *[WSO]* Wait until ALIGN lamp illuminates steadily (approximately **2 minutes 15 seconds**). This indicates the completion of the initial BATH (Best Available True Heading) or "Fine" alignment.
14. *[WSO]* Set INS Power Selector – NAV.
15. *[WSO]* Confirm ALIGN light extinguishes.
16. *[WSO]* Flip INS Alignment Mode guard DOWN. This will ensure INS Alignment Mode stays to GYRO COMP.

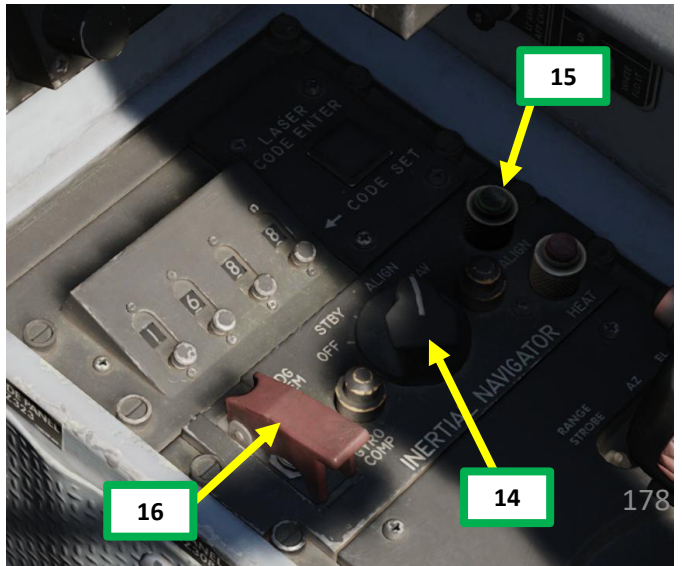








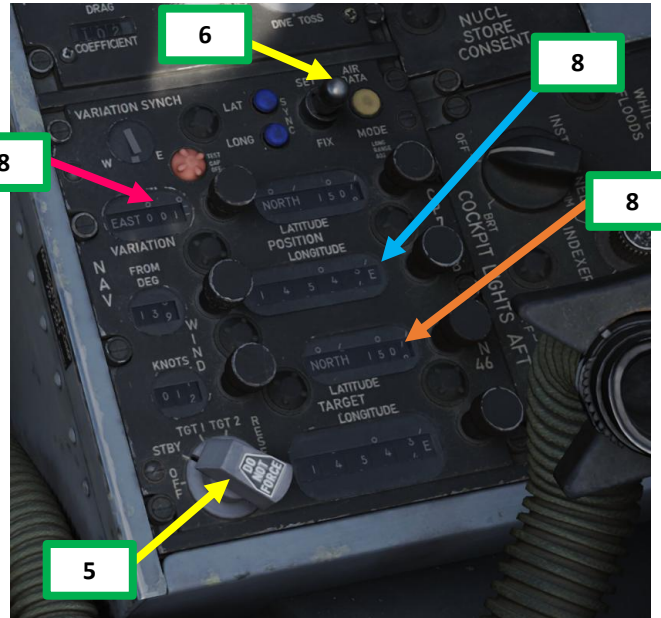


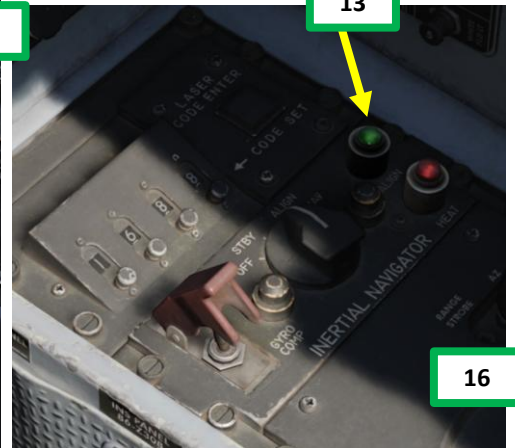


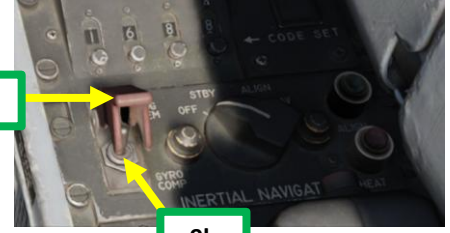
C – INS (INERTIAL NAVIGATION SYSTEM) ALIGNMENT (WSO)

Option C: HDG MEM (Stored Heading) Alignment

4. HDG MEM (INS Reference Alignment Stored Heading) option must be enabled via the Mission Editor. This should be explained in the Mission Briefing.
5. *[WSO]* Set Navigation Computer Mode Selector – STBY (Standby)
6. *[WSO]* Set Position Update Switch – NORMAL (Middle position)
7. *[WSO]* Initial Point Data:
   - LATITUDE : **15 deg 06 minutes North**
   - LONGITUDE: **145 deg 43 minutes East**
   - MAGVAR (Magnetic Variation): **1.47 deg**
8. *[WSO]* We will assume latitude, longitude and MAGVAR values have all been entered correctly in the Navigation Computer already and is memorized by the navigation computer.
9. *[WSO]* Flip INS Alignment Mode Switch guard UP, then check INS Alignment Mode Switch is set FWD to HDG MEM (Heading Memory or "Stored Heading").
10. *[WSO]* Set INS Power Selector – Momentarily to STBY (Standby), then to ALIGN.
11. *[WSO]* Power is applied to the INS heaters and temperature control system and initiates Coarse alignment.
12. *[WSO]* For HDG MEM alignment, we will disregard the status of the HEAT lamp.
13. *[WSO]* Wait until ALIGN lamp flashes (approximately **2 minutes 15 seconds**). This indicates the completion of gyrocompassing alignment.
14. *[WSO]* Set INS Power Selector – NAV.
15. *[WSO]* Confirm ALIGN light extinguishes.
16. *[WSO]* Flip INS Alignment Mode guard DOWN. This will set the INS Alignment Mode to GYRO COMP.





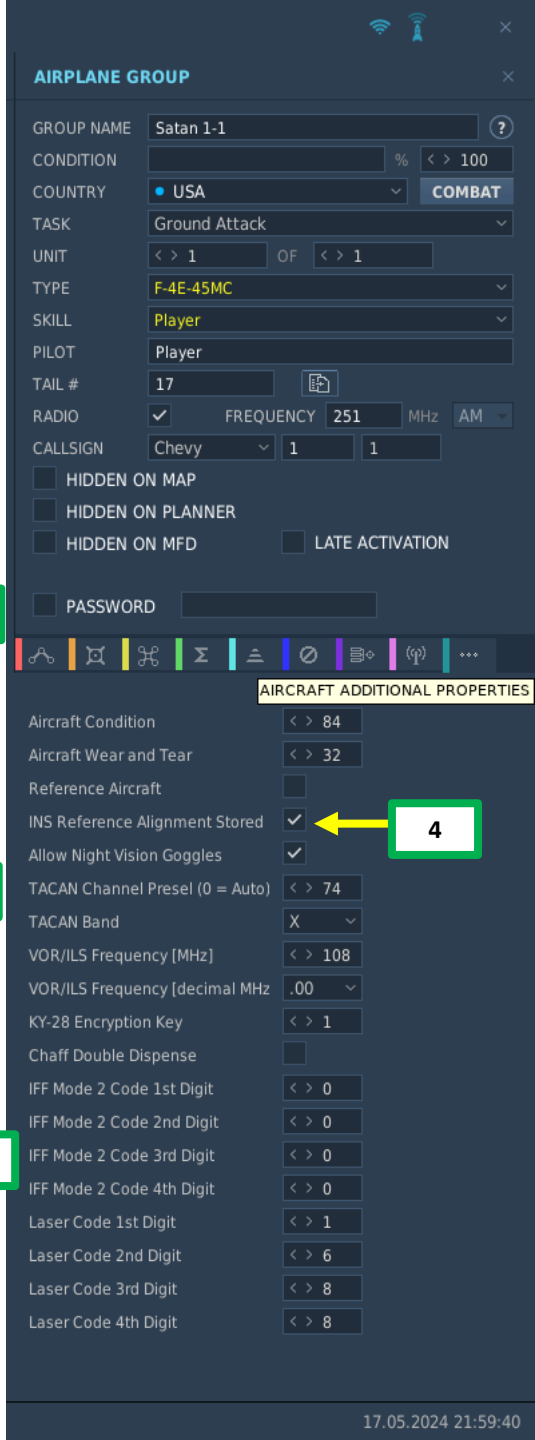








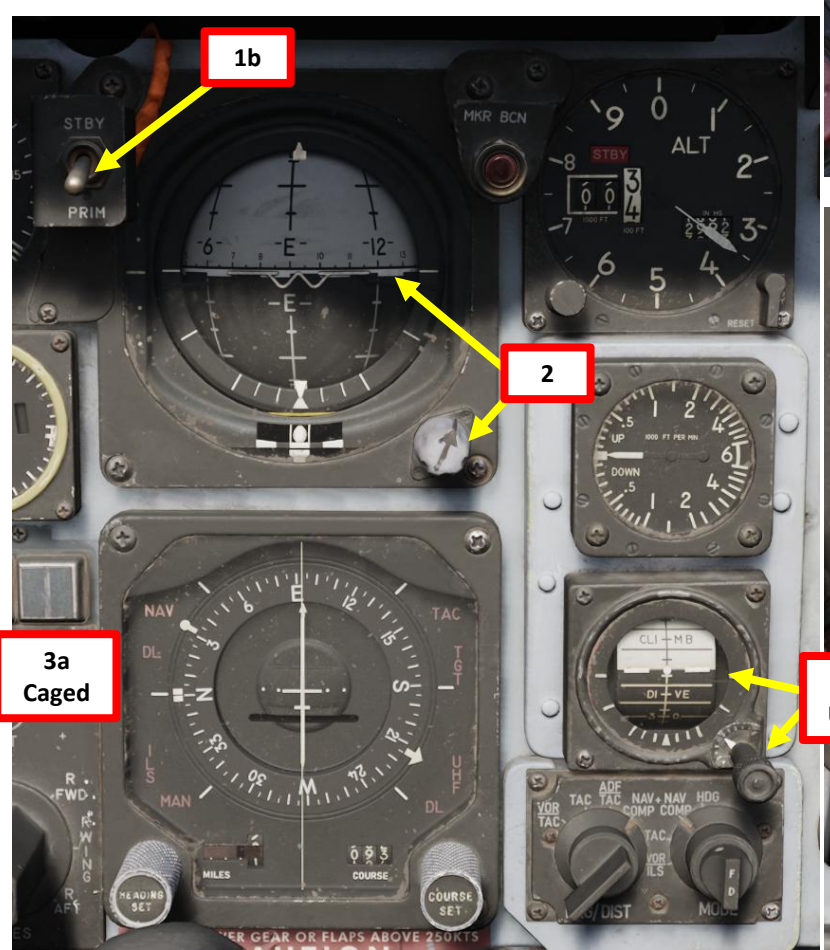




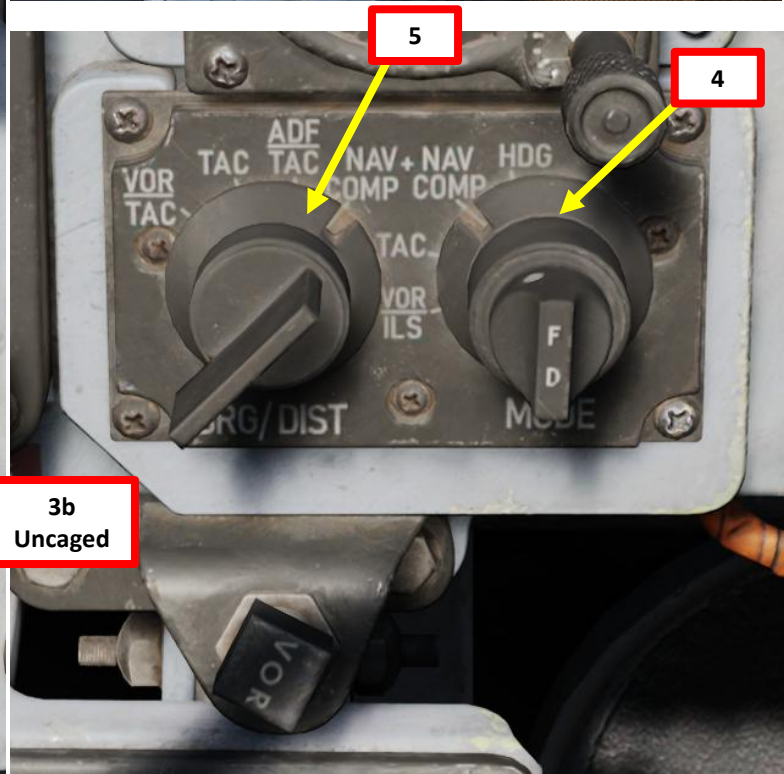
D – BEFORE TAXI (PILOT)

1. *[P]* Once INS alignment is complete, set Reference System Switch – PRIMARY (DOWN).
2. *[P]* Adjust ADI (Attitude Director Indicator) Pitch Trim Line with the Horizon Line position.
3. *[P]* Uncage Standby Attitude Indicator by pushing the Cage/Uncage Knob IN, then adjust the horizon line with the center of the ball. Check that red flag disappears.
4. *[P]* Set Navigation Mode Selector (Outer Knob) – NAV COMP (Navigation Computer)
5. *[P]* Set Navigation Input Selector – NAV COMP (Navigation Computer).
6. *[P]* Set Compass Mode Selector – Set to SYNC (Synchronize), then release. Selector will spring back to SLAVED.



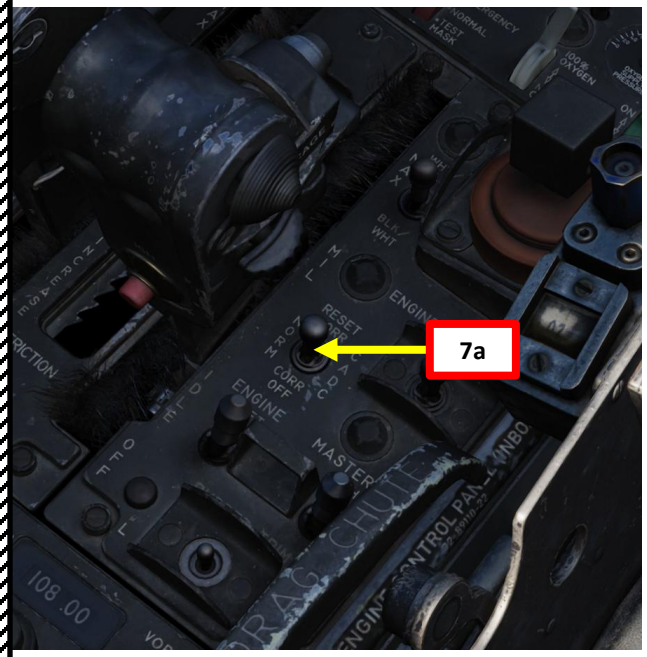


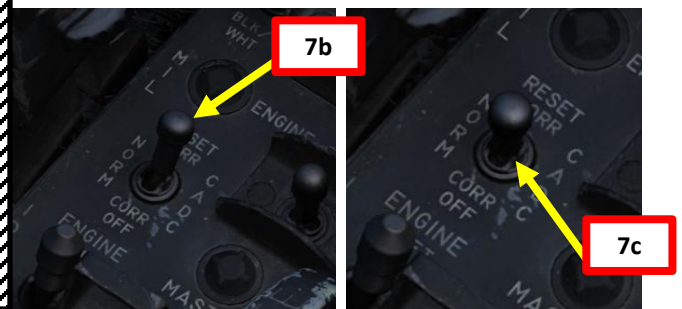




D – BEFORE TAXI (PILOT)

7. *[P]* If the STATIC CORR OFF light is illuminated, the SPC (Static Pressure Compensator), must be reset. Set CADC (Central Air Data Computer) Switch to RESET CORR (FWD), then to NORM (MIDDLE). Confirm the STATIC CORR OFF light extinguishes.
    - The SPC performs correction of altimeter lag caused by rapid altitude change.
8. *[P]* Press the Master Caution Reset Button to clear MASTER CAUTION light.



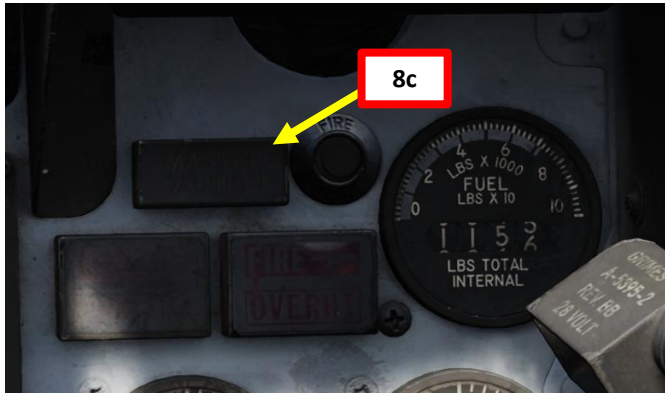






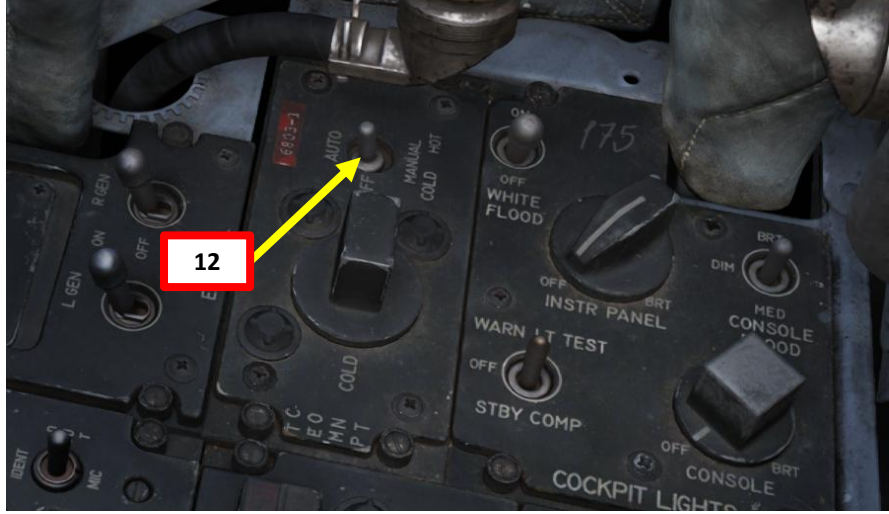


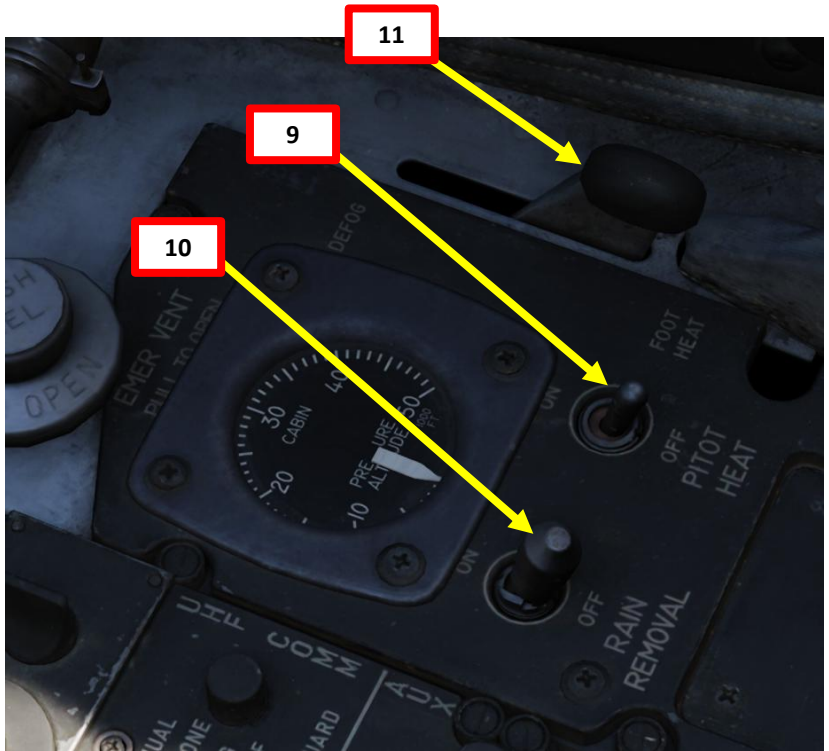




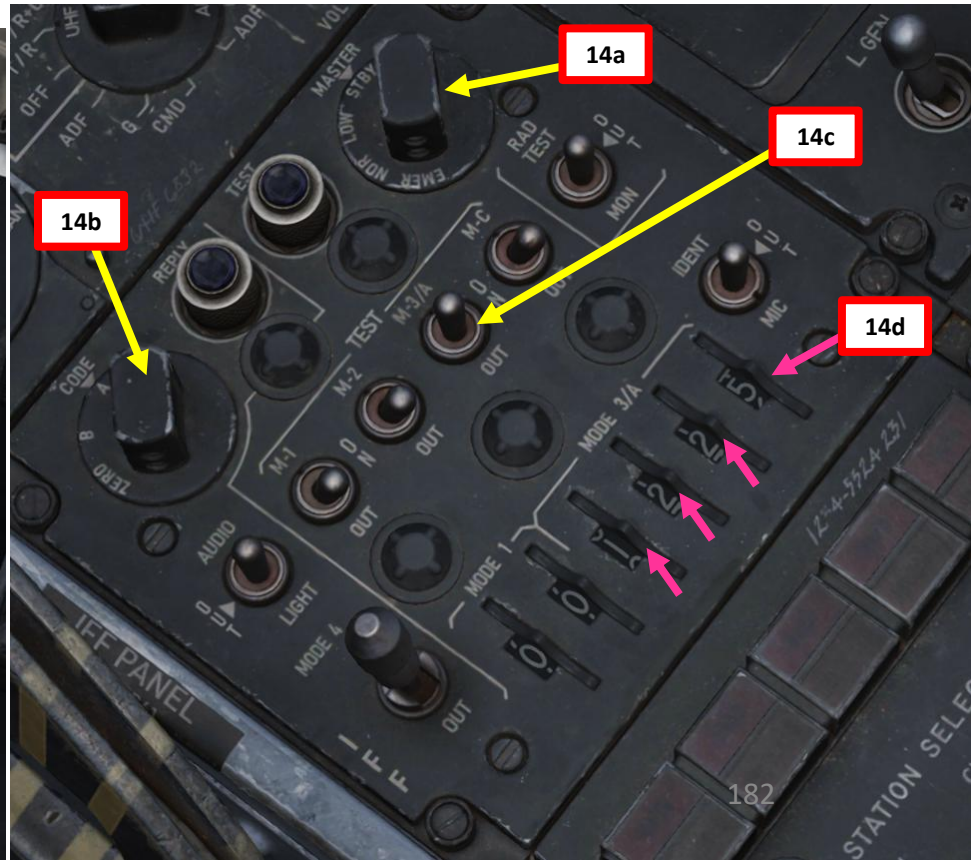
D – BEFORE TAXI (PILOT)

9. *[P]* Set Pitot Heat Switch– OFF (AFT)
    - *Note: The Pitot Heat switch should always be turned on before takeoff but not for longer than one minute as it could damage the instrument.*
10. *[P]* Set Rain Removal Switch – OFF (AFT)
11. *[P]* Set Defog Handle – OFF (AFT)
12. *[P]* Set Cockpit Temperature Control Switch – AUTO (FWD)
13. *[P]* Check Pneumatic Pressure – Within White Range. Sufficient air must be available to cool avionics.
14. *[P]* Set your IFF (Identify-Friend-or-Foe) Transponder Code – As required by mission briefing. As an example, if we need an IFF Transponder set to Mode 3/A Code 1225:
    a) Set IFF Master Selector to STANDBY.
    b) Set IFF Code Selector to A
    c) Set IFF Mode 3/A Switch – ON (MIDDLE)
    d) Set IFF Mode 3/A Channel Wheel Selectors to “1225”.





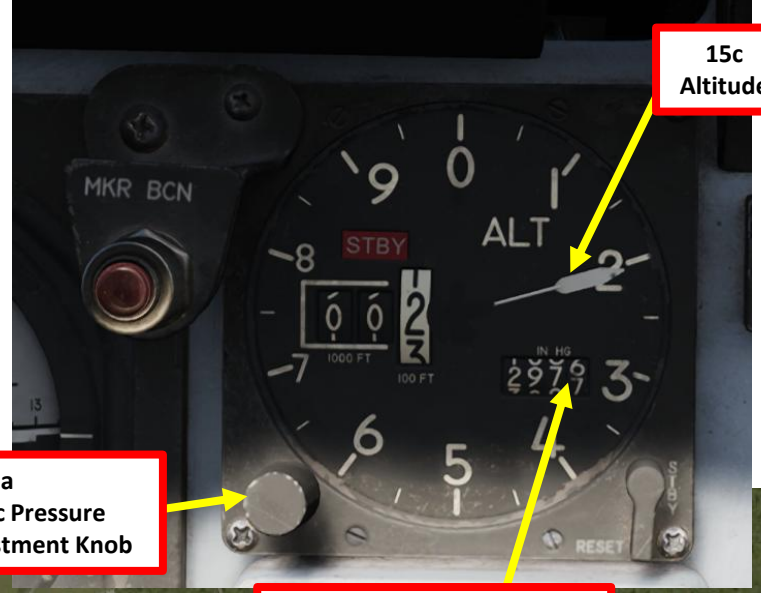


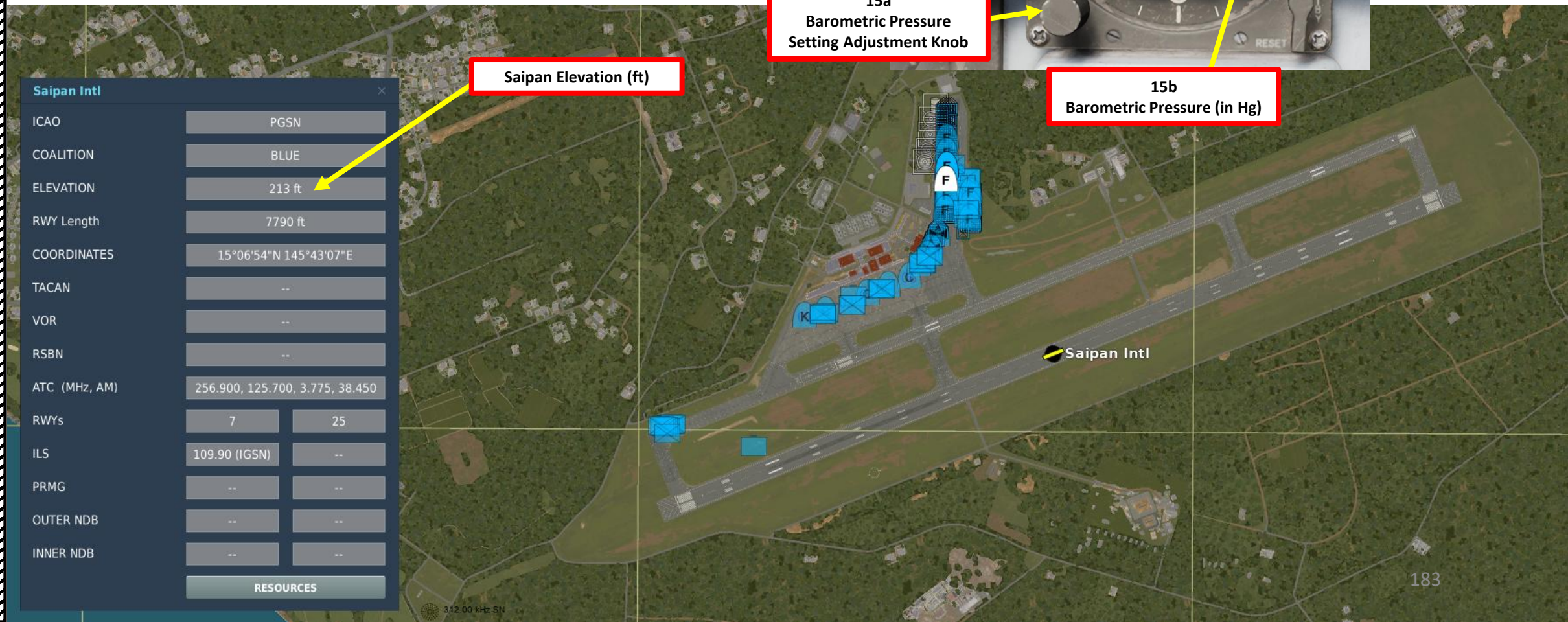


D – BEFORE TAXI (PILOT)

15. [P+WSO] Set altimeter barometric pressure setting.

- If airfield elevation data is available, you can adjust the barometric pressure knob to make the altimeter reading match the airfield elevation (which would be 213 ft in our case since we takeoff from Saipan). However, you will have to keep in mind that your altitude reading will be AMSL (Above Mean Sea Level), not from the ground. This is important to remember when being directed by the ATC (Air Traffic Controller).
- Alternatively, you can set the barometric pressure knob to make the altimeter reading match "0". In that case, the altitude reading will be AGL (Above Ground Level), not from sea level.





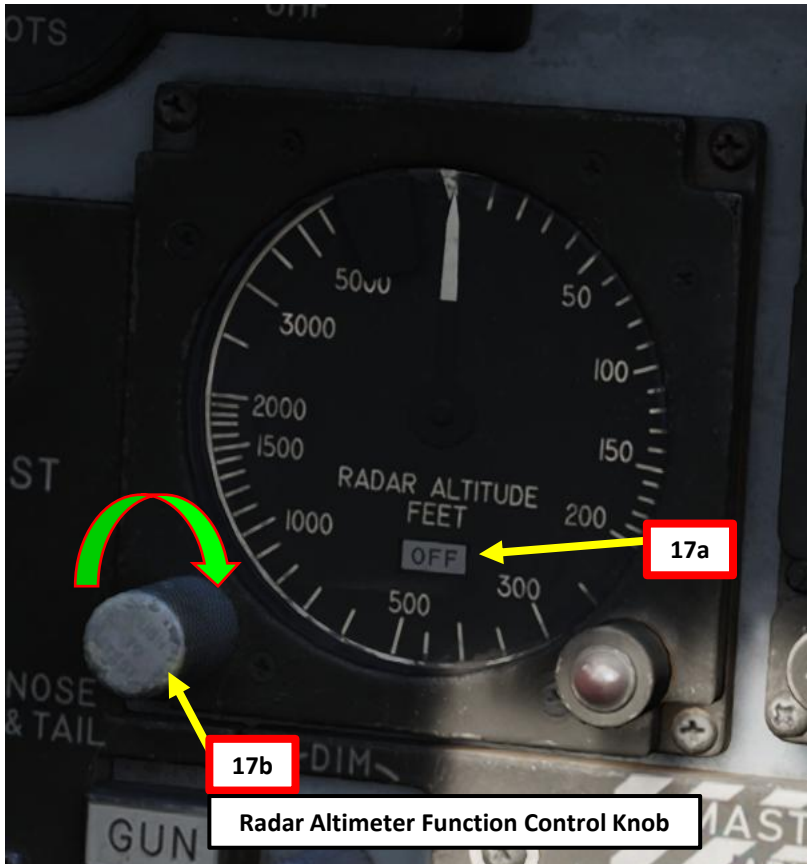
D – BEFORE TAXI (PILOT)

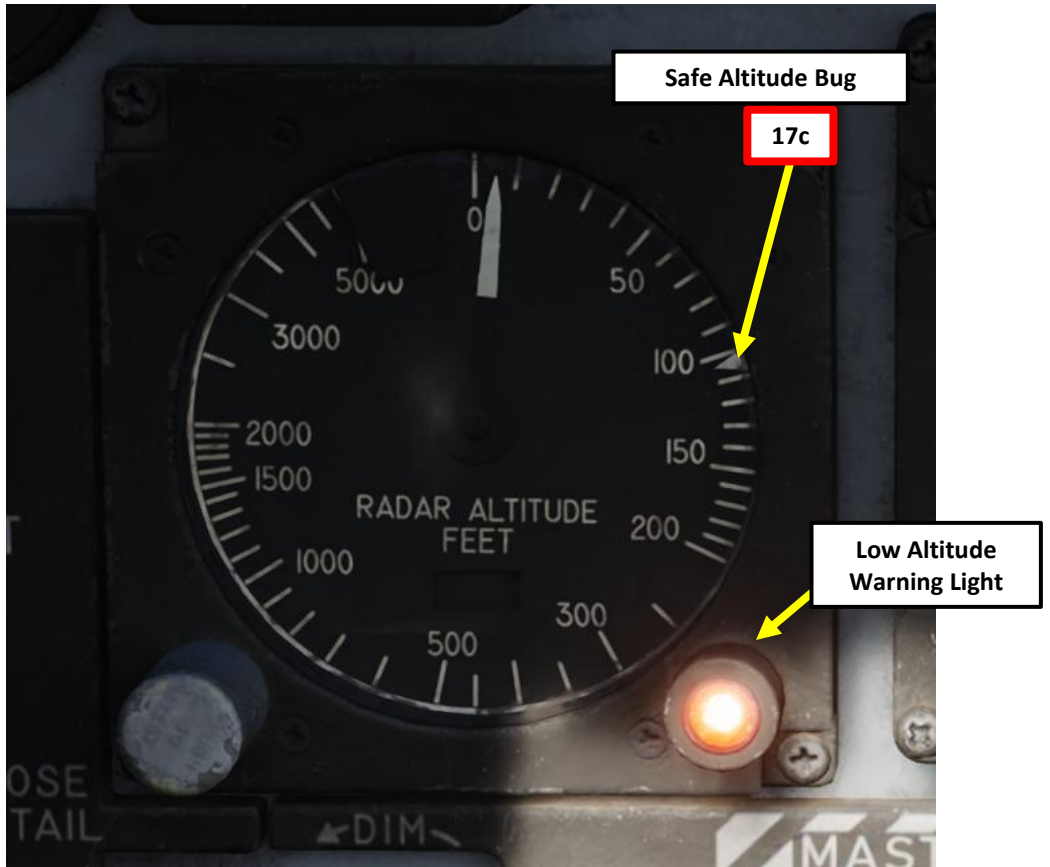
16. *[P+WSO]* Hold altimeter mode switch to RESET until STBY red flag disappears, then release switch back to vertical position.
17. *[P]* Power Up Radar Altimeter by turning the Radar Altimeter Function Control Knob clockwise until the OFF flag is removed. Then, turn the knob until safe altitude bug is set. We will set it to 100 ft. As a result, a low altitude warning light illuminates, which is expected.
    - Note: A self-test can be initiated by pressing the Radar Altimeter Function Control Knob IN. The radar altimeter will then show 35 ±15 feet until the knob is released.











D – BEFORE TAXI (PILOT)

18. *[P]* Set AN/ALE-40 Flare Mode Switch – NORMAL (INBOARD).
19. *[P]* Press on the AN/ALR-46 RWR (Radar Warning Receiver) Power Button.
20. *[P]* A BIT (Built-In Test) will occur; the RWR control panel and display will cycle through their initial 9-second warmup, with the display and illuminated buttons undergoing rapid flashing as the system is prepared for use and proper functioning is confirmed. Search mode is deactivated by default upon startup.
21. *[P]* Select RWR Search Mode.



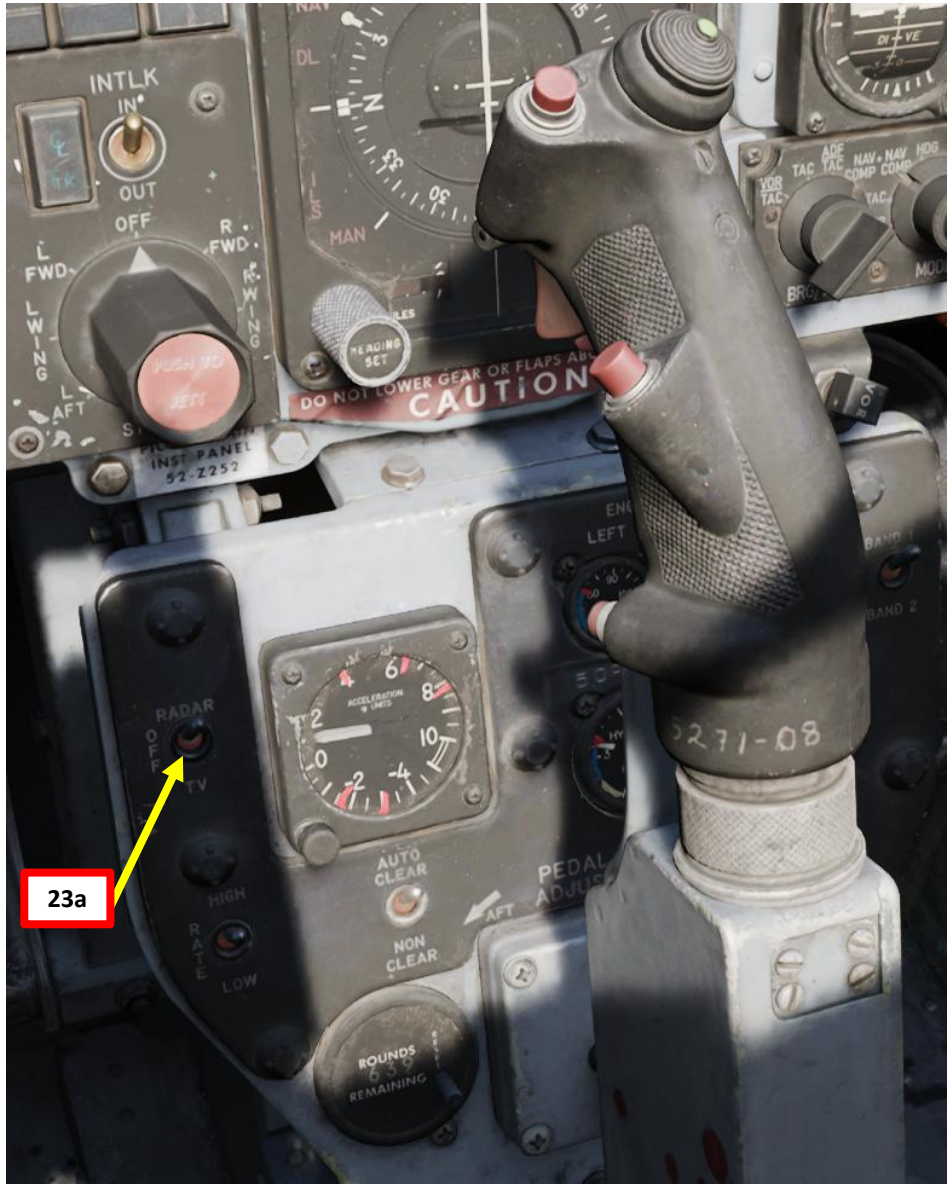


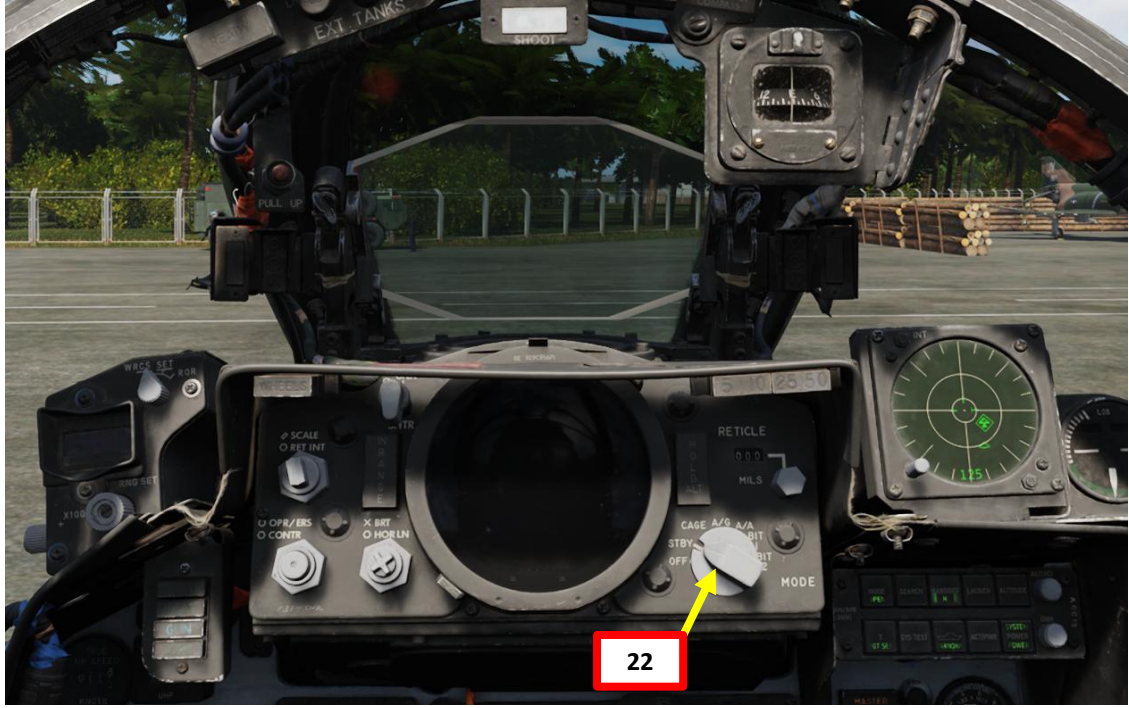


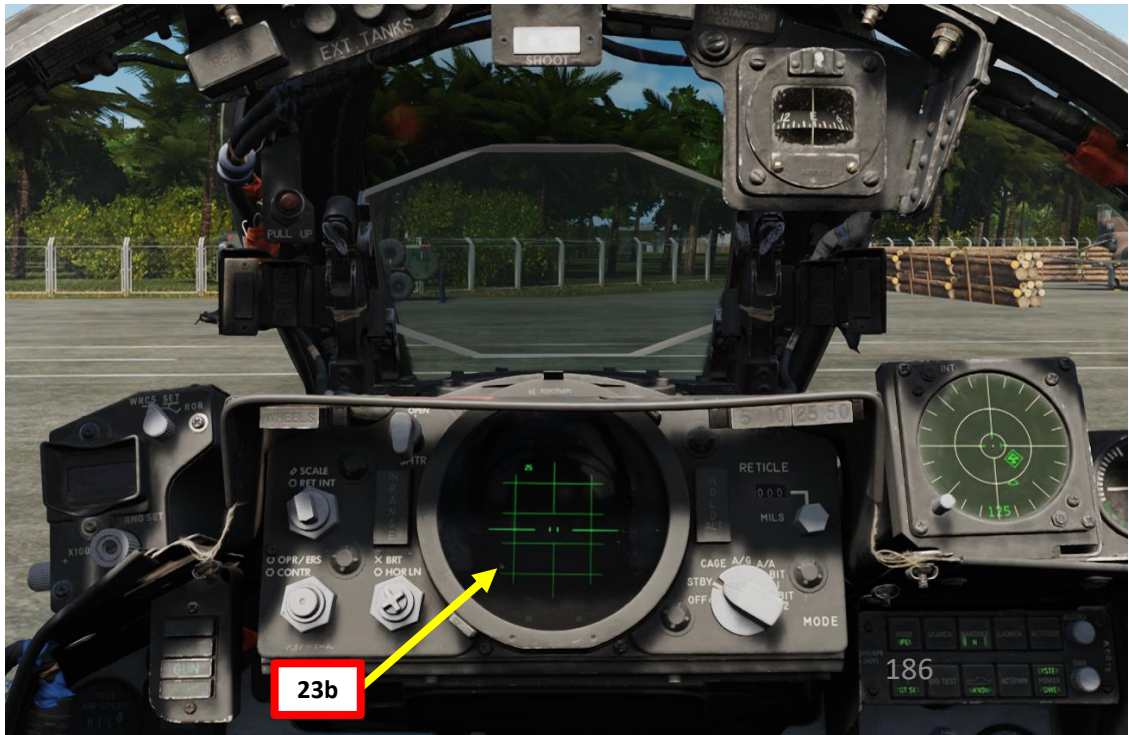


D – BEFORE TAXI (PILOT)

22. *[P]* Set Optical Sight Mode – STANDBY (or CAGE).
23. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).





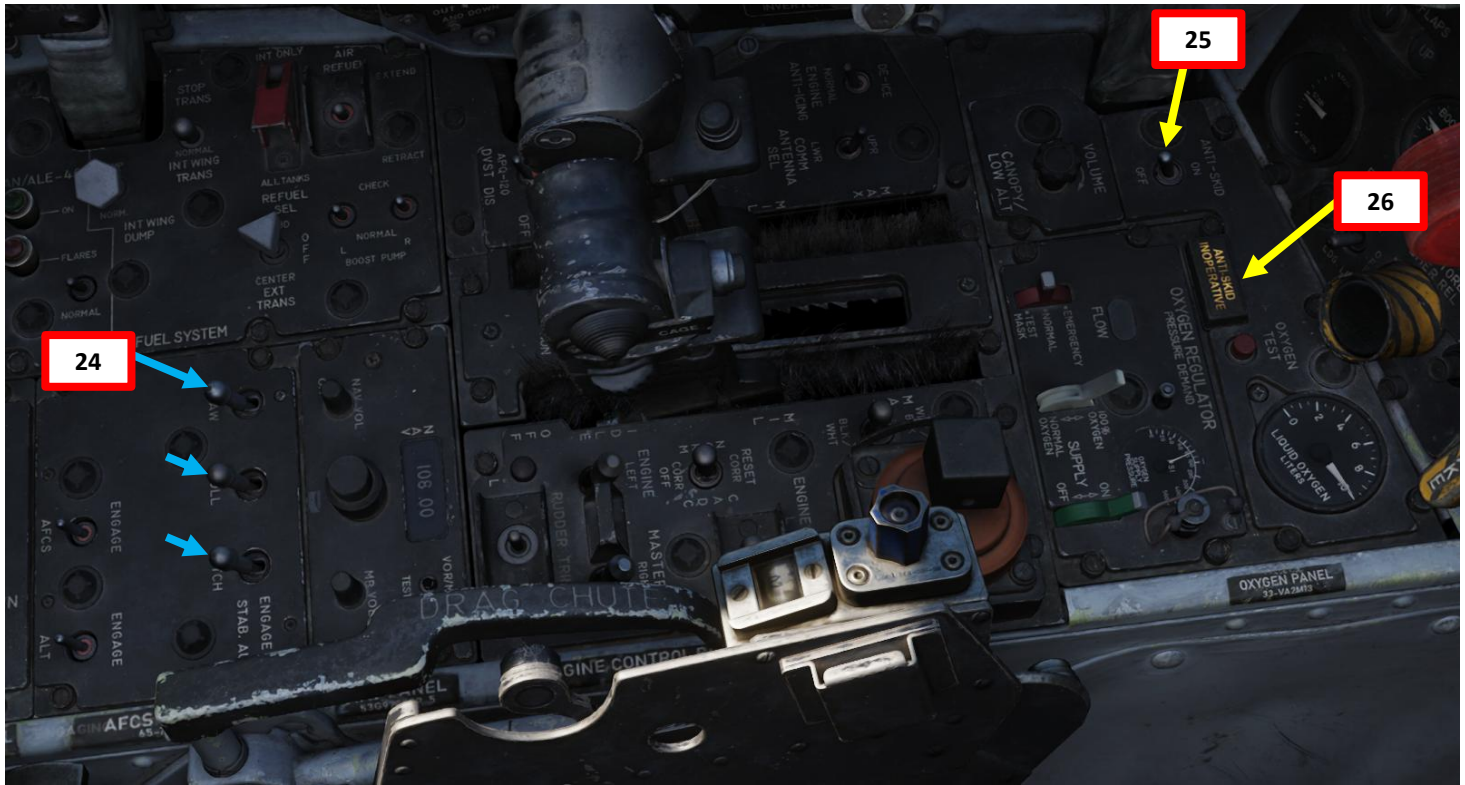


D – BEFORE TAXI (PILOT)

24. *[P]* On AFCS (Automatic Flight Control System) panel, set Yaw, Roll & Pitch Stability Augmentation System Switches – OFF (AFT). Confirm PITCH AUG OFF light is illuminated.
25. *[P]* Set Anti-Skid Switch – OFF (AFT).
26. *[P]* Confirm ANTI-SKID INOPERATIVE light is illuminated.
27. *[P]* Set Pitch Trim – 3 Units Nose Down





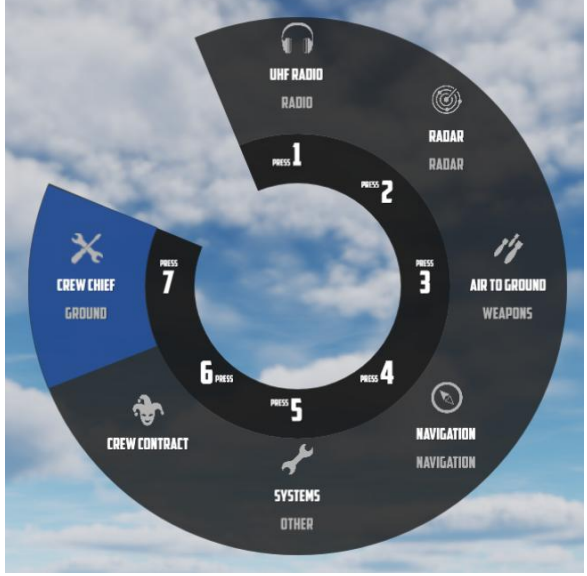


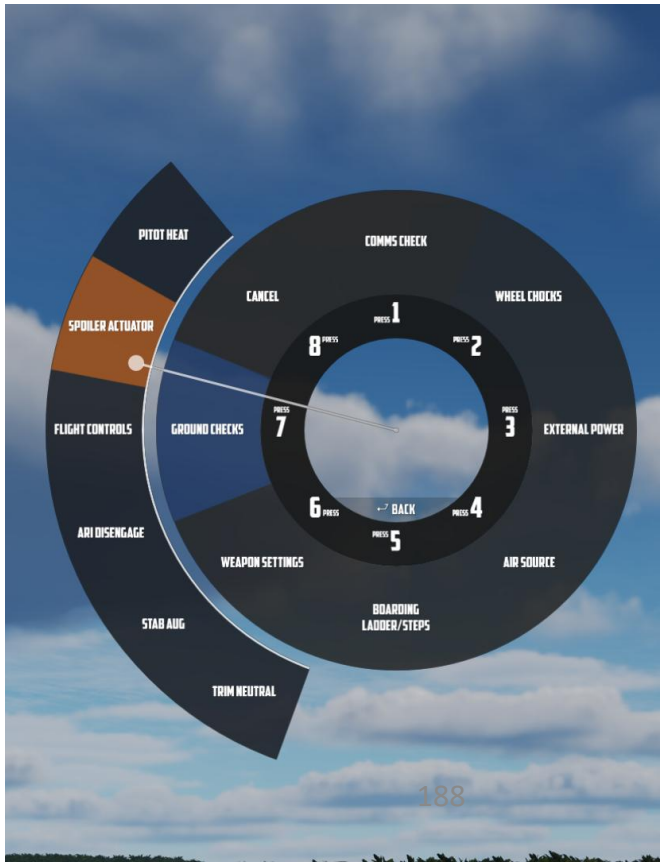


D – BEFORE TAXI (PILOT)

28. *[P]* From the CREW CHIEF menu, it is possible to perform a number of ground checks.
For simplicity, we will skip them and assume the aircraft is fully operational.

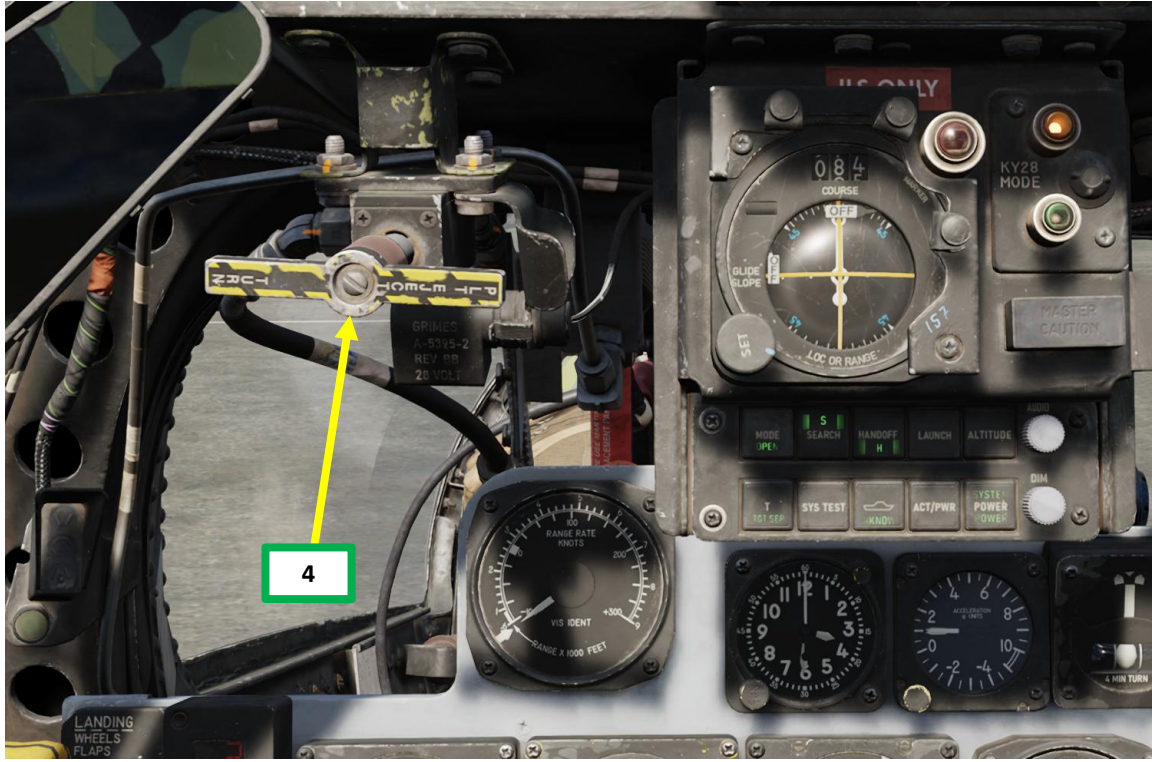


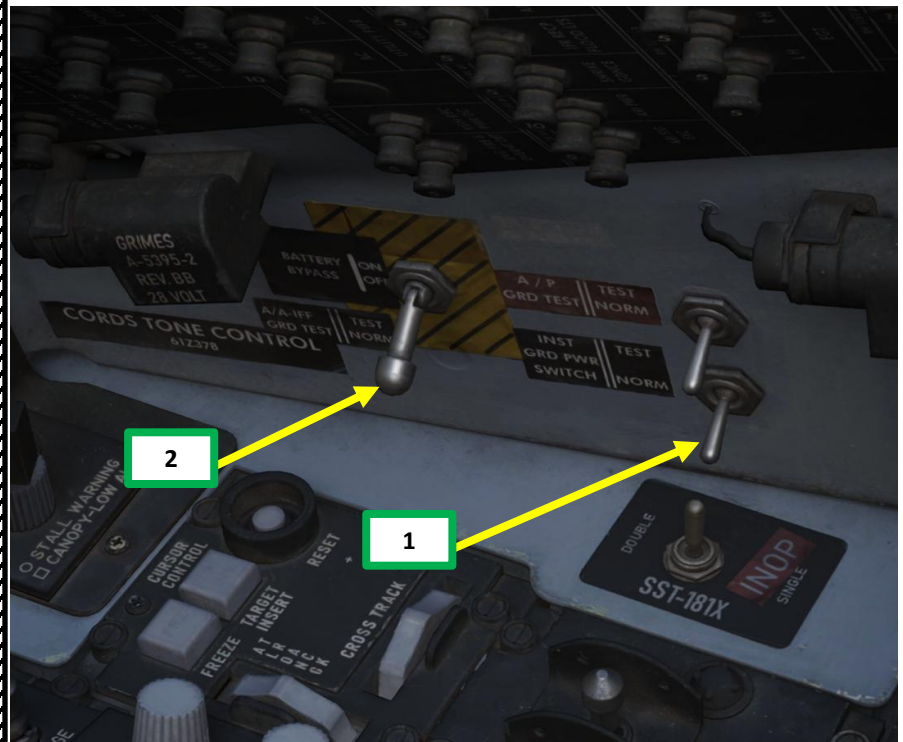


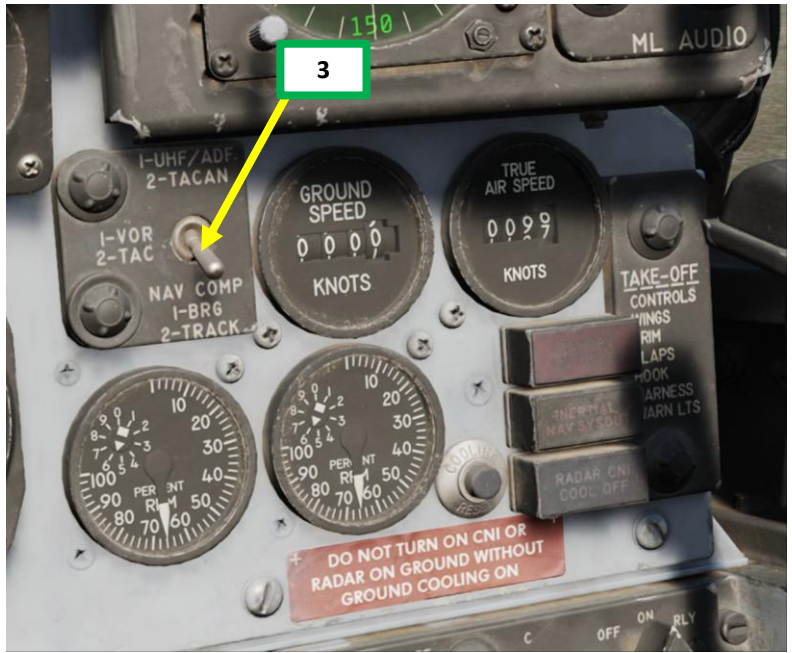


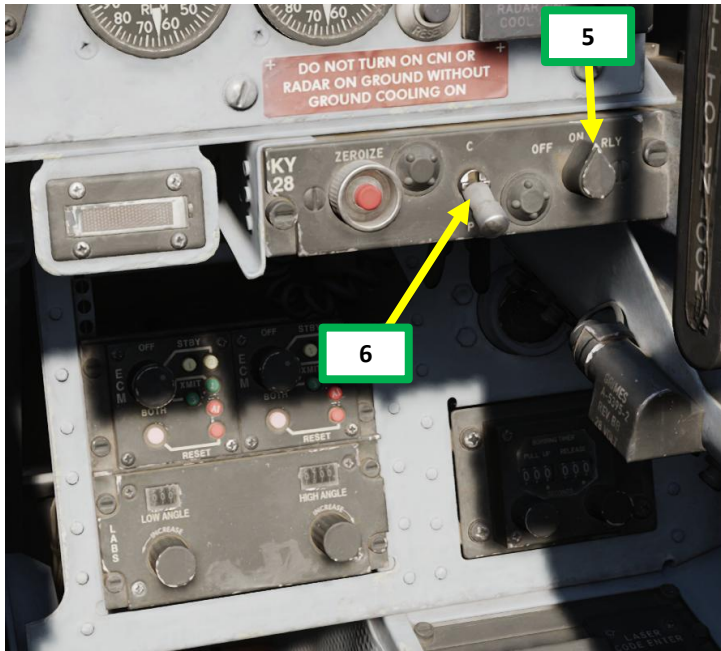
E – BEFORE TAXI (WSO)

1. *[WSO]* Once engines are running, generator switches are set to ON (FWD) and INS alignment is complete, make sure the Instrument Ground Power Test Switch is set to NORM (DOWN).
2. *[WSO]* Check Battery Bypass Switch is set to OFF (DOWN).
3. *[WSO]* Set WSO Navigation Mode Selector Switch – NAVIGATION COMPUTER (DOWN)
4. *[WSO]* Set Ejection Command Selector Handle – As required.
    - **Handle Vertical**: WSO setting, initiation of ejection by the WSO ejects only the rear seat.
    - **Handle Horizontal**: BOTH setting, initiation of ejection by the WSO ejects both crew members.
5. *[WSO]* Set KY-28 Encryption Power Selector – ON
6. *[WSO]* Select KY-28 Encryption Mode Selector – As required.
    - C (Cipher) if encrypted communications are required
    - P (Plain) if unencrypted communications are allowed



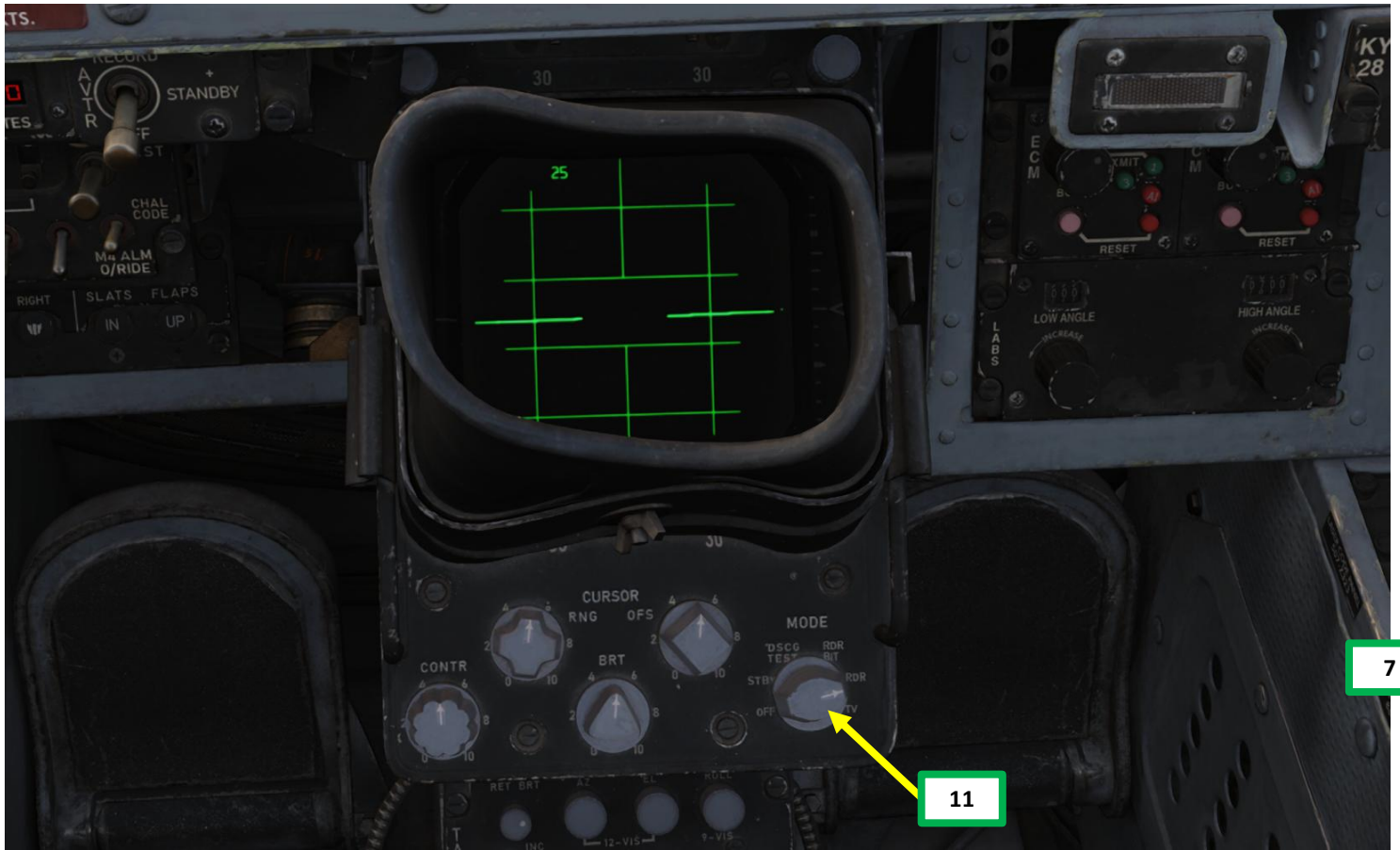


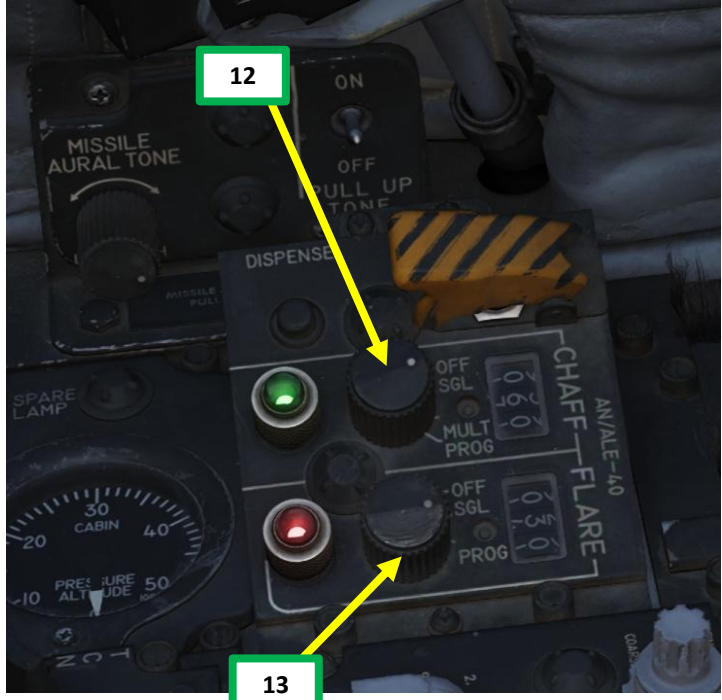


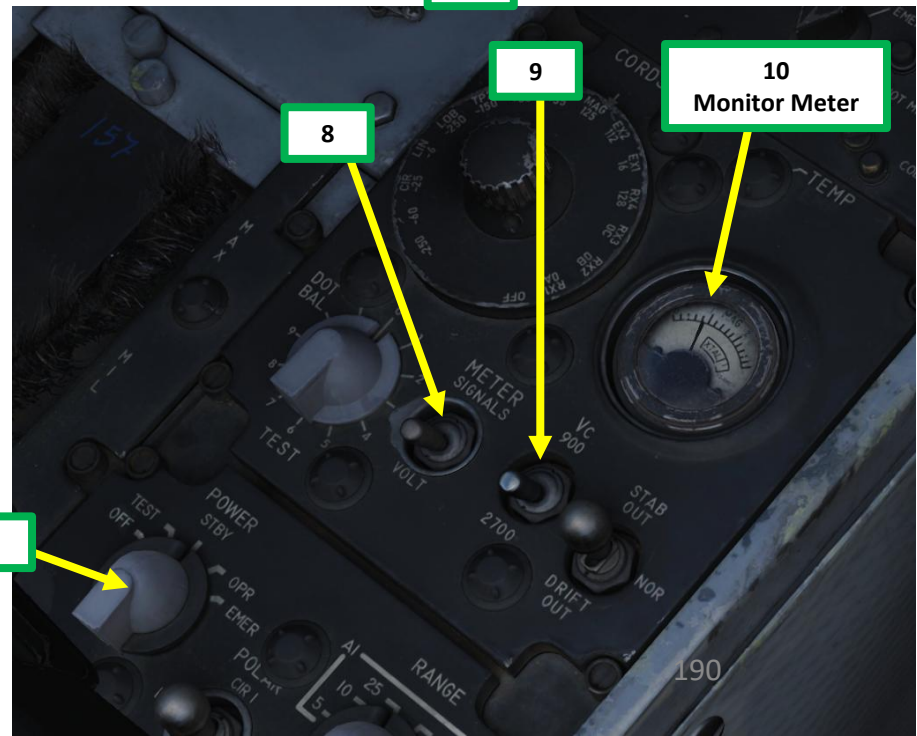


E – BEFORE TAXI (WSO)

7. *[WSO]* Power up AN/APQ-120 Fire Control Radar. Set Radar Power Selector Knob – STBY (Standby).
8. *[WSO]* Set Meter Switch – VOLTS (AFT)
9. *[WSO]* Set Vc (Closure Rate) Display Switch – 2700 (AFT)
10. *[WSO]* **Radar warmup cycle requires 3 minutes**. After 30 seconds, Monitor Meter displays roughly 250 Vdc; from the point the needle shows power at this nominal value, the warm-up procedure will be 2.5 minutes.
11. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar) or STBY (Standby), as desired.
12. *[WSO]* Set AN/ALE-40 Chaff Mode Switch – As required. We will set SGL (Single).
13. *[WSO]* Set AN/ALE-40 Flare Mode Switch – As required. We will set SGL (Single).







E – BEFORE TAXI (WSO)

14. [WSO] If AN/AVQ-23 Pave Spike Targeting Pod is equipped:

a) Set Target Designation Power On Button – ON.

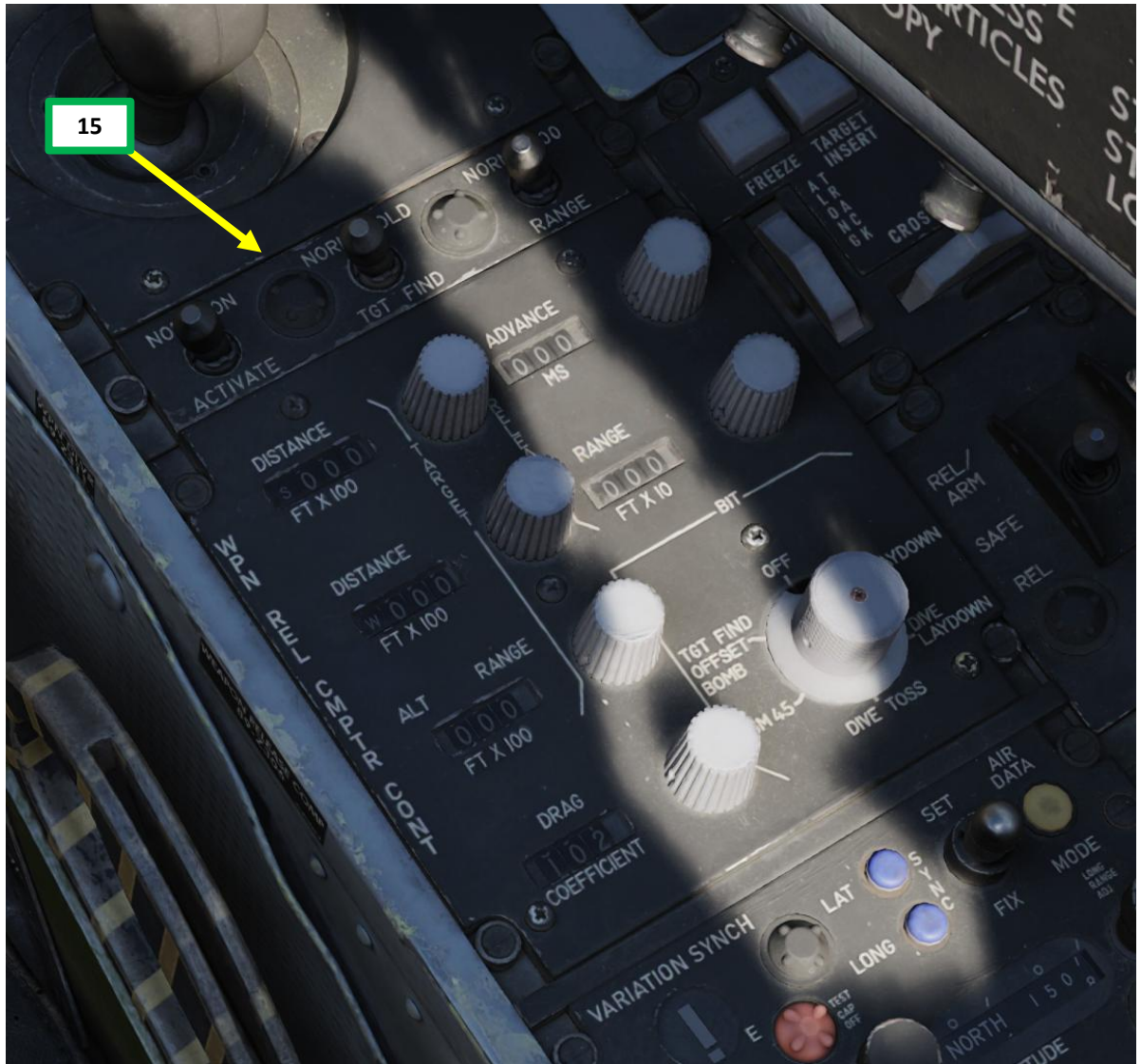
b) Set Target Designation Stow Button – ON. The pod's head is stowed when the button is illuminated.





E – BEFORE TAXI (WSO)

15. [WSO] Set WRCS (Weapon Release Computer Set) Panel – As required based on mission parameters. *This step will be omitted for simplicity*.



E – BEFORE TAXI (WSO)

16. [WSO] Once all systems are set up, contact the pilot and let him know that the aircraft is ready for taxi.



PART 4 – START-UP PROCEDURE





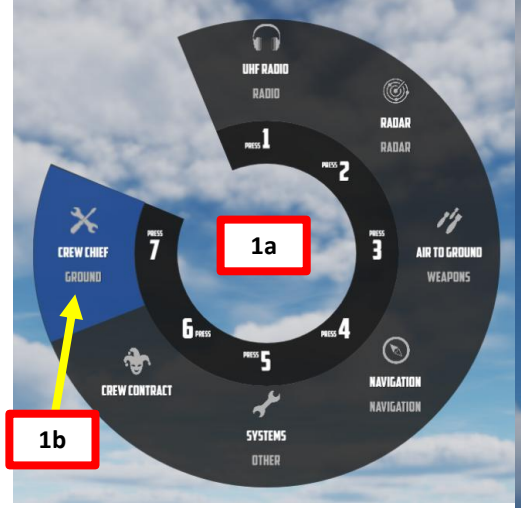


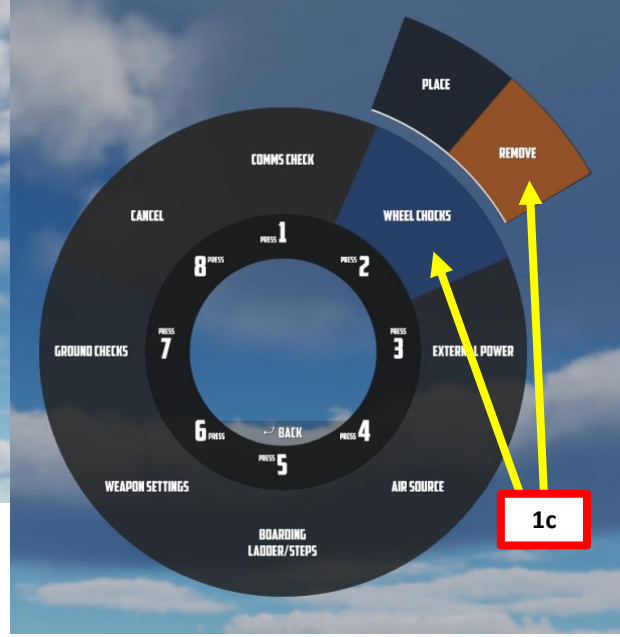
TAXI

1. *[P]* Request ground crew to remove wheel chocks.
   a) Open JESTER AI wheel by short-pressing “A”.
   b) Click on CREW CHIEF
   c) Click on WHEEL CHOCKS, then REMOVE
   d) Close JESTER AI wheel by long-pressing “A”.
2. *[P]* Hold wheel toe brakes and check braking action.

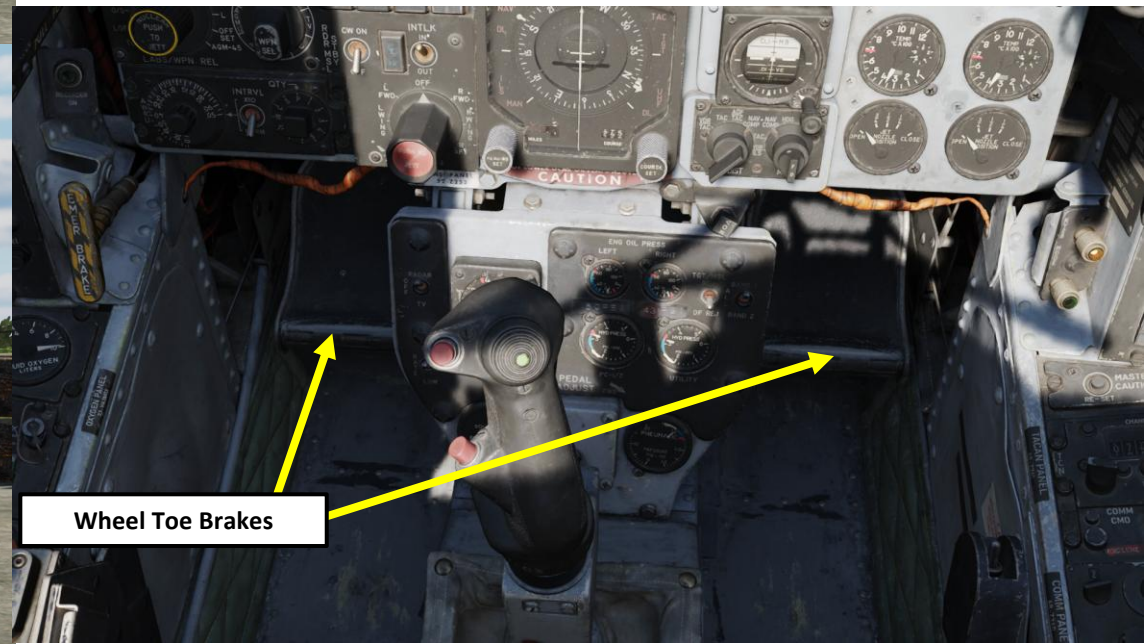








See Part 20 – REFERENCE MATERIAL for Abbreviated Checklists.

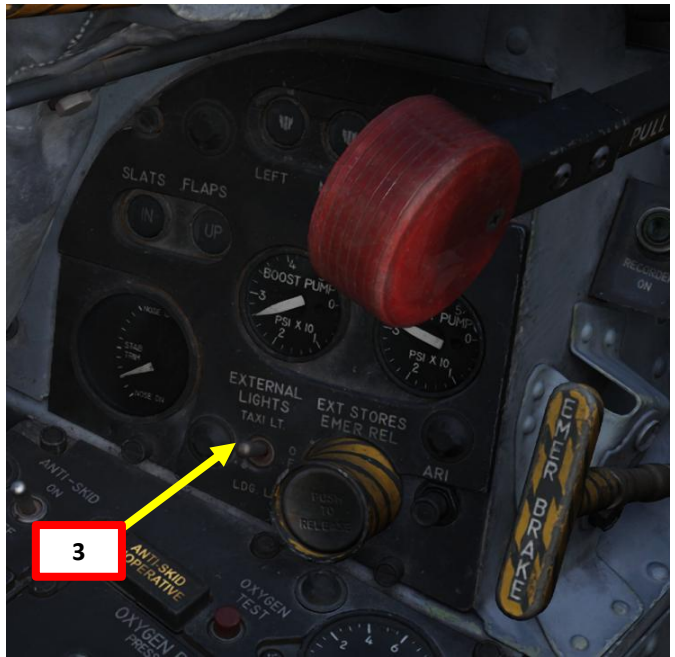


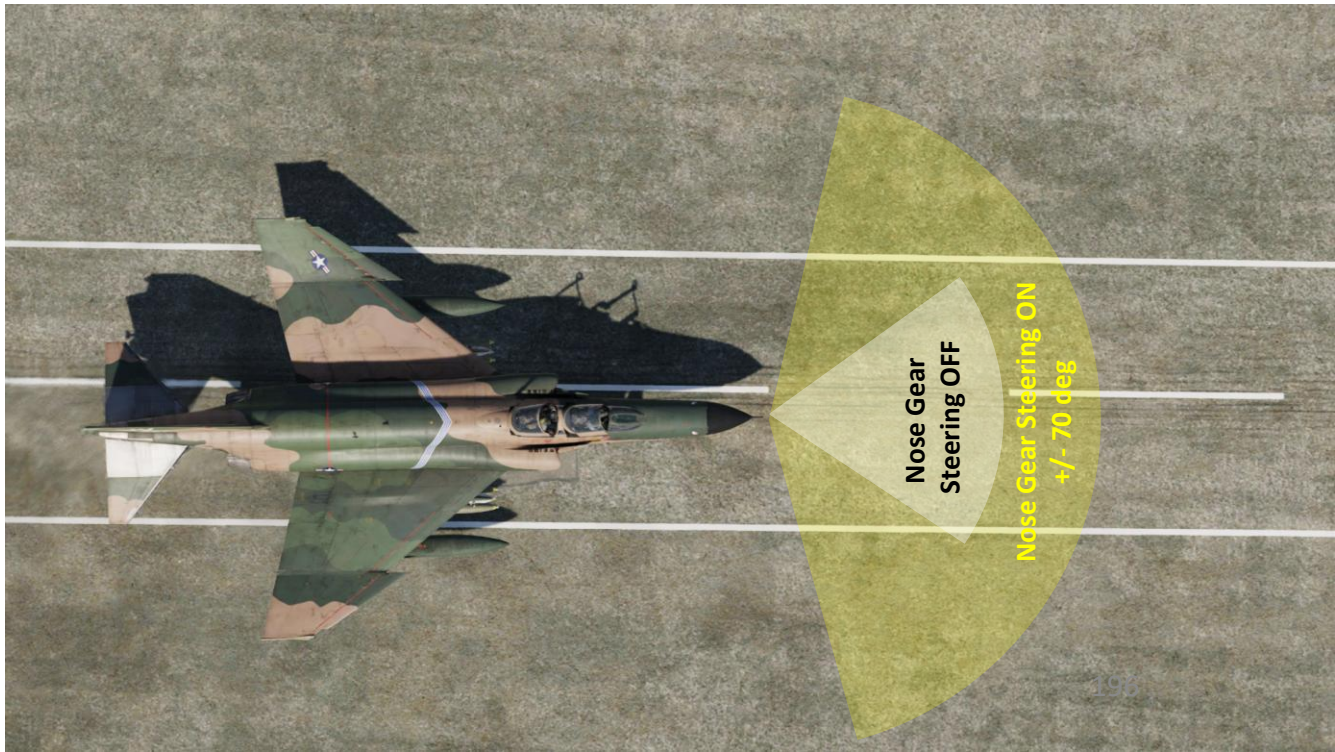
TAXI

3. *[P]* Set Taxi/Landing Light Switch – TAXI LT (UP)
4. *[P]* Release brakes, then slowly throttle up until aircraft starts moving.
5. *[P]* To perform a turn, press and hold the Nose Gear Steering Button on the stick (“N” binding) and use rudder pedals to turn in the desired direction. Steering limit of the nose gear is 70 deg from centerline in both direction. Release Nose Gear Steering Button when turn has been performed.
6. *[P]* Do not exceed 15 knots for taxi speed during turns.









TAXI

7. *[P]* While taxiing, JESTER will ask you if we are going low for the mission. Based on your answer, his tolerance before ejecting due to a perceived risk of pilot CFIT (controlled flight into terrain) will be adjusted accordingly.
8. *[P]* Taxiing with open canopies was common practice for Phantom crews due to the abysmal air conditioning system. Heat inside the cockpit was a real problem on the ground since most of the available engine bleed air was used to cool off avionics. Maintain taxi speeds below 60 kts to prevent damage to the canopy operating mechanism.
9. *[P]* Adequate distance between aircraft must be maintained during formation taxi. An open canopy may be damaged by engine exhaust blast.
10. *[P]* When taxiing during high gross weight conditions, the turning radius should be increase to relieve excessive side loads on the main landing gear struts, wheels and tires.
11. *[P]* Hold short of the runway departure area and perform Before Takeoff checks.

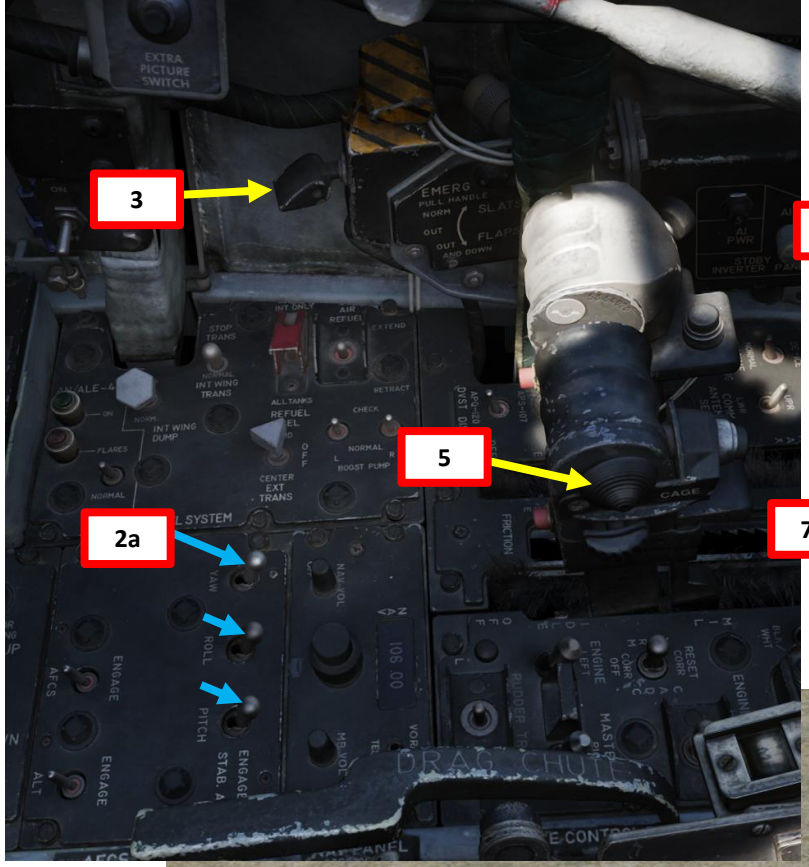


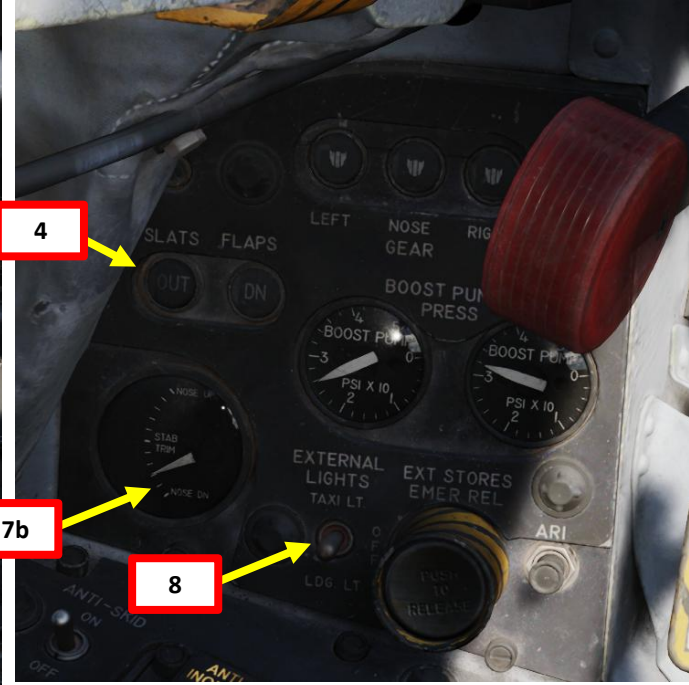


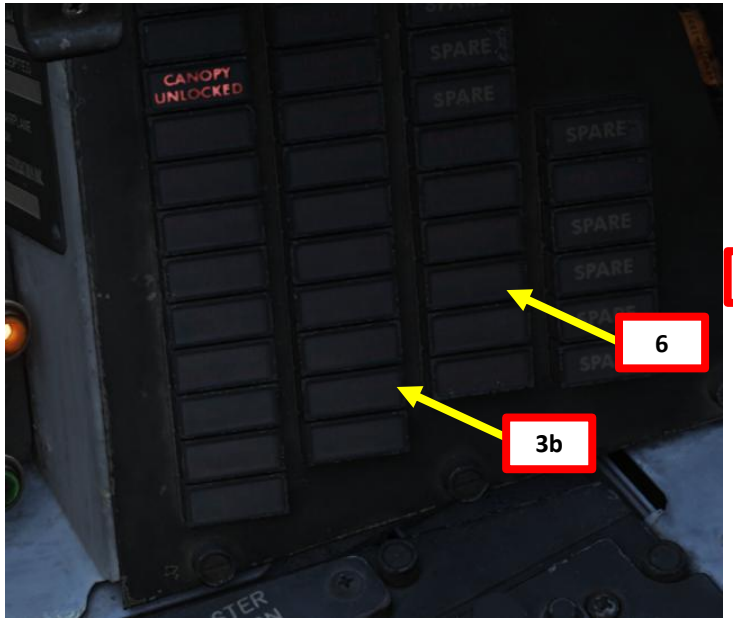


BEFORE TAKEOFF

1. *[P]* Contact tower and obtain clearance for takeoff.
2. *[P]* On AFCS (Automatic Flight Control System) panel, set Yaw, Roll & Pitch Stability Augmentation System Switches – ON (FWD). Confirm PITCH AUG OFF light extinguishes.
3. *[P]* Set Flaps/Slats Control Lever – OUT & DOWN (FULLY DOWN)
4. *[P]* Check SLATS indication displays OUT and FLAPS indication displays DN (Down).
5. *[P]* Set Speed Brake Switch – IN/RETRACTED (FWD).
6. *[P]* Check SPEEDBRAKE OUT light is extinguished, then set Speed Brake Switch – NEUTRAL (MIDDLE).
7. *[P]* Check Pitch Trim is set to 3 Units Nose Down.
8. *[P]* Set Taxi/Landing Light Switch – OFF (MIDDLE).





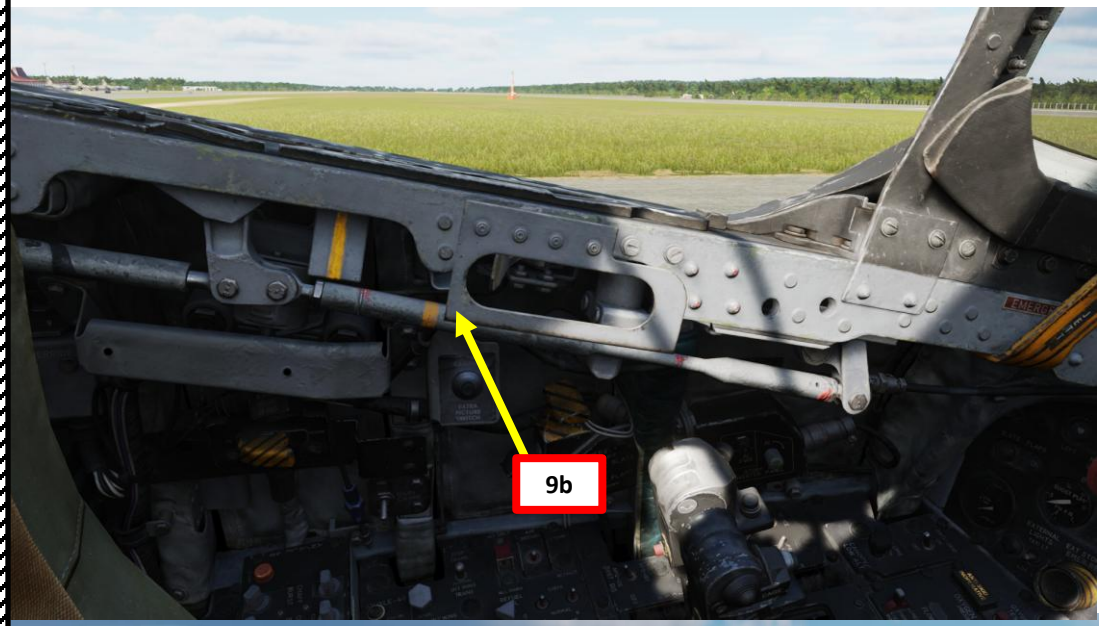






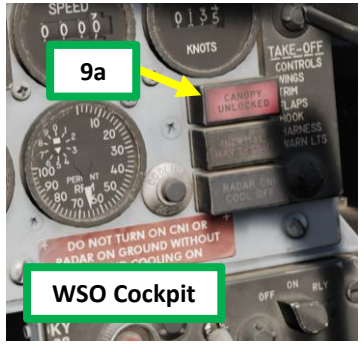
BEFORE TAKEOFF

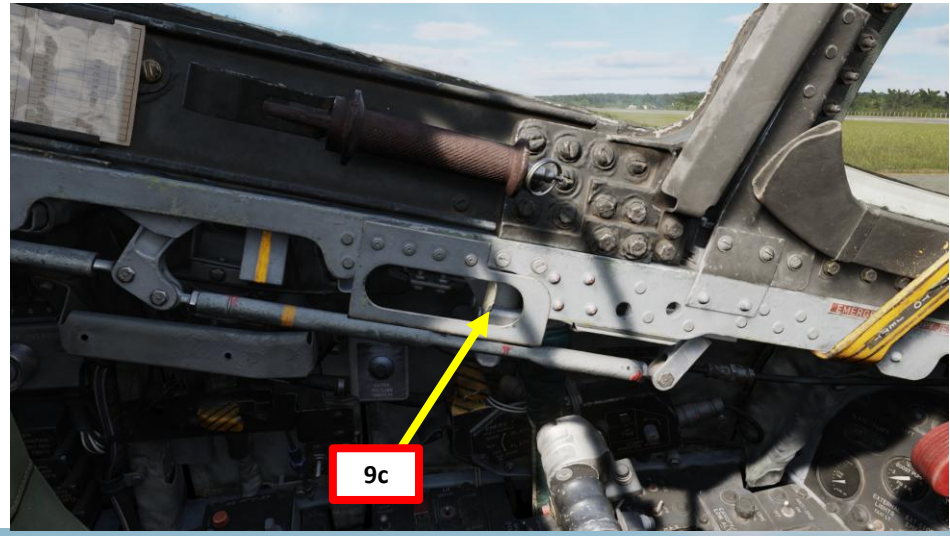
9. *[P+WSO]* Close canopy by setting the Canopy Control Lever FWD. Confirm CANOPY UNLOCKED light extinguishes. (WSO first, then Pilot)











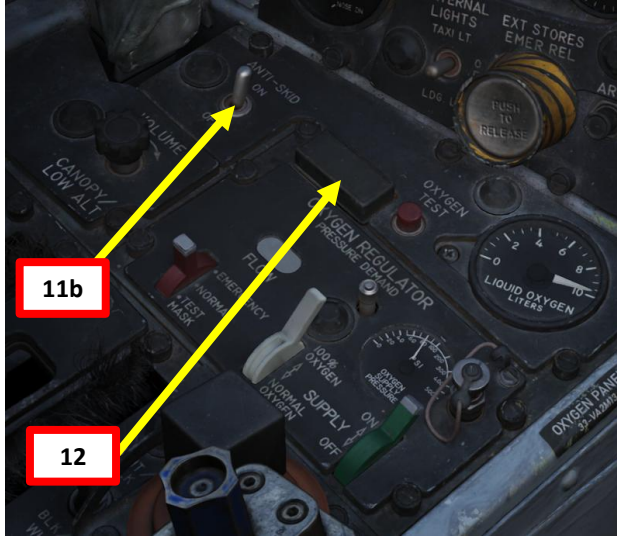


BEFORE TAKEOFF

10. *[P]* Line up on the runway.
11. *[P]* Set Anti-Skid Switch – ON (FWD).
12. *[P]* Confirm ANTI-SKID INOPERATIVE light is extinguished.
13. *[P]* Set Pitot Heat Switch– ON (FWD)
    - *Note: The Pitot Heat switch should always be turned on before takeoff but not for longer than one minute as it could damage the instrument.*
14. *[P]* Set your IFF (Identify-Friend-or-Foe) Transponder Master Selector to NORMAL.
15. *[P+WSO]* Check Circuit Breakers – IN
16. *[P+WSO]* Check Warning Lights – OUT







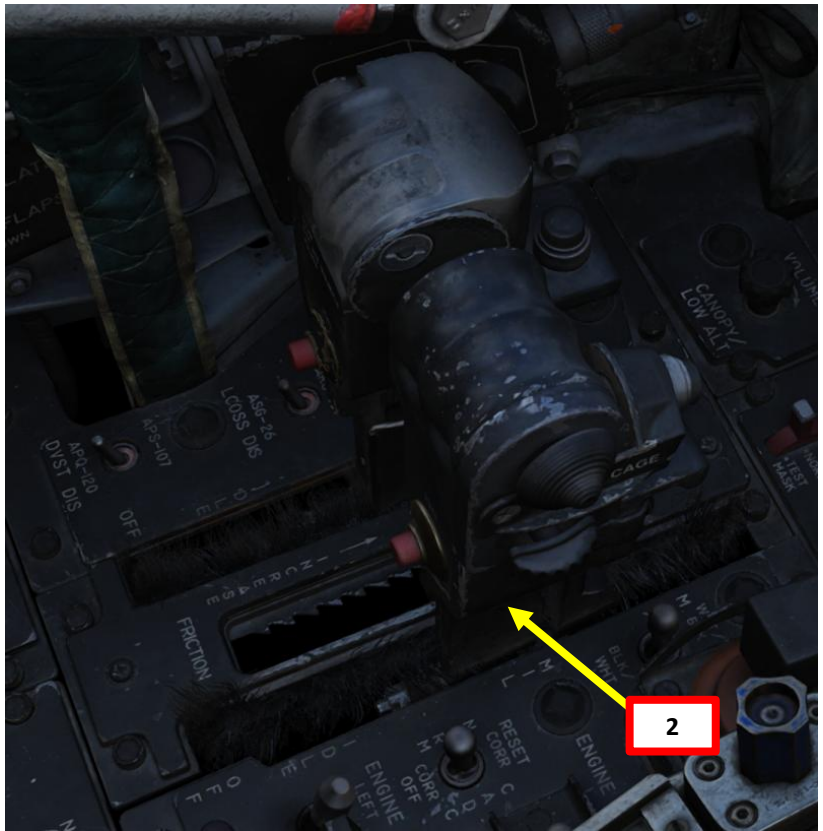


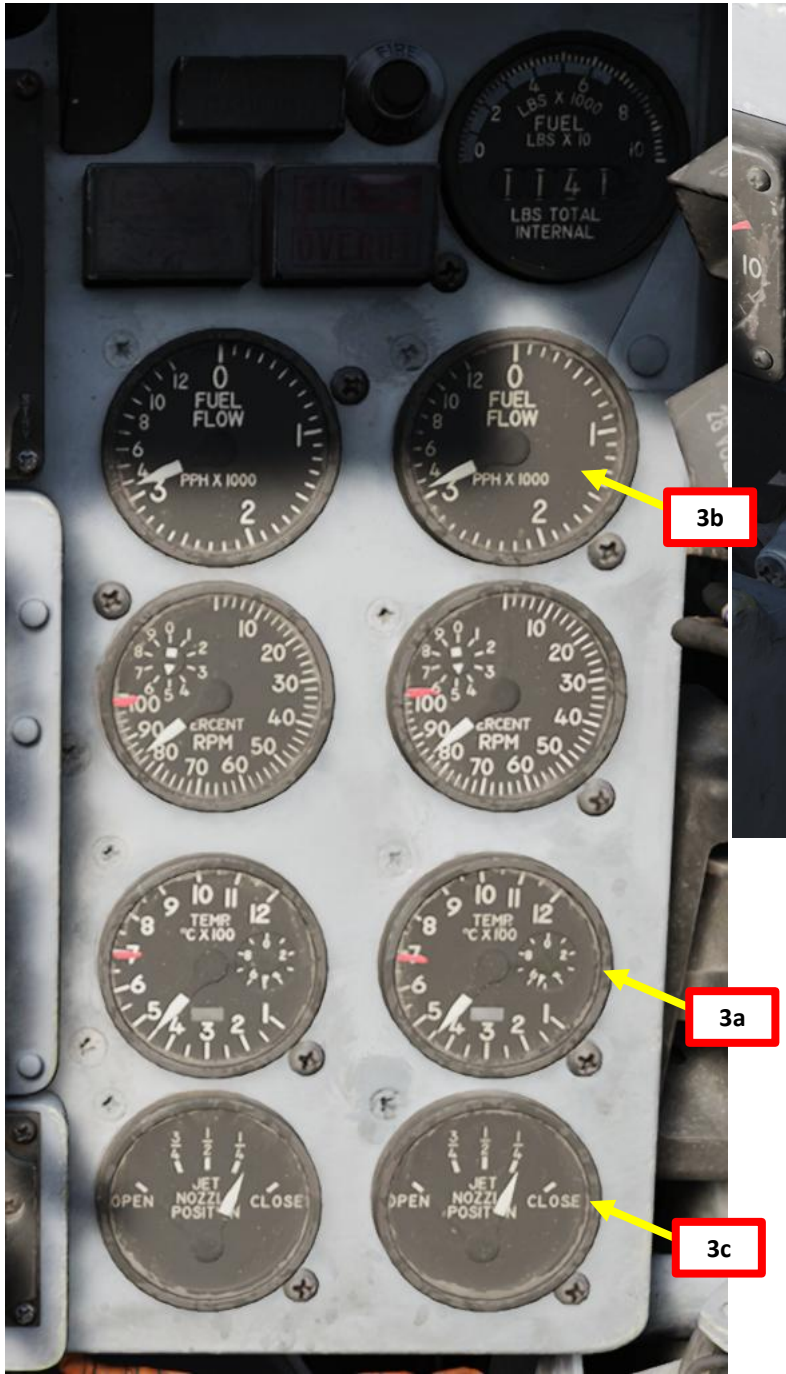


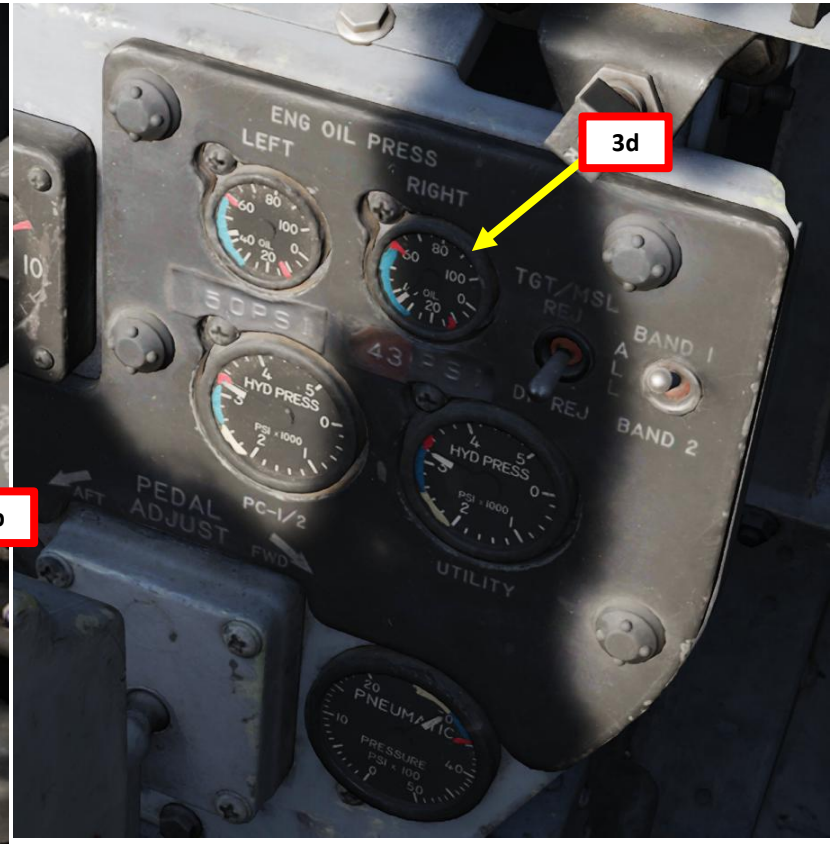
TAKEOFF

1. *[P]* Apply wheel brakes.
2. *[P]* Throttle up to 85 % RPM.
3. *[P]* Check engine parameters.
   a) Exhaust Gas Temperature: 220 to 420 deg C
   b) Fuel Flow Indicator: 800 to 1400 lbs/hour (pph)
   c) Nozzles: 1/4 Open
   d) Engine Oil Pressure: 30 to 40 psi
4. *[P]* Release wheel brakes.
5. *[P]* Throttle up to MIL (Military) Power
6. *[P]* Engine Gauges – Check

See Part 20 – REFERENCE MATERIAL for Abbreviated Checklists.

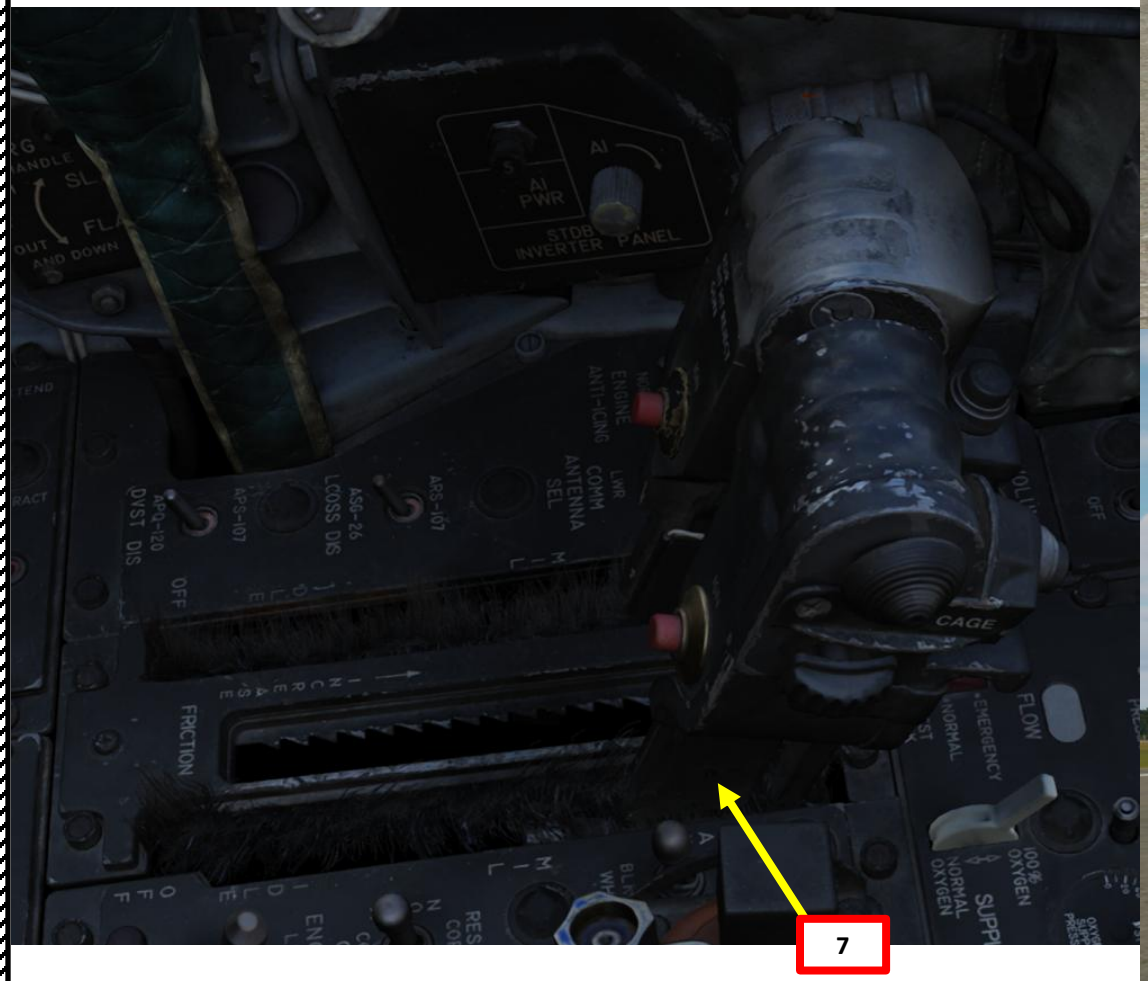






TAKEOFF

7. *[P]* Throttle up to Afterburner
8. *[P]* Nose Gear Steering must be disengaged prior to accelerating to 70 kts.
    - *Note: Rapid full aft movement of the stick between takeoff airspeed and 30 knots below takeoff airspeed may result in the stabilator hitting the runway with the possibility of stabilator actuator damage.*







TAKEOFF

9. *[P]* Pull aft on the stick at 80 kts.
10. *[P]* Maintain 10 deg to 12 deg Pitch Attitude. Trim as required.



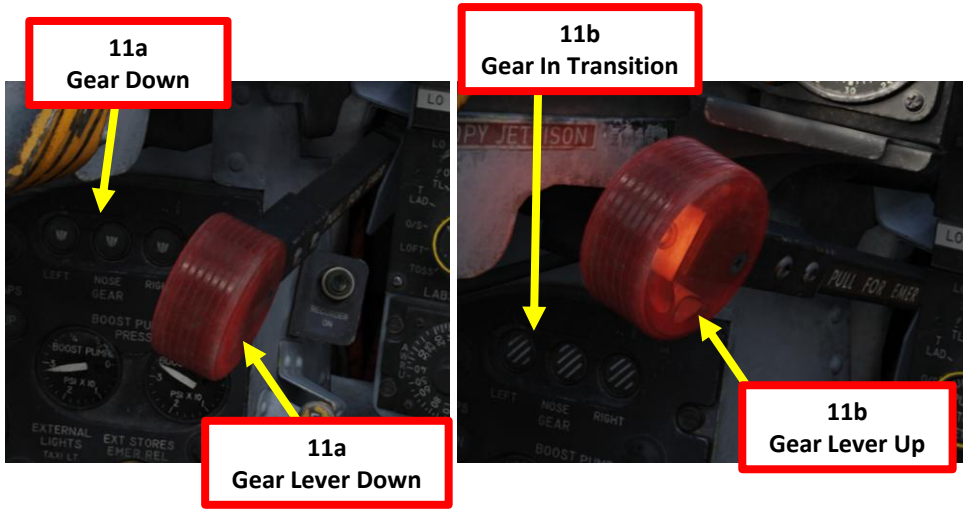


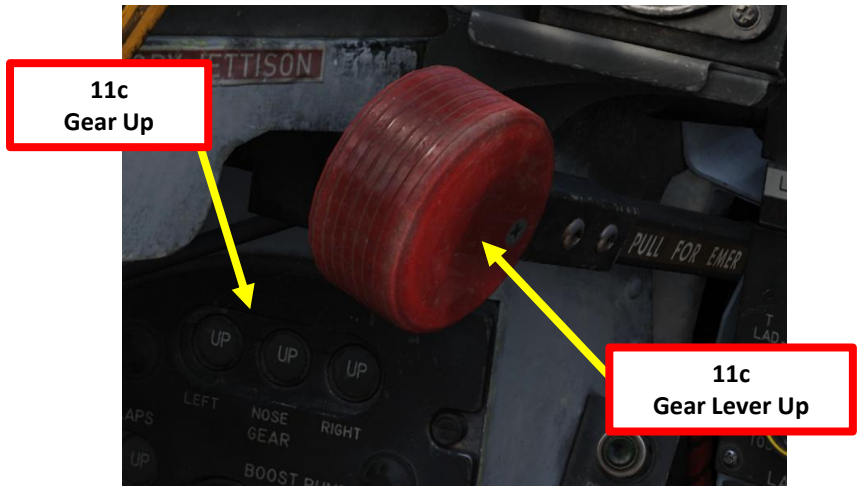


TAKEOFF

11. *[P]* After rotation and attaining a positive rate of climb, set Landing Gear Lever – UP.
    - *Note: The landing gear and gear doors should be completely up and locked before the gear limit airspeed of 250 knots is reached. Otherwise, excessive air loads may damage the landing gear mechanism and prevent subsequent operation.*
12. *[P]* The AUX AIR DOORS, WHEELS, and MASTER CAUTION lights may illuminate momentarily as the landing gear and flaps are retracted.









TAKEOFF

13. *[P]* Accelerate to 180 kts, then set Flaps/Slats Control Lever – NORM (FULLY UP)
    - *Note: Rudder jumps may occur during flap retraction with a lateral stick input. If an audible chattering occurs during slats flaps retraction (associated with slat flap and utility hydraulic pressure indicator fluctuating in unison), maintain airspeed below 250 knots and cycle slats flaps.*
14. *[P]* Check SLATS indication displays IN and FLAPS indication displays UP.

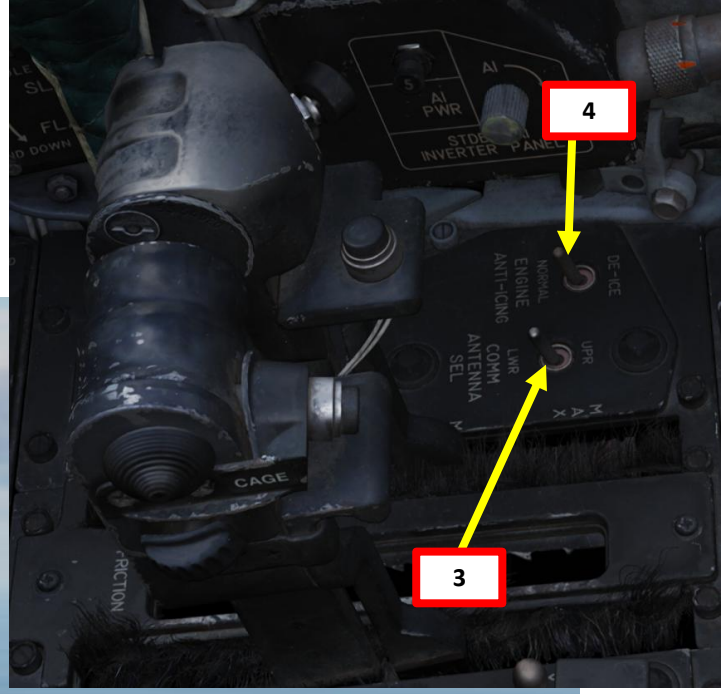






CLIMB

1. *[P]* Throttle back off afterburner, then adjust pitch attitude between 10 and 12 deg while accelerating to 350 kts.
2. *[P]* Climb at 350 kts; adjust aircraft pitch to maintain climb speed until reaching cruising altitude.
3. *[P]* During the climb, it may be necessary to place the antenna selector switch to the LWR (Lower) position to maintain ground communication.
4. *[P]* Set Engine Anti-Icing (De-Ice) Switch – As required.





CRUISE

1. *[P]* Cruise is typically performed between Mach 0.7 and 0.9 depending on drag index.

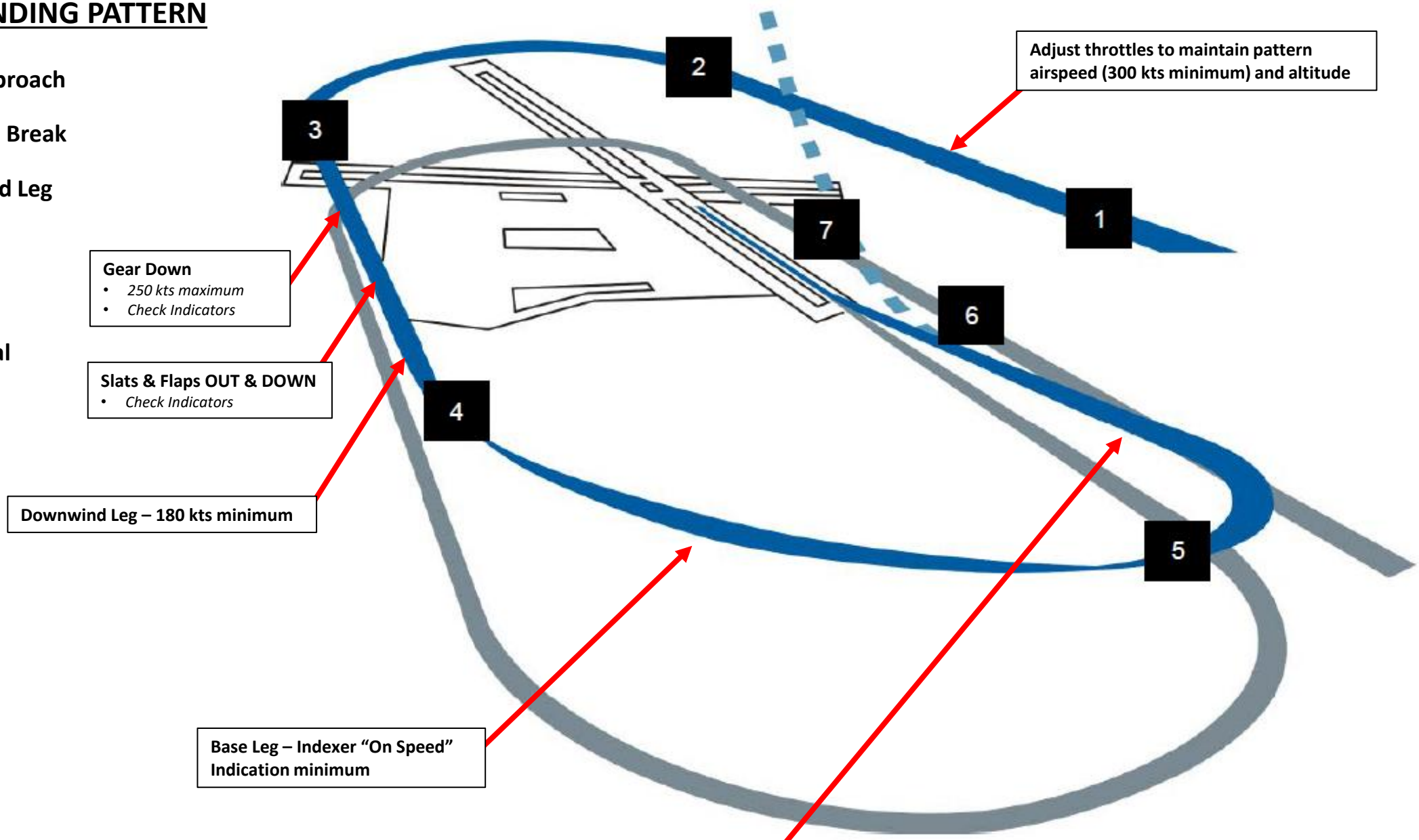


PART 6 – LANDING



VISUAL LANDING PATTERN

1. Initial Approach
2. Overhead Break
3. Downwind Leg
4. Base Turn
5. Final Turn
6. Short Final
7. Roll-Out



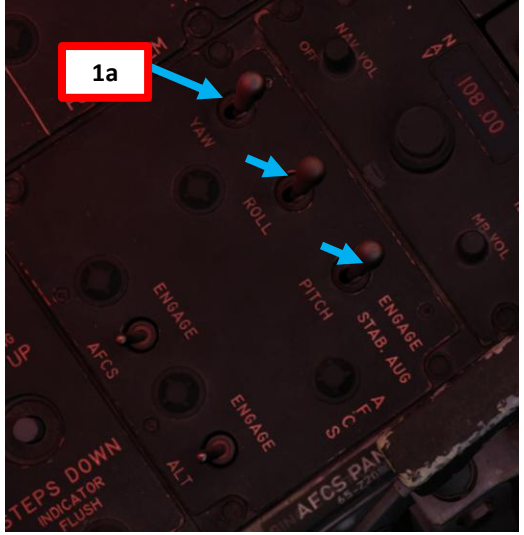
See Part 20 – REFERENCE MATERIAL for Abbreviated Checklists.

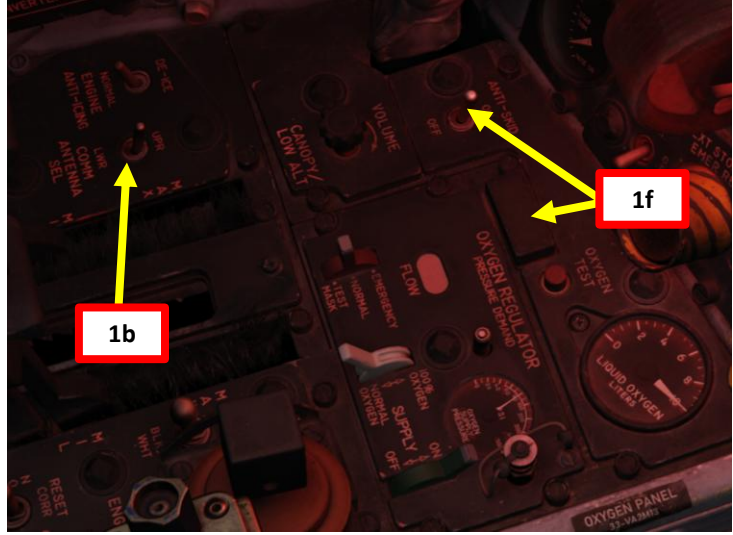
VISUAL LANDING

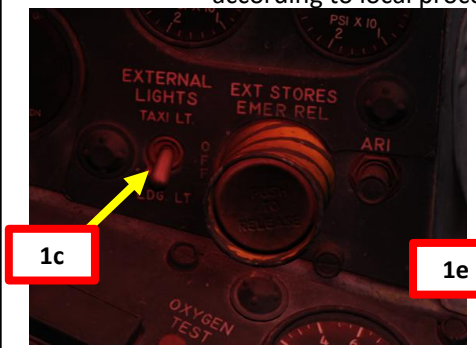


VISUAL LANDING

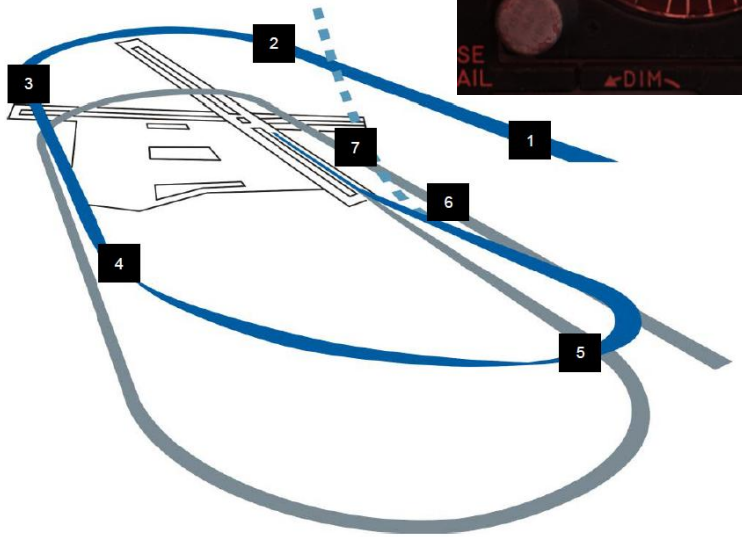
1. **Initial Approach**
   a) On AFCS (Automatic Flight Control System) panel, check Yaw, Roll & Pitch Stability Augmentation System Switches are ON (FWD). Confirm PITCH AUG OFF light is extinguished.
   b) Set Communication Antenna Select Switch – UPR.
      - *Note: Anti-Skid and nosewheel steering may malfunction while transmitting on the lower antenna due to electromagnetic interference.*
   c) Set Taxi/Landing Light Switch – LDG LT (DOWN)
   d) Set Optical Sight Mode – STANDBY (or CAGE).
   e) Set Radar Altimeter Low Altitude Warning Setting – As desired.
   f) Check Anti-Skid Switch is ON (FWD) and confirm ANTI-SKID INOPERATIVE light is extinguished
   g) Align your aircraft with the landing runway at 1500 ft above ground level (or according to local procedures) and maintain 300 kts.







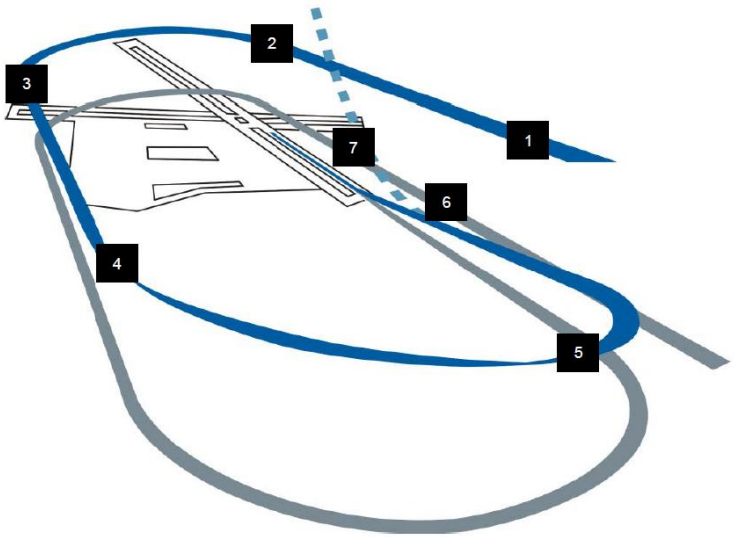






VISUAL LANDING

2. **Overhead Break**
   a) Break left or right over the desired touchdown point
   b) Reduce throttle – as required
   c) Deploy Speed Brakes if required
   d) Fly the break pulling approx. 3 to 4 Gs.
   e) Maintain a level turn

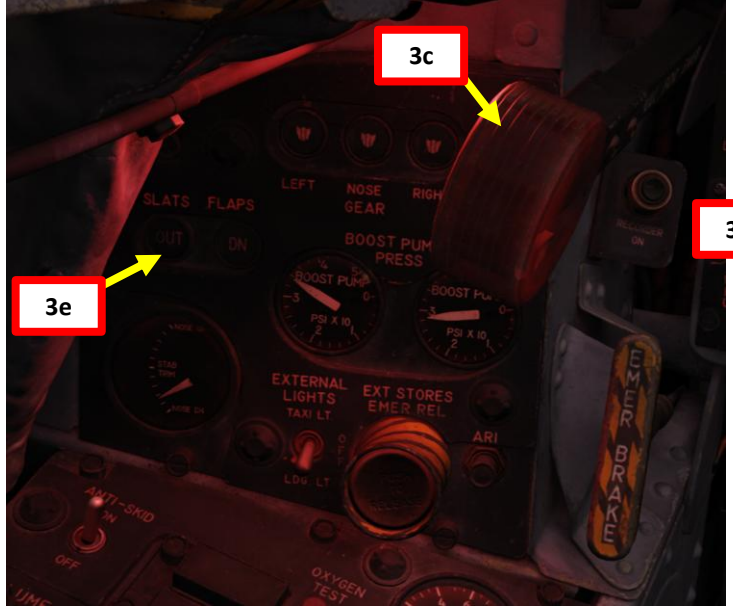


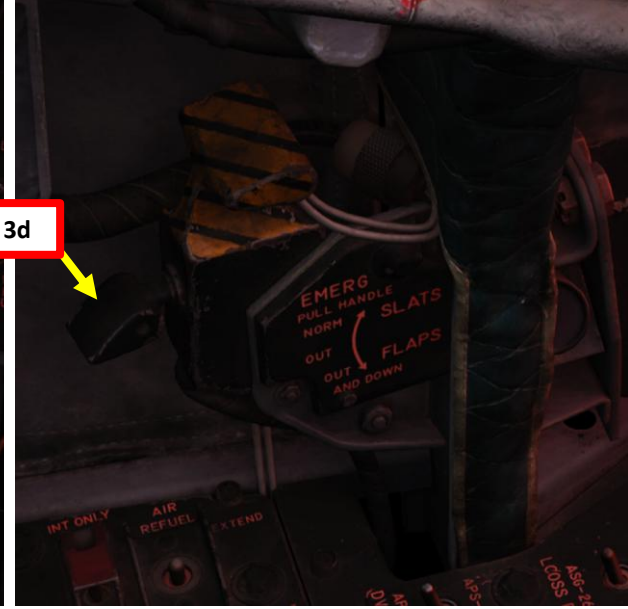


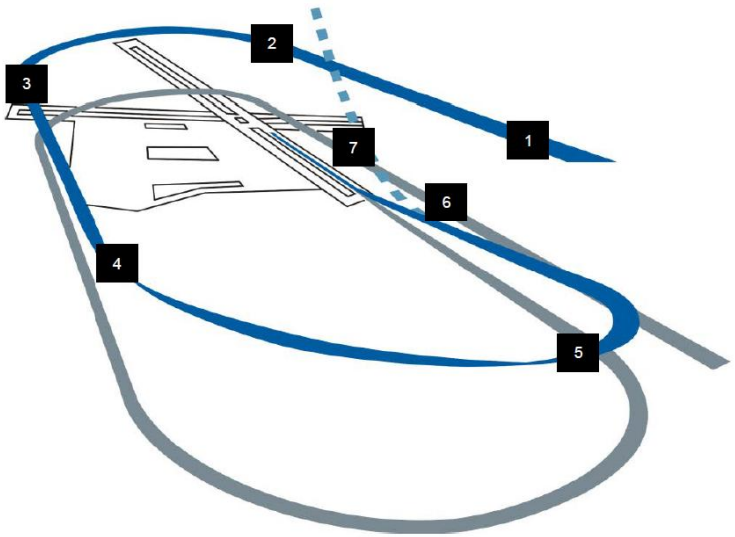


VISUAL LANDING

3. **Downwind Leg**
   a) Roll out on the downwind leg opposite the landing heading at about 200-220 kts and 1500 ft AGL. **Do not exceed 250 kts.**
   b) Avoid buffet throughout the landing pattern. Adjust power as necessary to attain allowable gear lowering airspeed.
   c) Extend landing gear.
   d) Set Flaps/Slats Control Lever – OUT & DOWN (FULLY DOWN).
   e) Check SLATS indication displays OUT and FLAPS indication displays DN (Down).
      - *Note: Actual flap extension may not occur until slowing to 210 knots.*
   f) Reduce speed **(180 kts minimum)** as required to prevent excessive airspeed buildup in the base turn



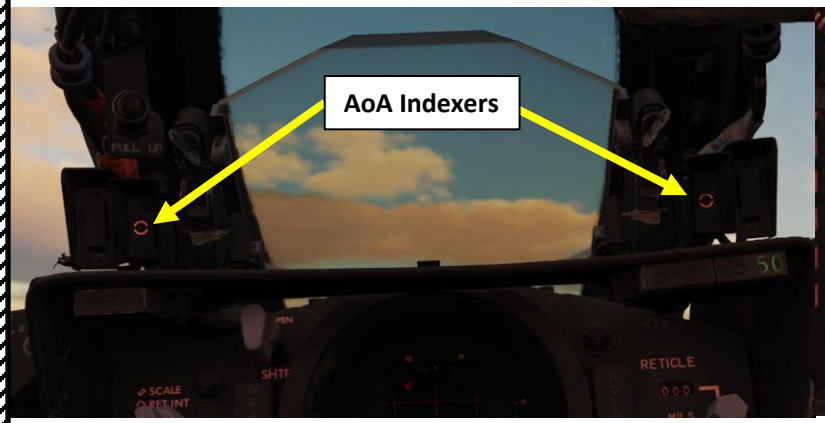


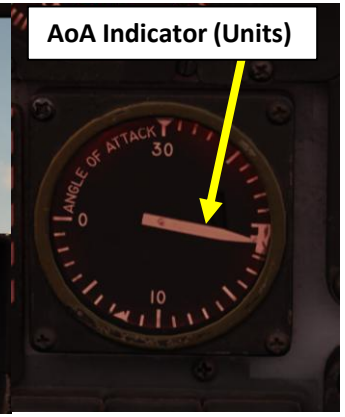


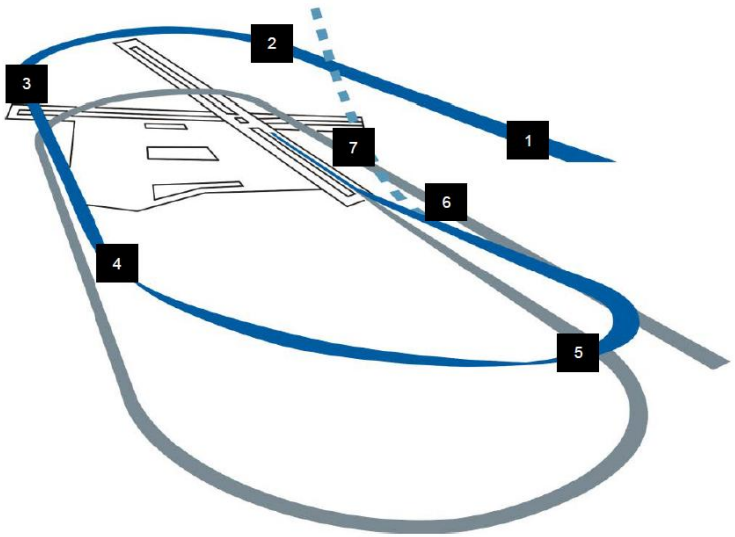


VISUAL LANDING

4. **Base Turn**
   a) Initiate base turn when your wingtip is at a 45 deg angle from the runway edge.
   b) Trim aircraft pitch to set a ON SPEED Angle of Attack (AoA), which is 19.2 units. Use the following to determine ON SPEED AOA:
      - AoA Indexer (doughnut = On Speed)
      - AoA Indicator (angle of attack in units)
      - AoA aural tone system indicates an on-speed approach with steady tone played at medium pitch.



















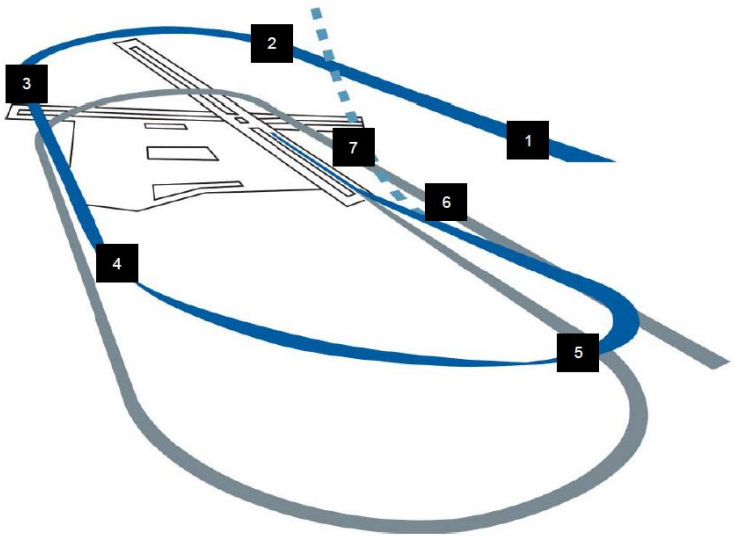






VISUAL LANDING

5. **Final Turn**
   a) Use throttle to control rate of descent while using the stick to maintain a 19.2 units AoA through the turn.
   b) Roll out on final and raise the nose to maintain proper glide path (300 ft AGL, 1 nm from the touchdown point)



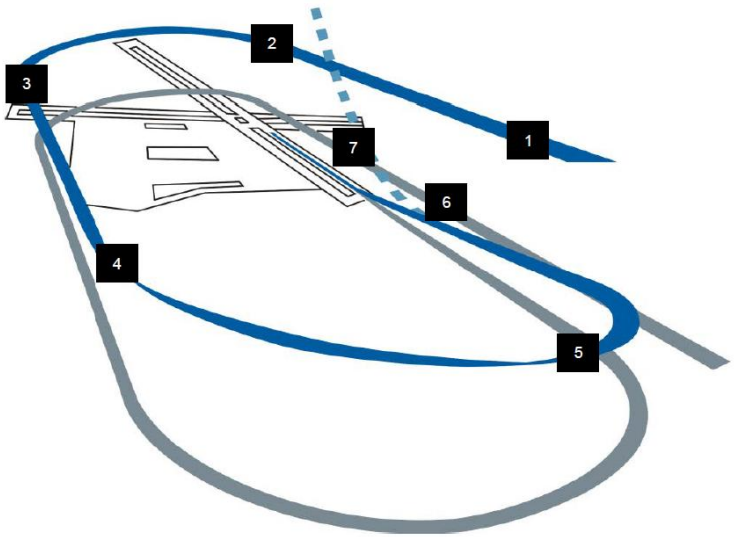




VISUAL LANDING

6. **Short Final**
   a) When on final, align the center of the sight glass with the runway threshold to ensure proper glidepath (3 deg glide slope) while maintaining 19.2 deg AoA.
   b) Use throttle to control rate of descent and glide slope while using the stick to maintain a 19.2 units AoA.
   c) If too high on glide slope, reduce power, establish a new glide slope, then add power to maintain glide slope when captured.
   d) If too low on glide slope, add power, hold on speed and reduce power to maintain glide slope when captured.
   e) Maintain final approach angle of attack all the way to touchdown. The F-4 is flown down final approach at touchdown speed, therefore the power is held relatively constant to touchdown.

Approach Speed Formula: Final approach airspeed is approximately 142 kts at a gross weight of 33000 lbs + 2 knots for each 1000 lbs above 33000 lbs







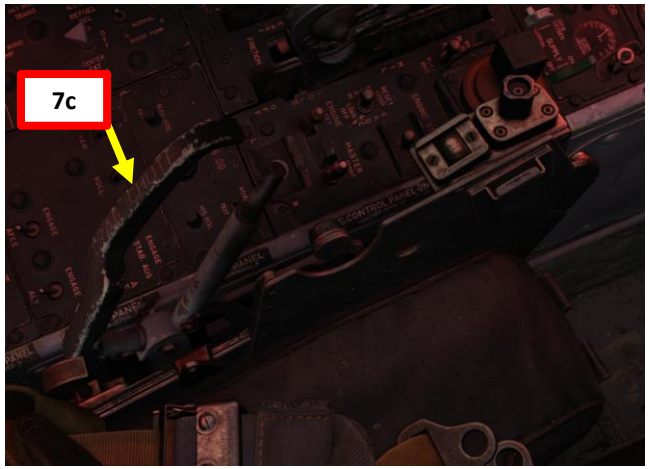
VISUAL LANDING

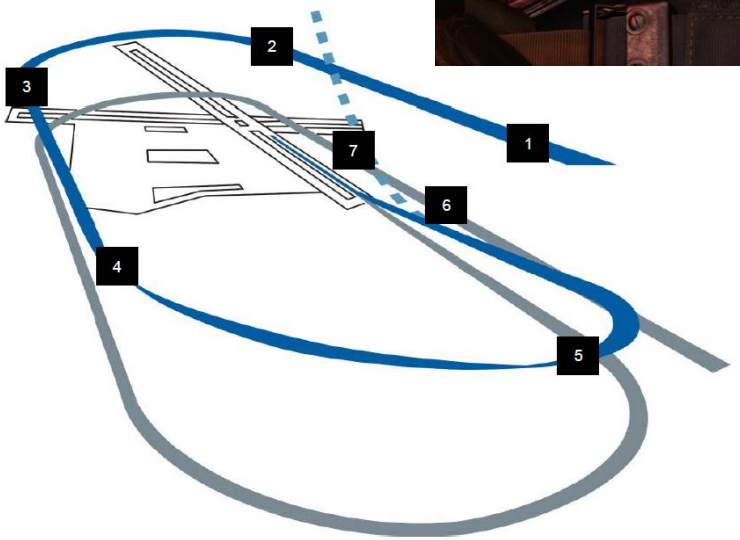
7. Roll-Out

a) Flare at 20 ft by gently pulling the stick aft and let the aircraft touchdown.
- Note: When the aircraft is 20 ft above the runway, ground effect will tend to pitch the aircraft nose down. Pitch attitude should be maintained by increasing aft stick pressure during touchdown. If you were high above glide path, the rate of descent will be high, and as a result some additional power will be necessary to decrease the excessive rate of descent.

b) At touchdown, reduce power to IDLE.

c) Pull Drag Chute Lever to deploy drag chute ("P" binding).









VISUAL LANDING

7. Roll-Out

d) Use full aft stick to help decelerate.

e) Use rudder and ailerons for directional control down to 70 knots, then use differential braking. Nose gear steering should not be required for directional control in light crosswind conditions. However, if rudder, aileron, and/or differential braking are not effective in maintaining directional control, use nose gear steering as required. Engage nose gear steering only with the rudder at or near neutral.

f) Gently tap wheel brakes when below 70 kts until you come to a full stop.

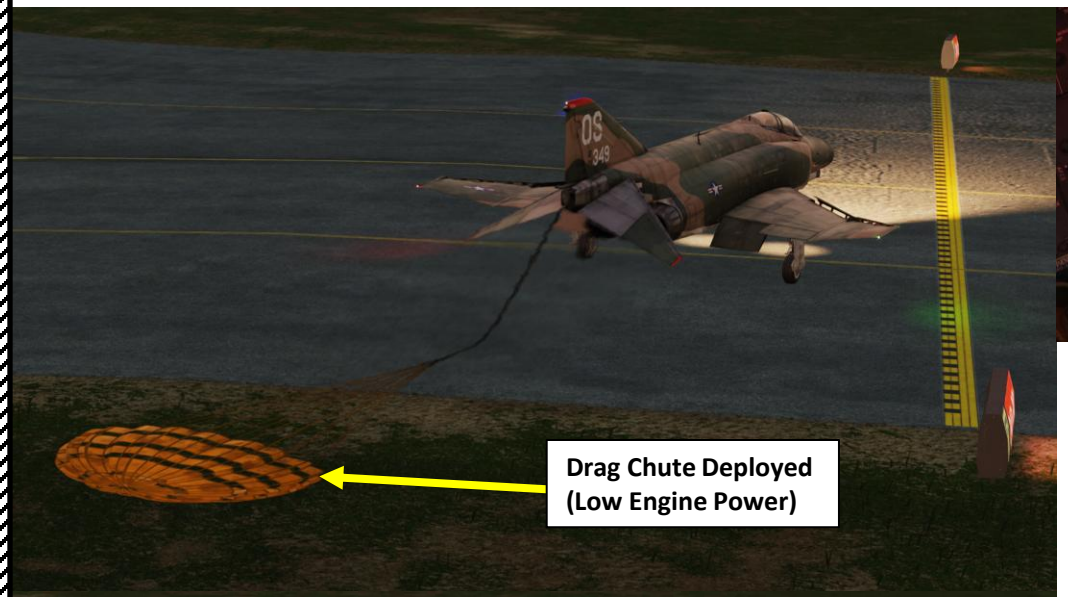


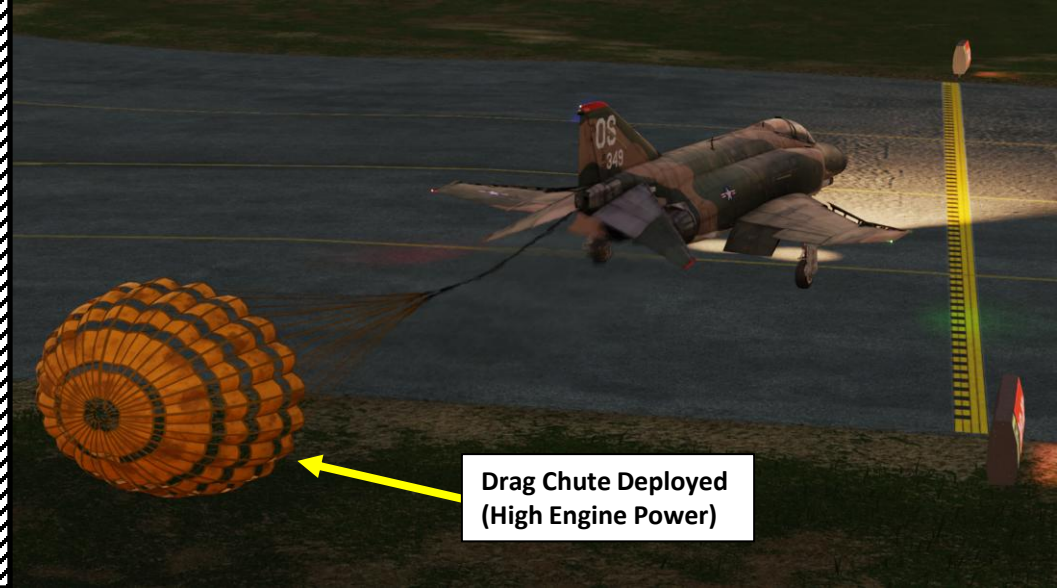
VISUAL LANDING

7. Roll-Out

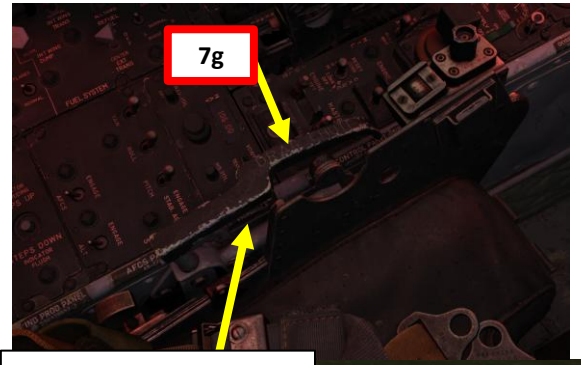
g) When able, push Drag Chute Lever back IN to jettison drag chute.

- *Note: Drag chute should not be jettisoned on the runway or a taxiway. A popular technique is to leave it on the side of a taxiway by appropriately orienting the aircraft, inflating the chute with the engines and then releasing it in the desired direction.*











VISUAL LANDING

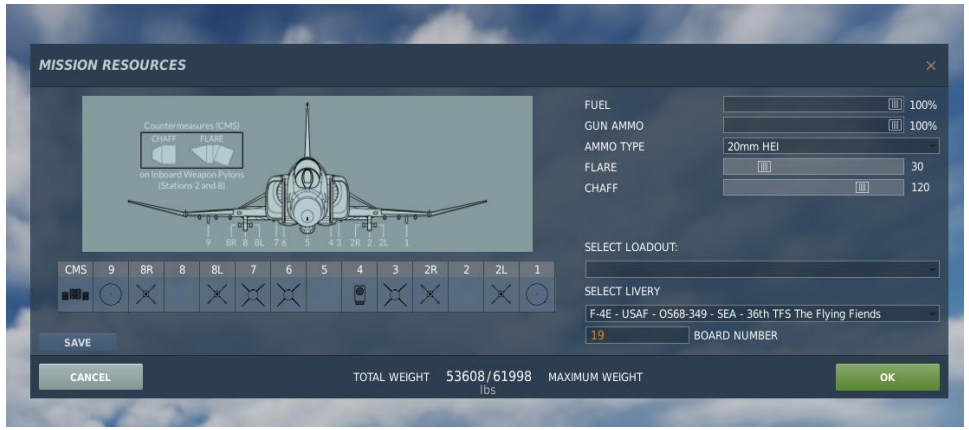
7. Roll-Out

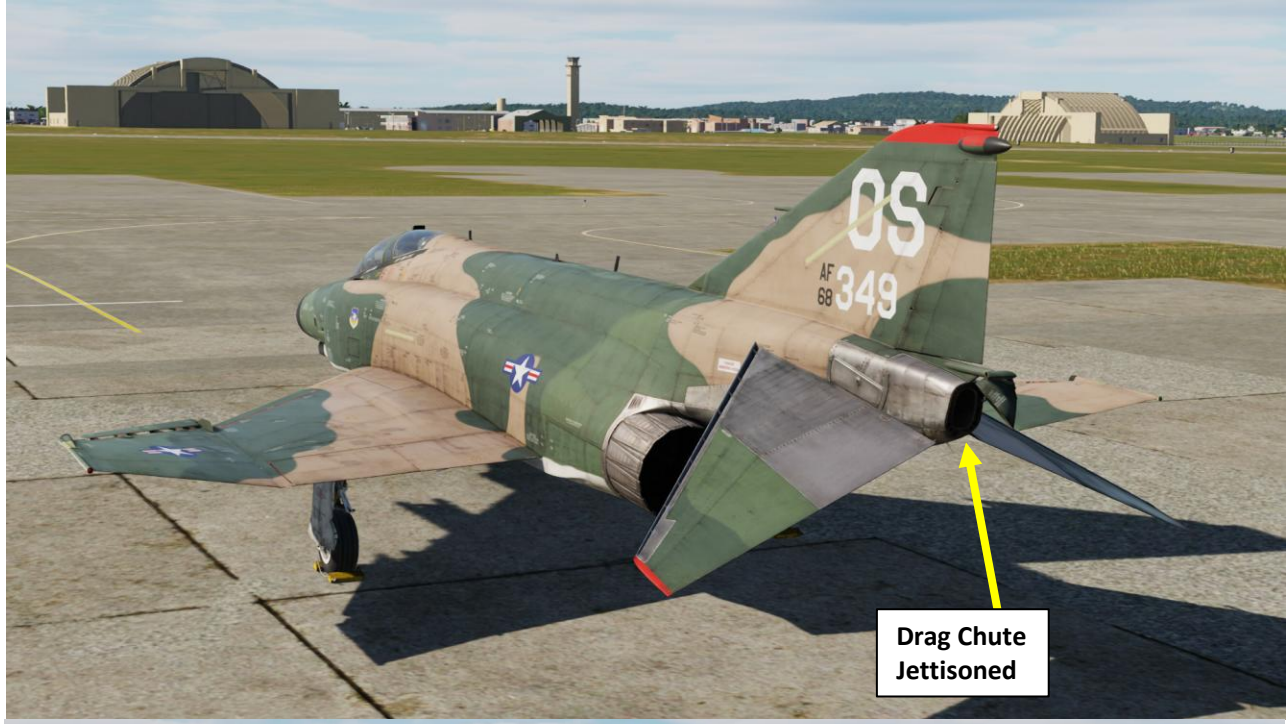
h) Taxi to the parking area and shutdown aircraft.



AFTER LANDING

If you have landed and want to go on another mission, don't forget to use the ground crew for refueling and re-arming. Once refueling/rearming is complete, the ground crew will install a new drag chute and replenish various expendables.









SECTION STRUCTURE

- **1 – POWERPLANT**
  - 1.1 – General Electric J79-GE-17A/F Engines
  - 1.2 – Engine Instruments & Parameters
  - 1.3 – Engine Controls
  - 1.4 – Afterburners
  - 1.5 – Engine Fire Detection & Suppression
  - 1.6 – Compressor Surge/Stall
  - 1.7 – Engine Limits
  - 1.8 – Engine Flameout – In-Air Relight Procedure
  - 1.9 – Engine Start with Cartridges

- **2 – FUEL**
  - 2.1 – Fuel System Overview
  - 2.2 – External Fuel Drop Tanks
  - 2.3 – Fuel Planning & Mission Profile
  - 2.4 – Fuel Dumping
  - 2.5 – Fuel Venting

1 – POWERPLANT
1.1 – General Electric J79-GE-17A/F Engines

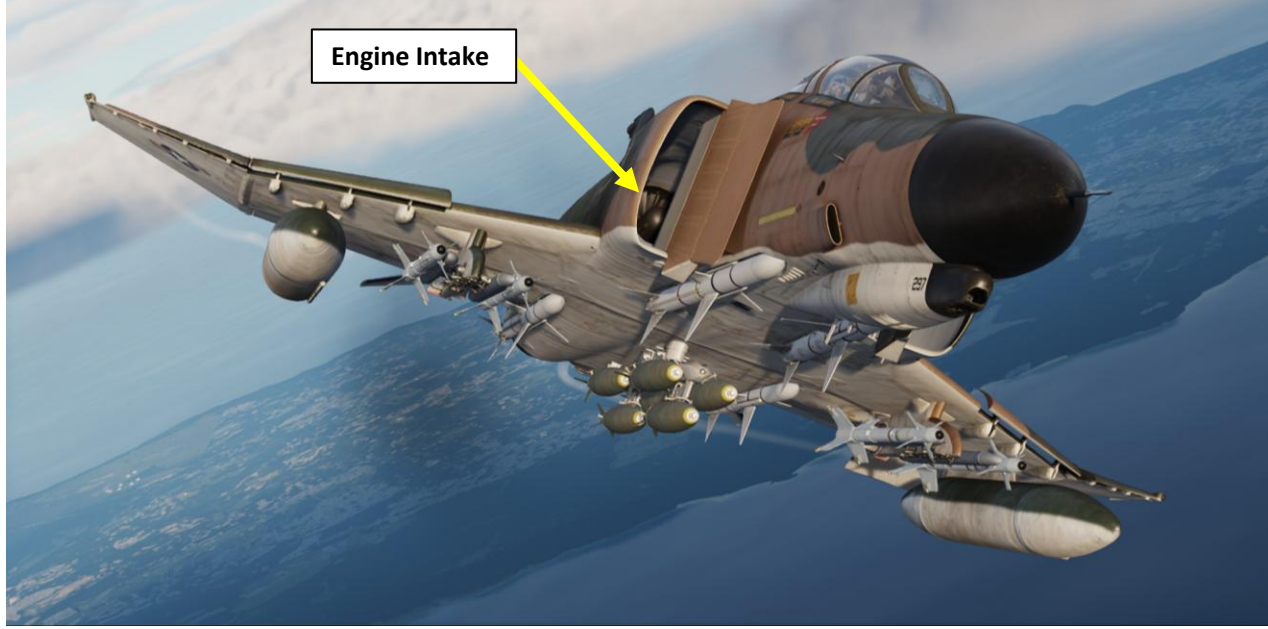
The Phantom II is powered by two General Electric J79-GE-17A/F engines. The development of the J79 turbojet began in 1952 as a more powerful follow-up to the General Electric J47 turbojet. The J79 has a rated static sea-level power delivery of 11,870 lbs of thrust in MIL (Military Power), and 17,900 lbs in afterburner.

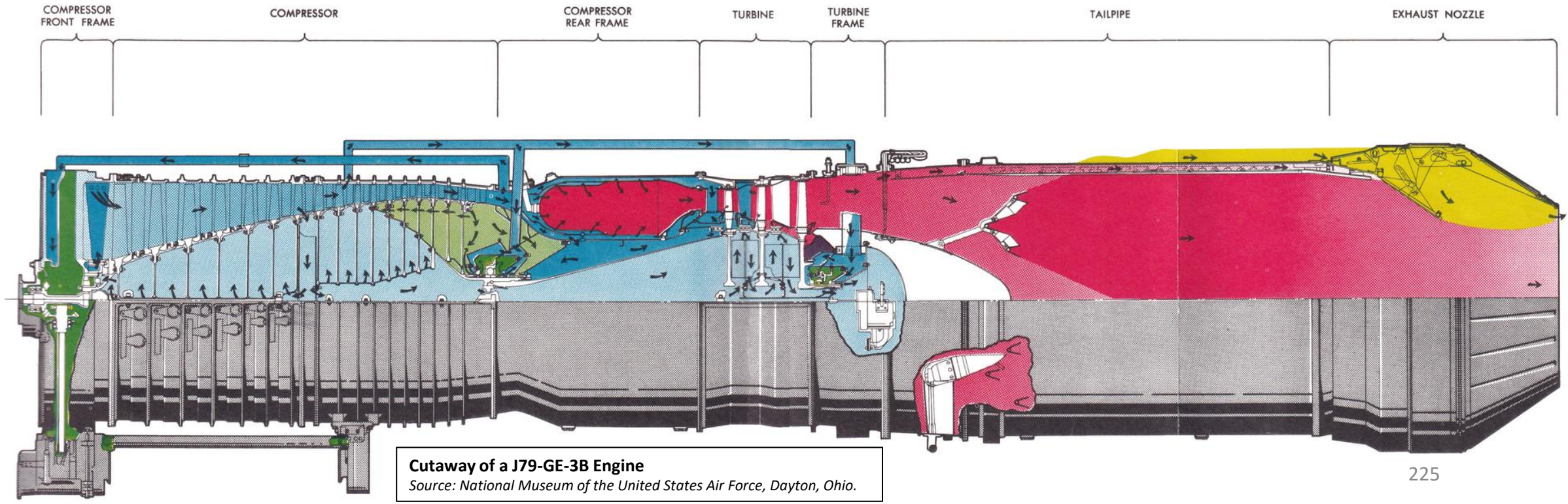


1 – POWERPLANT
1.1 – General Electric J79-GE-17A/F Engines

The J79 has a single-spool 17-stage axial compressor, which has one row of variable inlet guide vanes (VIGV's) followed by 6 rows of variable stator vanes (VSV's). This compressor is driven by a 3-stage high-pressure turbine. Fuel is burned in a combustion chamber with 10 annular combustion liners and hot gases are ejected through a variable area exhaust nozzle. The J79 produced noticeable amounts of black smoke at mid-throttle/cruise settings, a severe disadvantage in that it made it easier for the enemy to spot the aircraft. These unmistakable trails behind the jet will make you realize that the F-4 was nicknamed "Old Smokey" for a good reason.

The F-4E has a turbine-type starter for engine cranking. The engines have provision for both assisted pneumatic start at fields with an available air pressure cart, or via a propellant cartridge to initiate spin-up. Similarly, the engines can utilize the aircraft's internal battery for initial power, or connection with an external power cart.



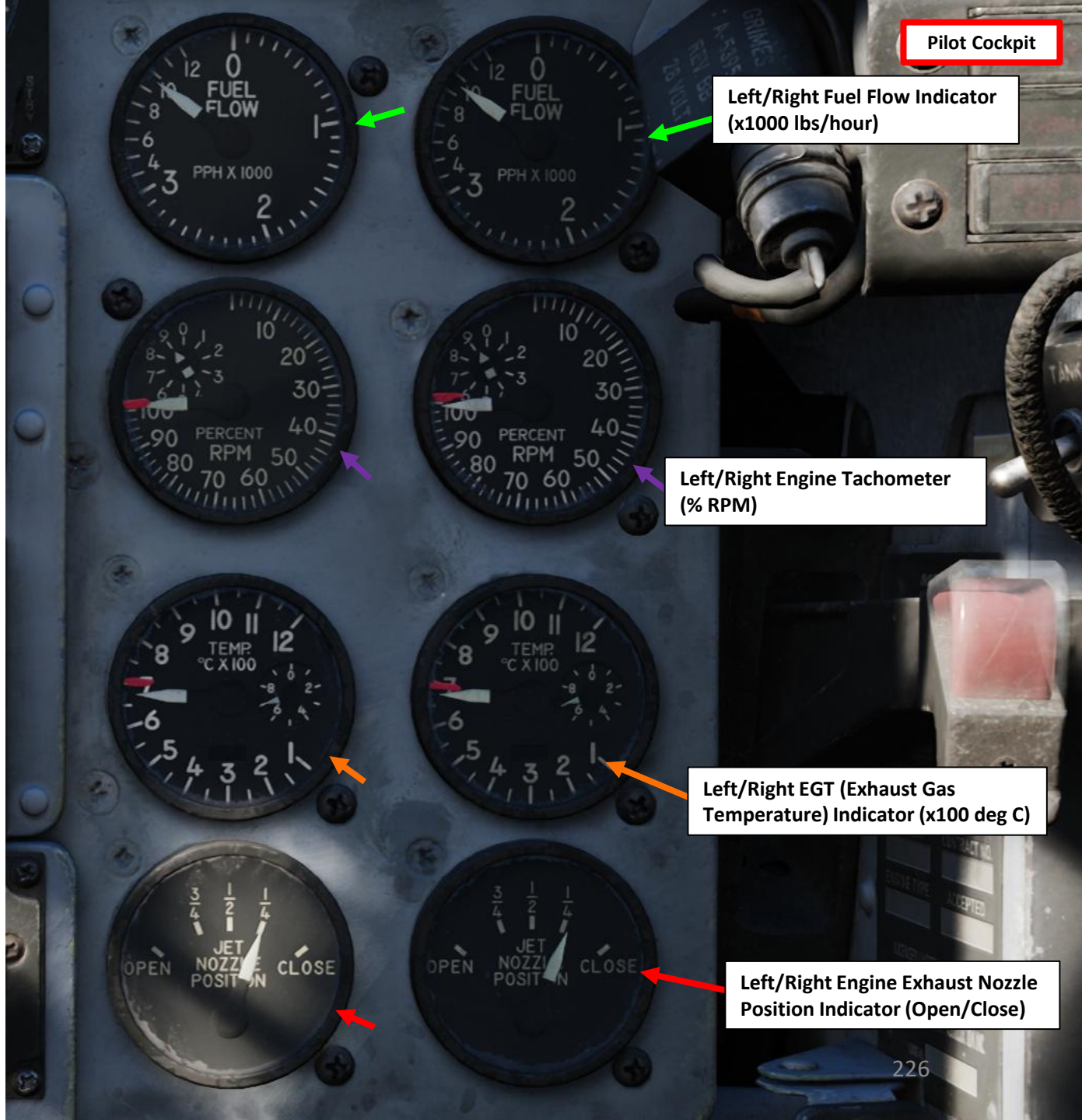


Cutaway of a J79-GE-3B Engine
Source: National Museum of the United States Air Force, Dayton, Ohio.

1 – POWERPLANT
1.2 – Engine Instruments & Parameters

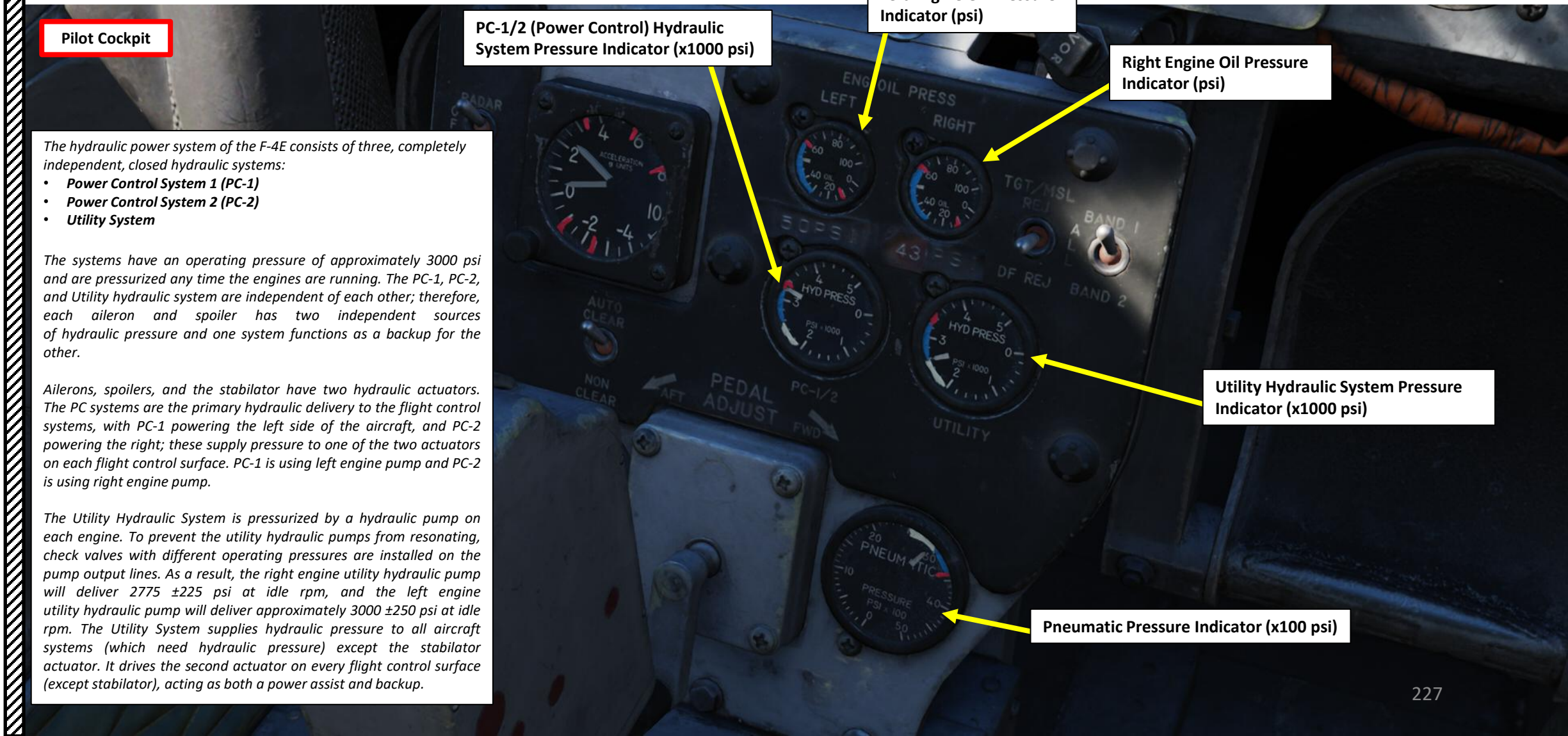
Most engine indications are visible from the pilot cockpit. Engine RPM, EGT, Fuel Flow and Nozzle Position are the main parameters being monitored on a regular basis.





1 – POWERPLANT
1.2 – Engine Instruments & Parameters

Secondary indications include engine oil pressure, pneumatic pressure (engine bleed air is used to cool down avionics, provide de-icing, cabin pressurization, fuel tank pressurization, windshield rain removal and air conditioning) and hydraulic pressure (powered by engine-driven pumps).



The hydraulic power system of the F-4E consists of three, completely independent, closed hydraulic systems:

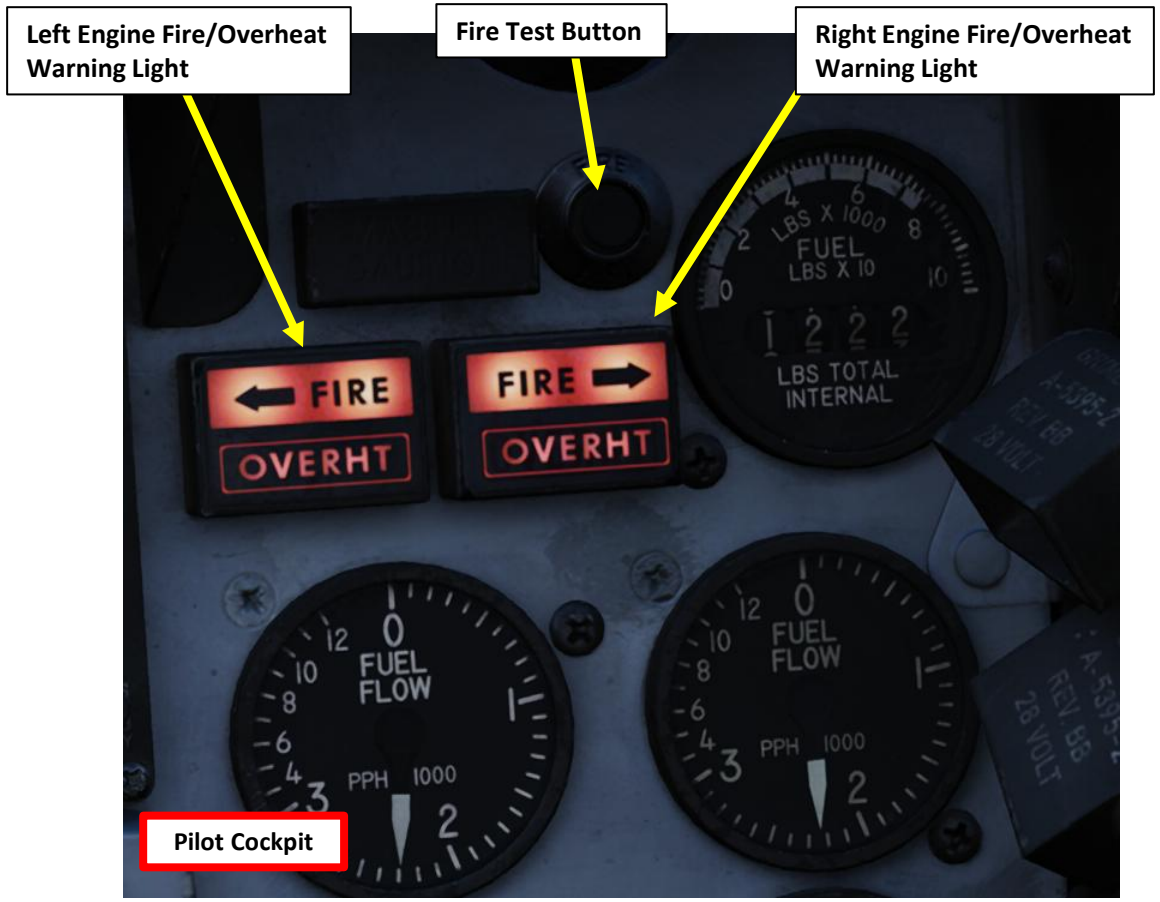
- ***Power Control System 1 (PC-1)***
- ***Power Control System 2 (PC-2)***
- ***Utility System***

The systems have an operating pressure of approximately 3000 psi and are pressurized any time the engines are running. The PC-1, PC-2, and Utility hydraulic system are independent of each other; therefore, each aileron and spoiler has two independent sources of hydraulic pressure and one system functions as a backup for the other.

Ailerons, spoilers, and the stabilator have two hydraulic actuators. The PC systems are the primary hydraulic delivery to the flight control systems, with PC-1 powering the left side of the aircraft, and PC-2 powering the right; these supply pressure to one of the two actuators on each flight control surface. PC-1 is using left engine pump and PC-2 is using right engine pump.

The Utility Hydraulic System is pressurized by a hydraulic pump on each engine. To prevent the utility hydraulic pumps from resonating, check valves with different operating pressures are installed on the pump output lines. As a result, the right engine utility hydraulic pump will deliver 2775 ±225 psi at idle rpm, and the left engine utility hydraulic pump will deliver approximately 3000 ±250 psi at idle rpm. The Utility System supplies hydraulic pressure to all aircraft systems (which need hydraulic pressure) except the stabilator actuator. It drives the second actuator on every flight control surface (except stabilator), acting as both a power assist and backup.

1 – POWERPLANT
1.2 – Engine Instruments & Parameters



Warning Telelight Panel		
L ANTI ICE ON *Left anti-ice bleed air system is on.*	**R ANTI ICE ON** *Right anti-ice bleed air system is on.*	**DUCT TEMP HIGH** Temperature within the engine intake duct is beyond allowable limits.
L AUX AIR DOOR Left auxiliary air door operates out of phase with the landing gear handle.	**R AUX AIR DOOR** Right auxiliary air door operates out of phase with the landing gear handle.	**FIRE SYS** Either a fire/overheat detector sensor tube is burned through, a detector wire chafes to ground or the control module fails.



1 – POWERPLANT
1.3 – Engine Controls

Paired throttles are provided in both cockpits for engine thrust control. In normal use, movement of the throttles from IDLE to OFF will perform fuel cutoff; to prevent inadvertent engine shutdown, a pair of finger lifts are provided to lock out the OFF position without performing this actuation. Afterburner is attained by shifting the throttles outboard (left) at the MIL stop, then pushing them forward.

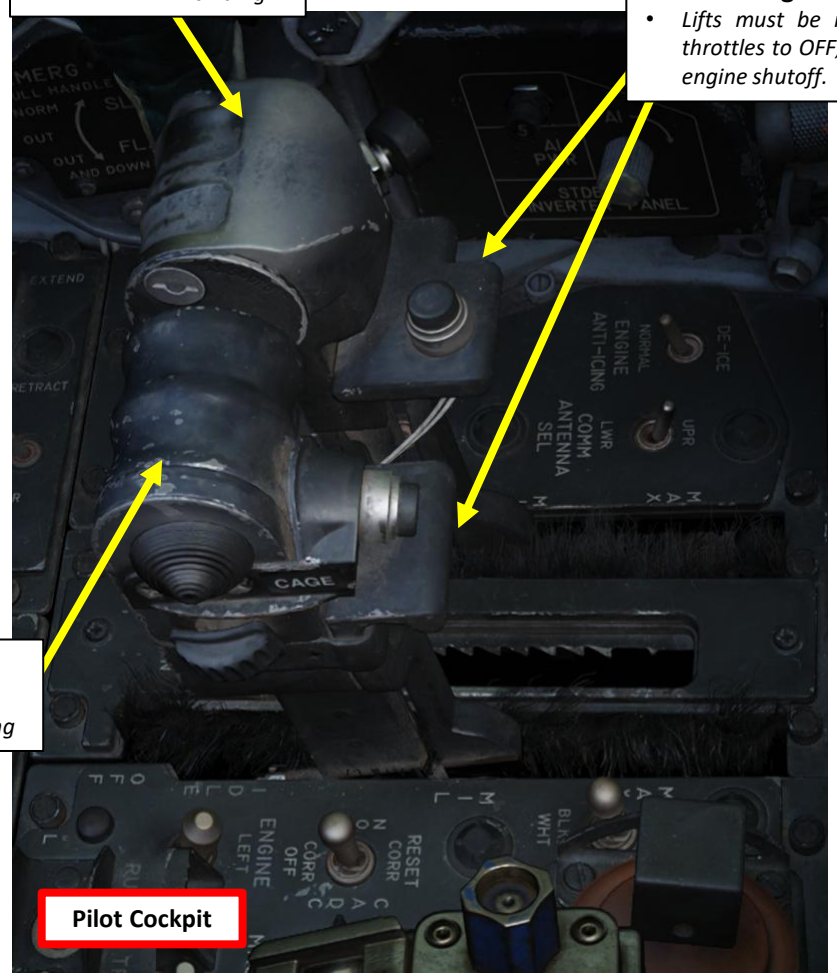
The rear cockpit throttles are connected to the front throttles in such a fashion that only the pilot can start the engines or enter the afterburner range; the WSO can reduce throttles out of the afterburner region back into MIL operation and lower. While the rear throttles can be shifted from OFF without pilot assistance, return to OFF for shutdown requires pilot engagement of the finger lifts.

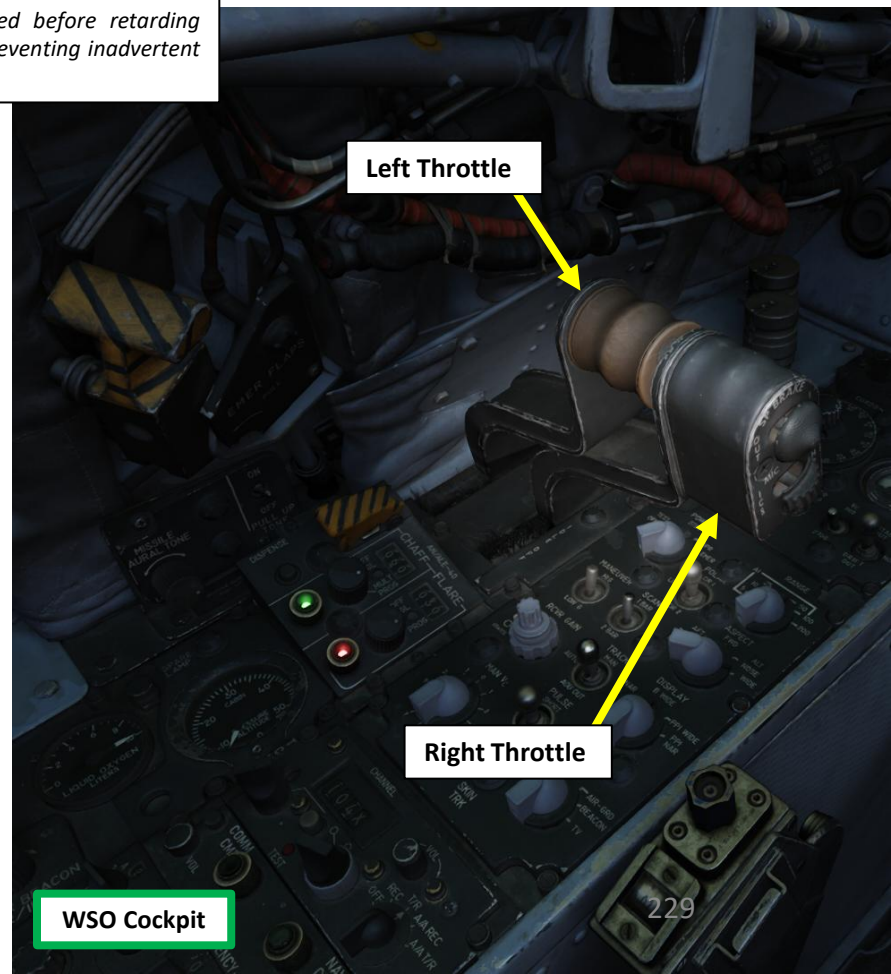
In the event of opposing commands on the throttle arms between seats, the rear throttles will be disconnected from the front throttles to prevent damage to the linkage. This condition may cause a reduction in afterburner authority from the front throttle pair. Resetting the throttle linkage is performed by placing the front throttles at the IDLE or MIL stop and moving the rear throttles in the opposite direction to which the disconnect occurred.

Left Throttle
- *OFF/IDLE Toggle: "RALT+END" binding.*

Throttle Finger Lifts
- *Lifts must be raised before retarding throttles to OFF, preventing inadvertent engine shutoff.*

Right Throttle
- *OFF/IDLE Toggle : "RCTRL+END" binding*

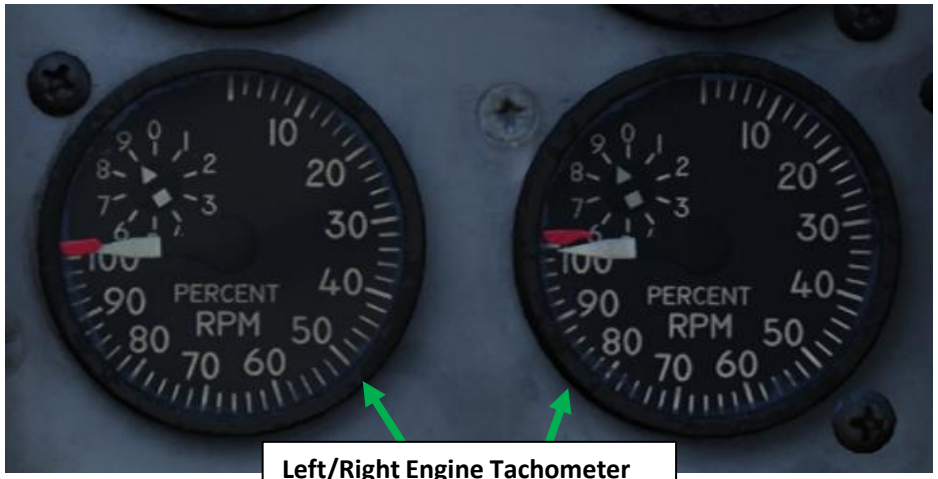




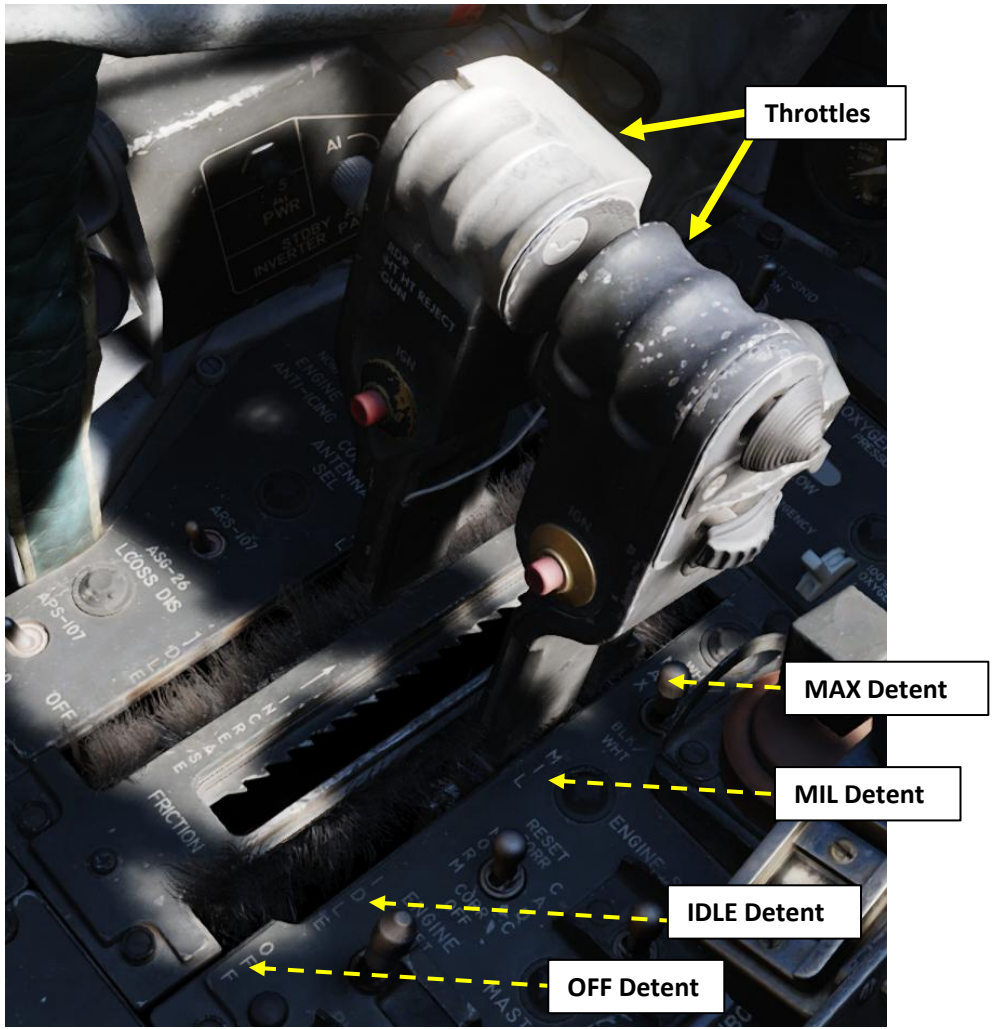
1 – POWERPLANT
1.3 – Engine Controls

Power settings are controlled by the throttles and these settings monitored with the Engine Tachometer Gauges.

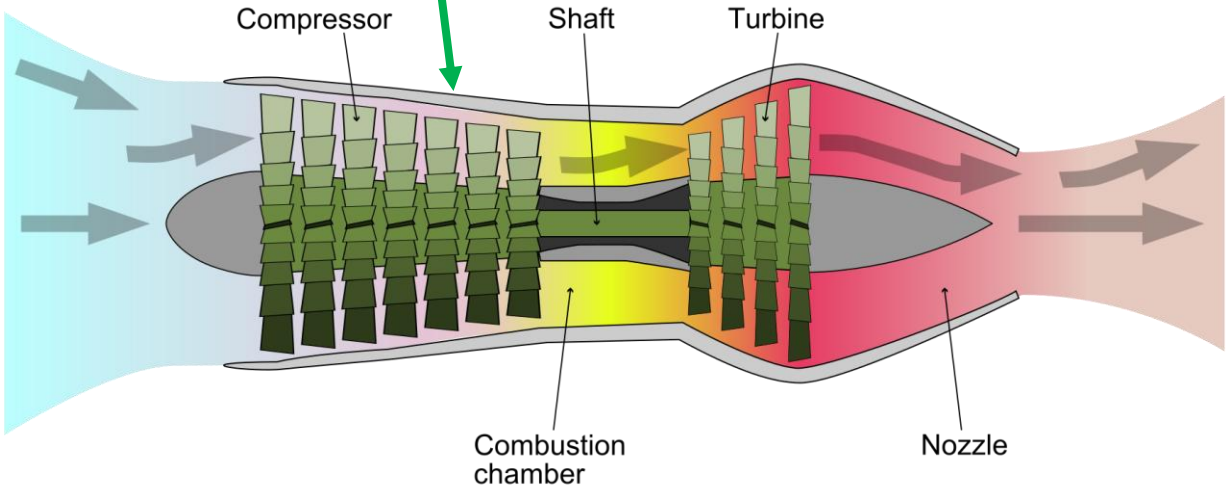
- **Idle Power Setting**: 65 % RPM
- **MIL (Military) Power Setting**: 95 % RPM
- **MAX (Full Afterburner) Power Setting**: 105 % RPM



Left/Right Engine Tachometer (% RPM)

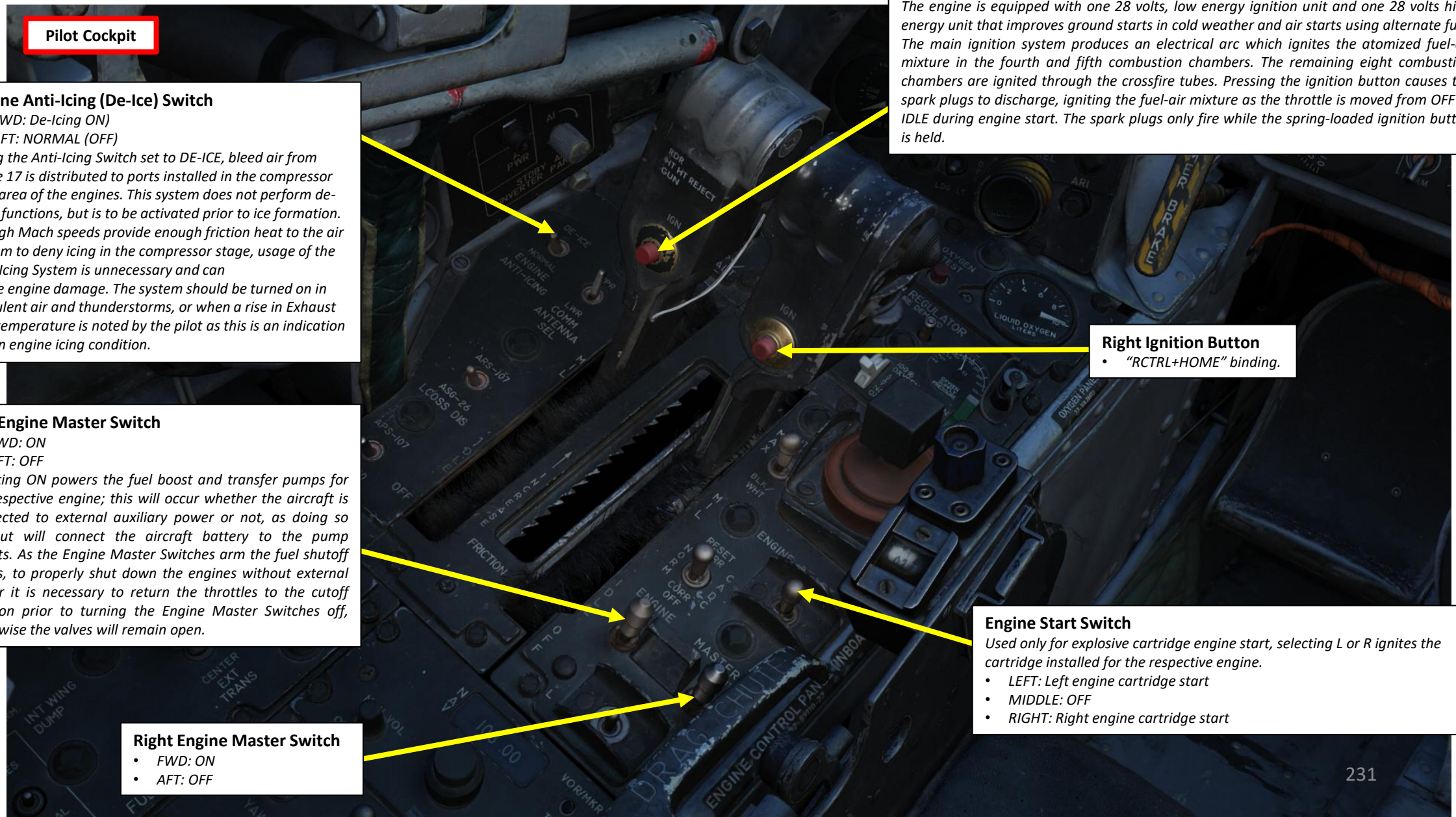


Compressor and turbine are driven by the same shaft. This speed in percentage of maximum RPM.



Axial Flow Turbojet Concept
from Emoscopes

1 – POWERPLANT
1.3 – Engine Controls



Engine Anti-Icing (De-Ice) Switch
- *FWD: De-Icing ON)*
- *AFT: NORMAL (OFF)*

Using the Anti-Icing Switch set to DE-ICE, bleed air from stage 17 is distributed to ports installed in the compressor face area of the engines. This system does not perform de-icing functions, but is to be activated prior to ice formation. As high Mach speeds provide enough friction heat to the air stream to deny icing in the compressor stage, usage of the Anti-Icing System is unnecessary and can cause engine damage. The system should be turned on in turbulent air and thunderstorms, or when a rise in Exhaust Gas temperature is noted by the pilot as this is an indication for an engine icing condition.

Left Engine Master Switch
- *FWD: ON*
- *AFT: OFF*

Selecting ON powers the fuel boost and transfer pumps for the respective engine; this will occur whether the aircraft is connected to external auxiliary power or not, as doing so without will connect the aircraft battery to the pump circuits. As the Engine Master Switches arm the fuel shutoff valves, to properly shut down the engines without external power it is necessary to return the throttles to the cutoff position prior to turning the Engine Master Switches off, otherwise the valves will remain open.

Right Engine Master Switch
- *FWD: ON*
- *AFT: OFF*

Left Ignition Button
- "RALT+HOME" binding

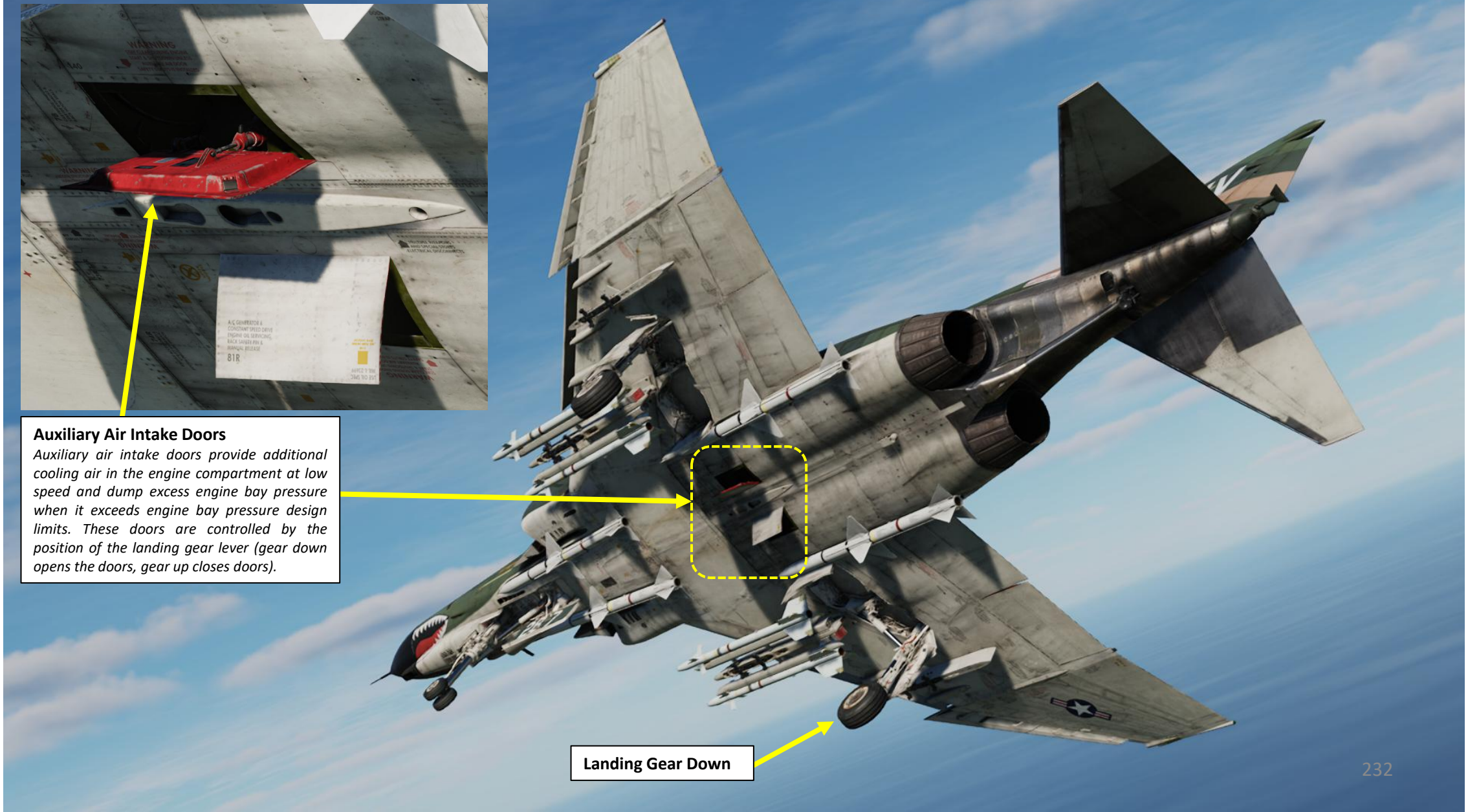
The engine is equipped with one 28 volts, low energy ignition unit and one 28 volts high energy unit that improves ground starts in cold weather and air starts using alternate fuel. The main ignition system produces an electrical arc which ignites the atomized fuel-air mixture in the fourth and fifth combustion chambers. The remaining eight combustion chambers are ignited through the crossfire tubes. Pressing the ignition button causes the spark plugs to discharge, igniting the fuel-air mixture as the throttle is moved from OFF to IDLE during engine start. The spark plugs only fire while the spring-loaded ignition button is held.

Right Ignition Button
- *"RCTRL+HOME" binding.*

Engine Start Switch

Used only for explosive cartridge engine start, selecting L or R ignites the cartridge installed for the respective engine.
- *LEFT: Left engine cartridge start*
- *MIDDLE: OFF*
- *RIGHT: Right engine cartridge start*

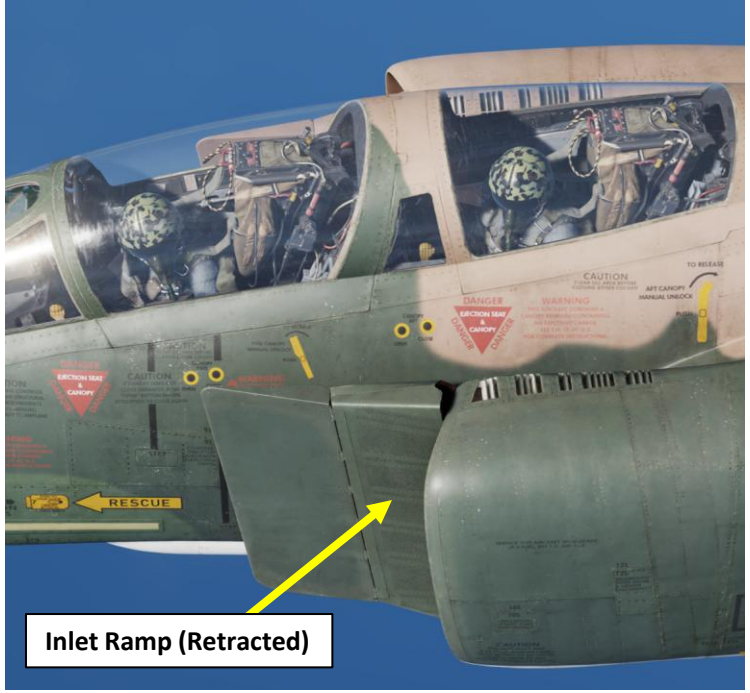
1 – POWERPLANT
1.3 – Engine Controls



1 – POWERPLANT
1.3 – Engine Controls

Optimization of air to the engines is performed by a Variable Duct Ramp system directed by the Automatic Duct Control (ADC); this optimization uses a pair of **variable inlet ramps** to decelerate incoming air to subsonic for best engine performance. In the event limits are exceeded for inlet temperature, the Duct Temperature High Indicator Light (DUCT TEMP HI) on the telelight panel will illuminate. Permitting the issue to continue can cause permanent engine damage.

Inlet ramps extend or retract automatically based on OAT (Outside Air Temperature) and Mach scheduling. Their position is typically monitored visually by the WSO from the rear seat.





Inlet Ramp Schedule At 40000 ft Pressure Altitude	
OAT (Outside Air Temperature, deg C)	Ramps Begin to Extend at Mach
-40	1.40
-45	1.45
-50	1.50
-55	1.55
-60	1.60
-65	1.65
-70	1.70

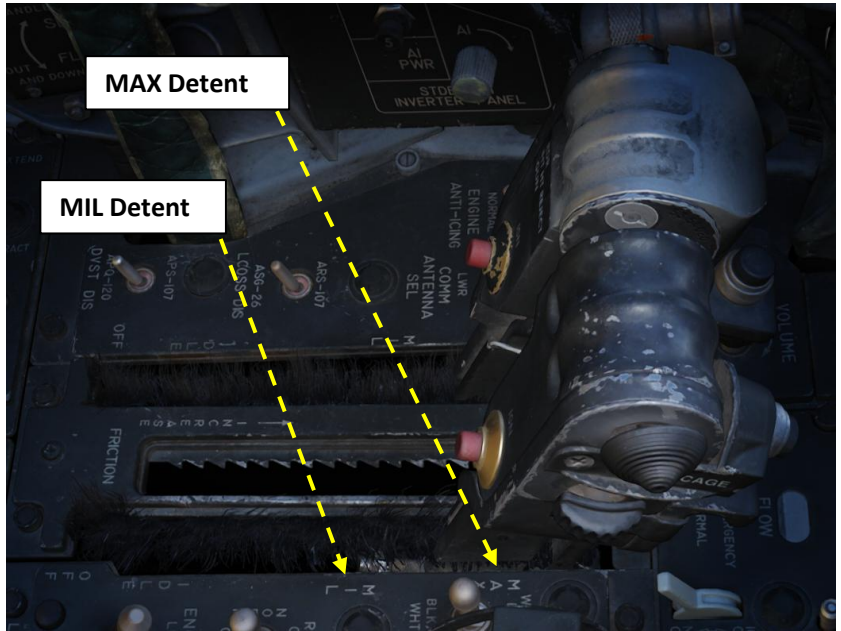




1 – POWERPLANT
1.4 – Afterburners

Afterburners are engaged by throttling past the MIL (Military Power) detent. Afterburner intensity varies progressively as the throttle is pushed forward within the afterburner operation envelope.

Only the pilot can enter the afterburner range; the WSO can reduce throttles out of the afterburner region back into MIL operation and lower.





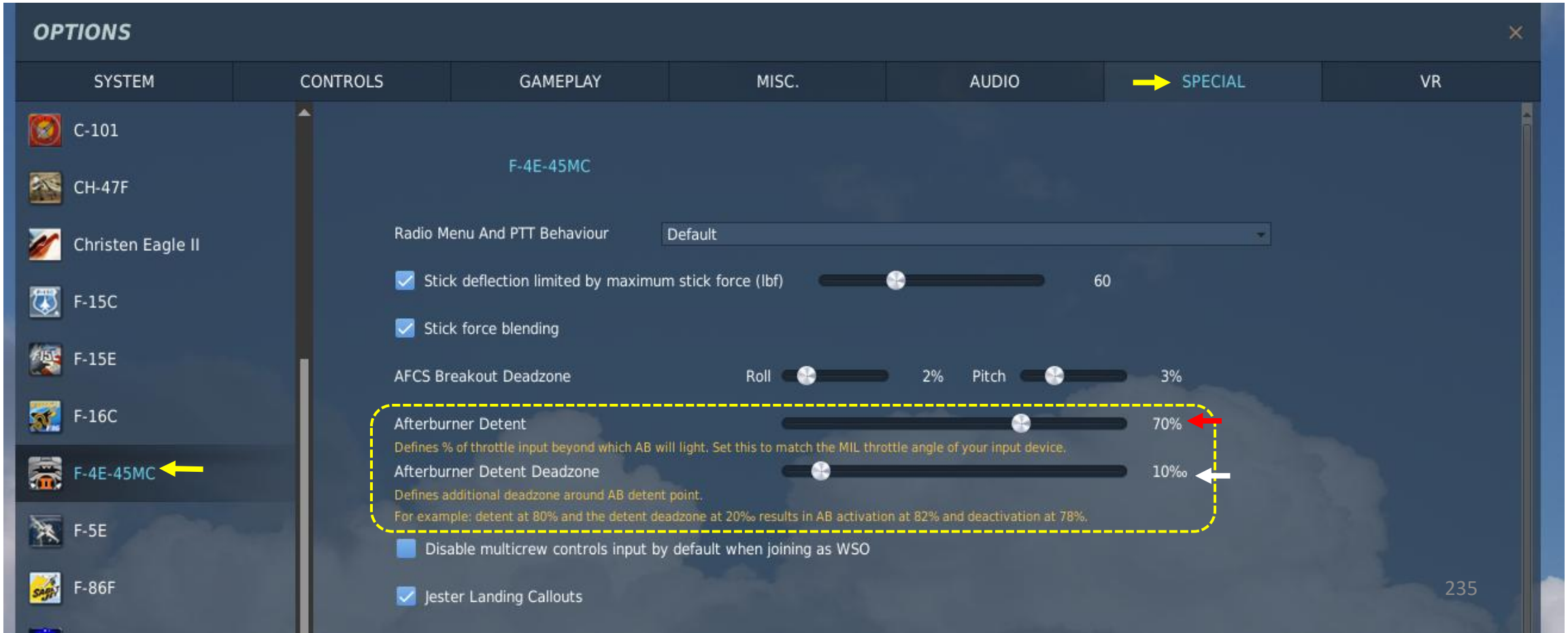
1 – POWERPLANT
1.4 – Afterburners

DCS Options for Afterburner Detents:

In the DCS SPECIAL OPTIONS menu, there are two options to define at which point of the physical hardware throttle input (0 to 100%) the aircraft will light the afterburner.

- If the **Afterburner Detent option** setting is set to 70%, the MIL power range of the aircraft will be commanded between 0% and 70% of your physical throttle, while the remaining 30% will control the afterburner range.
- The **Afterburner Detent Deadzone option** can be used to split the points in the range at which the afterburner will be turned on and off. For example, setting 10 ‰ (or 1 %) for the deadzone and 70% for the detent results in afterburner activation at 71% and deactivation at 69% of throttle input.





1 – POWERPLANT
1.5 – Engine Fire Detection & Suppression

In the front cockpit are four warning lamps: two FIRE and two OVERHT (Overheat) lights, one for each side.

Should a fire be detected in an engine compartment, the applicable **FIRE lamp** will illuminate.

Overheat detectors are mounted at the rear of the fuselage adjacent to the engine nozzles, and illuminate the respective **OVERHT lamp** should temperatures become dangerous to the aircraft.

Note: the F-4E does not have fire extinguisher squibs, which means that an engine fire during flight may be very difficult to extinguish since the best you can do is shut off the fuel valve to the affected engine.



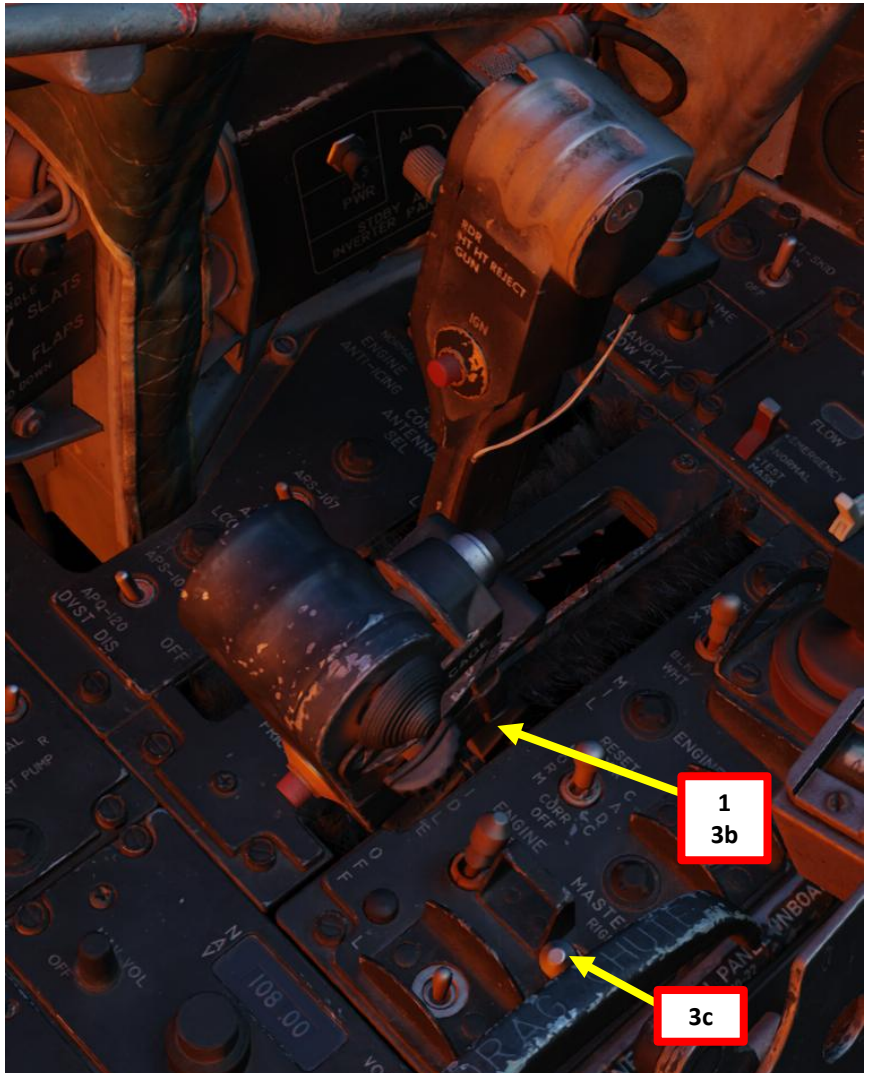


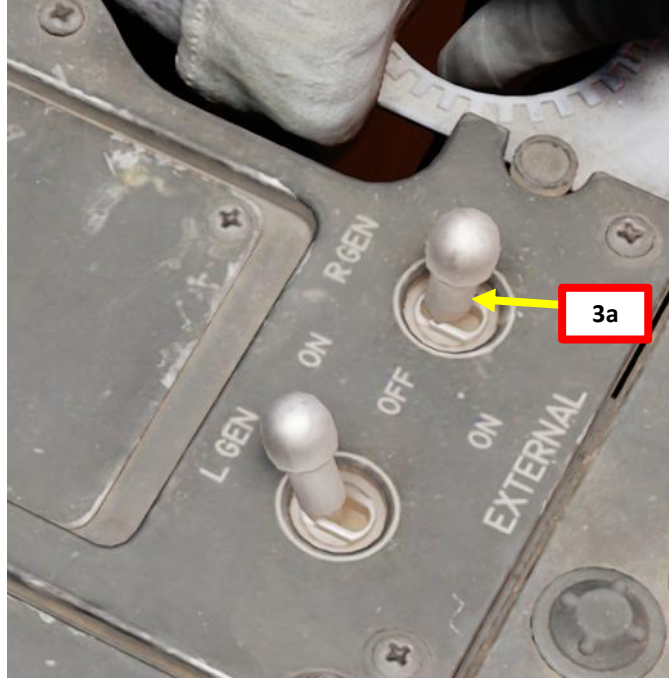
1 – POWERPLANT
1.5 – Engine Fire Detection & Suppression

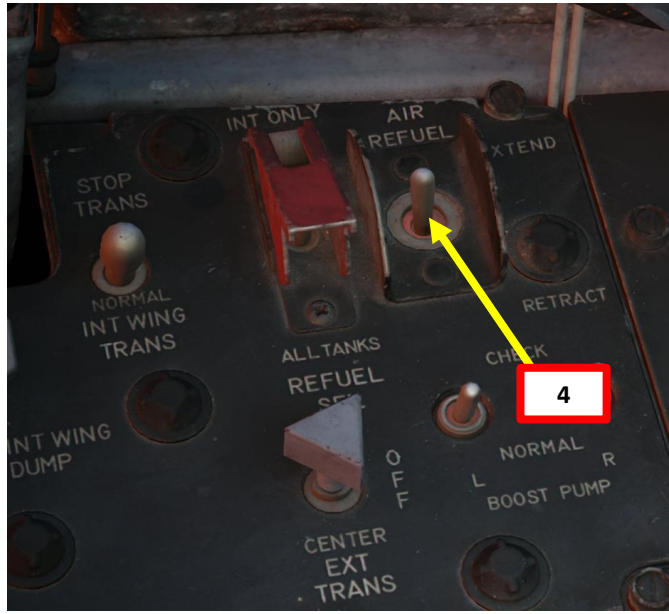
If an engine fire or an overheat condition is detected:

1. Set throttle of affected/burning engine – IDLE.
2. Maintain an airspeed of 300 kts minimum. Anticipate utility hydraulic system failure and avoid turning into the affected engine.
3. For the affected engine:
   a) Set Generator Switch – OFF
   b) Set Throttle – OFF
   c) Set Master Switch – OFF
4. Set Air Refueling Switch – EXTEND (OUTBOARD)









1 – POWERPLANT
1.5 – Engine Fire Detection & Suppression

If an engine fire or an overheat condition is detected:

5. If fire persists, eject.
6. If fire extinguishes, land as soon as possible.
7. **Do not attempt to restart the affected engine.**



1 – POWERPLANT
1.6 – Compressor Surge/Stall

Compressor stalls may occur when you move the throttle too quickly. You will notice a sudden loss in engine RPM. The J79-GE-17A/F turbojet engine is slow to respond to throttle input, so it should be treated gently. In case of compressor stall, pull back the throttle to IDLE and slowly throttle up. Major compressor failure may result in an engine flameout.

A **compressor stall** is a local disruption of the airflow in the compressor of a gas turbine or turbocharger. A stall that results in the complete disruption of the airflow through the compressor is referred to as a **compressor surge**. The severity of the phenomenon ranges from a momentary power drop barely registered by the engine instruments to a complete loss of compression.

in case of a surge, requiring adjustments in the fuel flow to recover normal operation. Compressor stall was a common problem on early jet engines with simple aerodynamics and manual or mechanical fuel control units, but has been virtually eliminated by better design and the use of hydromechanical and electronic control systems such as Full Authority Digital Engine Control (FADEC). Modern compressors are carefully designed and controlled to avoid or limit stall within an engine's operating range.

The compressor stall sensitivity of an engine is increased by foreign object damage, high angles of attack at low airspeeds and high altitudes, abrupt yaw impulses at low airspeeds (below approximately 150 KIAS), temperature distortion, and ice formation on the engine inlet ducts or inlet guide vanes. Compressor stalls can also be caused by component malfunctions; engine rigged out of limits; throttle bursts to MIL or MAX power at high altitude and low airspeed; hot gas ingestion from other aircraft or during gun firing at high altitudes and negative G conditions; and maneuvering flight with landing gear down at altitudes above 30,000 feet.

Keep in mind that compressor stall still can be caused by combination of adverse conditions.

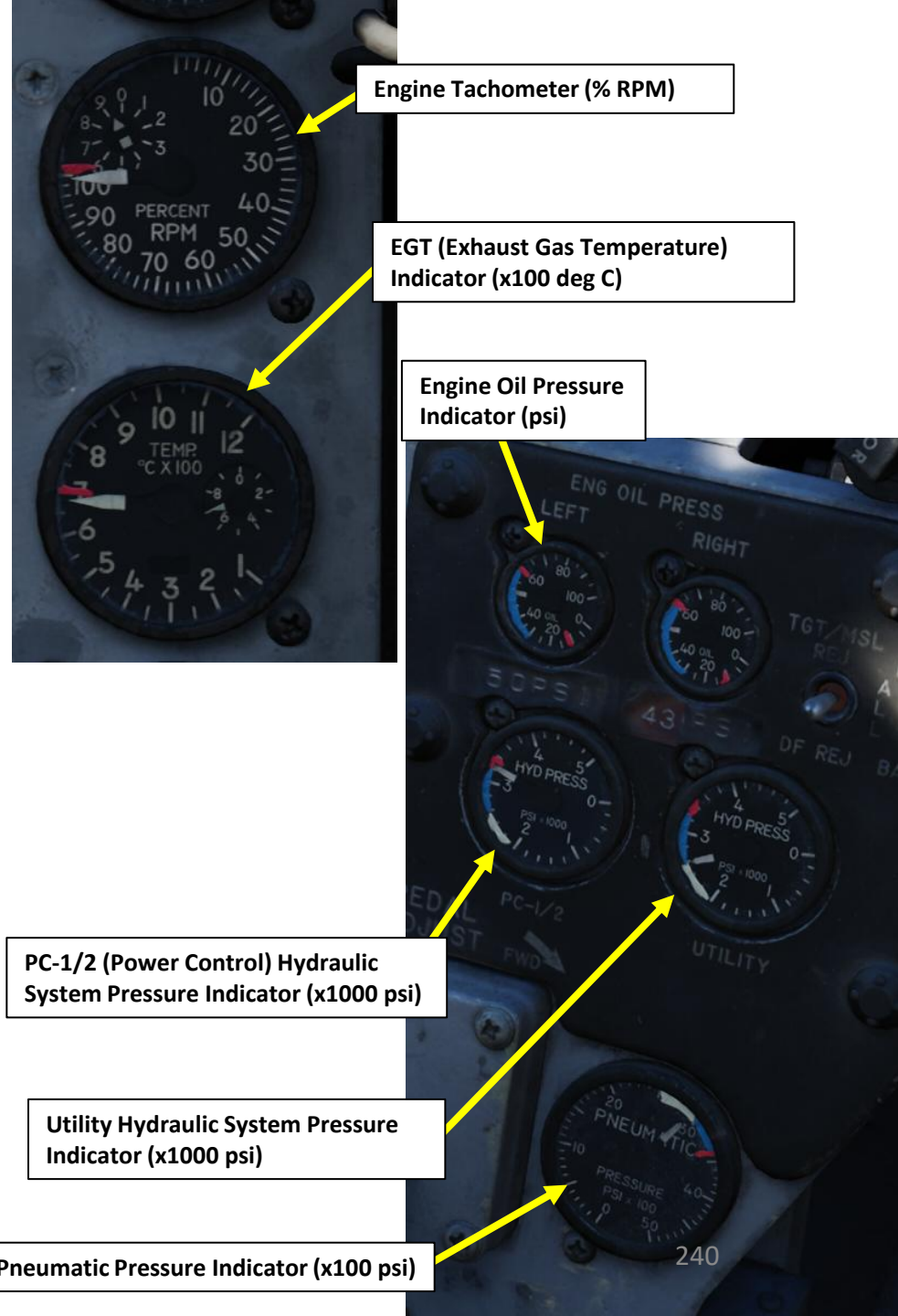
To recover from a partial compressor stall reduce engine power of the stalled engine to IDLE and pitch down to increase air flow to the engine. The procedure is as follows:

1. Set Throttle – IDLE
2. Pitch aircraft nose down to get an airspeed greater than 300 kts
3. When EGT (Exhaust Gas Temperature) decreases to nominal values and buffet ceases, advance the throttle and check that the engine accelerates normally.
    - If EGT values increase above permissible values, shut down the engine.
4. If compressor stall does not clear for the affected engine:
    a) Set Generator Switch – OFF
    b) Set Throttle – OFF
    c) Check Inlet Ramps – FULLY RETRACTED (performed by WSO)
    d) Press and hold Ignition Button
    e) Set Throttle – IDLE
    f) Monitor RPM, EGT (Exhaust Gas Temperature), Oil Pressure & Fuel Flow – Parameters increase to nominal values
    g) Set Generator Switch – ON



1 – POWERPLANT
1.7 – Engine Limits

Engine Limits Table	
EGT (Exhaust Gas Temperature)	Normal Range (No Limit): 670 deg C & Below Maximum Steady State: 678 deg C Max Operation Range: 679 to 715 deg C for no more than 5 minutes Max Operation Range: 716 to 750 deg C for no more than 1 minute Max Operation Range: 750+ deg C for no more than 3 sec
Engine RPM	Maximum Steady State – In Flight: 102 % RPM
Oil Pressure	Minimum at IDLE Thrust: 12 PSI Minimum at MIL Thrust – Static: 35 PSI Normal Range at MIL Thrust – In Flight: 30-60 PSI Maximum: 60 PSI
Hydraulic Pressure	PC-1/PC-2/UTILITY System Normal Range: 2750 to 3250 PSI Caution Range (Low): 2000 to 2750 PSI Caution Range (High): 3250 to 3400 PSI Maximum: 3400 PSI
Pneumatic Pressure	Normal Range: 2650 to 3300 PSI Caution Range: 3300 to 3500 PSI Maximum: 3500 PSI
Engine G Limitation (Fuel Starvation)	Negative G Flight: No more than 30 sec 0 G Flight: No more than 10 sec



1 – POWERPLANT
1.8 – Engine Flameout – In-Air Relight Procedure

To relight an engine using windmilling (external airflow going through the engine inlet drives the compressor blades to facilitate in-air engine relight):

1. Maintain airspeed greater than 300 kts (or Mach 0.6)
2. Set Engine Master Switch – ON (FWD)
3. Set Throttle – OFF
4. Press and hold Ignition Button
5. Set Throttle – IDLE
6. Monitor RPM, EGT (Exhaust Gas Temperature), Oil Pressure & Fuel Flow – Parameters increase to nominal values



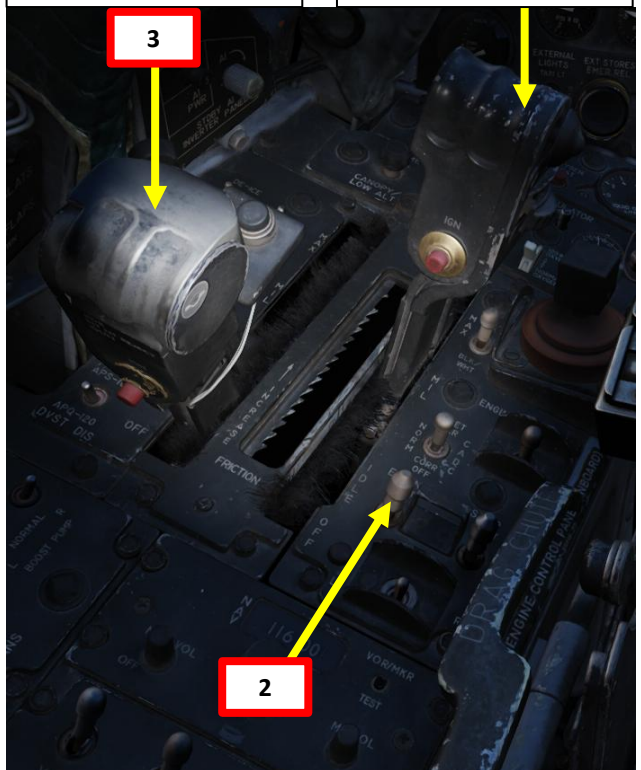


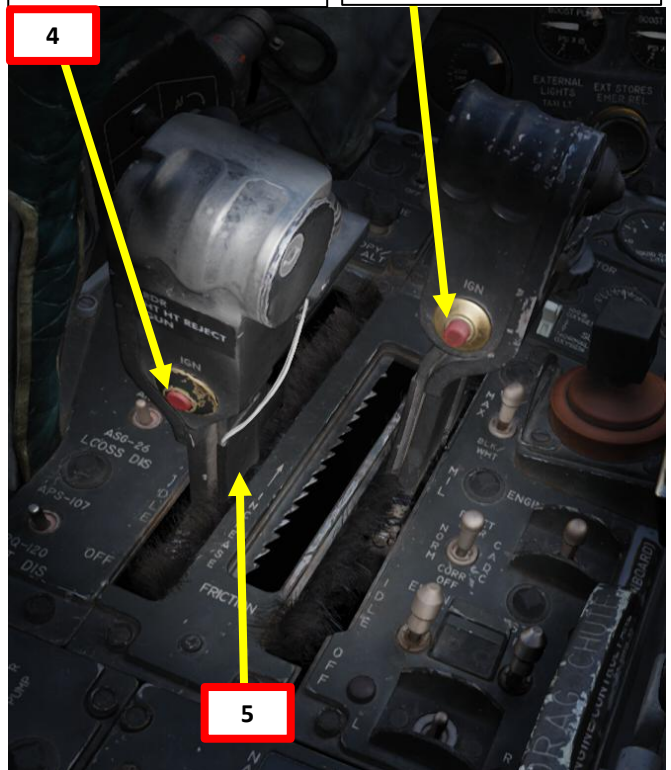
Left Throttle
- *OFF/IDLE Toggle: "RALT+END" binding.*

Right Throttle
- *OFF/IDLE Toggle : "RCTRL+END" binding*

Left Ignition Button
- "RALT+HOME" binding

Right Ignition Button
- *"RCTRL+HOME" binding.*



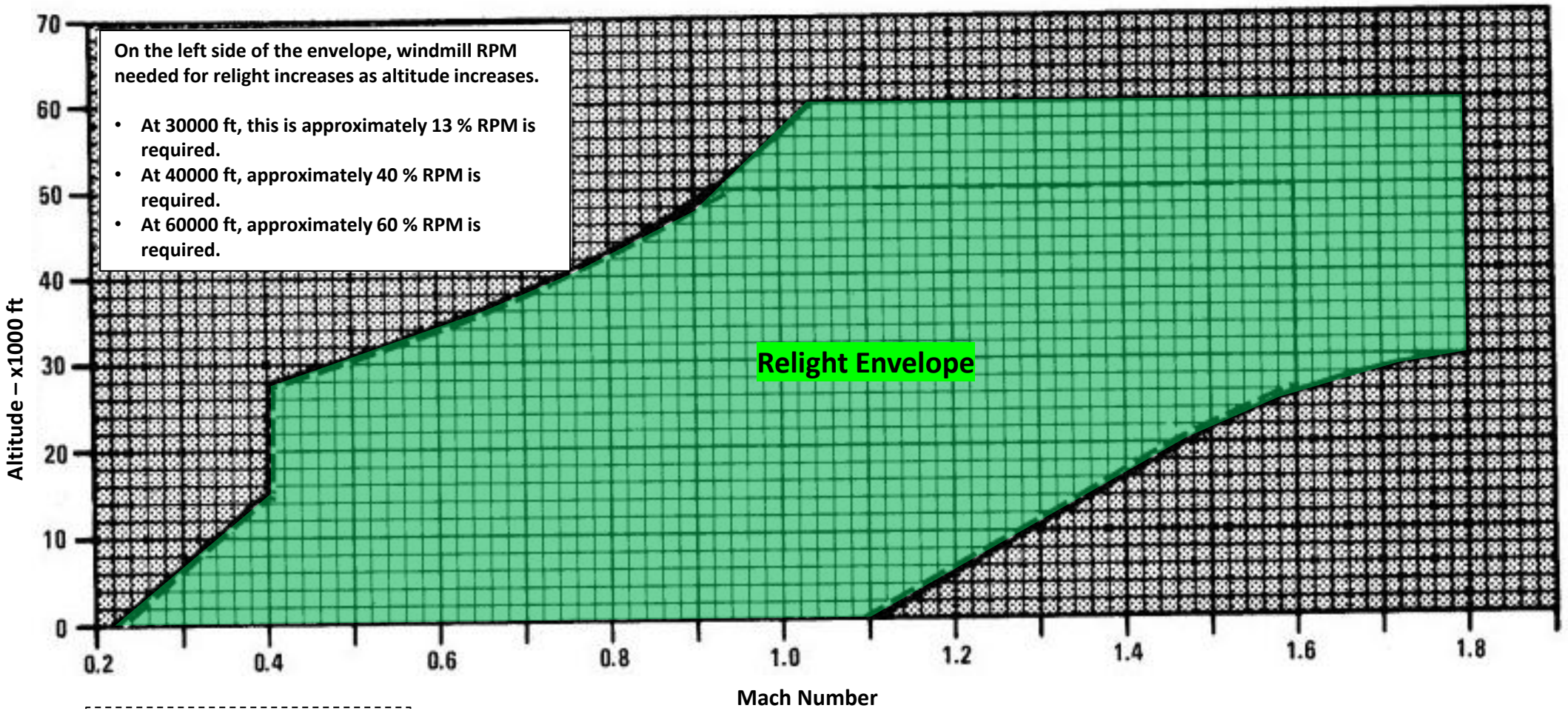






1 – POWERPLANT
1.8 – Engine Flameout – In-Air Relight Procedure

Engine In-Air Relight Envelope



Source: Heatblur Simulations Wiki

1 – POWERPLANT
1.9 – Engine Start with Cartridges

If an air pressure cart is not available at an airport, the F-4 can use explosive cartridges instead to start the engines. These cartridges are installed by the ground crew.

Cartridge mode is considered an alternate method of starting supplied for operational and emergency needs. A propellant charge is used to turn the starter turbine, which in turn cranks the engine to initiate startup. Cartridge ignition is controlled by the engine start switch providing the respective engine master switch is on. Remember that these cartridges are explosive and, unless fired, must not be forgotten to be removed. Under no circumstances will the aircraft be flown with unfired cartridges in the starter.

This procedure is based upon external power not being available. During routine (other than scramble/exercise) cartridge starts, it is advisable to use external electrical power, if available, as this will allow use of the CNI (Communication, Navigation & Identification Systems), fire and overheat warning circuits, and all engine instruments during the start. If external power is used, normal generator switching should be used. To avoid possible irritation caused by cartridge exhaust smoke/gases, it may be advisable to close canopies and select 100% oxygen during start cycle.

Note: *Never attempt to load or unload a cartridge in either starter with the engine master switches on, ground refueling switch on, or external electrical power applied. If a malfunction in safety circuits occurs, serious injury could result.*



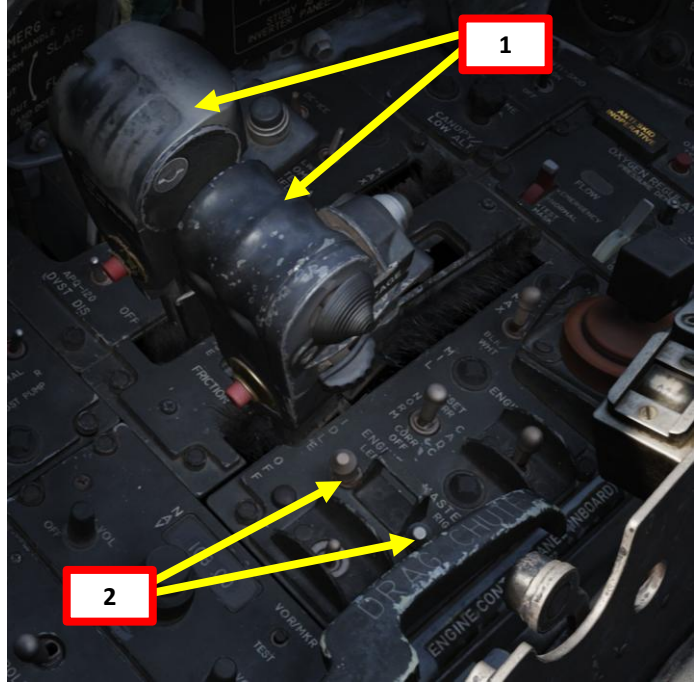
Cartridge Engine Start Checklist

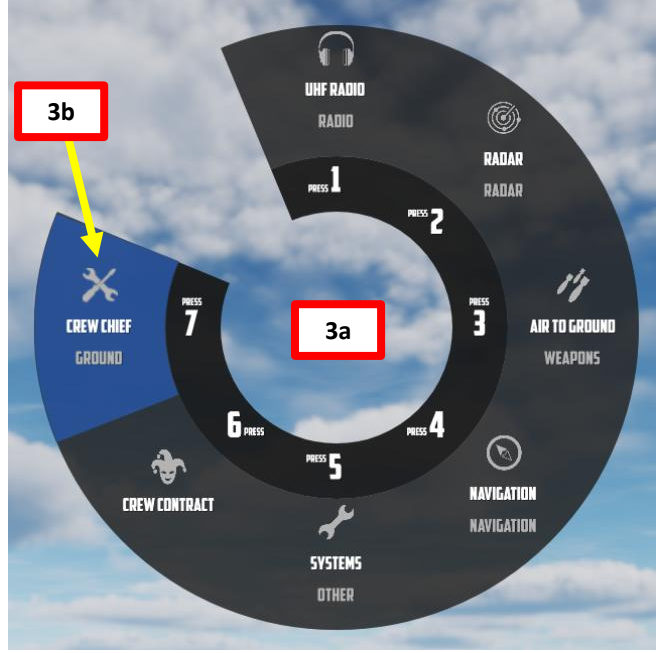
Step	System	Action
1.	Engine master switches	ON
2.	Right generator switch	GEN ON
3.	Ignition button	PRESS AND HOLD
4.	Throttle	HALF THEN IDLE
5.	Engine start switch	R (right)
6.	At Lightoff (EGT INCR)	
	Ignition Button	RELEASE
7.	Check Parameters	
	a. Exhaust Gas Temperature	220 - 420 °C
	b. Idle RPM	65 ± 1%
	c. Right Boost Pump	30 ± 5 PSI
	d. Oil Pressure	12 - 50 PSI
	e. Fuel Flow Indicator	800 - 1400 pph
	f. Hydraulic Pressure	WITHIN LIMITS
8.	Spoiler Actuator	CHECK (LEFT)
9.	Air Refueling door	CHECK (if required)
10.	Left Engine	START PER STEPS 1-7
11.	Left Generator	ON
12.	Right Generator	CYCLE OFF/ON
13.	Bus Tie Open Light	OUT
14.	Interior Check	COMPLETE

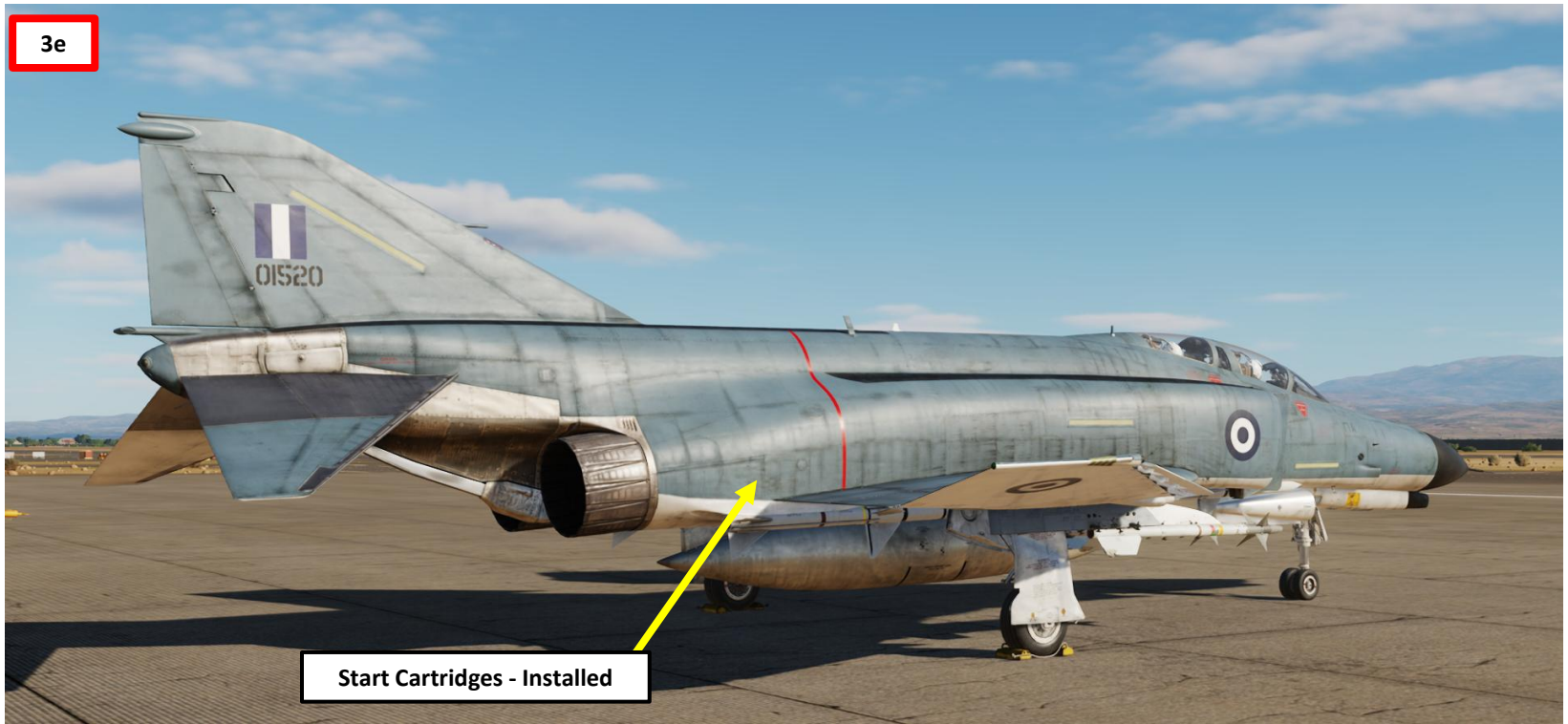
1 – POWERPLANT
1.9 – Engine Start with Cartridges

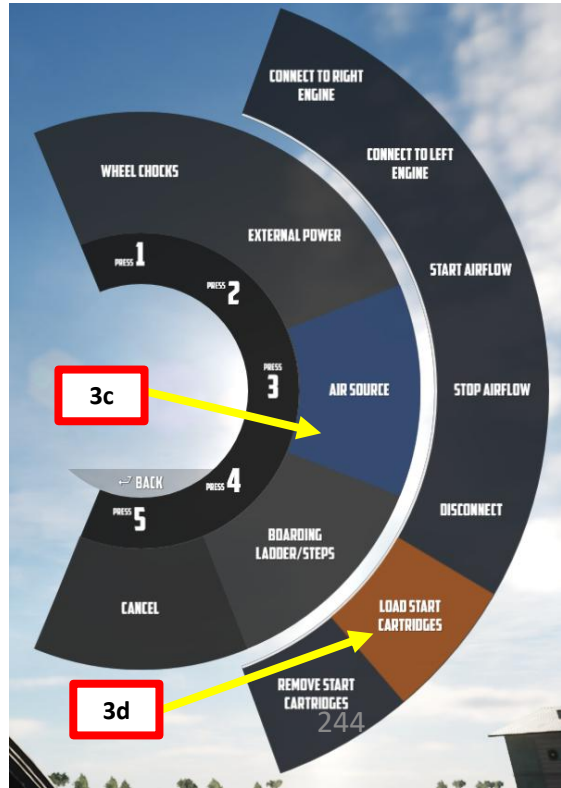
Here is an example of a cartridge start for the right engine.

1. *[P+WSO]* Verify throttles are set to OFF detent. Attempting to start the engines with throttles out of the OFF detent will result in fuel puddling and the possibility of a hot start (or even… engine fire!).
    - Left Throttle OFF/IDLE Toggle: "RALT+END" binding.
    - Right Throttle OFF/IDLE Toggle : "RCTRL+END" binding.
2. *[P]* Verify Left & Right Engine Master Switches are set to OFF (AFT)
3. *[P]* Call ground crew to load start cartridges:
    a) Open JESTER AI wheel by short-pressing "A".
    b) Click on CREW CHIEF
    c) Click on AIR SOURCE, then LOAD START CARTRIDGES
    d) Close JESTER AI wheel by long-pressing "A".
    e) Once cartridges are installed, the ground crew will call out "Cartridges are loaded".







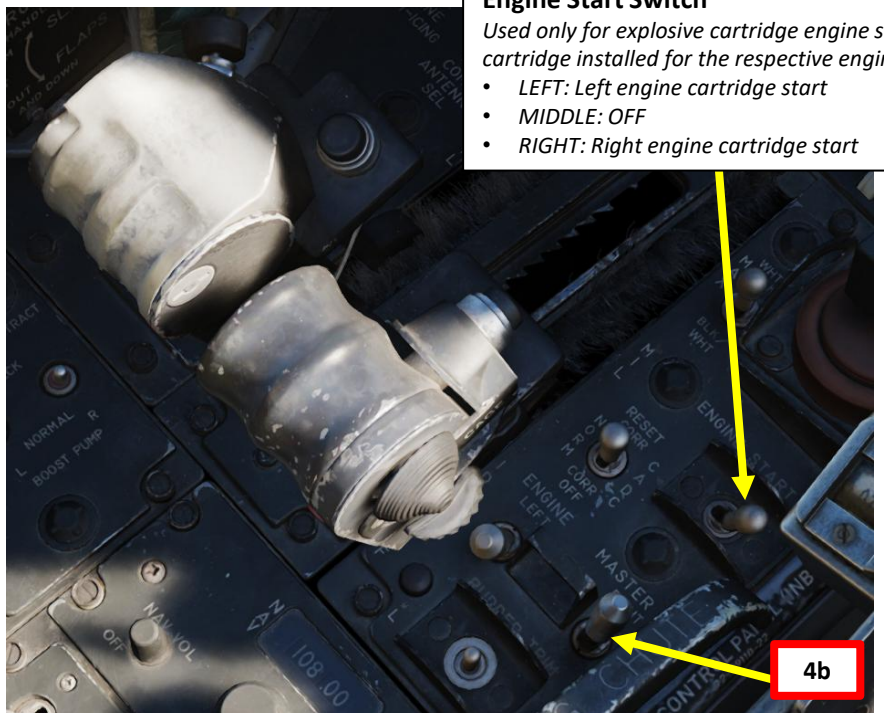


1 – POWERPLANT
1.9 – Engine Start with Cartridges

4. *[P]* Check right engine RPM is at 0 %, then set Right Engine Master Switch – ON (FWD).
5. *[P]* Set Right Generator Switch – ON (FWD)
6. *[P]* Set Engine Start Switch – RIGHT (Right engine cartridge start). This will ignite the cartridge and drive the engine starter.







Engine Start Switch

Used only for explosive cartridge engine start, selecting L or R ignites the cartridge installed for the respective engine.

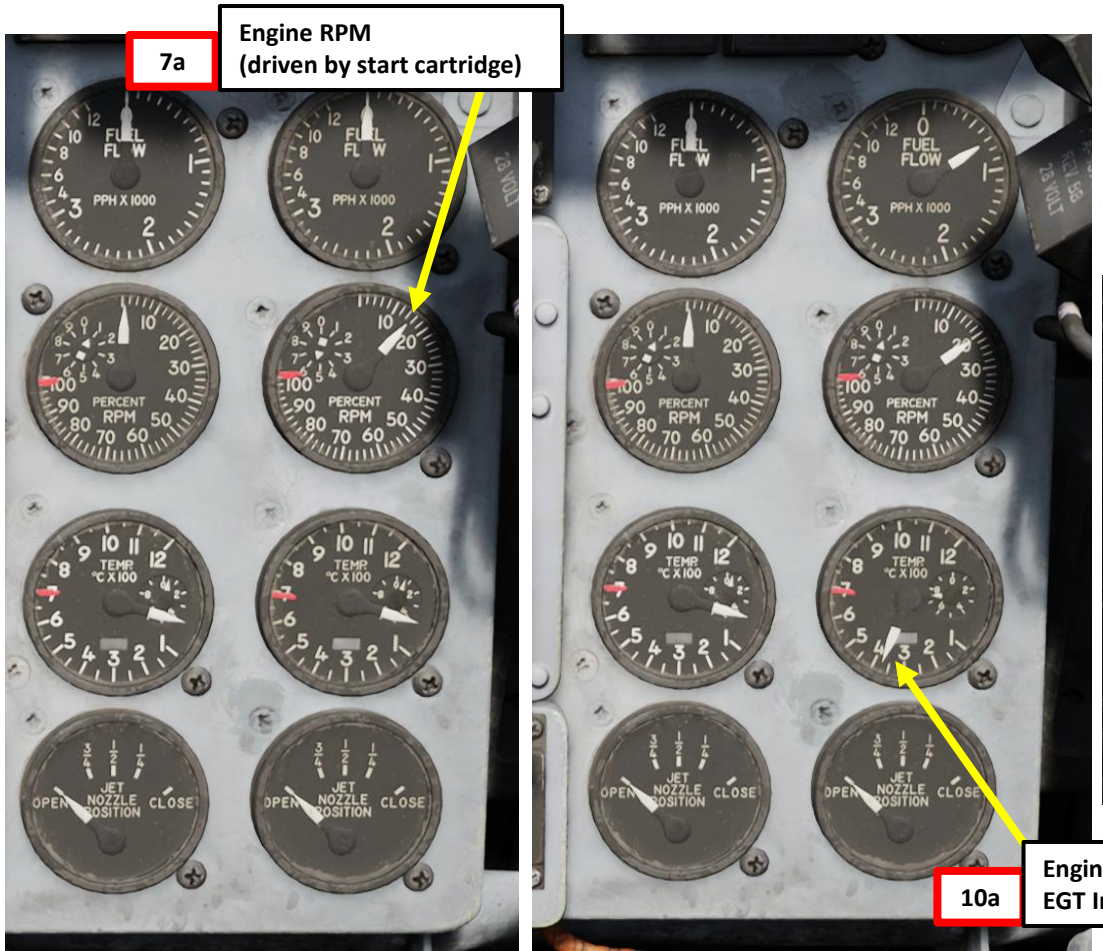
- *LEFT: Left engine cartridge start*
- *MIDDLE: OFF*
- *RIGHT: Right engine cartridge start*

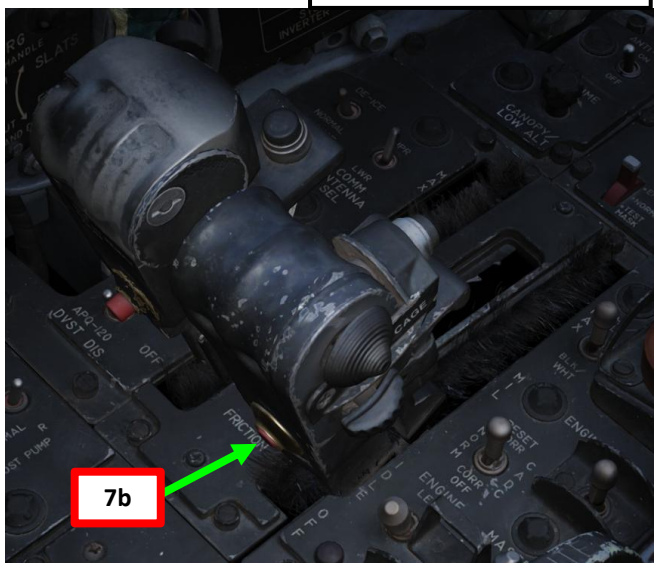
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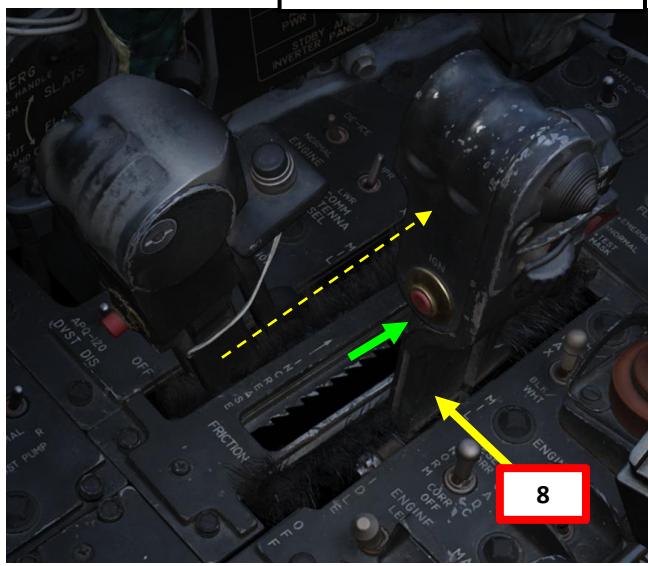


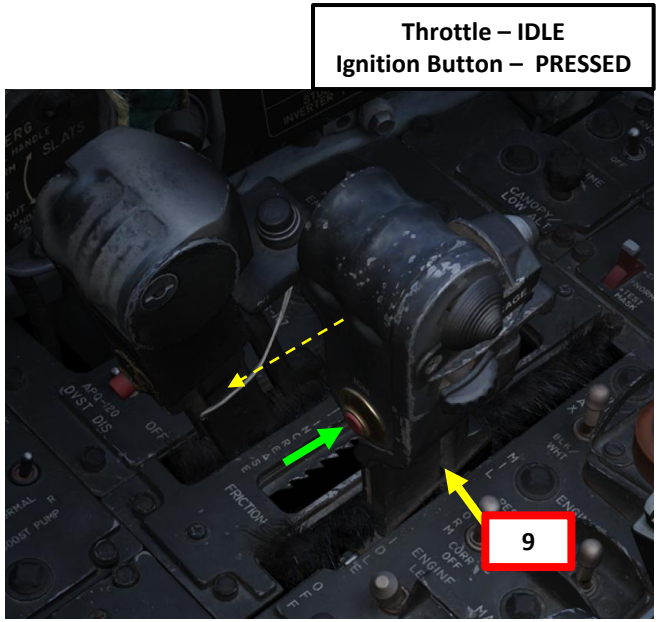
1 – POWERPLANT
1.9 – Engine Start with Cartridges

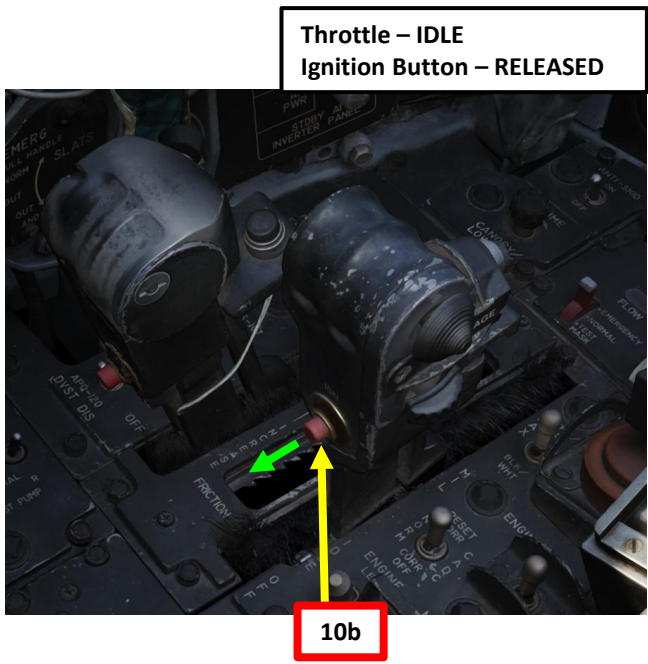
7. *[P]* Right engine RPM will gradually increase, its starter being driven by the explosive cartridge. When Engine RPM reaches 10 %, press and hold the Right Ignition Button. I recommend clicking and holding the button.
    - Right Throttle Ignition Button: “RCTRL+HOME” binding.
8. *[P]* Move Right Throttle out of the OFF detent halfway forward. Keep Right Ignition Button PRESSED.
    - Right Throttle OFF/IDLE Toggle : “RCTRL+END” binding.
9. *[P]* Move Right Throttle back to IDLE detent. Keep Right Ignition Button PRESSED.
10. *[P]* Confirm right engine lightoff occurs by checking for EGT (Exhaust Gas Temperature) increase, then release Right Ignition Button.





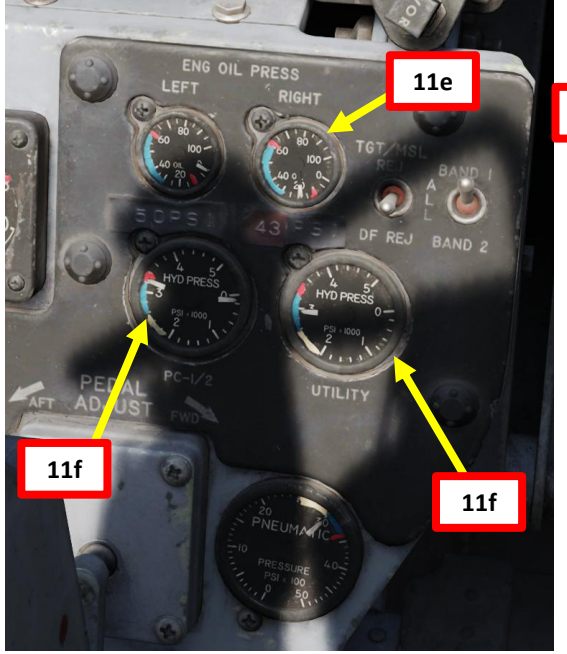


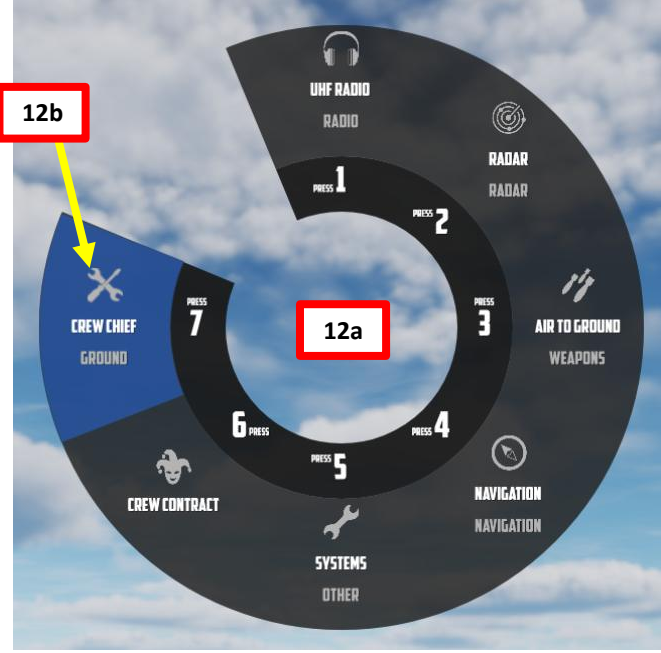


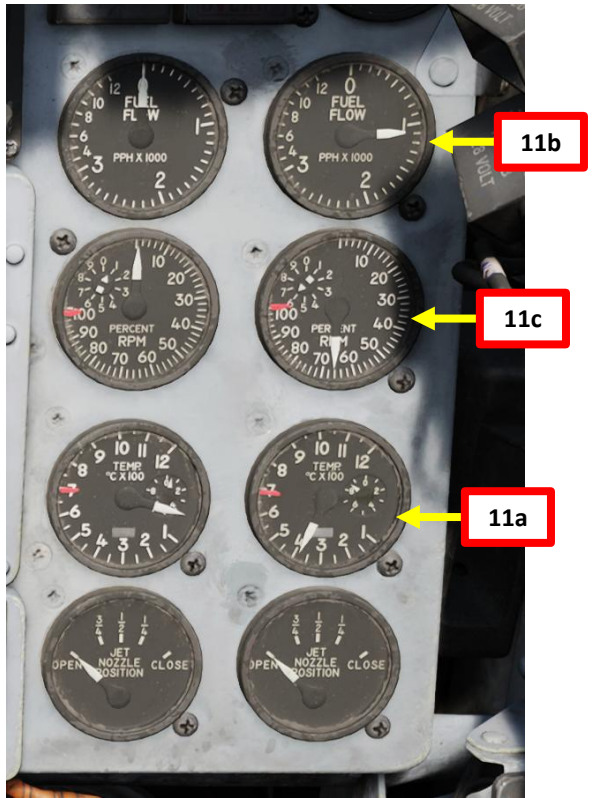


1 – POWERPLANT
1.9 – Engine Start with Cartridges

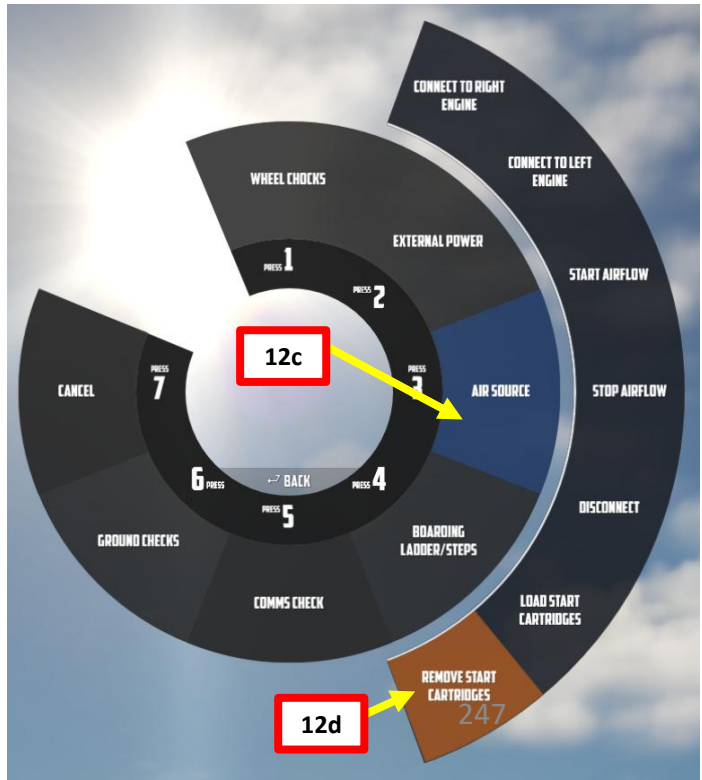
11. *[P]* Wait for engine parameters to stabilize, then check parameters are within nominal ranges.
    a) Exhaust Gas Temperature: 220 to 420 deg C
    b) Fuel Flow Indicator: 800 to 1400 lbs/hour (pph)
    c) Idle RPM: 65 %
    d) Fuel Boost Pump Pressure: 30 (+/- 5) psi
    e) Engine Oil Pressure: 12 to 50 psi
    f) Hydraulic Pressure – Within Limits
        - PC-2 Hydraulic Pressure: 3000 (+/- 250) psi
        - Utility Hydraulic Pressure: 2755 (+/- 255) psi
12. *[P] Important Note:* If starter cartridges are installed and you want to remove them:
    a) Open JESTER AI wheel by short-pressing "A".
    b) Click on CREW CHIEF
    c) Click on AIR SOURCE, then REMOVE START CARTRIDGES.
    d) Close JESTER AI wheel by long-pressing "A".











2 – FUEL
2.1 – Fuel System Overview

Fuel Tanks

The F-4E's fuel system consists of interconnected fuel tanks. By design, all internal fuel can be transferred even in the eventuality that the fuel transfer pump fails.

Total Fuel Quantity (Internal + 1x600 gal Ext Tk + 2x370 gal Ext Tk): 3195 gal (20768 lbs)

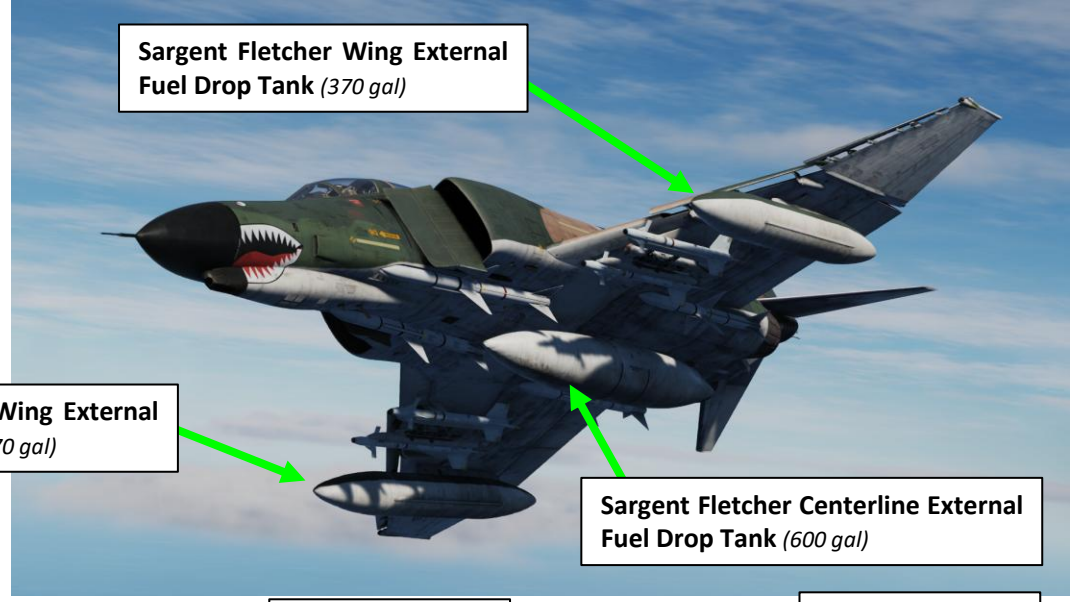
Internal Fuel Tanks:

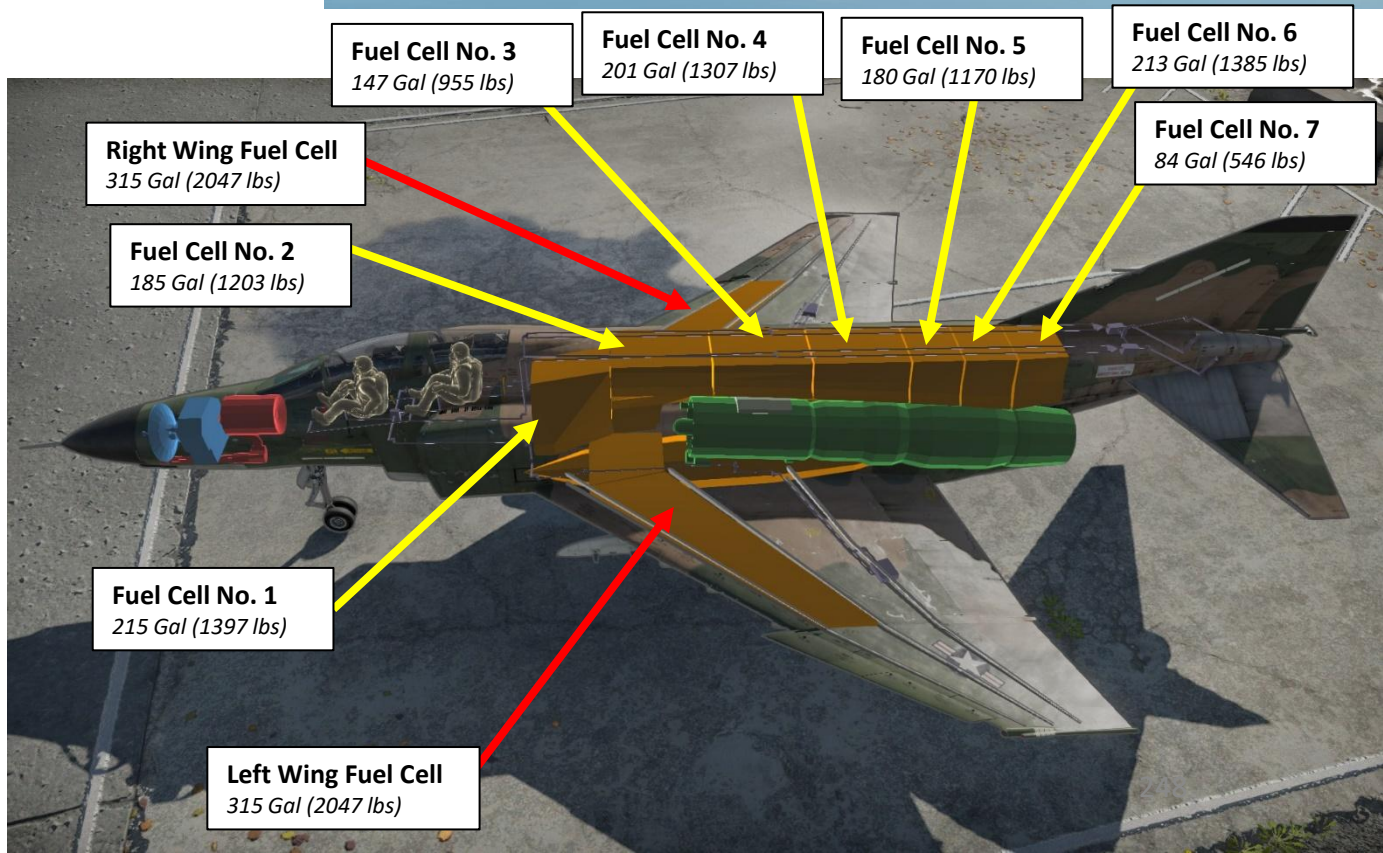
- ***Fuselage Fuel Tanks: 1225 gal (7963 lbs)***
  - Cell No. 1: 215 gal (1397 lbs)
  - Cell No. 2: 185 gal (1203 lbs)
  - Cell No. 3: 147 gal (955 lbs)
  - Cell No. 4: 201 gal (1307 lbs)
  - Cell No. 5: 180 gal (1170 lbs)
  - Cell No. 6: 213 gal (1385 lbs)
  - Cell No. 7: 84 gal (546 lbs)
- ***Wing Fuel Tanks: 630 gal (4095 lbs)***
  - Left Wing Fuel Tanks: 315 gal (2047 lbs)
  - Right Wing Fuel Tank: 315 gal (2047 lbs)

Total Fuel Quantity (Internal): 1855 gal (12058 lbs)

External Fuel Tanks

- ***Drop Tanks***
  - Centerline External Fuel Tank Quantity: 600 gal (3900 lbs)
  - Wing External Fuel Tank Quantity (per tank): 370 gal (2405 lbs)





2 – FUEL
2.1 – Fuel System Overview

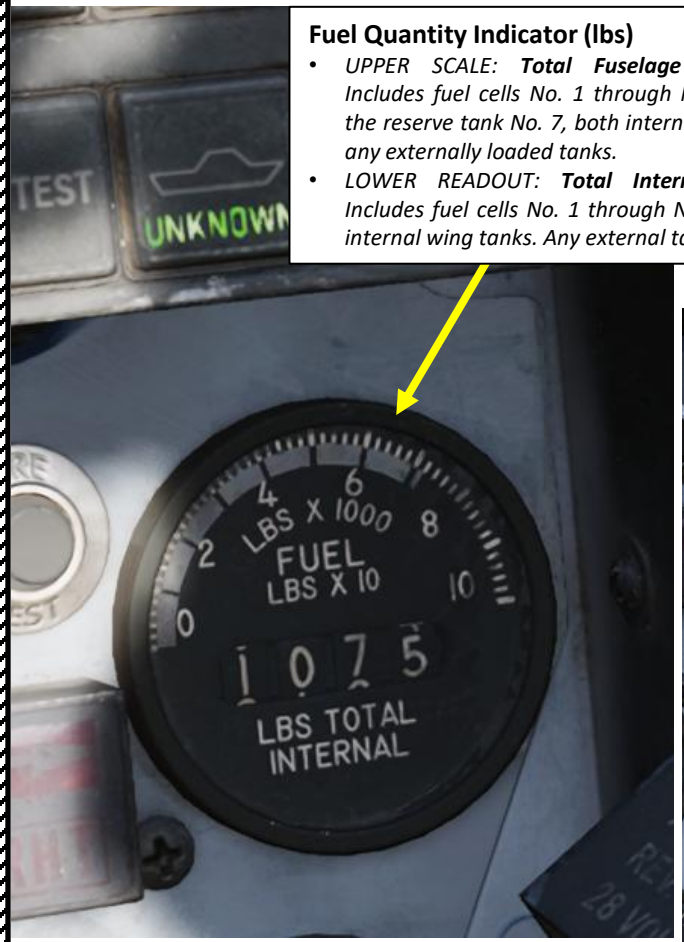
Fuel Quantity Indications

Fuel quantity is monitored with the **Fuel Quantity Indicator** and the **FUEL LEVEL LOW**, and **LEFT/CTR/RIGHT EXT FUEL** warning lights on the Warning Telelight Panel.

Warning Telelight Panel		
LEFT EXT FUEL *Left external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*	**CTR EXT FUEL** *Centerline external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*	**RIGHT EXT FUEL** *Right external fuel tank is selected and there is no fuel flow from the tank to the fuselage.*
FUEL LEVEL LOW *Fuel level in cells 1 and 2 has reached a predetermined fuel state of 1650 ± 200 pounds.*	**CHK FUEL FILTERS** *Fuel filter is clogged. The filter automatically opens to bypass, allowing normal fuel flow to the engine.*	**TANK 7 FULL** *Tank 7 fuel transfer valve fails to open.*

Fuel Quantity Indicator (lbs)

- *UPPER SCALE: **Total Fuselage Fuel** x 1000 lbs. Includes fuel cells No. 1 through No. 6, while excluding the reserve tank No. 7, both internal wing tanks and also any externally loaded tanks.*
- *LOWER READOUT: **Total Internal Fuel** x 10 lbs. Includes fuel cells No. 1 through No. 7 and also the two internal wing tanks. Any external tanks are excluded.*



Feed Tank Check Switch

- *UP: Feed Tank Check position. In this position, fuel quantity gauge will indicate solely the current fuel quantity in the engine feed tank on both the tape and counter. When the feed tank is full, the indicated value should read 1400 lbs +/- 200 on the counter, and the tape value should be 1400 lbs +/- 150.*
- *DOWN: Normal Position*





2 – FUEL
2.1 – Fuel System Overview

Fuel Transfer Sequence

The F-4 carries two internal wing tanks, along with seven fuel cells down the length of the fuselage, with cell 1 resting just behind the aft cockpit, and the remaining cells numbered in order to the rear of the aircraft.

- Fuel Cell 1 is the feed cell for the engines
- Fuel Cells 4 and 6 each carry a hydraulic and an electric transfer pump to supply fuel to cells 1 and 2.
- The remaining fuselage cells perform a gravity feed into cells 1, 4, or 6. Cell 2 feeds cell 1, cell 3 feeds cell 4; and cell 5, as well as cell 7 feed cell 6.

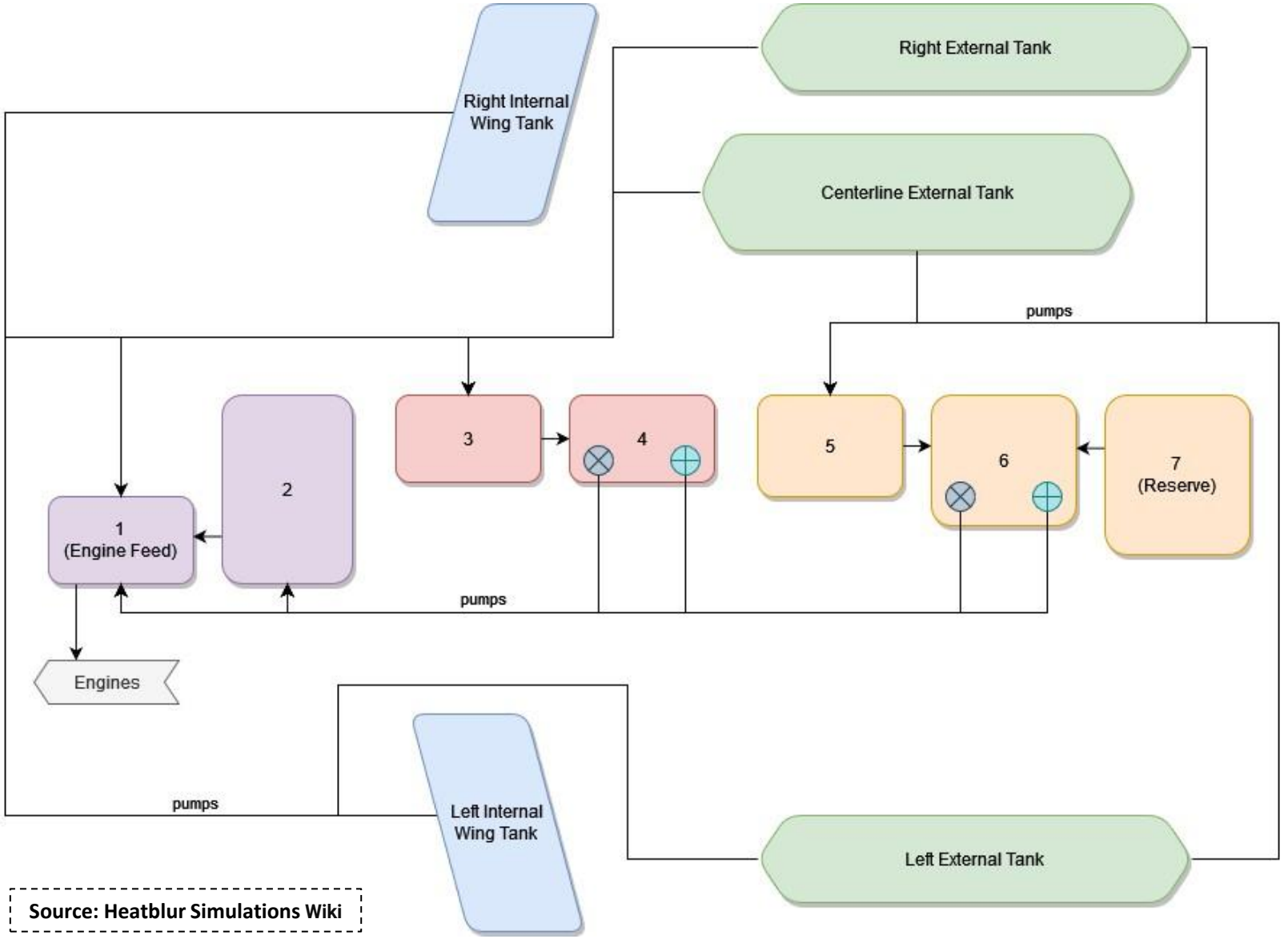
With this arrangement, center of gravity balance is maintained along the centerline. Cell 7 is the last cell to initiate transfer in the sequence, and does not begin until the total fuel in cells 1 and 2 fall below 1800 lbs.

Fuel transfer from the wing and external tanks is performed by bleed air pressurization once airborne. Internal wing tank fuel is transferred into fuselage cells 1 and 3, whereas fuel from external tanks are balanced between cells 1, 3, and 5.

When the aircraft reaches a low fuel state, automatic fuel transfer activates, forcing valves from internal wing and external tanks open regardless of what has been selected on the panel.

Automatic fuel transfer, once activated, can only be deactivated again by cycling the Air Refuel Switch. This is important, as most switches on the fuel system panel are ignored while activated. An indication for the automatic transfer being active are all three external tank fuel lights being lit regardless of their actual status.

Internal wing and external tanks will **not transfer when not pressurized**. This is the case with either the landing gear out or the AAR (Air-to-Air Refueling) door open.



Source: Heatblur Simulations Wiki

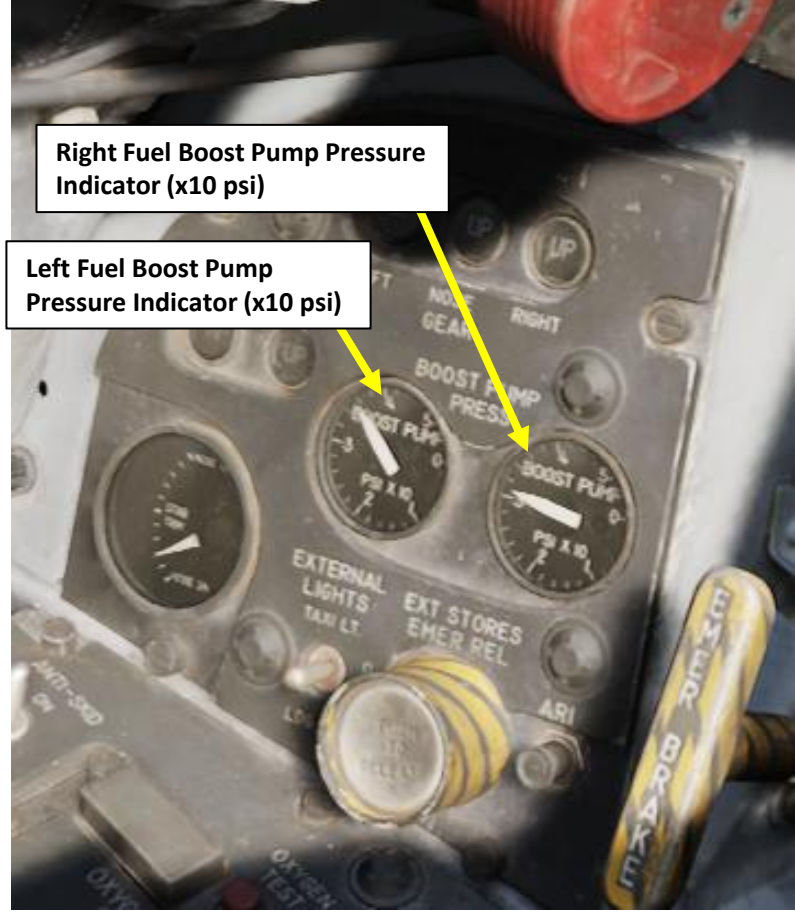
2 – FUEL
2.1 – Fuel System Overview

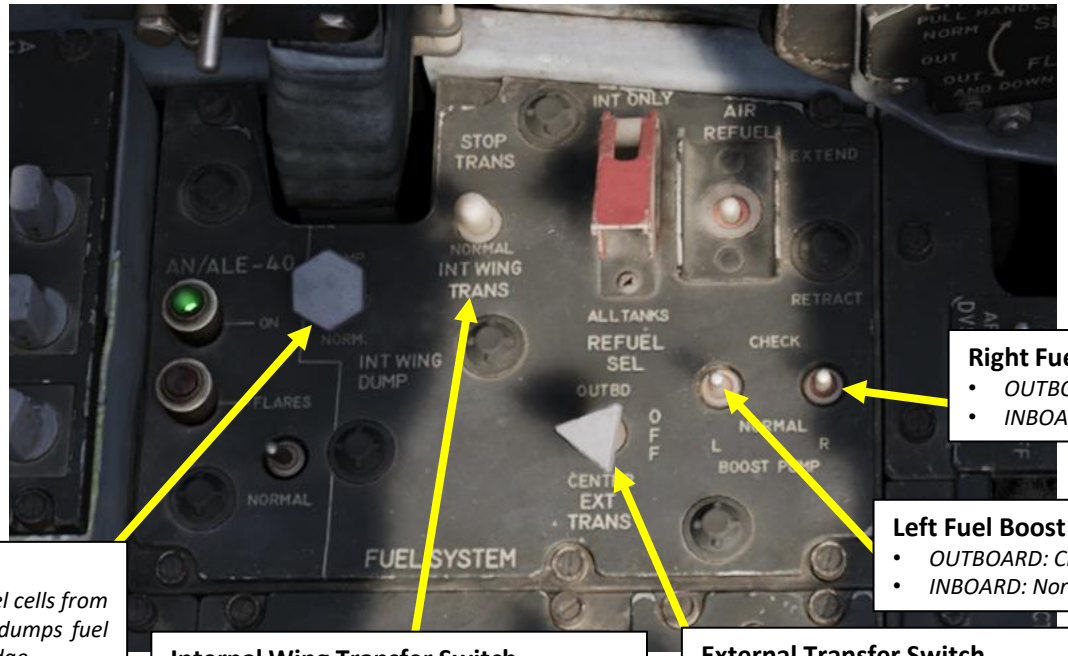
Fuel Boost Pumps

Flow from Fuel Cell 1 to the engines is performed by a pair of **boost pumps**. The pumps are installed at the bottom of the tank to provide fuel in the event of a negative G excursion. The function of these pumps can be confirmed on the **Fuel Boost Pump Pressure Indicators**. Engine idle pump flow rate is 30 PSI. To confirm a ground check, a pair of **Boost Pump switches** are found on the fuel control panel. Holding one of these switches in the CHECK position will perform an engine shutdown due to the shutoff valve being opened, and provide feedback on the respective Pressure Indicator.

Should it be necessary, **Internal Wing Transfer switch** is available to turn off transfer from the wing internal tanks. External tank transfer is controlled by the **External Transfer switch**.

It is **not possible to transfer from the wing tanks and external tanks at the same time**. If both are selected, the external tanks will take priority.





Right Fuel Boost Pump Switch
- *OUTBOARD: Check*
- *INBOARD: Normal*

Left Fuel Boost Pump Switch
- *OUTBOARD: Check*
- *INBOARD: Normal*

Internal Wing Dump Switch
- *OUTBOARD: Dump, closes off the wing fuel cells from transfer into the fuselage fuel cells and dumps fuel from the valves at the wing fold trailing edge.*
- *INBOARD: Normal, closes the dump valves and reconnects the wing cells for transfer to the fuselage*

Internal Wing Transfer Switch
- *OUTBOARD: STOP TRANS, ceases flow from the wings to the fuselage feed tanks*
- *INBOARD: Normal, permits fuel transfer.*

External Transfer Switch
- *OUTBOARD: OUTBD, outboard external fuel tank is transferring fuel to the fuselage tanks*
- *MIDDLE: OFF, no external fuel tank is transferring fuel to the fuselage tanks.*
- *INBOARD: CENTER, center external fuel tank is transferring fuel to the fuselage tanks*

2 – FUEL
2.1 – Fuel System Overview

Air Refueling System Components

The air refueling door system is opened or closed with the **Air Refuel Switch**. The **Refuel Select Switch** provides options for two modes of refueling: internal fuselage and internal wing tanks (INT ONLY), and ALL TANKS, used to include external tanks in the refueling operation.

Refueling Select Switch
- *OUTBOARD: INT ONLY, internal tanks only are refueled during air-to-air refueling cycle*
- *INBOARD: ALL, all tanks are refueled during air-to-air refueling cycle.*

Air Refuel Switch
- *OUTER: ON/EXTEND, in-flight refueling receptacle is powered ON and extended.*
- *INNER: OFF, in-flight refueling receptacle is unpowered and lowered/stowed*





Air-to-Air Refueling (AAR) Door



2 – FUEL
2.1 – Fuel System Overview

Air Refueling System Components

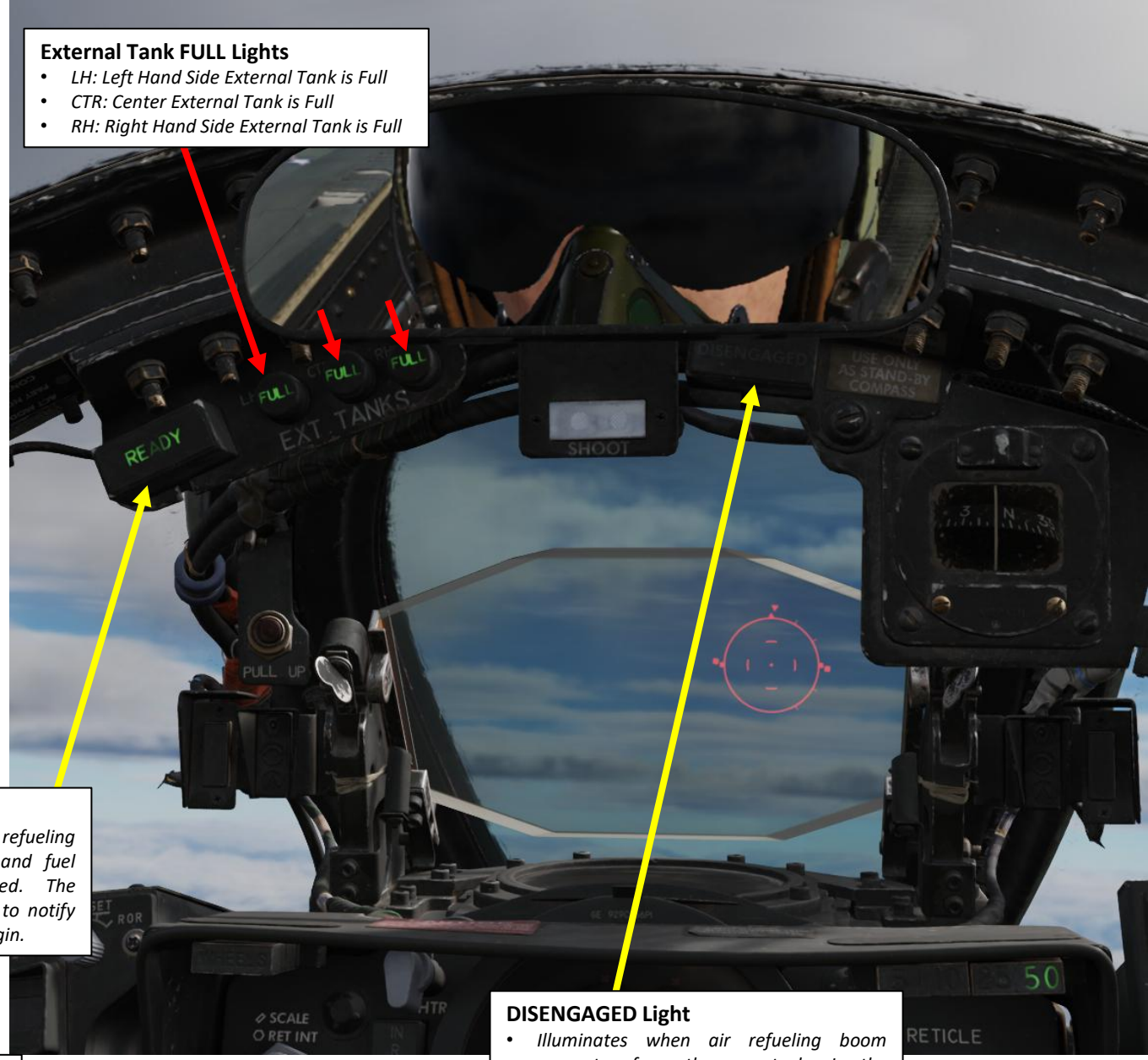
With the receptacle extended and tanks depressurized, the **READY** lamp illuminates to notify the pilot refueling can begin. The lamp will turn off when the boom is connected to the receptacle, or the receptacle is lowered by the RETRACT command on the Air Refuel Switch. Should the boom separate from the receptacle, the **DISENGAGED** lamp will illuminate. In the event of a DISENGAGED signal, the system must be reset to continue refueling. The system must be reset by toggling the air refuel switch.

The **Air Refueling Release Button** is used to release the receptacle from the boom in the event of a manual refueling cycle (one in which the boom operator cannot force a disconnect remotely), or perform a disengagement on demand based on flight conditions or emergency situation. Pressing the button will disengage the boom, and illuminate the DISENGAGED lamp.

Three indicator lamps provide confirmation that the external tanks have been filled during the air refueling process: **L.H. FULL, CTR. FULL,** and **R.H. FULL** (Left Hand, Center, Right Hand). The lamps will remain lit until the air refueling receptacle retracted.



Air Refueling Release Button
- *Dual-role control that performs the boom disconnect function, as well as a number of weapon selection functions*
- *Binding: S*



External Tank FULL Lights
- *LH: Left Hand Side External Tank is Full*
- *CTR: Center External Tank is Full*
- *RH: Right Hand Side External Tank is Full*

READY Light
- *Illuminates when the air refueling receptacle is extended and fuel tanks are depressurized. The READY lamp illuminates to notify the pilot refueling can begin.*

DISENGAGED Light
- *Illuminates when air refueling boom separates from the receptacle. In the event of a DISENGAGED signal, the system must be reset to continue refueling by toggling the Air Refuel Switch.*

2 – FUEL
2.2 – External Fuel Drop Tanks

The F-4E can equip two types of Sargent Fletcher external fuel tanks:
- Wing External Drop Tanks: 370 gal (each)
- Centerline External Drop Tank: 600 gal

There are no indications in the cockpit to show the actual fuel quantity in the tanks.

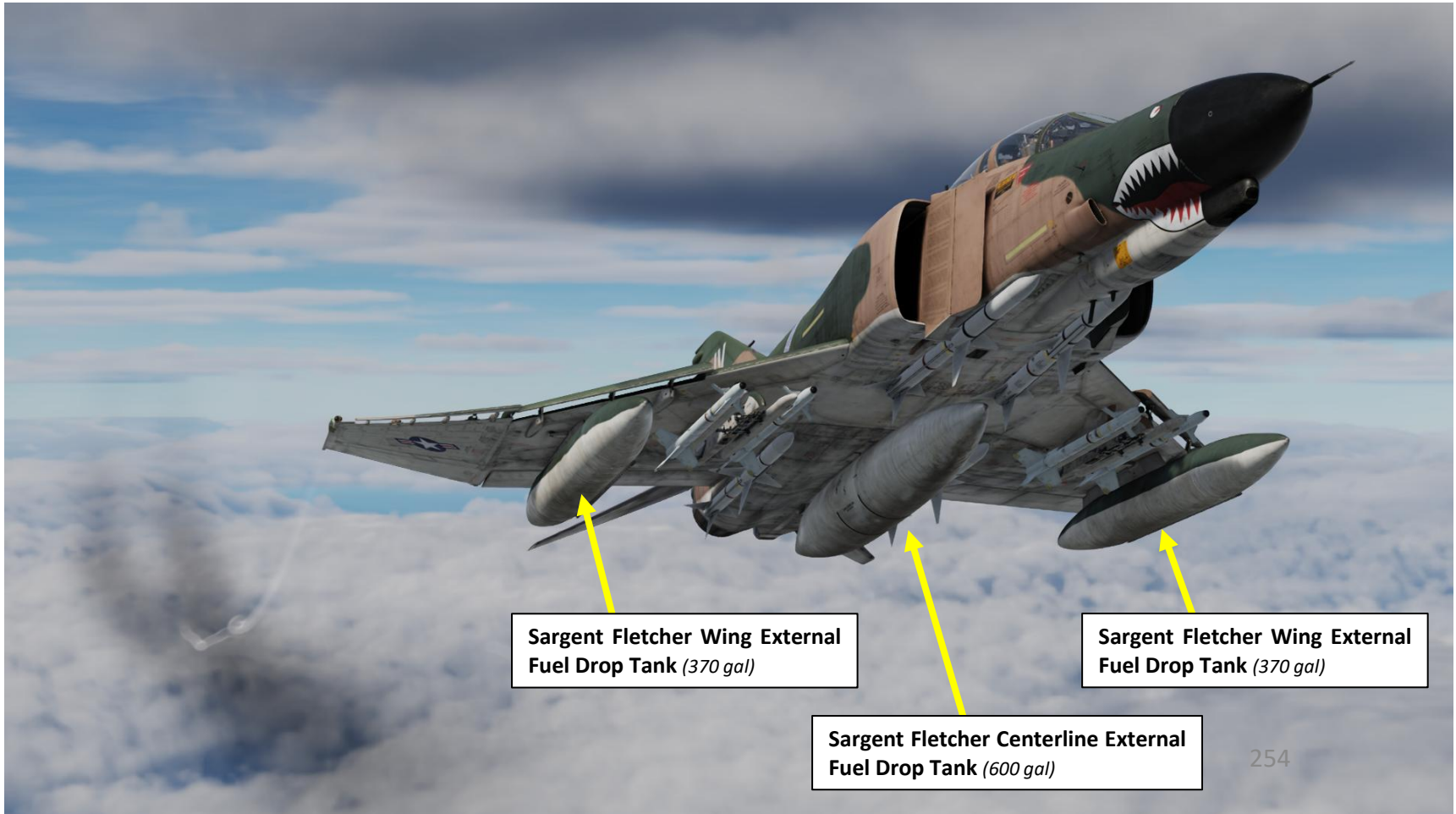
G Limits for External Tanks:

600 Gal External Centerline Tank:

- **Symmetrical configuration**
  - +6.5G / -2.0G
- **Asymmetrical configuration**
  - +5.2G / 0G

370 Gal External Wing Tanks:

- **Symmetrical configuration**
  - +4.0G / -1.0G: Tanks 75%+ Full
  - +5.0G / -2.0G: Tanks 10% to 75% Full
  - +6.0G / -2.0G: Tanks Empty to 10% Full
- **Asymmetrical configuration**
  - +2.0G / 0G: Tanks 75%+ Full
  - +4.0G / 0G: Tanks 10% to 75% Full
  - +4.8G / 0G: Tanks Empty to 10% Full

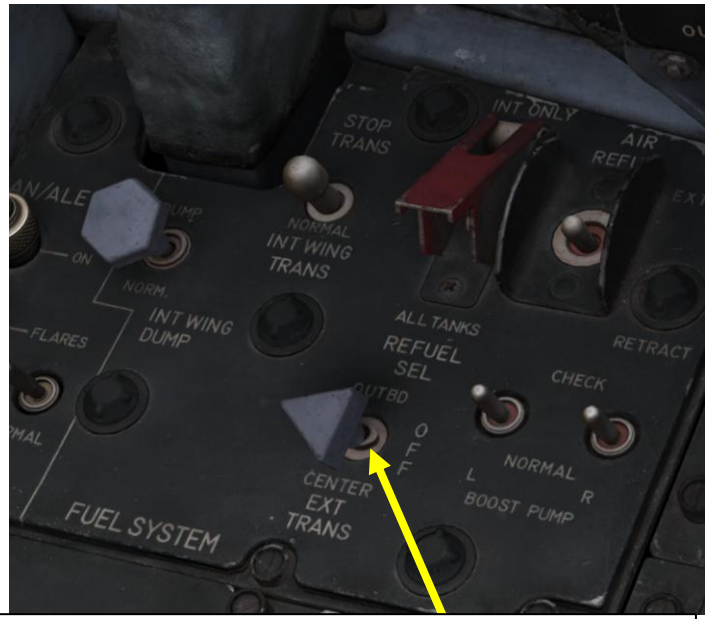


2 – FUEL
2.2 – External Fuel Drop Tanks



External Fuel Tanks Operation:

1. *[P]* Before takeoff:
   - If configured with wing tanks only, set **External Transfer switch to OUTBOARD position (OUTBD)** to feed from the outboard wing tanks first.
   - If configured with both wing tanks and the centerline tank, set **External Transfer switch to INBOARD position (CENTER)** to feed from the centerline tank.
2. *[P]* While aircraft is on the ground (weight on wheels), fuel is not used from external or internal wing tanks as they are not pressurized. The engines burn internal fuselage fuel until off the ground, which results in the center of gravity gradually shifting forward.
3. *[P]* Once airborne, the **LEFT, RIGHT or CTR EXT FUEL tank lights** will cycle on and off, indicating when the external fuel tanks are not feeding because the internal tanks are full.
4. *[P]* When the external tanks are empty, the lights are on (LEFT EXT FUEL, CTR EXT FUEL, RIGHT EXT FUEL) and the counter portion of the fuel gauge will drop steadily. At that time, set **External Transfer switch to MIDDLE position (OFF)**. Failing to do so will trap your internal wing fuel until the emergency transfer is activated at about 2300 lbs total fuel remaining.
   - Because transfer can occur intermittently due to flow from the tanks exceeding engine fuel consumption, the warning lamp is not immediately indicative of an empty external tank, and should be checked against the quantity indication system. A good general indication that the tanks are empty is the total fuel counter showing a value below 11.000 lbs. To confirm, fly level and watch if the light stays on and the fuel gauge is not going up for at least one or two minutes.





1
4

External Transfer Switch
- *OUTBOARD: OUTBD, outboard external fuel tank is transferring fuel to the fuselage tanks*
- *MIDDLE: OFF, no external fuel tank is transferring fuel to the fuselage tanks.*
- *INBOARD: CENTER, center external fuel tank is transferring fuel to the fuselage tanks*

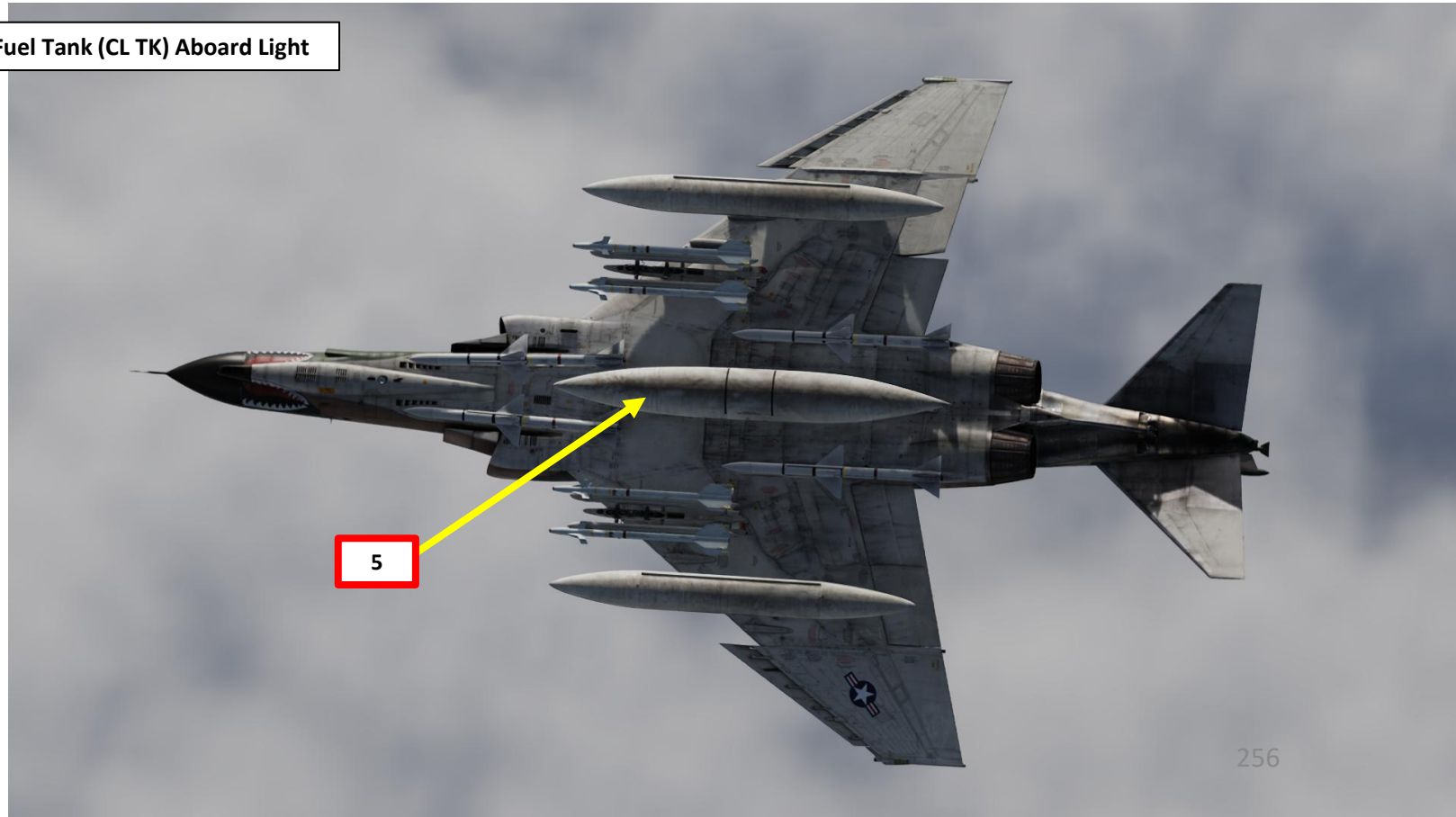
2 – FUEL
2.2 – External Fuel Drop Tanks

External Fuel Tanks Operation:

5. *[P]* If the CL TK (Centerline External Fuel Tank Aboard) Light is illuminated, a stores condition exists that precludes ejection or launch of an AIM-7 Sparrow missile installed in one of the two forward positions. In other words, the external centerline tank prevents use of the forward AIM-7s. To use the Sparrows on these stations, the centerline store must be first jettisoned.
6. *[P]* If you perform air-to-air refueling from a tanker, after refueling set External Transfer switch to OUTBOARD position (OUTBD) again if needed.

Remember that in the F-4, you should always drop your externals before an air-to-air engagement unless going after a bomber or transport – and even then, you should still definitely drop the center tank.

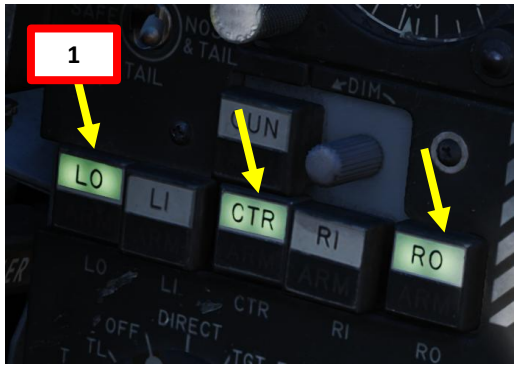




2 – FUEL
2.2 – External Fuel Drop Tanks

If you need to jettison the external fuel tanks:

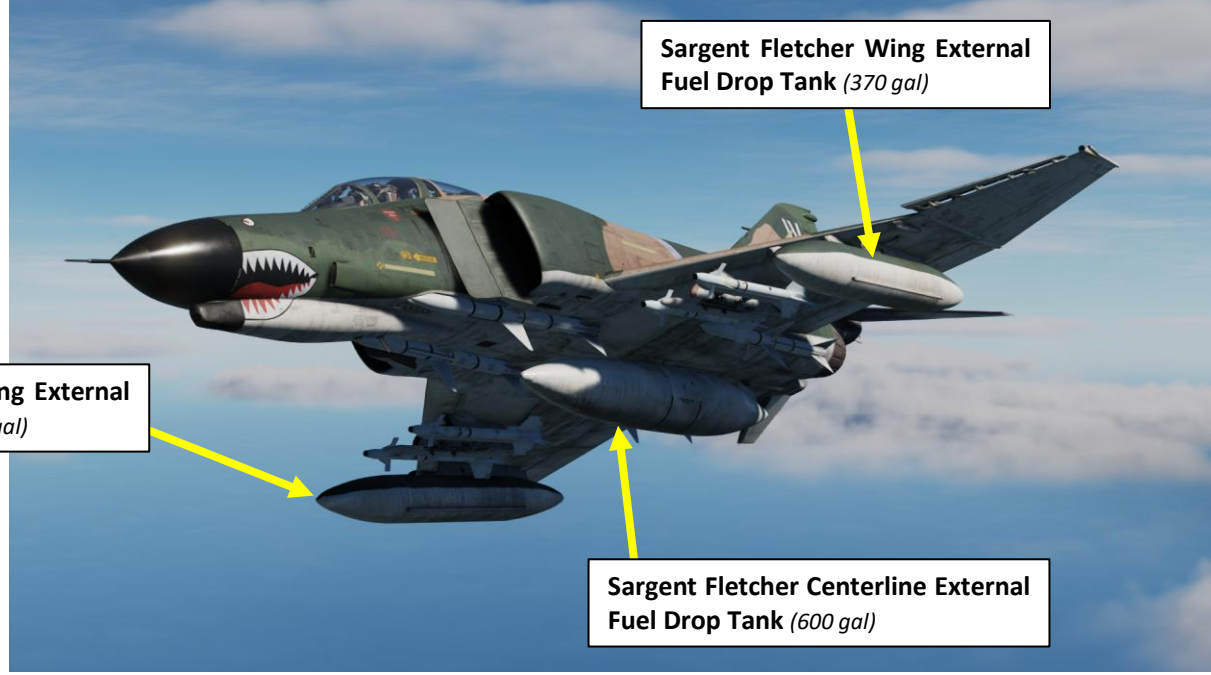
1. *[P]* Select desired Station Select Buttons. We will select LO, CTR and RO.
   - Stations: LO (Left Outer), CTR (Center), RO (Right Outer)
2. *[P]* Set Selective Jettison Control Knob – STORES (FULLY DOWN)
3. *[P]* Push Selective Jettison Control Knob – IN.
4. *[P]* Selected external fuel tanks will jettison.
5. *[P]* Set Selective Jettison Control Knob – OFF (FULLY UP)
6. *[P]* De-select Station Select Buttons.





Centerline External Fuel Tank (CL TK) Aboard Light







2 – FUEL
2.3 – Fuel Planning & Mission Profile

Here is a mission profile for a typical "counter air" mission.

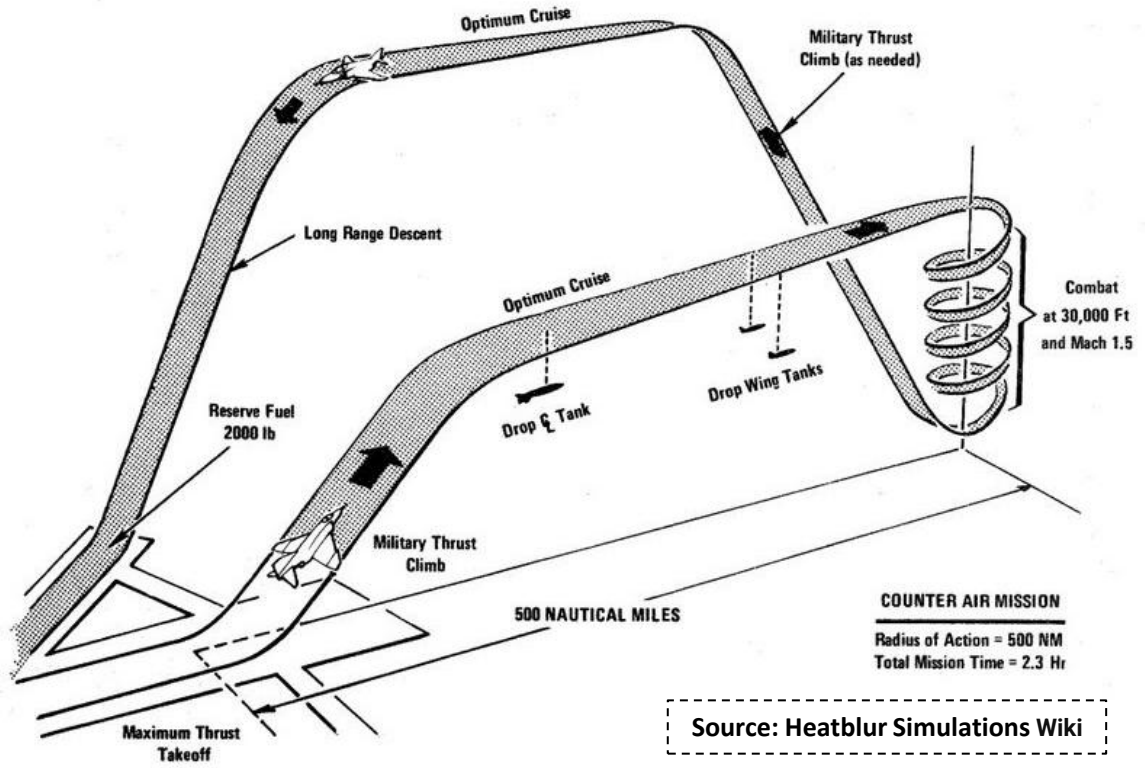
1. Perform maximum thrust takeoff and climb at military thrust.
2. Cruise at optimum altitude and maximum range speed to a combat zone 500 nm from the air base.
3. Drop external tanks when empty.
4. Perform combat maneuvering at maximum thrust for the full duration — allowed by return and landing fuel requirements.
5. Missiles and gun rounds are assumed to be expended at the end of the combat period.
6. Return to the airfield at optimum altitude and airspeed.
7. Descend at maximum range descent, arriving at the destination with 2000 lbs landing fuel reserve.

Counter Air Mission Profile

Total Mission Time: 2.3 Hours
Radius of Action: 500 nm

Phase of Flight	Fuel (lbs)	Gross Weight (lbs)	Distance from Base (nm)
Taxi, Takeoff & Acceleration	20800	58300	0
Start Climb	19200	56700	5
Start Cruise • Cruise Altitude: 30000 ft • Cruise Speed: Mach 1.5	17000	54500	90
Drop Centerline Tank	16900	54100	95
Drop Wing Tanks	12200	48600	375
Start Combat	10300	46800	500
Fire Missiles	6100	40100	500
Start Descent	2200	36500	60
End of Descent	2000	36200	0

Counter Air Mission Overview



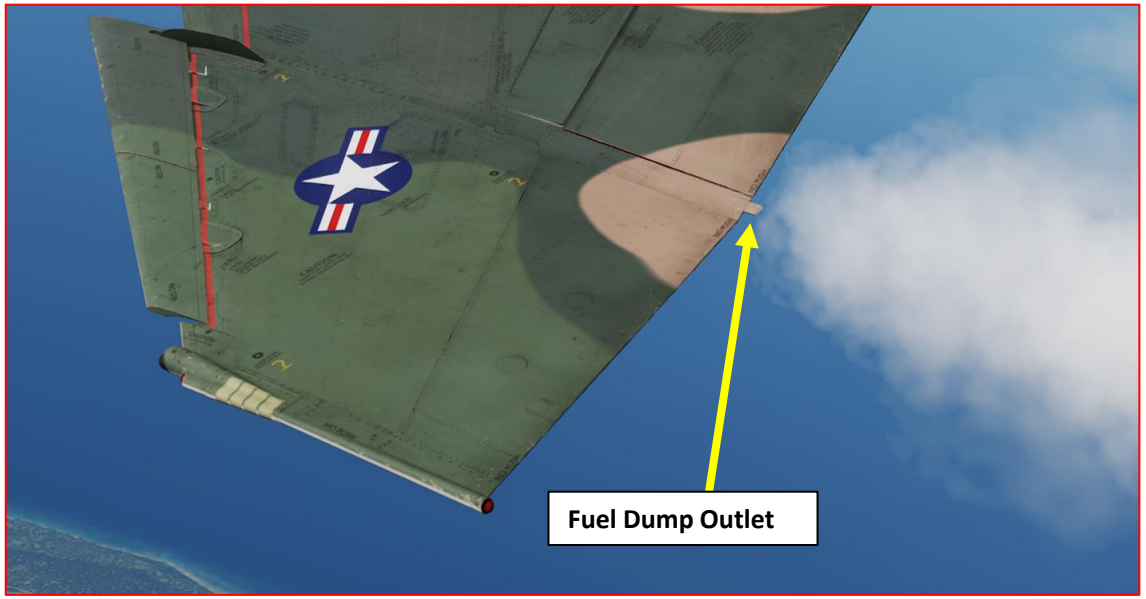
Source: Heatblur Simulations Wiki

2 – FUEL
2.4 – Fuel Dumping

In an emergency landing situation, the Phantom might need to reduce excess weight due to runway length or landing weight requirements. A quick way to reduce this weight is to jettison fuel.

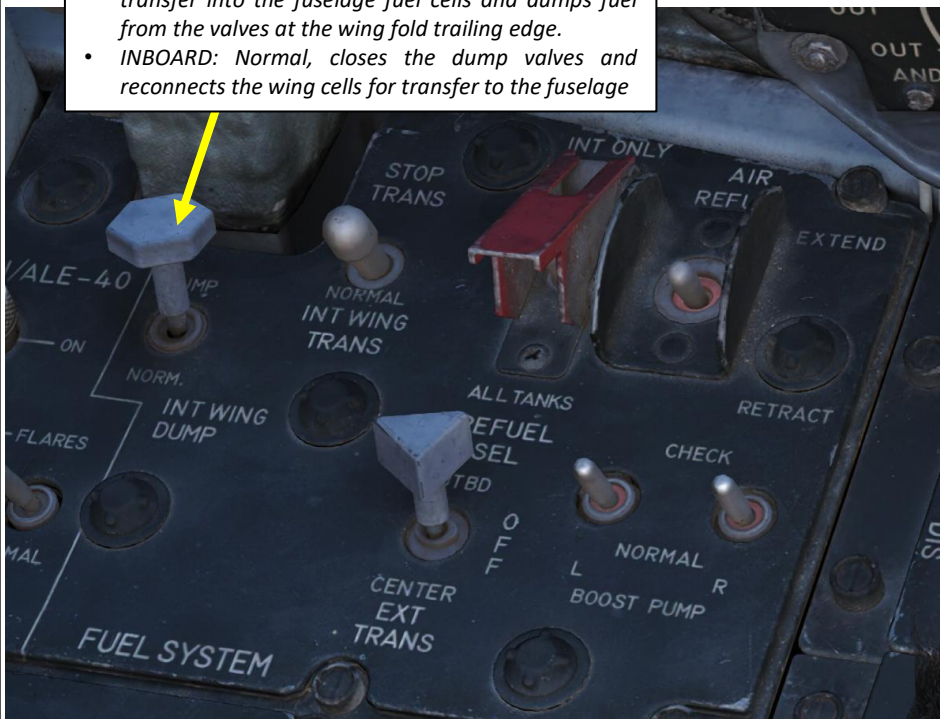
Fuel from the wings can be dumped directly, rather than requiring transfer into the fuselage, using the Wing Fuel Dump Switch. This switch, when selected to DUMP, will release fuel from the internal wing tanks at their dump lines at the wing fold trailing edge.

Fuel dumping flow rate is dependent on power setting and attitude; higher engine RPM and positive pitch increases dump speed, whereas lower RPM and a nose low condition reduces dump speed. In level flight at 85% RPM, the dump flow rate is roughly 650 pounds per minute… leading to the entire fuel being dumped after roughly 15 minutes.



Internal Wing Dump Switch

- *OUTBOARD: Dump, closes off the wing fuel cells from transfer into the fuselage fuel cells and dumps fuel from the valves at the wing fold trailing edge.*
- *INBOARD: Normal, closes the dump valves and reconnects the wing cells for transfer to the fuselage*





2 – FUEL
2.5 – Fuel Venting

To prevent issues with overpressure, the aircraft provides a venting system.

Should an overpressure condition occur, tanks will vent fuel until the pressure is corrected. The process is fully automated. External wing tanks vent through the fuel dump system, while all other cells are connected to the vent mast (Fuselage Fuel Tank Jettison Outlet) below the rudder.

Under normal conditions, overpressure only occurs momentarily whenever the internal wing fuel tanks are pressurized and made ready for transfer. This is the case whenever the gear is retracted or the air-to-air refueling door is closed. Fuel venting can also occur when flying slow and inverted, due to strong negative G forces. This can often be seen during aerobatics.







FLIGHT CONTROLS

Basic Controls

The F-4E has a **hydraulically-powered flight control system**. The primary flight controls of the aircraft consist of the stabilator, rudder, ailerons, and spoilers. Artificial feel systems provide simulated aerodynamic forces to the control stick and rudder pedals. Secondary controls are leading edge flaps/slats, trailing edge flaps, and wing mounted speed brakes.

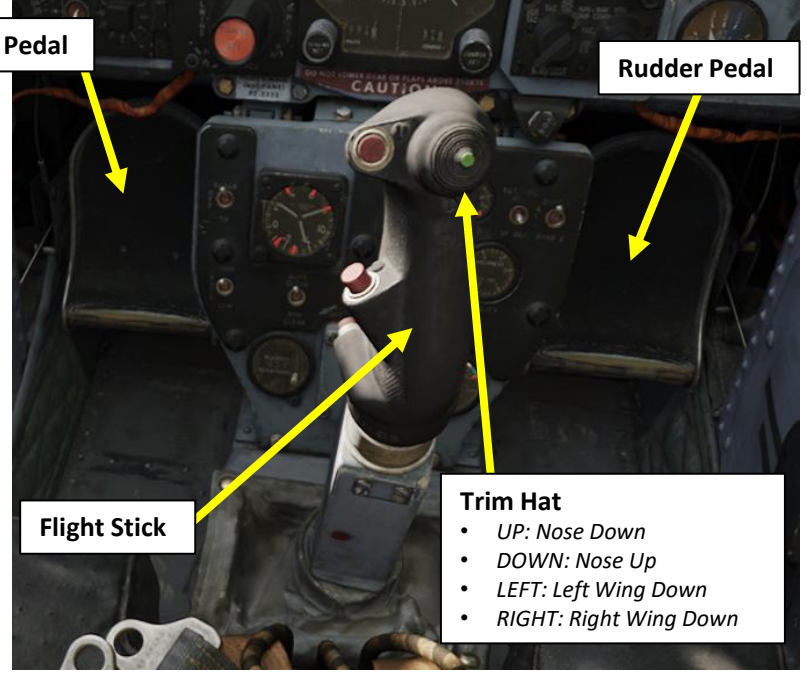
Both the pilot and WSO can control the aircraft with the flight stick and rudder pedals.

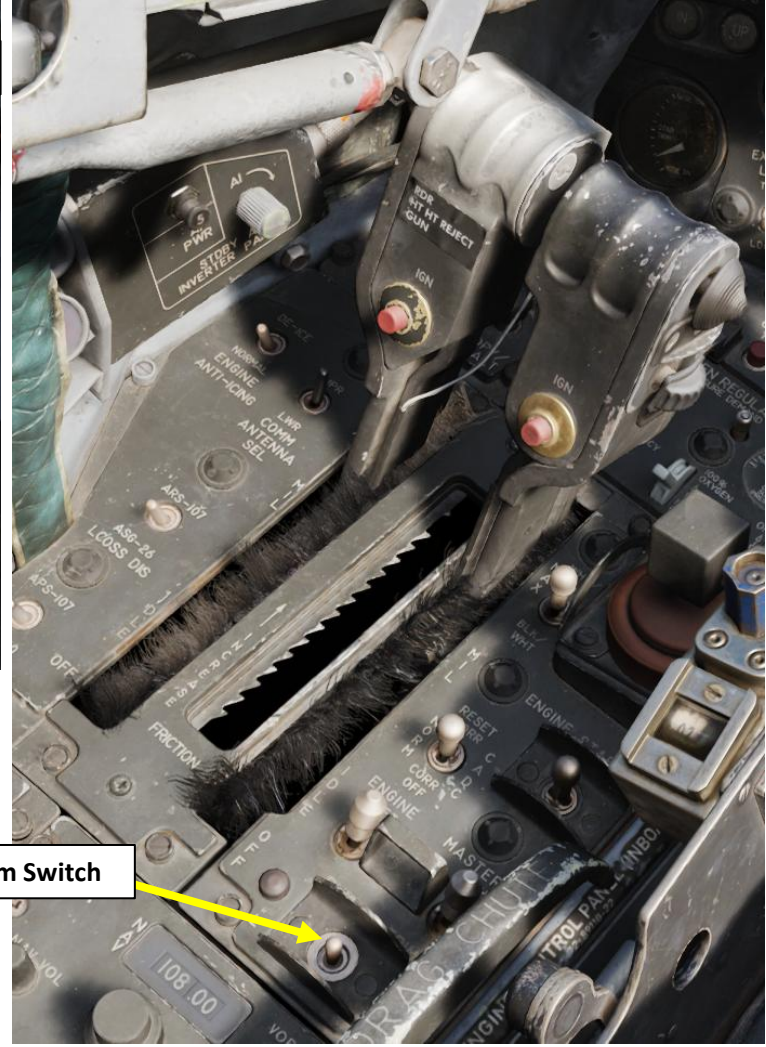
Linkages between stick, control surfaces and interactions with the trim system, as well as the AFCS (Automatic Flight Control System) are a complex combination of forces that balance out each other. Bobweights connected to the stick increase the force required to move it depending on the current G-force by pushing the stick forward. The bobweights are countered from the opposing direction by the bellows system operated by ram air pressure sensed at the bellows inlet on the vertical fin. The bellows pull the stick aft depending on the relative airspeed.

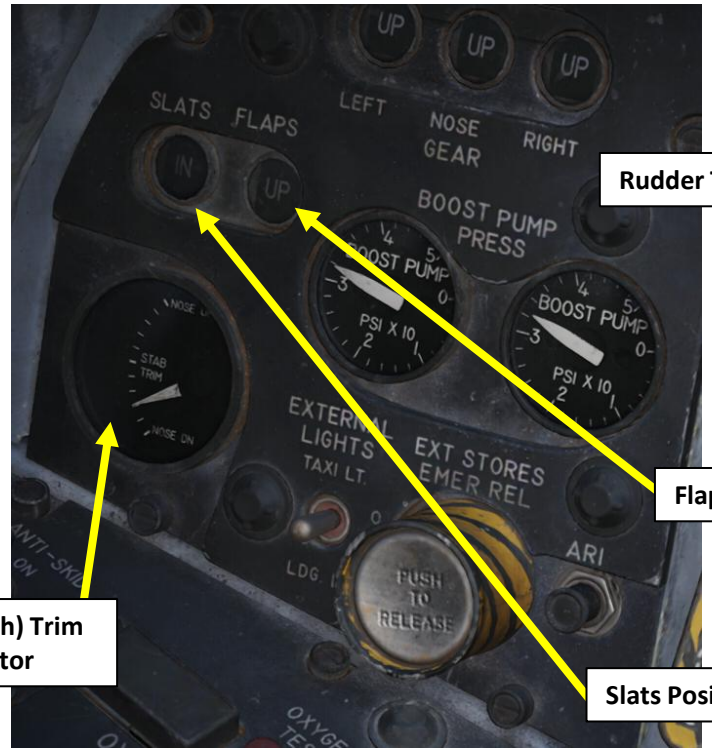
The lateral control system is a combined aileron-spoiler system. This consists of tandem forward and aft control sticks connected to the left and right aileron-spoiler by override spring cartridges, push-pull rods, walking beam bellcranks, aileron dual power cylinders with integrated control valves, spoiler power cylinders with follow-up type dual control valves, autopilot series servos, and lateral feel trim actuators.

Trimming the aircraft results in changing the length of the lever arm connecting the bellows system with the stick, changing the effective force they can apply. The two opposing forces are carefully balanced out to keep the stick in a neutral position during level flight at normal airspeeds. However, due to the dynamic nature of the system, the aircraft constantly has to be retrimmed after even the smallest flight condition changes. Especially under G's or when changing airspeed, the feel of the stick behavior changes drastically.

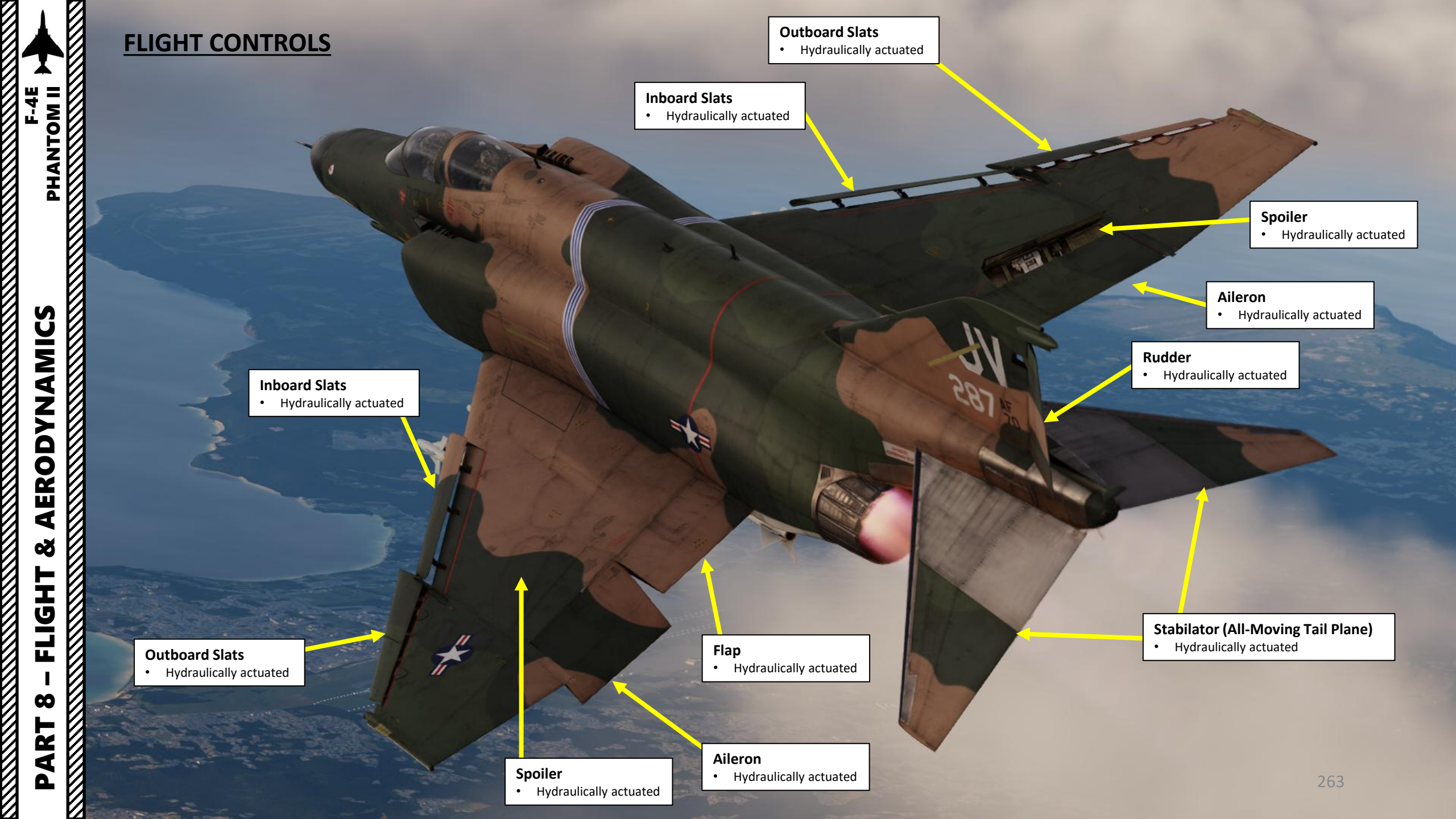
F-4E Flight Control Systems Video: https://youtu.be/EXsTImokAIQ







FLIGHT CONTROLS



FLIGHT CONTROLS

Stability Augmentation

The flight control system is supplemented with a **Stability Augmentation System**, which improves airplane stability in the pitch, roll and yaw axis. It opposes any change of attitude but does not return the airplane to a given attitude or ground track. This mode of operation may be used while the aircraft is under manual control. Stability augmentation can be engaged individually or in any combination for pitch, roll, or yaw axis.

The **automatic flight control system (AFCS)** is an electro-hydraulic system designed to provide stable, accurate, and coordinated flight maneuvers without interfering with manual control. The automatic flight control system is capable of performing two modes of operation, stability augmentation and AFCS. The term "AFCS" is the name of the whole system but also its sub-mode in which the aircraft attitude and/or heading is held and altitude hold can be activated. An automatic pitch-trim feature is included in the AFCS which attempts to keep the airplane longitudinally trimmed to the flight conditions experienced while in AFCS mode.

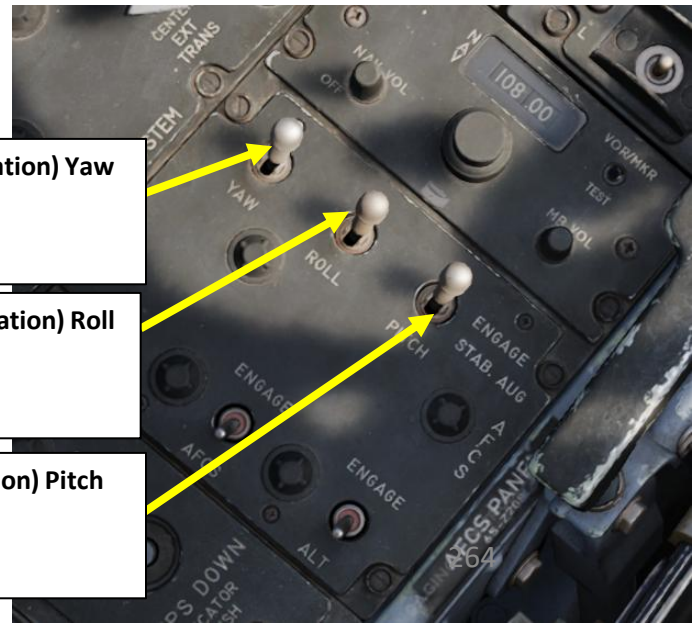
- Note: See Part 15 – AUTOPILOT for more information about AFCS operation.

A spring-loaded **Emergency Quick Release Lever** is on each control stick. This lever operates in the same manner from both the front and the rear cockpits. Depressing the lever causes the AFCS and altitude hold switch to return to OFF. The stability augmentation mode, ARI (Aileron-Rudder Interconnect) and anti-skid, are disengaged as long as the lever is held depressed. When the lever is released, the stability augmentation, anti-skid, and ARI are again in operation, but the AFCS is no longer engaged.

To permanently disengage the stability augmentation mode, the pitch, roll, and yaw STAB AUG switches must be placed off. To permanently disengage the ARI and anti-skid, the yaw STAB AUG switch must be off and the ARI circuit breaker, on the front cockpit left sub-panel, must be pulled.

Emergency Quick Release Lever
- *When pressed, deactivates the anti-skid system, the automatic flight control system, stability augmentation and the aileron-rudder interconnect*





Stab Aug (Stability Augmentation) Yaw Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Stab Aug (Stability Augmentation) Roll Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

Stab Aug (Stability Augmentation) Pitch Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

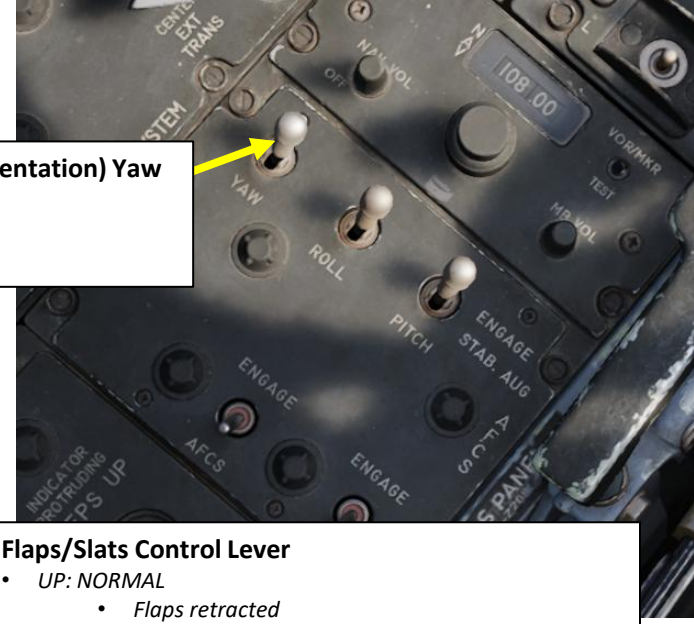
FLIGHT CONTROLS

ARI (Aileron-Rudder Interconnect) System

The ARI (aileron-rudder interconnect) system causes rudder displacement proportional to aileron displacement to provide coordinated turns at low airspeeds. It is engaged automatically with the **Flaps/Slats Control Lever** in the OUT AND DOWN position, and the airspeed below the flap blowup speed (230 knots). The limits of the system are 15 deg of rudder displacement when the automatic flight control system is in the stability augmentation or autopilot mode, and 10 deg rudder displacement when the **Yaw STAB AUG switch** is disengaged (AFT).

In the event either seat in command requires the ARI deactivated, the system can be disconnected by pulling the Emergency Quick Release Lever on their respective control stick. When the switch is released, the ARI (10 deg) and the Yaw STAB AUG (5 deg) rudder authority is regained. Function of the ARI can always be overridden through the rudder pedals.

To permanently disengage the ARI, the **ARI (Aileron-Rudder Interconnect) Circuit Breaker** must be pulled and the **Yaw STAB AUG switch** must be disengaged (AFT). Pulling the circuit breaker with the switch still engaged will still provide 5 deg of ARI rudder authority. When the ARI circuit breaker is pulled, the anti-skid system is disabled as well.



Stab Aug (Stability Augmentation) Yaw Channel Switch
- *FWD: Engage (ON)*
- *AFT: Disengage (OFF)*

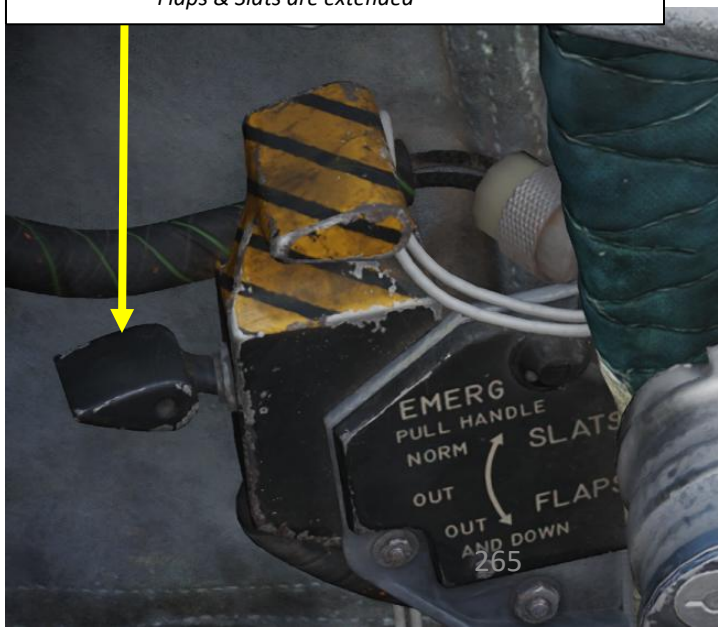
Flaps/Slats Control Lever
- *UP: NORMAL*
  - *Flaps retracted*
  - *Slats operate as function of AoA (Angle of Attack)*
- *MIDDLE: OUT*
  - *Flaps extended if nose gear is DOWN, Flaps retracted if nose gear is UP.*
  - *Slats are extended*
- *DOWN: OUT & DOWN*
  - *Flaps & Slats are extended*



ARI (Aileron-Rudder Interconnect) Circuit Breaker
- *When pulled in conjunction with the Yaw ARI Stab Aug Switch disengaged, Yaw ARI will be fully removed. With the Yaw ARI Stab Aug Switch engaged, 5 degrees of ARI authority will be maintained.*

Emergency Quick Release Lever
- *When pressed, deactivates the anti-skid system, the automatic flight control system, stability augmentation and the aileron-rudder interconnect*





FLIGHT CONTROLS

Flaps & Slats

The Slats & Flaps system is manually selected for takeoff and landing, then automatically controlled relative to AoA for best handling performance in all other flight regimes. Control is through the **Flaps/Slats Control Lever** in the front cockpit and driven by the aircraft hydraulic system.

The Flaps/Slats Control Lever positions are Norm, Out, and Out & Down, and the resulting command can be moderated based on whether or not the landing gear is being deployed.

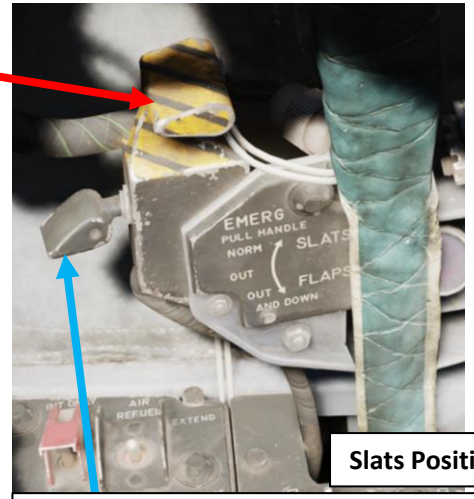
- **Norm** is the standard in-flight position, locking the Flaps and automatically programming the Slat deployment as a function of AoA (Angle of Attack).
- **Out** deploys the Slats to their fully deployed position. Should the landing gear be deployed, both the Slats and Flaps will deploy.
- **Out & Down** fully deploys both the Slats and the Flaps. Should the landing gear not be down, the Wheels Light on the telelight Panel will illuminate and flash.

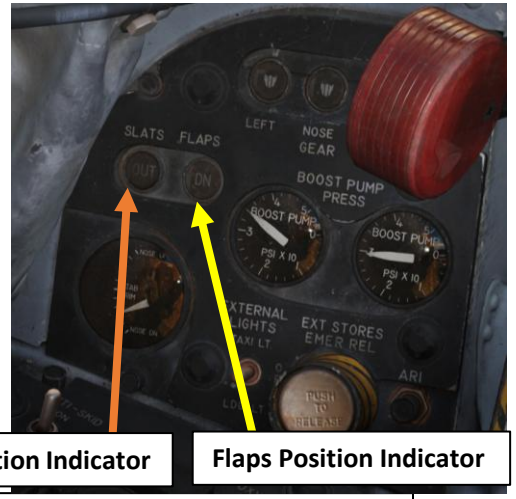
Both cockpits have a Slats & Flaps Indicator, which read **In** and **Out**, along with a barber-pole reading when the surfaces are in transition.

To the rear of the Fuel Control Panel in the front cockpit is the **Slat Override Switch**. Guarded, this switch has two positions: NORM and IN. Defaulted to NORM under the guard, switching to IN forces the retraction of the slats, no matter the current aircraft angle of attack or state of the Slats Flap lever position; this action will trigger the SLATS IN warning on the telelight Panel and illuminate the Master Caution.

The Slats Flaps system also has an Emergency system; **Flaps/Slats Emergency Control Levers** are found on the Slats & Flaps control panel in the front cockpit, and next to the rear cockpit throttle pair. The emergency system uses pneumatic pressure, and does not require electrical power to force deployment. The emergency system can only function once, and can be actuated at any airspeed; however, above 230 knots, the Flaps will retract based on air pressure, and the normal Slat retraction speeds also apply.

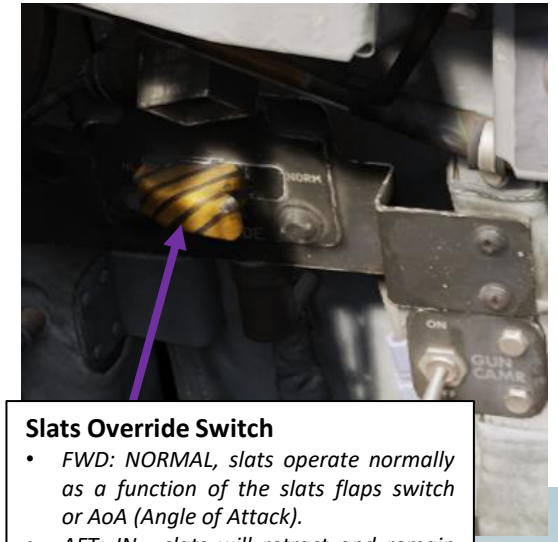
Flaps/Slats Emergency Control Lever
- *Handle is pulled to force high pressure air into the slats/flaps actuation system, causing them to deploy in event of control system failure*





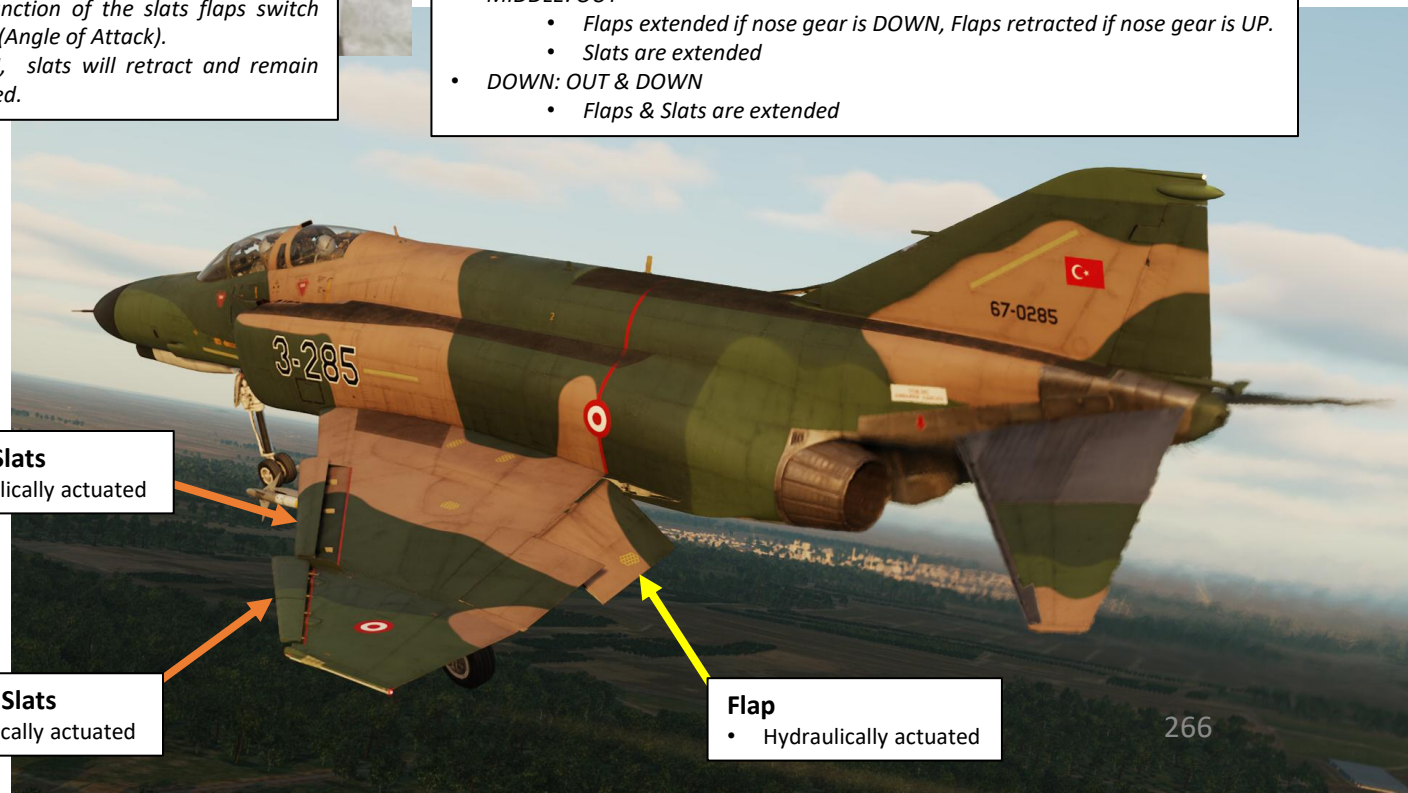
Slats Position Indicator

Flaps Position Indicator



Slats Override Switch
- *FWD: NORMAL, slats operate normally as a function of the slats flaps switch or AoA (Angle of Attack).*
- *AFT: IN, slats will retract and remain retracted.*

Flaps/Slats Control Lever
- *UP: NORMAL*
  - *Flaps retracted*
  - *Slats operate as function of AoA (Angle of Attack)*
- *MIDDLE: OUT*
  - *Flaps extended if nose gear is DOWN, Flaps retracted if nose gear is UP.*
  - *Slats are extended*
- *DOWN: OUT & DOWN*
  - *Flaps & Slats are extended*



Inboard Slats
- Hydraulically actuated

Outboard Slats
- Hydraulically actuated

Flap
- Hydraulically actuated

FLIGHT CONTROLS

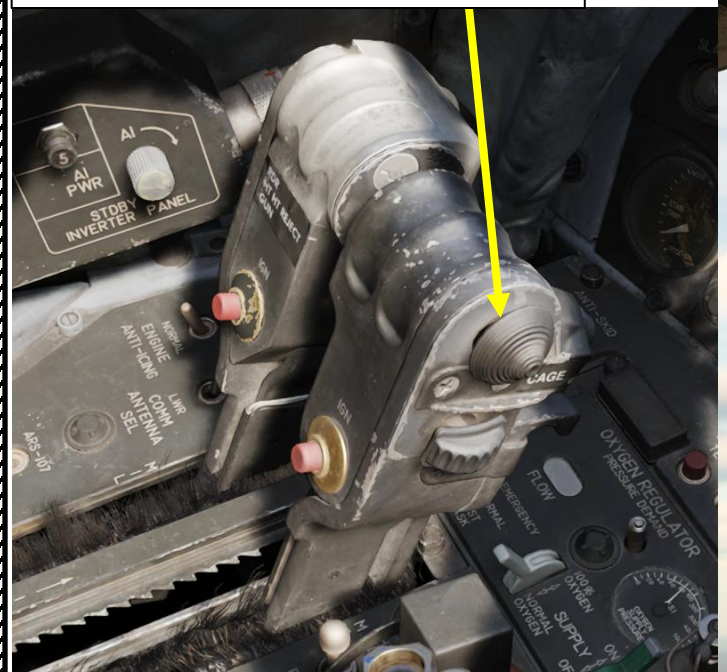
Speed Brakes

Underneath the aircraft and close to the rear Sparrow recesses are the speed brakes, installed on the wings. The speed brakes are driven by the aircraft's hydraulic system and actuated by a three-position **Speed Brake Switch** found on the inboard throttle in both cockpits. Either switch will actuate the brakes. The positions are Out, Stop, and In; the Out position is momentary and reverts back to Stop when released.

Brake actuation illuminates the **Speed Brake Out Indicator Light** found on the telelight Panel. Brake deployment and illumination of the Indicator does not trigger the Master Caution.



Speed Brake Switch
- *FWD: IN, Speed Brakes Retracted (LSHIFT+B)*
- *MIDDLE: STOP*
- *AFT: OUT, Speed Brakes Extended (LCTRL+B)*





Speed Brake
- Hydraulically actuated

Speed Brake
- Hydraulically actuated

FLIGHT CONTROLS

Hydraulic Power

The control system is powered by three completely independent, closed hydraulic systems: Power Control System 1 (PC-1), Power Control System 2 (PC-2), and the Utility System.

The systems have an operating pressure of approximately 3000 psi and are pressurized any time the engines are running. The PC-1, PC-2, and Utility hydraulic system are independent of each other; therefore, each aileron and spoiler has two independent sources of hydraulic pressure and one system functions as a backup for the other.

Ailerons, spoilers, and the stabilator have two hydraulic actuators. The PC systems are the primary hydraulic delivery to the flight control systems, with PC-1 powering the left side of the aircraft, and PC-2 powering the right; these supply pressure to one of the two actuators on each flight control surface. PC-1 is using left engine pump and PC-2 is using right engine pump.

The Utility Hydraulic System is pressurized by a hydraulic pump on each engine. The Utility System supplies hydraulic pressure to all aircraft systems (which need hydraulic pressure) except the stabilator actuator. It drives the second actuator on every flight control surface (except stabilator), acting as both a power assist and backup.



PC-1/2 (Power Control) Hydraulic System Pressure Indicator (x1000 psi)

Utility Hydraulic System Pressure Indicator (x1000 psi)

WING DESIGN

The wing profile of the F-4 has a very recognizable design.

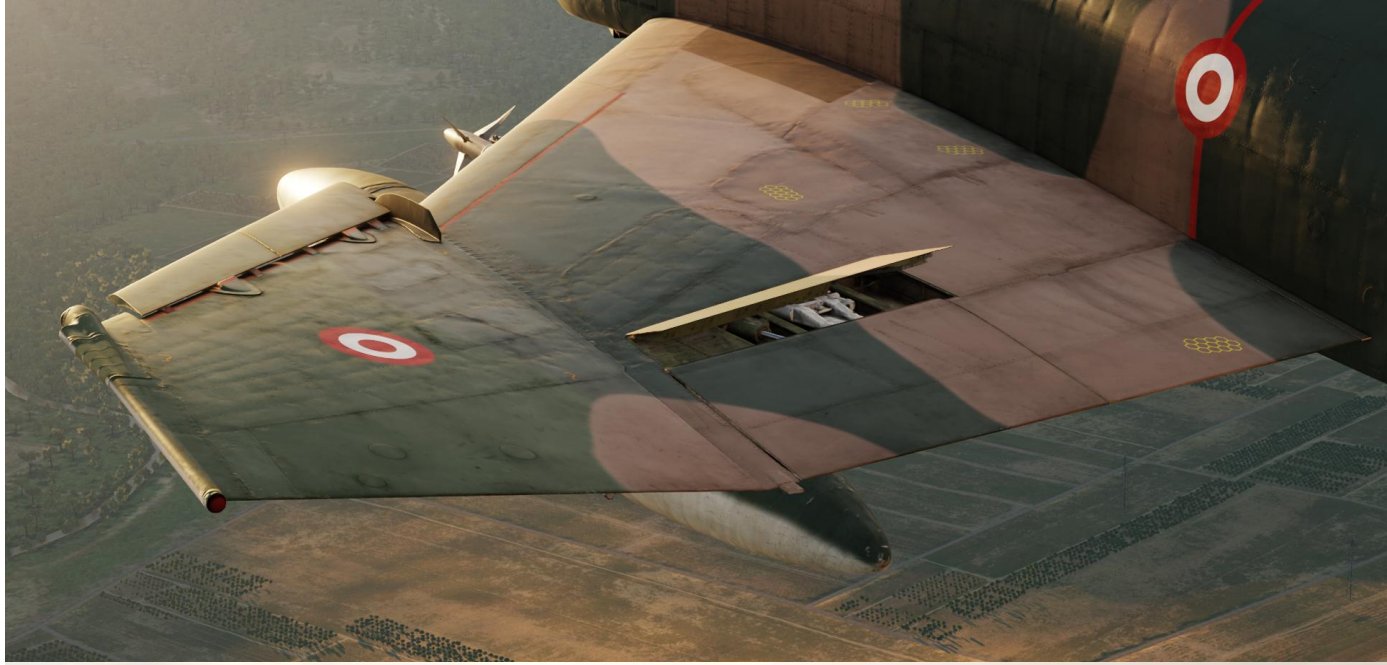
Initial wind tunnel testing of the early Phantom XF4H-1 prototype showed that the aircraft had a tendency to roll at high speeds, meaning that it had lateral instability at speeds above Mach 2.

In order to fix that problem, engineers had to change the wing design to add a 5 deg dihedral angle, which reduced the rolling moment caused by sideslip, increasing aircraft stability. To avoid redesigning the titanium central section of the aircraft, McDonnell engineers angled up only the outer portions of the wings by 12 deg, which averaged to the required 5 deg over the entire wingspan.

The thin-section wing has a leading edge sweep of 45° and is equipped with blown flaps for better low-speed handling.

The all-moving tailplane was given 23 deg of anhedral angle to improve control at high angles of attack, while still keeping the tailplane clear of the engine exhaust.







WING DESIGN

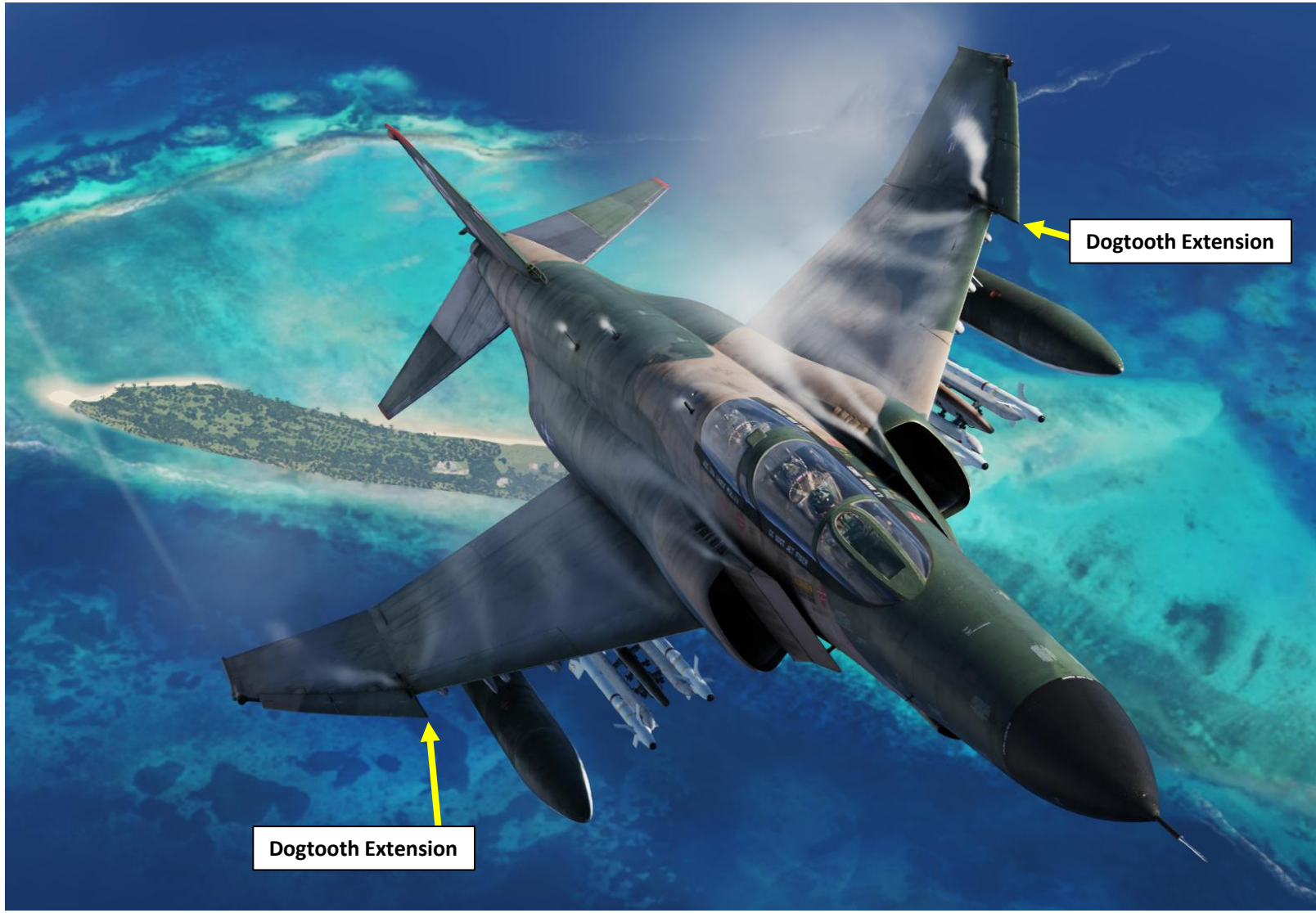
The wings also received distinctive "dogtooth“ extensions for improved control at high angles of attack. They consist of small, jagged notches near the tip. This seemingly small feature is quite important, especially when an airplane is flying at high angles of attack, like during takeoff, landing, or when performing sharp turns.

Unlike most other leading-edge extensions, however, dogtooth extensions are fixed. They aren’t hinged, nor can they be adjusted or otherwise controlled.

With dogtooth extensions on their wings’ leading edges, airplanes will generate vortices. The air will essentially flow around an axis line in a spiral-like pattern. These vortices will increase the airplane’s lift while also making it more resistant to stalls.

At high angles of attack, the air can flow around the wings in a way that leads to a loss of lift. If left unchecked, the airplane may not produce enough lift to stay in the air, resulting in a condition known as a stall. Dogtooth extensions help to prevent stalls by creating a controlled area of turbulence with vortices. This turbulence keeps the air flowing more smoothly over the wing, reducing the risk of a stall and helping the pilot maintain control of the aircraft.

Dogtooth extensions offer improved maneuverability. Airplanes with dogtooth extensions can perform more complex maneuvers without stalling thanks to these leading-edge extensions. Dogtooth extensions help them generate more lift so that they can handle extreme maneuvers without stalling.



AURAL TONE SYSTEM & STALL WARNING VIBRATOR

The **Aural Tone System** provides audible feedback in maneuvering flight and during landing configuration. Beginning above 15 units AoA (Angle of Attack) with gear down, and 21 units AoA with the gear up and slats in, a pulse will be heard by both crew-members.

The rate of the pulse can vary from 1.5 to 20 pulses per second, with increasing frequency based on higher AoA values.

This tone can be lowered in volume below 20.3 units AoA gear down/25 units gear up with controls in each cockpit; exceeding these values will cause the system to override the volume limits and deliver the warning pulses at a minimum volume to ensure they are audible regardless of volume setting. The respective knobs are labelled **STALL WARNING** and can be found on the right side in either cockpit.

Due to limited forward visibility, the tones are a crucial aid during landing. If a low pitch tone playing at a pulse is heard, the aircraft is too fast. If a high pitch tone playing at a pulse is heard, the aircraft is too slow. For the proper on-speed configuration, a steady tone at a medium pitch is played.

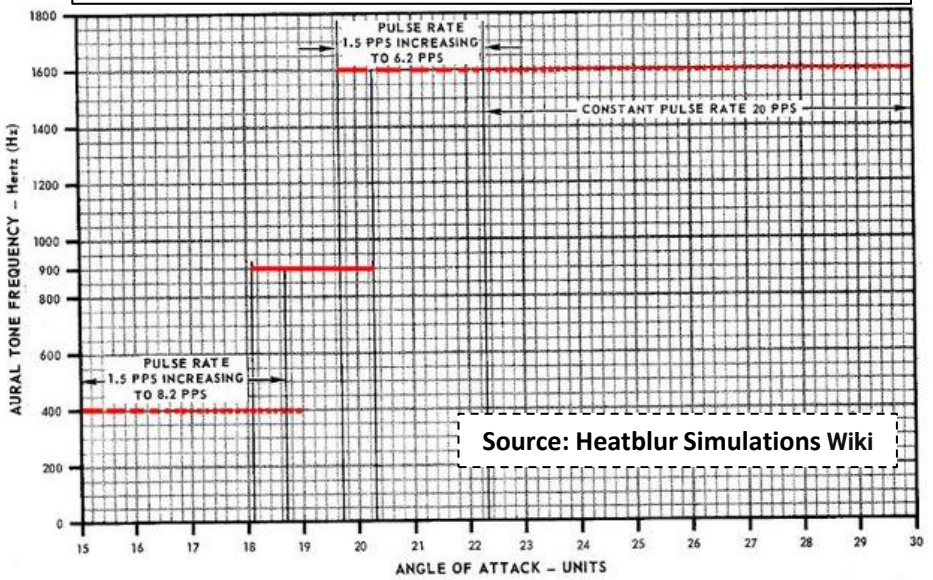
The left front cockpit pedal includes a **Stall Warning Vibrator**, which is activated over 22.3 units Angle of Attack. This physical (and in DCS audible) indication is given to make the pilot aware of the potential of an impending stall and provide enough time to reduce AoA and prevent the loss of control of the aircraft. Reducing AoA below the threshold will deactivate the warning.



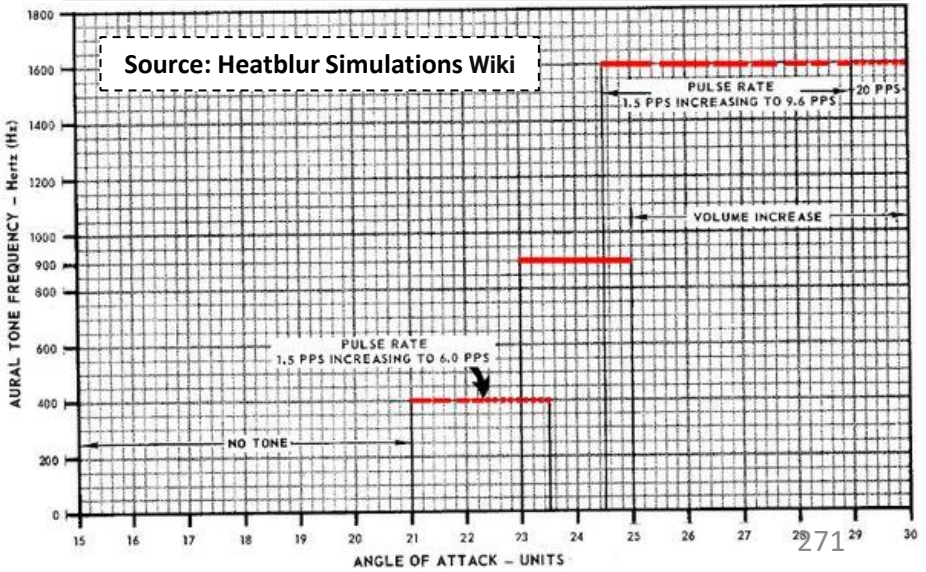


ANGLE OF ATTACK AURAL TONE INDICATIONS

Slats IN or Landing Gear DOWN



Slats OUT and Landing Gear UP



SPECIFICATIONS & LIMITATIONS

Aircraft Specifications			
Crew	2 (pilot + WSO)	**Maximum Speed**	1,280 kn (1,470 mph, 2,370 km/h) or Mach 2.23 at 40,000 ft (12,000 m)
Powerplant	2 x General Electric J79-GE-17A • Dry Thrust (without afterburner): 11905 lbs each • Afterburner Thrust: 17845 lbs each	**Cruise Speed**	510 kn (580 mph, 940 km/h)
Length	63 ft 0 in (19.2 m)	**Combat Range**	370 nmi (420 mi, 680 km)
Wingspan	38 ft 5 in (11.7 m)	**Ferry Range**	1,457 nmi (1,677 mi, 2,699 km)
Height	16 ft 5 in (5 m)	**Service Ceiling**	60,000 ft (18,000 m)
Wing Area	530 sq ft (49.2 m^2)	**Rate of Climb**	41,300 ft/min (210 m/s)
Aspect Ratio	2.77	**Lift-to-Drag Ratio**	8.58
Empty Weight	30,328 lb (13,757 kg)	**Wing Loading**	78 lb/sq ft (380 kg/m^2)
Gross Weight	41,500 lb (18,824 kg)	**Thrust-to-Weight Ratio**	0.86 at loaded weight, 0.58 at Max Takeoff Weight
Max Takeoff Weight	61,795 lb (28,030 kg)	**Takeoff Roll Distance**	4,490 ft (1,370 m) at 53,814 lb (24,410 kg)
Max Landing Weight	36,831 lb (16,706 kg)	**Landing Roll Distance**	3,680 ft (1,120 m) at 36,831 lb (16,706 kg)
Fuel Capacity	• 1,994 US gal (7,550 L) or 12,961 lbs (5,879 kg) internal • 3,335 US gal (12,620 L) or 21,678 lbs (9,833 kg) with 2x 370 US gal (1,400 L) external tanks on the outer wing hardpoints and a 600 US gal (2,300 L) tank for the centerline station.		

SPECIFICATIONS & LIMITATIONS

Aircraft Limitations – Table 1

	Maximum Airspeed	Load Factor
Landing Gear Extended	250 kts IAS	0 to +2.0 G
Flaps Extended	250 kts IAS	0 to +2.0 G
Slats Extended	600 kts IAS or Mach 2.0	Same as airplane
Air Refueling Receptacle	320 kts IAS or Mach 0.85 for Extension 400 kts IAS or Mach 0.85 after Extension	-1.5 to +3.0 G
Canopy Open, Ground Operation	60 kts IAS	-
Canopy Jettison, In-Flight	Same as airplane	Same as airplane
Drag Chute Deployment	200 kts IAS	-

Aircraft Limitations – Table 2

Maximum Angle of Attack (AOA) Limit	• 25 units above 35000 ft • 30 units at or below 35000 ft
Prohibited Manoeuvers	• Full-deflection aileron roll in excess of 360 deg • Intentional spin
Additional Notes	• When flying below 10000 ft, caution should be used when operating the aircraft above Mach 0.87 to preclude oscillations in case of a stability augmentation failure

Aircraft Limitations – Table 3

Maximum Gross Weight Limit	58,000 lbs
Maximum Landing Weight Limit	36,831 lbs
Maximum Takeoff Weight Limit	61,795 lbs
Combat Design Gross Weight	37,500 lbs
Max Positive G Limit (Structural)	• +8.5 G: Max clean subsonic (Mach 0.75 or less) at combat design gross weight (37,500 lbs) • +6.5 G: Max clean supersonic (Mach 1.05 or greater) at combat design gross weight (37,500 lbs) • +4.2 G: Max at Maximum Gross Weight (58000 lbs)
Negative G Limit	• -1.9 G: Max at Maximum Gross Weight (58000 lbs) • -3.0 G: Max clean at combat design gross weight (37500 lbs)
Engine Airspeed Limits (At altitudes from sea Level to 30000 ft)	• Steady state limit is the point at which DUCT TEMP HI light illuminates (121 deg C) or 750 kts, whichever occurs first.
Engine Airspeed Limits (At altitude above 30000 ft)	• Steady state limit is the point at which DUCT TEMP HI light illuminates (121 deg C) or 750 kts, whichever occurs first. Transient limit • Transient limit is 5 minutes per flight above the steady state limit. Not to exceed 710 kts or 0.4 Mach above the speed at which the steady state limit is reached.

External Drop Tanks G Limits Table 4

600 Gal External Centerline Tank	
Symmetrical Config +6.5G / -2.0G	**Asymmetrical Config** +5.2G / 0G
370 Gal External Wing Tanks	
Symmetrical Config +4.0G / -1.0G (Tanks 75%+ Full) +5.0G / -2.0G (Tanks 10% to 75% Full) +6.0G / -2.0G (Tanks Empty to 10% Full)	**Asymmetrical Config** +2.0G / 0G (Tanks 75%+ Full) +4.0G / 0G (Tanks 10% to 75% Full) +4.8G / 0G (Tanks Empty to 10% Full)

EMERGENCY PROCEDURES: "BOLD FACE" ITEMS

When it comes to emergency procedures, critical items (referred as "**Bold Face**" items) cover the majority of adverse conditions a Phantom crew might encounter. Air crew members are expected to accomplish bold face procedures without reference to the checklist. A mark of a true Phantom Phlyer is the ability to recite all bold face EP procedures perfectly. In real life, **NO mistakes were allowed**.

GROUND OPERATION EMERGENCIES

ENGINE FIRE OR OVERHEAT DURING GROUND OPERATION

1. THROTTLES – OFF

EMERGENCY EVACUATION

1. LOWER GUARD – UP
2. SHOULDER HARNESS – RELEASE
3. INSIDE HANDLE – ROTATE AFT
4. OUTSIDE HANDLE – LOCK UP

TAKEOFF EMERGENCIES

ABORT

1. THROTTLES – IDLE
2. CHUTE – DEPLOY
3. HOOK – DOWN

AFTERBURNER MALFUNCTIONS AFTER LIGHT

If decision to stop is made -

1. ABORT

ENGINE FIRE/OVERHEAT OR FAILURE DURING TAKEOFF

If decision to stop is made -

1. ABORT
2. THROTTLE BAD ENGINE – OFF

If takeoff is continued -

1. THROTTLES – AFTERBURNER
2. LANDING GEAR HANDLE – UP
3. EXTERNAL LOAD – JETTISON

BLOWN TIRE DURING TAKEOFF

If decision to stop is made -

1. ABORT
2. NOSE GEAR STEERING – ENGAGE
3. ANTI-SKID – OFF

INFLIGHT EMERGENCIES

OUT-OF-CONTROL RECOVERY

1. STICK – FORWARD
2. AILERONS AND RUDDER – NEUTRAL
3. IF NOT RECOVERED – MAINTAIN FULL FORWARD STICK AND DEPLOY DRAG CHUTE

UPRIGHT SPINS

1. STICK – MAINTAIN FULL FORWARD
2. AILERONS – FULL WITH SPIN/TURN NEEDLE
3. AIRCRAFT UNLOADED – AILERONS NEUTRAL

LANDING EMERGENCIES

ENGINE FAILURE ON FINAL

1. THROTTLES – AFTERBURNER

BLOWN TIRE DURING LANDING ROLLOUT

1. NOSE GEAR STEERING – ENGAGE
2. ANTI-SKID – OFF
3. HOOK – DOWN


MINUTES
OFF
STANDBY
0 0 0 0
CHAL
TEST
CODE
CHAL CODE
ACT PAS OFF
M4 ALM O/RIDE
GEAR NOSE
RIGHT
SLATS
FLAPS
IN
UP
30
30
30
30
CURSOR
RNG
OFS
BRT
CONTR
MODE
DSCS TEST
RDR
STBY
OFF
STST
ECM
BOTH
RESET
HIGH ANGLE

SECTION STRUCTURE

- **1 – SENSORS**
  - 1.1 – Introduction to Sensors
  - 1.2 – My Sensors Control Setup

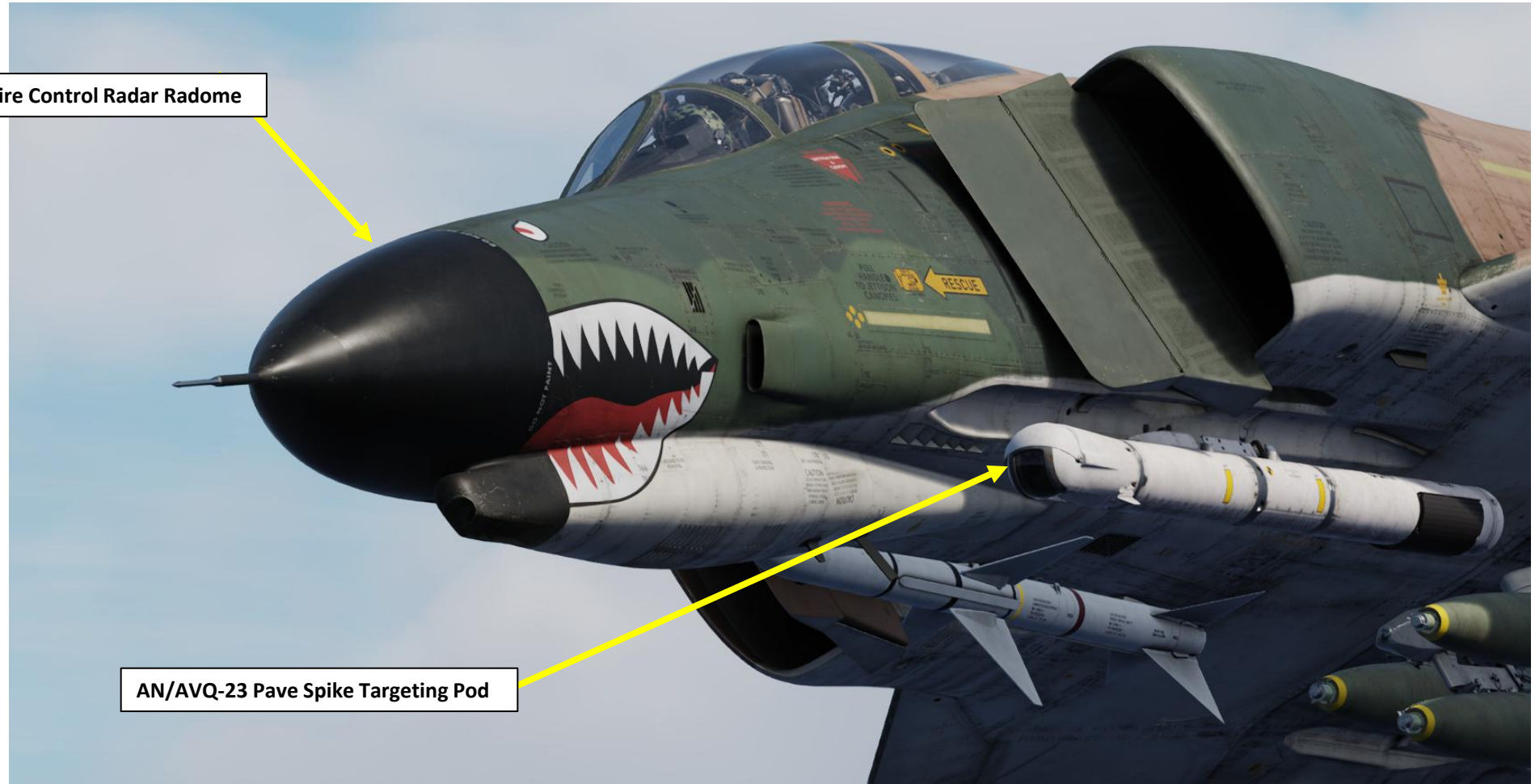
- **2 – AN/APQ-120 FIRE CONTROL RADAR**
  - 2.1 – Introduction
  - 2.2 – Radar Interface
    - 2.2.1 – Displays
    - 2.2.2 – Controls
    - 2.2.3 – Performance
    - 2.2.4 – Radar Power-Up
  - 2.3 – Radar Theory
    - 2.3.1 – Pulse Radar Basics
    - 2.3.2 – What affects the radar image?
    - 2.3.3 – Magnetron, Klystron, and Feedhorn Nutation
    - 2.3.4 – Electronic Warfare Interference
  - 2.4 – Air-to-Air Operation
    - 2.4.1 – Air-to-Air Modes Overview
    - 2.4.2 – Radar Operation with Multicrew
      - 2.4.2.1 – Beyond Visual Range (BVR) Employment
      - 2.4.2.2 – Air Combat Maneuvering (ACM) Close Range Employment
      - 2.4.2.3 – Advanced Topics
        - Angle Track & Range Track
        - Manual Tracking
        - VISIDENT (Visual Identification)
    - 2.4.3 – Radar Operation with JESTER AI
    - 2.4.4 – External Resources
  - 2.5 – Air-to-Ground Operation
    - 2.5.1 – Air-to-Ground Radar Ranging
    - 2.5.2 – Map PPI (Plan-Position Indicator) Mode
  - 2.6 – Radar Lingo & Terminology

- **3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)**
  - 3.1 – Introduction
  - 3.2 – Display
  - 3.3 – Controls
  - 3.4 – Start-Up & Lasing Procedure
  - 3.5 – Modes
    - 3.5.1 – 12-VIS Visual Acquisition Mode
    - 3.5.2 – 9-VIS Visual Acquisition Mode
    - 3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
      - A – Cueing/Slaving TGP to IP (Ingress Point) Offset
      - B – Cueing/Slaving TGP to Air-to-Ground Radar Designation
      - C – Cueing/Slaving TGP to Target Coordinates
    - 3.5.4 – Track Mode
    - 3.5.5 – Memory Mode
  - 3.6 – Targeting Pod Limitations
  - 3.7 – Smart-Track & Fast-Track Upgrades
  - 3.8 – Targeting Pod Operation with JESTER AI

1 – SENSORS
1.1 – Introduction to Sensors

The F-4E is one of the first fighter jets that started integrating « multirole » capabilities in terms of sensors. Air-to-air and air-to-ground roles were traditionally reserved to specific aircraft types, but the Phantom could somewhat almost do it all. Of course, these capabilities now pale in comparison to modern jets bristling with state-of-the-art avionics and sensors... But they were considered to be very advanced for the era.

The Westinghouse **AN/APQ-120 Fire Control Radar** is a pulse radar providing the F-4E with air-to-air intercept functionality, air-to-ground mapping, ground target reference provision to the LABS (Low Altitude Bombing System) and WRCS (Weapon Release Computer Set) bombing systems, as well as radar beacon capability. The Phantom can also equip the **AN/AVQ-23 Pave Spike Targeting Pod**, which provides a slewable TV image for spotting ground targets and can fire laser for determining range information and to guide laser guided weapons.



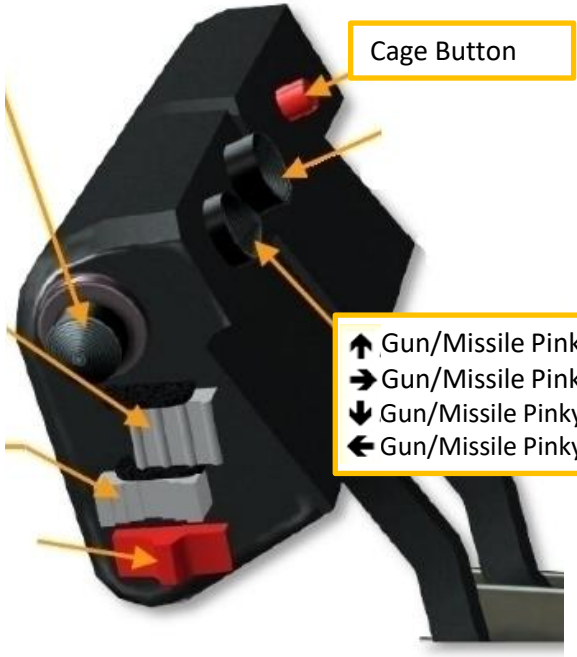
1 – SENSORS
1.2 – My Sensors Control Setup

PILOT
CONTROL SETUP



First Detent: Trigger Half-Action (2-stage trigger)
Second Detent: Trigger Full-Action (2-stage trigger) (Space)

Nose Gear Steering / Auto Acquisition Button



Cage Button

↑ Gun/Missile Pinky Switch – REJECT (UP)
→ Gun/Missile Pinky Switch – RADAR (FWD)
↓ Gun/Missile Pinky Switch – HEAT MISSILES (CENTER)
← Gun/Missile Pinky Switch – GUN (AFT)

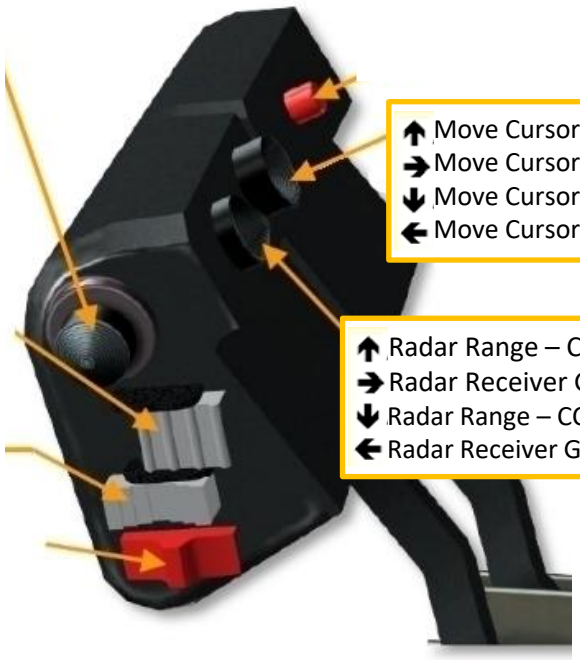
1 – SENSORS
1.2 – My Sensors Control Setup

WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



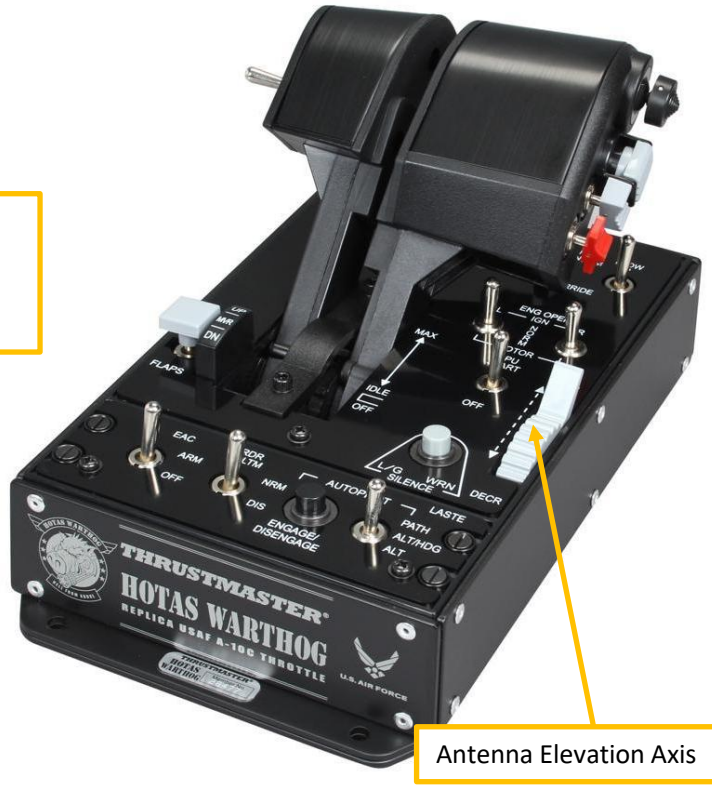
1 – SENSORS
1.2 – My Sensors Control Setup

WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



↑ Move Cursor (Along Track) (JOY_Y) – Inverted
→ Move Cursor (Cross Track) (JOY_X)
↓ Move Cursor (Along Track) (JOY_Y) – Inverted
← Move Cursor (Cross Track) (JOY_X)

↑ Radar Range – CW (Clockwise)
→ Radar Receiver Gain (Coarse) – Increase
↓ Radar Range – CCW (Counter-Clockwise)
← Radar Receiver Gain (Coarse) – Decrease



Antenna Elevation Axis

2 – AN/APQ-120 FIRE CONTROL RADAR



2 – AN/APQ-120 FIRE CONTROL RADAR

2.1 – Introduction

The Westinghouse **AN/APQ-120 Fire Control Radar** is a solid-state pulse radar providing the F-4E with air-to-air intercept functionality, air-to-ground mapping, ground target reference provision to the LABS (Low Altitude Bombing System) and WRCS (Weapon Release Computer Set) bombing systems, as well as radar beacon capability. The APQ-120 also functions as the display system for TISEO (Target Identification System Electro-Optical) and TV-guided weapon imagery, and is integrated with the APX-80 interrogation system.

While most of you may be familiar with the way the radar display works in a single-seat fighter, a two-seat fighter requires tasks to be separated. The pilot is mainly responsible for weapons launch, flying the aircraft, finding targets visually or using information forwarded by the WSO. The pilot's situational awareness extends from what he sees to what the repeater of the DSCG (Digital Scan Converter Group) scope can tell him. The pilot can operate in a very limited fashion radar close-range mode, but he cannot control the radar by himself. This is where the WSO (Weapon Systems Officer) comes in. He controls the radar (scanning pattern, azimuth/elevation, mode, etc.) and locks targets for the pilot, which can then be engaged by the pilot once a lock is acquired.





I strongly recommend that you consult Flyandwire's "Phantom Phamiliarisation" series of articles, which goes quite in-depth when it comes to the F-4's complex avionics: https://flyandwire.com/f-4e-phantom-phamiliarisation-series/

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (Overview)

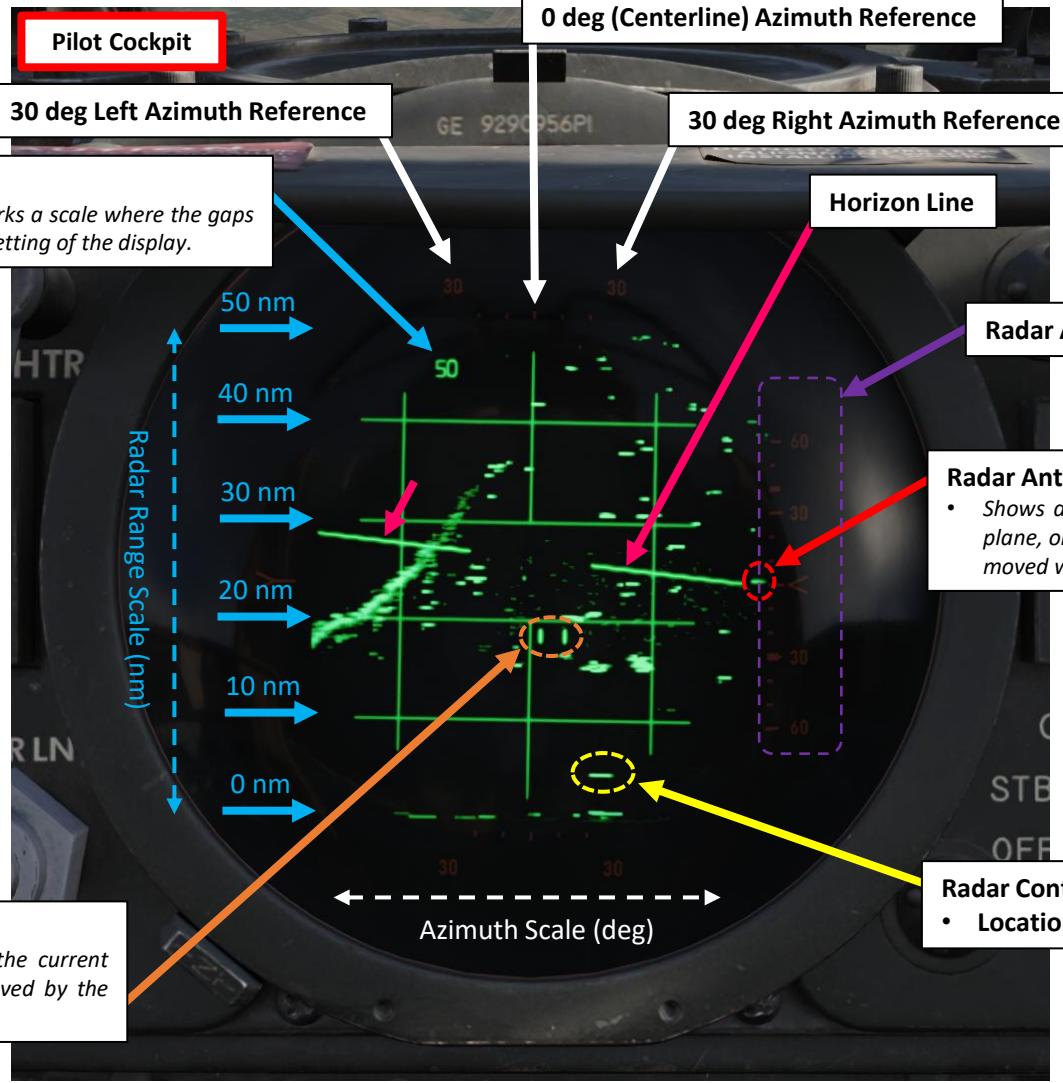
In the F-4 Phantom, radar information is displayed on a scope referred as the **DSCG (Digital Scan Converter Group) Screen**.



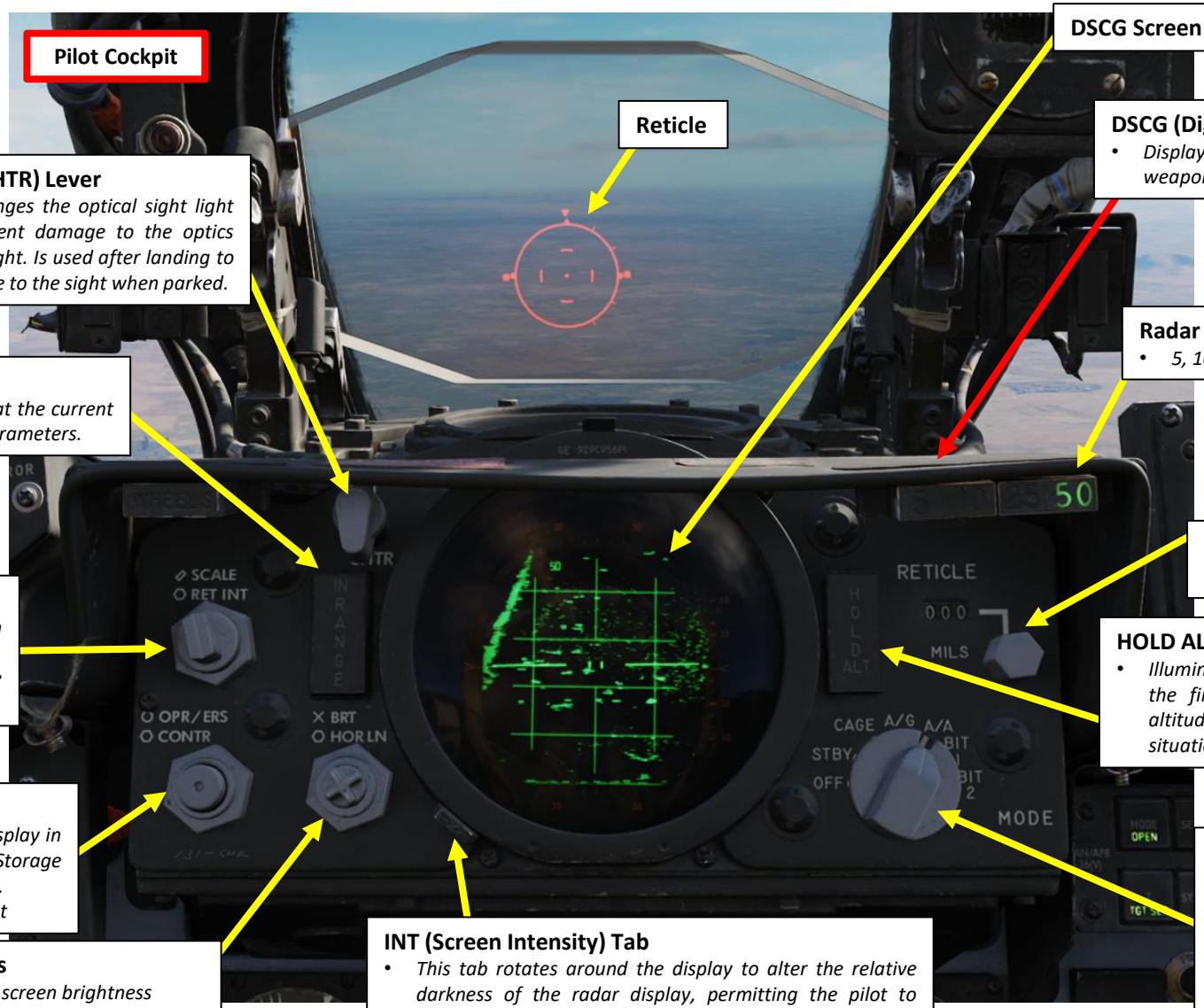


2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (Pilot)

When in automatic air-to-air search mode, the radar can have either a B-Scope or a PPI (Plan-Position Indicator) top-down representation depending on what setting is selected with the WSO's Display Selector.



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (Pilot)



Pilot Cockpit

Reticle

DSCG Screen (Scope)

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

Sight Shutter (SHTR) Lever
- *This lever changes the optical sight light source to prevent damage to the optics from high sunlight. Is used after landing to prevent damage to the sight when parked.*

Radar Range Indicator Lights (nm)
- *5, 10, 25 or 50 nm*

IN RANGE Light
- *Illuminates to alert the pilot that the current locked target is within range parameters.*

Reticle Depression Setting Knob (Mils)

SCALE & RET INT Knobs
- *Inner Knob: Controls screen scale brightness*
- *Outer Knob: Controls reticle brightness intensity*

HOLD ALT Light
- *Illuminates as an instruction to the pilot from the fire control system to maintain current altitude to assist in a snap-up intercept situation against a target above the fighter.*

OPR/ERS Button & CONTR Knob
- *Inner Button: Activates or erases display in aircraft with DVST (Direct View Storage Tube). No function with DSCG scope.*
- *Outer Knob: Controls screen contrast*

Sight Mode Selector
- *OFF*
- *STBY: Standby*
- *CAGE: Sight is caged*
- *A/G: Air-to-Ground Mode*
- *A/A: Air-to-Air Mode*
- *BIT 1: Built-In Test 1*
- *BIT 2: Built-In Test 2*

BRT & HOR LN Knobs
- *Inner Knob: Controls screen brightness*
- *Outer Knob: Controls relative horizon line shown on radar scopes in both cockpits*

INT (Screen Intensity) Tab
- *This tab rotates around the display to alter the relative darkness of the radar display, permitting the pilot to adjust the scope relative to ambient light. With the INT tab, a polarization filter is rotated over the scope.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (Pilot)

DSCG (Digital Scan Converter Group) Screen Mode Switch
- *UP: RADAR feed source is displayed on the DSCG screen*
- *MIDDLE: OFF*
- *DOWN: TV (Maverick or Pave Spike Targeting Pod) video source is displayed on the DSCG screen*

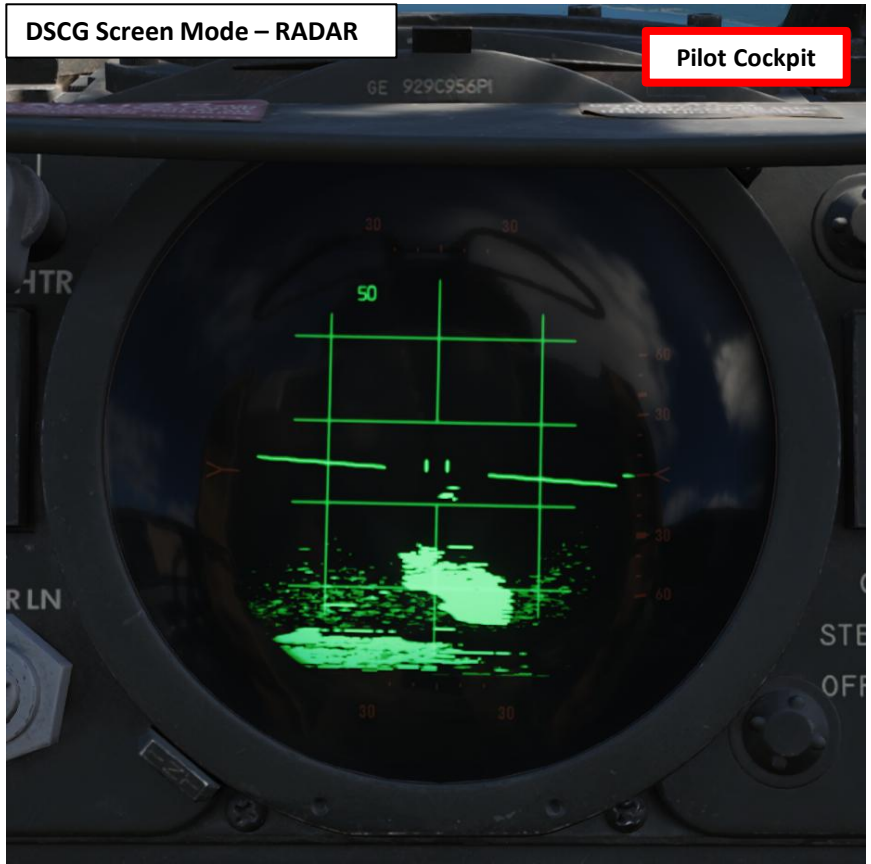


The **DSCG Screen Mode Switch** is used to determine which feed will appear on the scope screen. The **Video Select Button** in the WSO cockpit controls if the TV feed comes from the targeting pod or the Maverick missile.

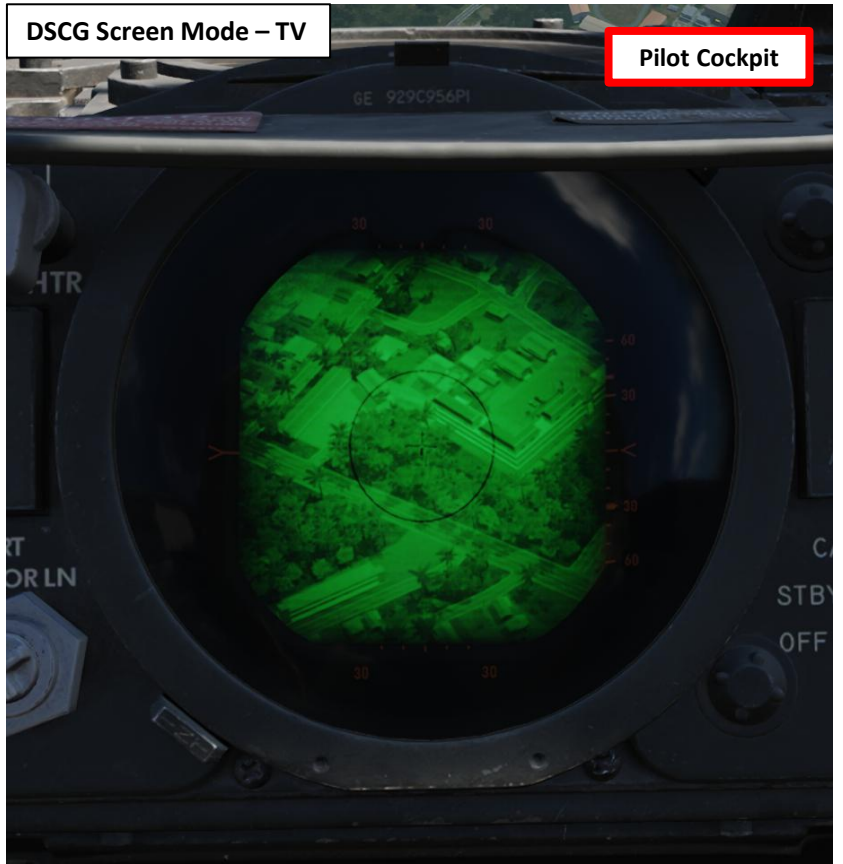
Video Select Button
- *Alternates between WEAPON (such as AGM-65 Maverick) and ASQ-153 (Pave Spike targeting pod) television video on the radar scope display when in TV mode.*



DSCG Screen Mode – RADAR

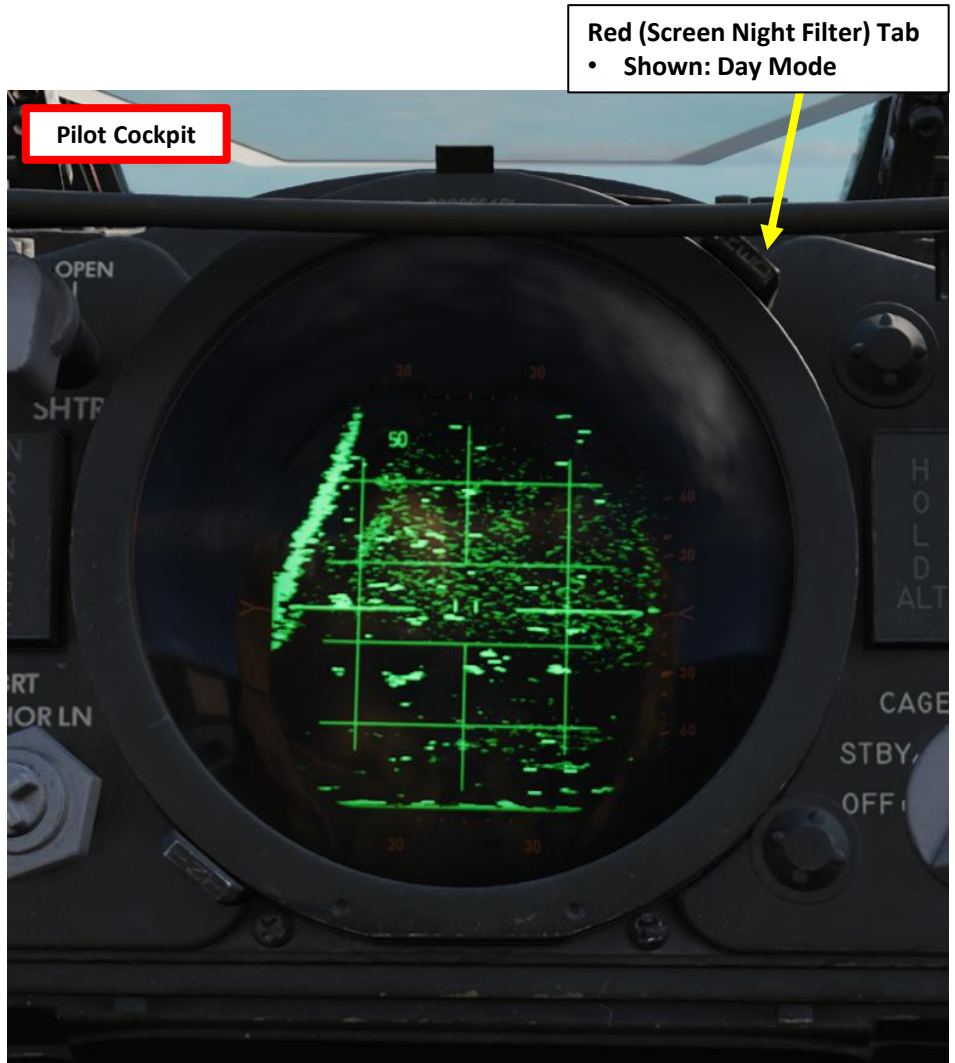


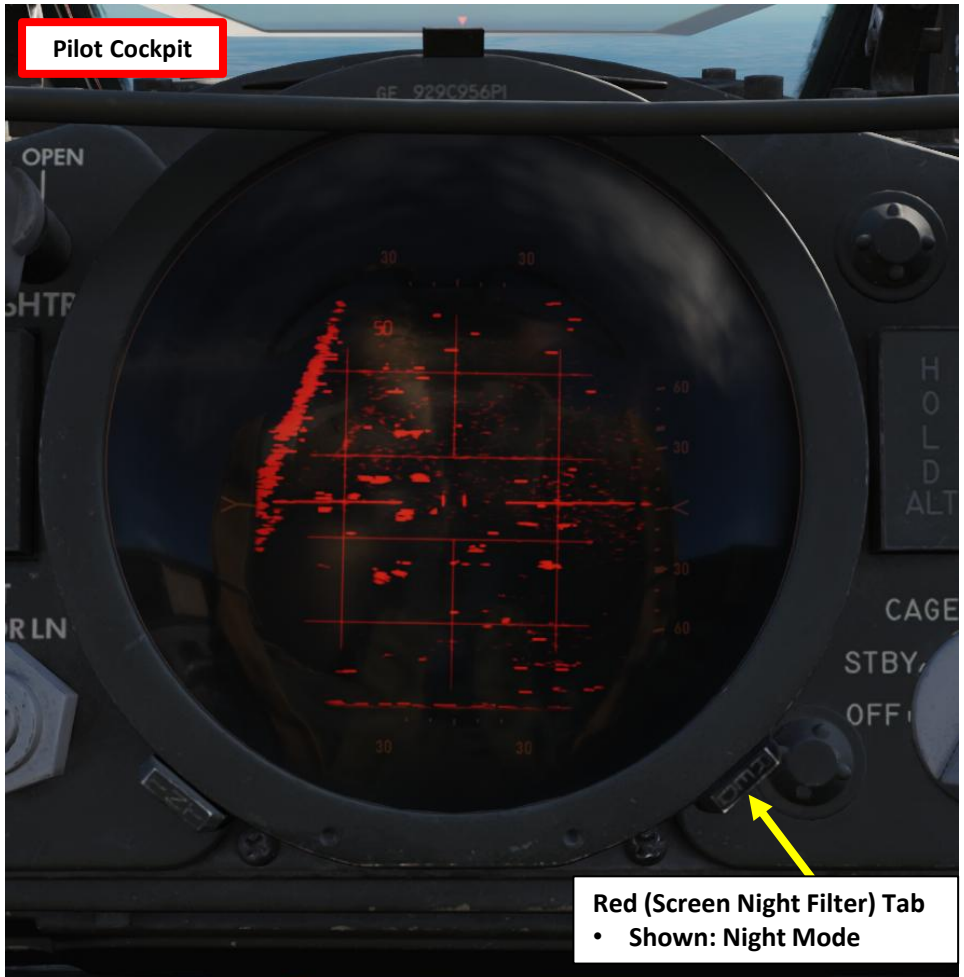
DSCG Screen Mode – TV



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (Pilot)

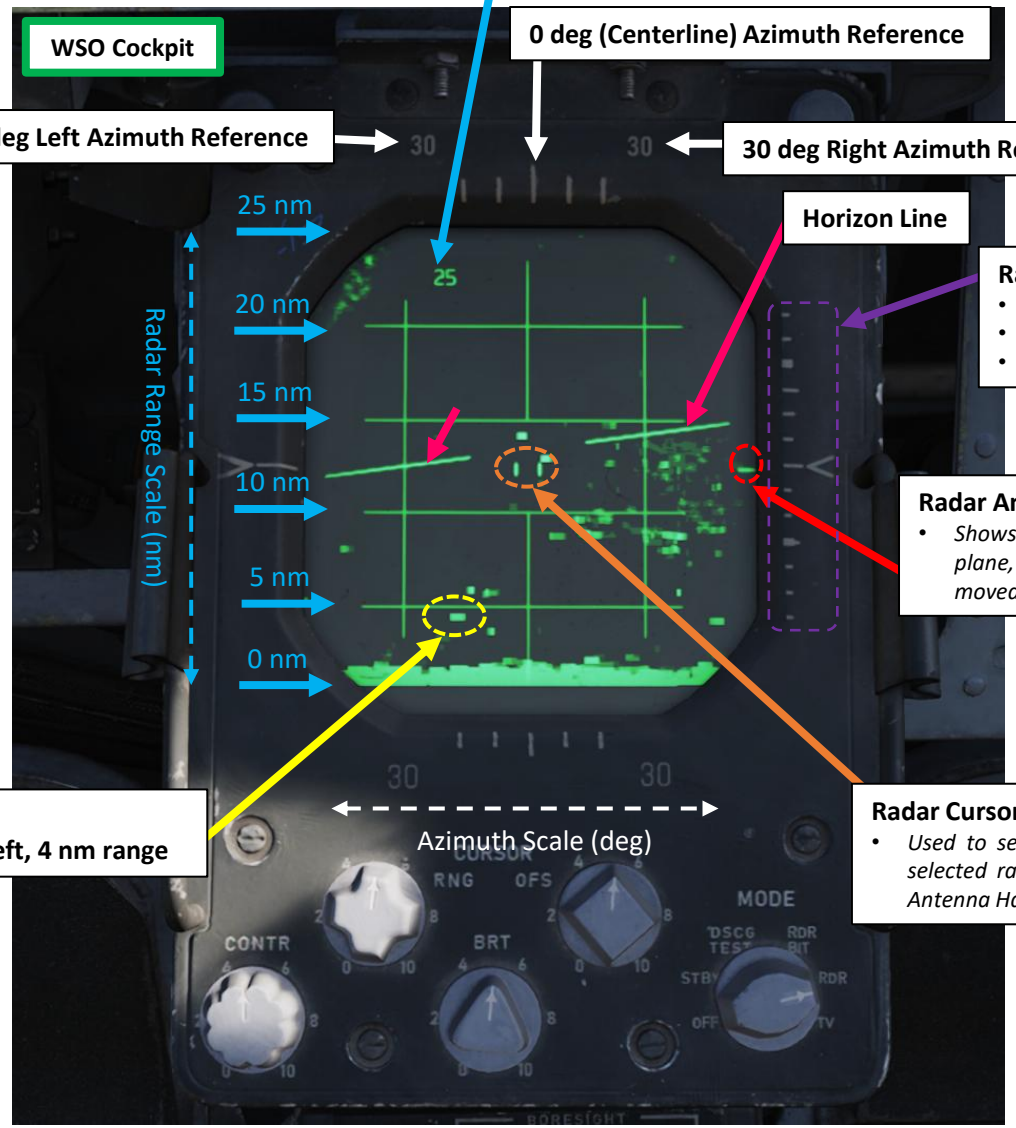
The **Red (Screen Night Filter) Tab** can be rotated to provide a red scope display for night flying.





2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)

When in automatic air-to-air search mode, the radar can have either a B-Scope or a PPI (Plan-Position Indicator) top-down representation depending on what setting is selected with the WSO's Display Selector.



Selected Range Scale (nm)
- *Each horizontal line of the grid marks a scale where the gaps are one fifth of the current range setting of the display.*

0 deg (Centerline) Azimuth Reference

30 deg Left Azimuth Reference

30 deg Right Azimuth Reference

Horizon Line

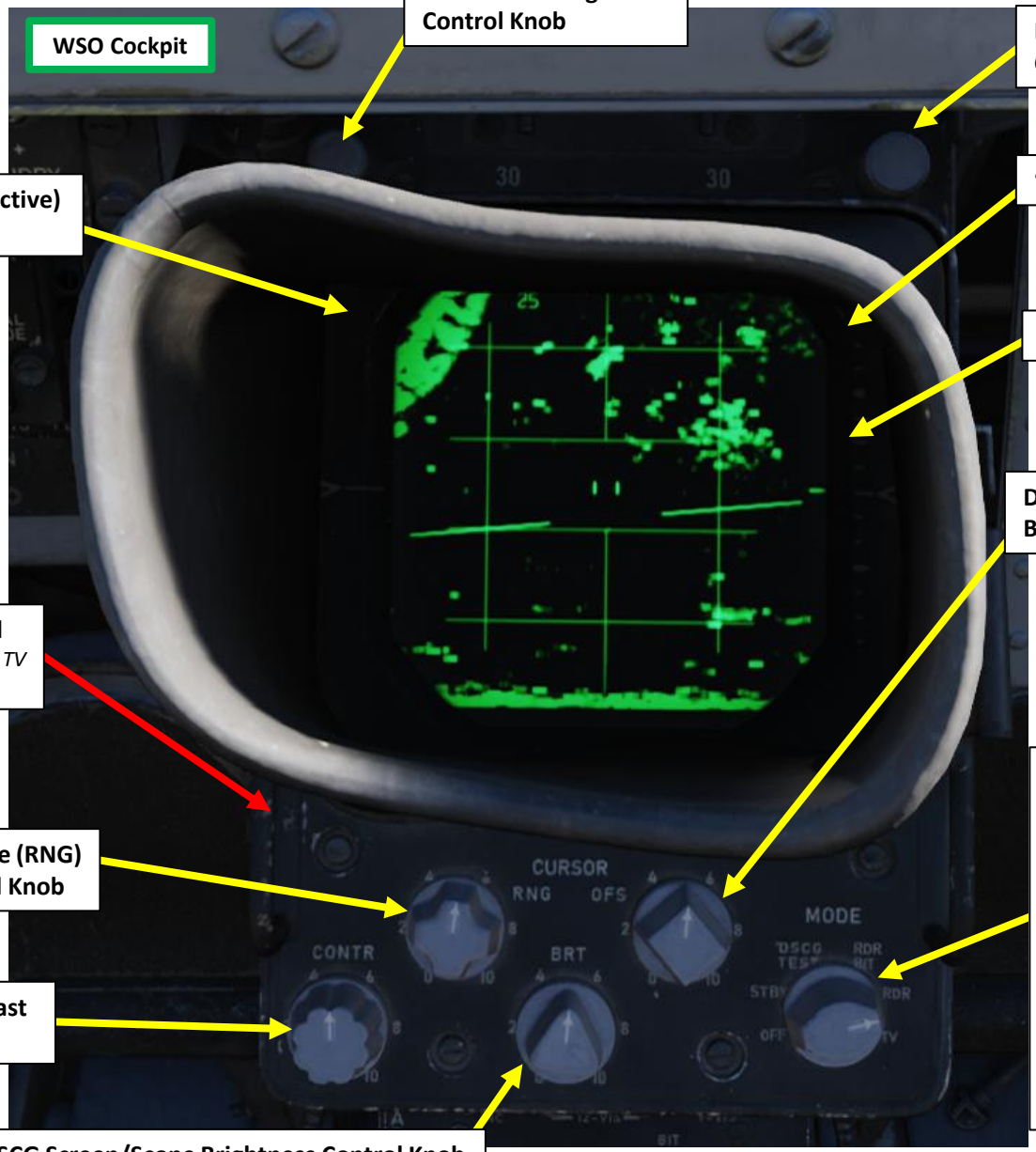
Radar Antenna Elevation Reference Scale (deg)
- Upper Section: +60 deg
- Center: 0 deg
- Lower Section: -60 deg

Radar Antenna Elevation Indicator
- *Shows antenna elevation (in degrees) relative to the radar plane, or aircraft if the Stab Switch is set to OUT. This can be moved with the Antenna Hand Control elevation wheel.*

Radar Contact
- **Location: 20 deg Left, 4 nm range**

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)



Radar Grid Brightness Control Knob

Radar Scale Brightness Control Knob

"H" (Home-On-Jam Active) Indicator Light

"T" (Radar Tracking) Indicator Light

DSCG Screen (Scope)

DSCG Cursor Offset (OFS) Brightness Control Knob

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

DSCG Cursor Range (RNG) Brightness Control Knob

DSCG Screen/Scope Contrast Control Knob

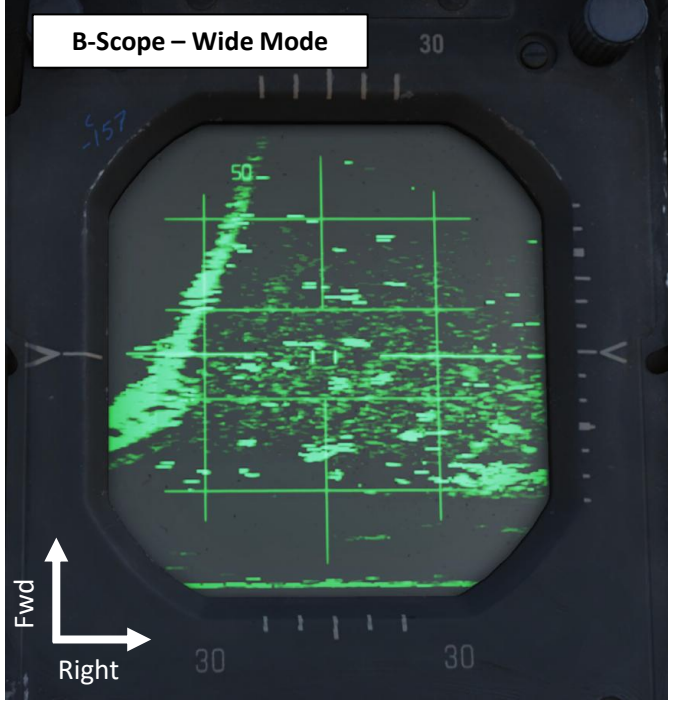
DSCG Screen/Scope Brightness Control Knob

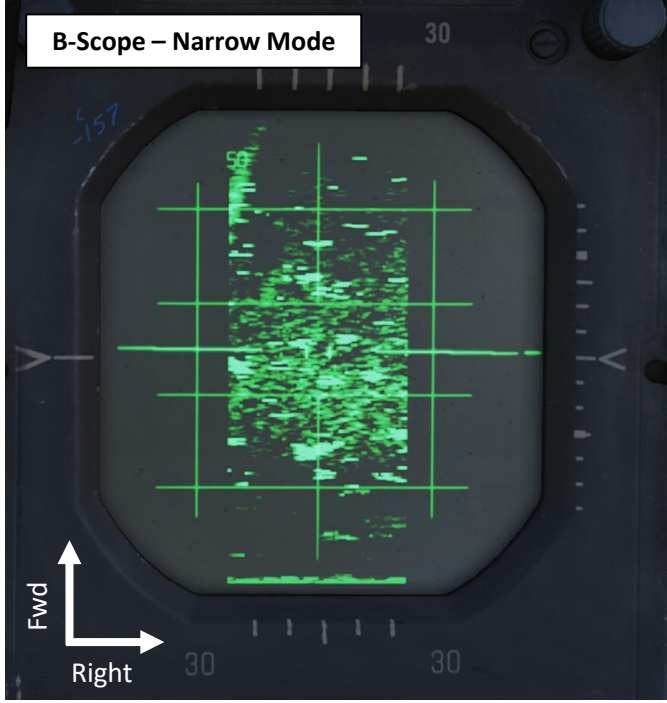
DSCG (Digital Scan Converter Group) Screen Mode Selector
- ***OFF***
- ***STBY****: Standby mode, used for takeoff and landing.*
- ***DSCG TEST****: Displays a test search display image with 8 shades of grey to confirm normal operation. Select Range 10 for proper sizing.*
- ***RDR BIT****: Radar Built-In Test*
- ***RDR****: Used for radar display functionality in all employment modes.*
- ***TV****: Used for TV raster imagery with EO (electro-optical) weapons, as well as the Pave Spike targeting pod.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)

The **Display Selector** allows the radar to display either a B-Scope or PPI (Plan-Position Indicator) format.

- Important: B-Scope display mode allows the WSO to lock targets for weapon employment, while **PPI display mode does not**.

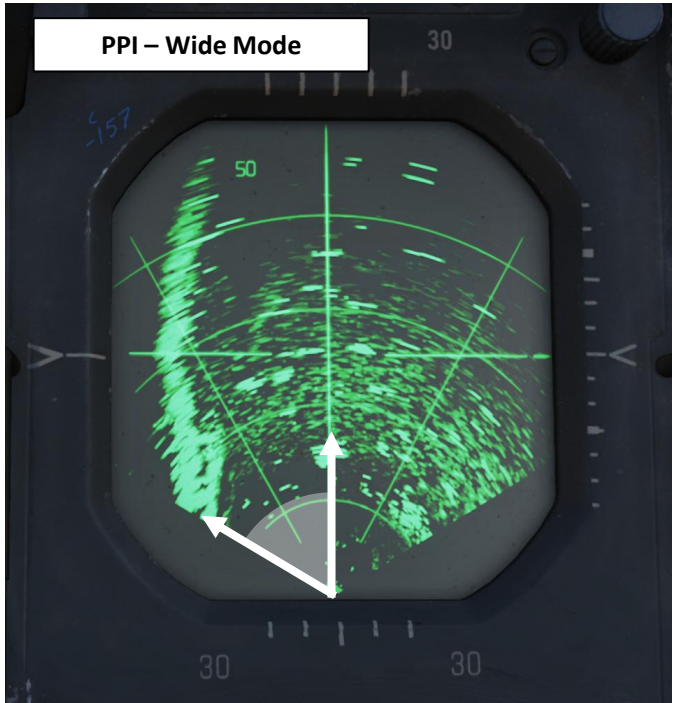


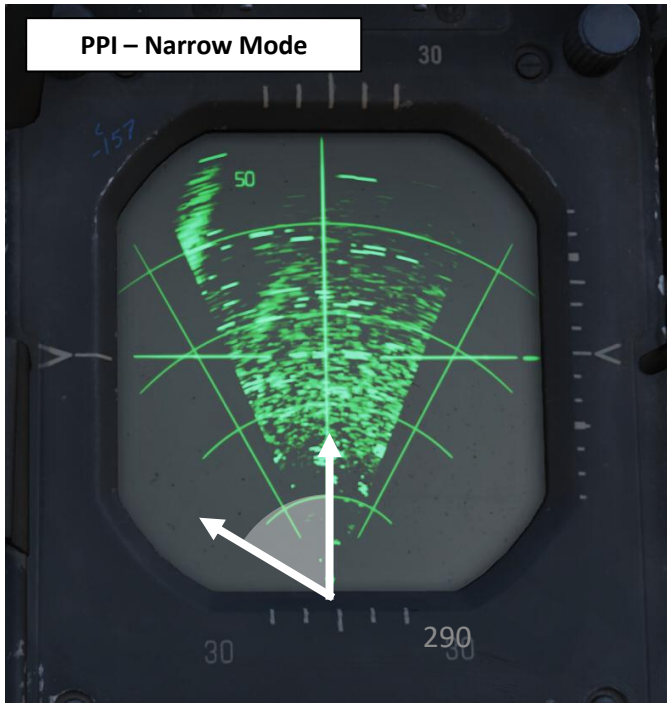


Display Selector

- *VI: provides course guidance for a VISIDENT (visual identification) intercept profile against a locked target.*
- *B NAR: B-Scope display format with Narrow Sweep Setting (45 deg sweep).*
- *B WIDE: B-Scope display format with Wide Sweep Setting (120 deg sweep).*
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*







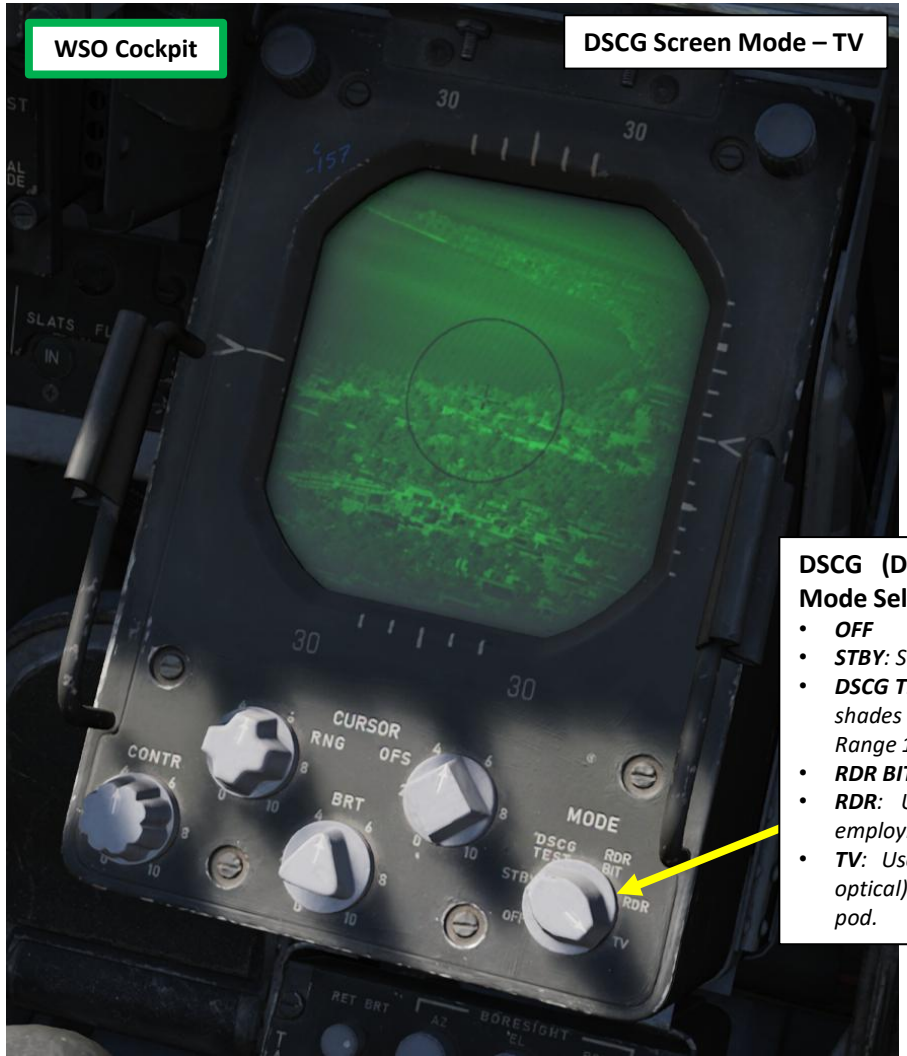
2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)

The **DSCG Screen Mode Selector** is used to determine which feed will appear on the scope screen. The **Video Select Button** controls if the TV feed comes from the targeting pod or the Maverick missile.

Video Select Button
- *Alternates between WEAPON (such as AGM-65 Maverick) and ASQ-153 (Pave Spike targeting pod) television video on the radar scope display when in TV mode.*





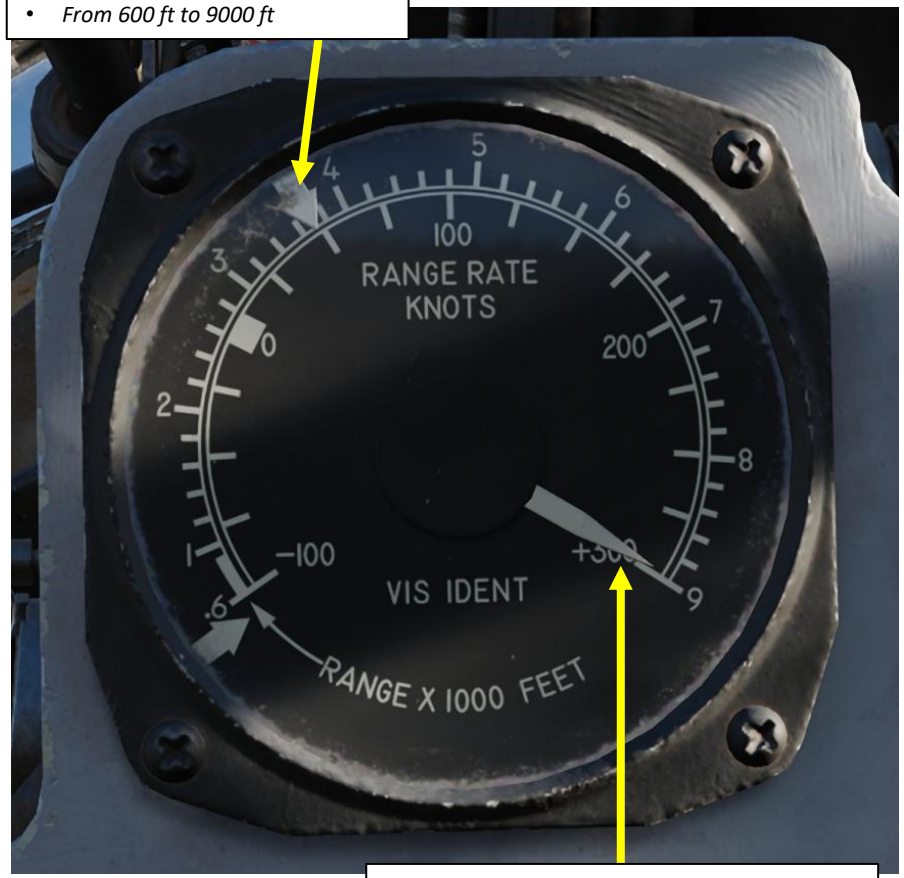


DSCG (Digital Scan Converter Group) Screen Mode Selector
- ***OFF***
- ***STBY***: *Standby mode, used for takeoff and landing.*
- ***DSCG TEST***: *Displays a test search display image with 8 shades of grey to confirm normal operation. Select Range 10 for proper sizing.*
- ***RDR BIT***: *Radar Built-In Test*
- ***RDR***: *Used for radar display functionality in all employment modes.*
- ***TV***: *Used for TV raster imagery with EO (electro-optical) weapons, as well as the Pave Spike targeting pod.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)

The **VISIDENT indicator** provides ranging information for close range interceptions (closer than 2 nm or 12000 ft) and range rate information (kts) once a radar lock is performed.

Outer Scale: Target Range (ft)
- *From 600 ft to 9000 ft*



Inner Scale: Target Range Rate (kts)
- *From -100 kts to +300 kts (positive values indicate the target is closing in)*

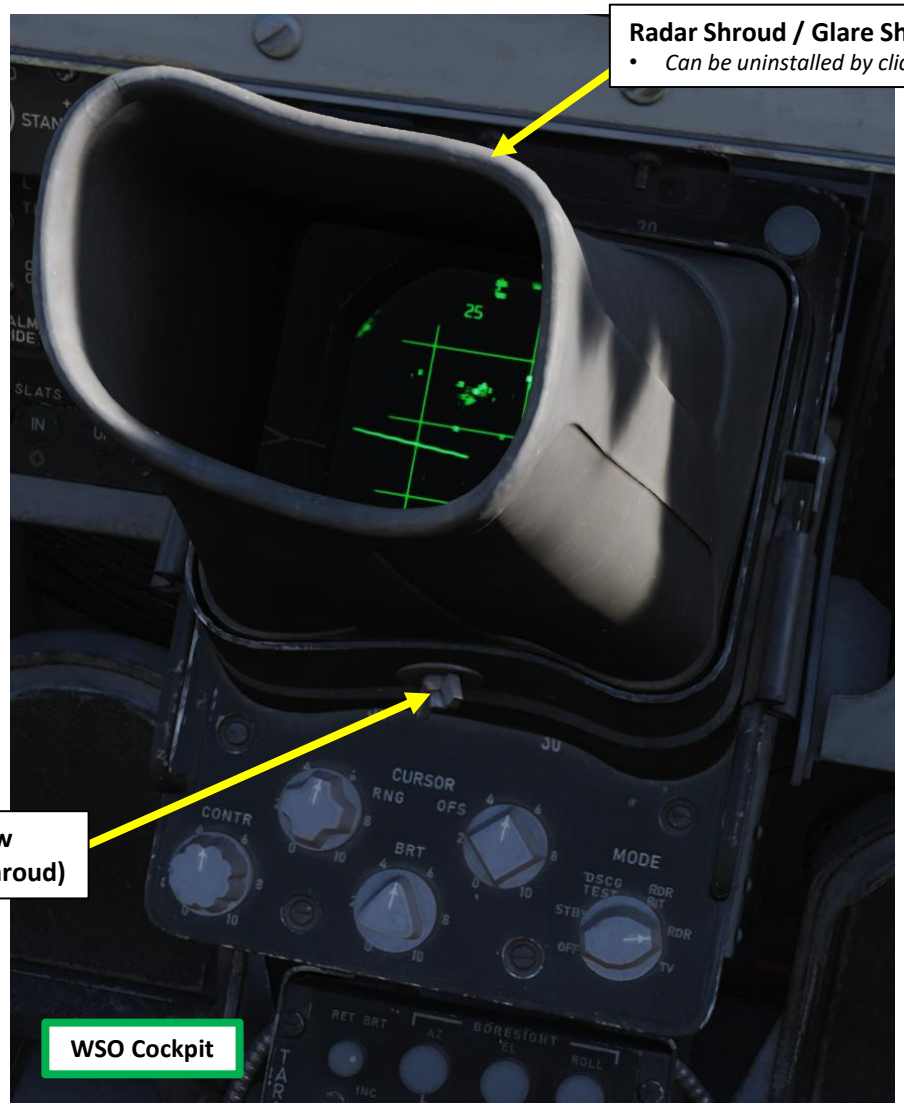
Radar Range VISIDENT (Visual Identification) Indicator
- *Used for close range VID (visual identification) intercept profiles, providing range information out to two miles and range rate information from inside of 9000'. The information is confirmed as radar-accurate once the range indicator jumps to 9.*
- *The gauge functions in the VI, B NAR, and B WIDE display modes*
- *The gauge does not function in air to ground modes.*



WSO Cockpit

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.1 – Displays (WSO)

The radar shroud allows better visibility of the radar scope in sunlit conditions, but it restricts the WSO to a narrow field-of-view. The shroud can be uninstalled by clicking on the Radar Shroud Screw. The shroud is used because the radar scope is a CRT (Cathode Ray Tube) unit, which becomes difficult to see when sun rays illuminate it at certain angles.

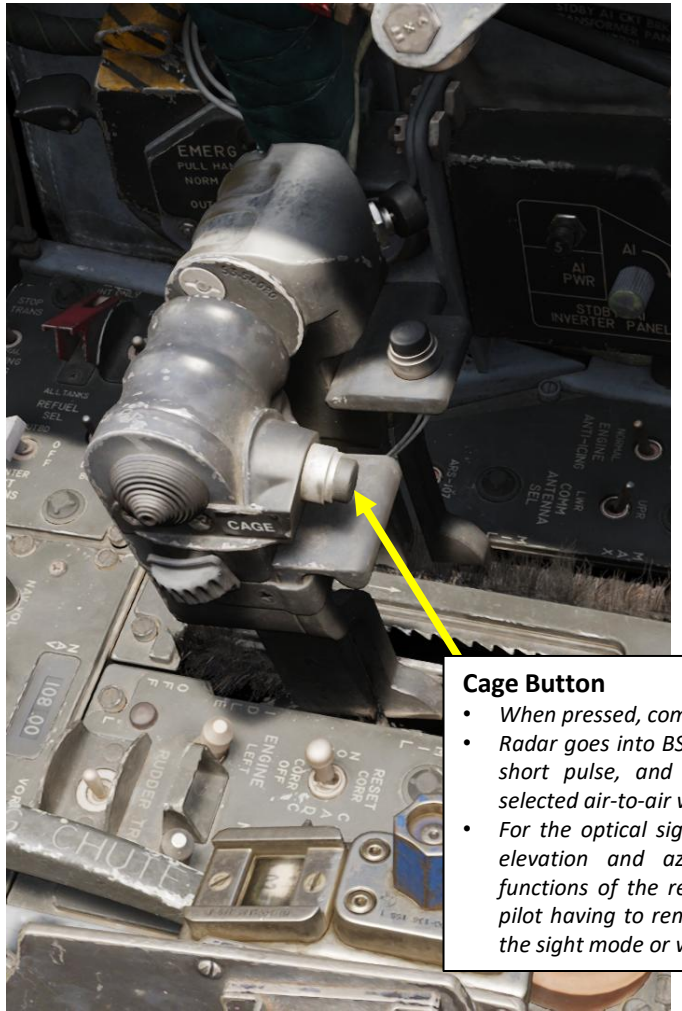




2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Overview (Pilot)

The pilot radar controls are quite limited to functions related to close-range radar employment; the **Nose Gear Steering / Radar Acquisition Button** allows the radar to enter an automatic acquisition mode, while the **Cage Button** sets the radar into a boresight mode with a five-mile range.



Cage Button
- *When pressed, commands Cage Mode.*
- *Radar goes into BST (Boresight) mode with a five mile range, short pulse, and sets the firing circuit for the currently selected air-to-air weapon relative to the Pinky Switch.*
- *For the optical sight, the command activates the respective elevation and azimuth tracking, roll mark, and range functions of the reticle for the chosen weapon, without the pilot having to remove a hand from throttle or stick to swap the sight mode or weapon control panel functions.*



Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Overview (WSO)

The **Antenna Hand Control Stick** is the primary control to slew the Radar Cursor, which is used to radar lock targets.



Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*

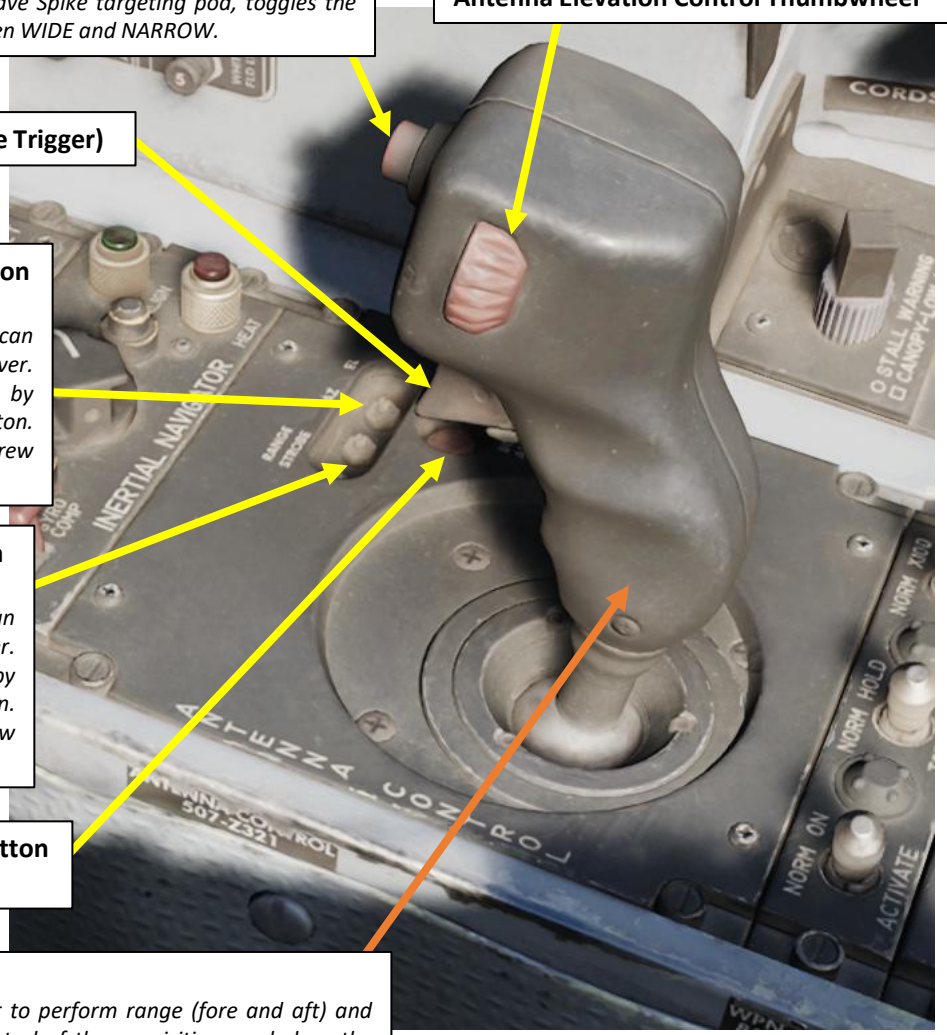
Antenna Elevation Control Thumbwheel

Action Switch (Two-Stage Trigger)

Antenna Stick Boresight Elevation Position Adjustment Screw (Not Simulated)
- *The boresight position of the antenna stick can be adjusted at its base using a screwdriver. Once set, the new values can be loaded by pressing the Antenna Stick Boresight Button. This is only accessible to ground crew personnel and has no function in DCS.*

Antenna Stick Boresight Azimuth Position Adjustment Screw (Not Simulated)
- *The boresight position of the antenna stick can be adjusted at its base using a screwdriver. Once set, the new values can be loaded by pressing the Antenna Stick Boresight Button. This is only accessible to ground crew personnel and has no function in DCS.*

Antenna Stick Boresight Button (Not Simulated)



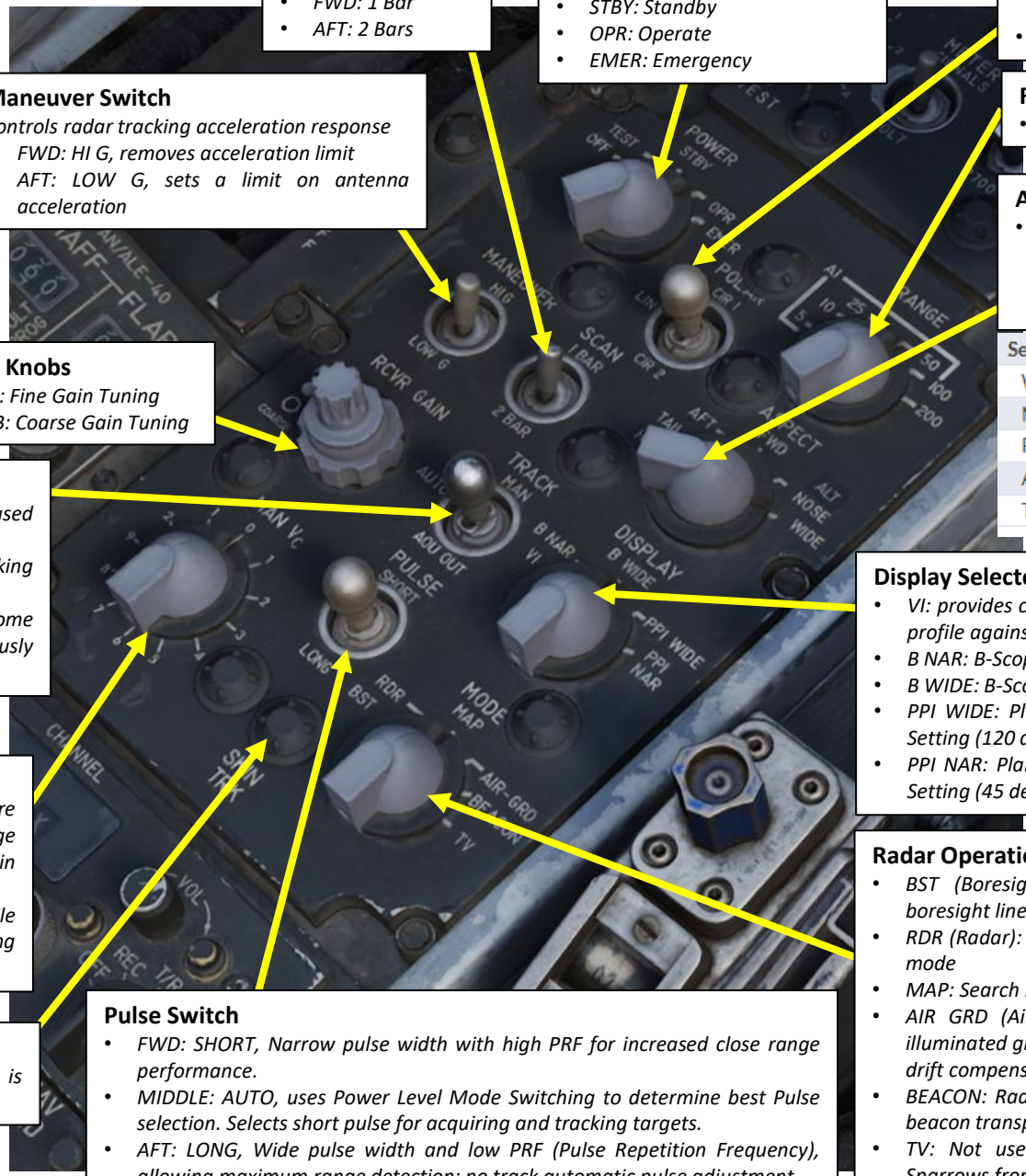
Antenna Hand Control Stick
- *This joystick integrates with the radar to perform range (fore and aft) and azimuth (left and right) positional control of the acquisition symbol on the radar display in the air-to-air modes, as well as seeker/electro-optical sensor direction with the AGM-65 Maverick and the Pave Spike Targeting Pod.*

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Overview (WSO)

Primary radar functions are controlled on the Radar Set Control Panel.



Bar Scan Switch
- *FWD: 1 Bar*
- *AFT: 2 Bars*

Radar Power Selector Knob
- *OFF*
- *TEST*
- *STBY: Standby*
- *OPR: Operate*
- *EMER: Emergency*

Polarization Switch
- *FWD: CIR 1 (Circularly polarized clockwise)*
- *MIDDLE: LIN (Lineally polarized in a vertical orientation), used in normal conditions*
- *AFT: CIR 2 (Circularly polarized counter-clockwise)*

Maneuver Switch
Controls radar tracking acceleration response
- *FWD: HI G, removes acceleration limit*
- *AFT: LOW G, sets a limit on antenna acceleration*

Radar Range Selector Knob
- *5, 10, 25, 50, 100 or 200 nm*

Aspect Selector
- *Used to program the AIM-7 missile with a pre-determined simulated Doppler instead of actual received Doppler, so that the WSO can provide an estimated correct speed-gate for the Sparrow when not tracking.*

Selection	DSCG Display	Sparrow Speed-Gate Setting (Vc)
WIDE	Closure Velocity	Entire Spectrum
NOSE	Altitude	TAS + 450 ±150 kts
FWD	Aspect	TAS + 240 ±150 kts
AFT	Closure Velocity	TAS - 240 ±150 kts
TAIL	Heading	0 ±150 kts

Receiver Gain Knobs
- *INNER KNOB: Fine Gain Tuning*
- *OUTER KNOB: Coarse Gain Tuning*

Track Switch
- *FWD: Manual, MAN Vc knob position will be used to set the tracking gate closure velocity*
- *MIDDLE: Auto, operates normal range tracking with Home on Jam (HOJ) if jamming is detected*
- *AFT: AOJ (Acquisition On Jam) OUT, disables Home on Jam in cases where jamming is erroneously detected*

Display Selector
- *VI: provides course guidance for a VISIDENT (visual identification) intercept profile against a locked target.*
- *B NAR: B-Scope display format with Narrow Sweep Setting (45 deg sweep).*
- *B WIDE: B-Scope display format with Wide Sweep Setting (120 deg sweep).*
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*

Man Vc (Closure Rate) Knob
- *Used to apply estimated range rate of closure (clockwise, 0-9), or estimated opening of range (counterclockwise, 0-2) against a target in manual track mode.*
- *The numbers are multiplied by 100 knots while closure means closing in to the F-4 and opening means the target is flying away from the F-4*

Radar Operation Mode Selector
- *BST (Boresight): Air-to-Air boresight with antenna aligned radar boresight line and optical sight with sight in A/A*
- *RDR (Radar): Search Mode with Feedhorn Nutation (wider beam-width) mode*
- *MAP: Search Mode without Feedhorn Nutation (narrower beam-width)*
- *AIR GRD (Air-to-Ground): Air-to-Ground boresight, Tracks range of illuminated ground, radar is boresighted to the radar boresight line with drift compensation.*
- *BEACON: Radar receives and displays signals from ground or airborne beacon transponders for navigation.*
- *TV: Not used with DSCG. De-tunes AIM-7 if selected, preventing Sparrows from guiding.*

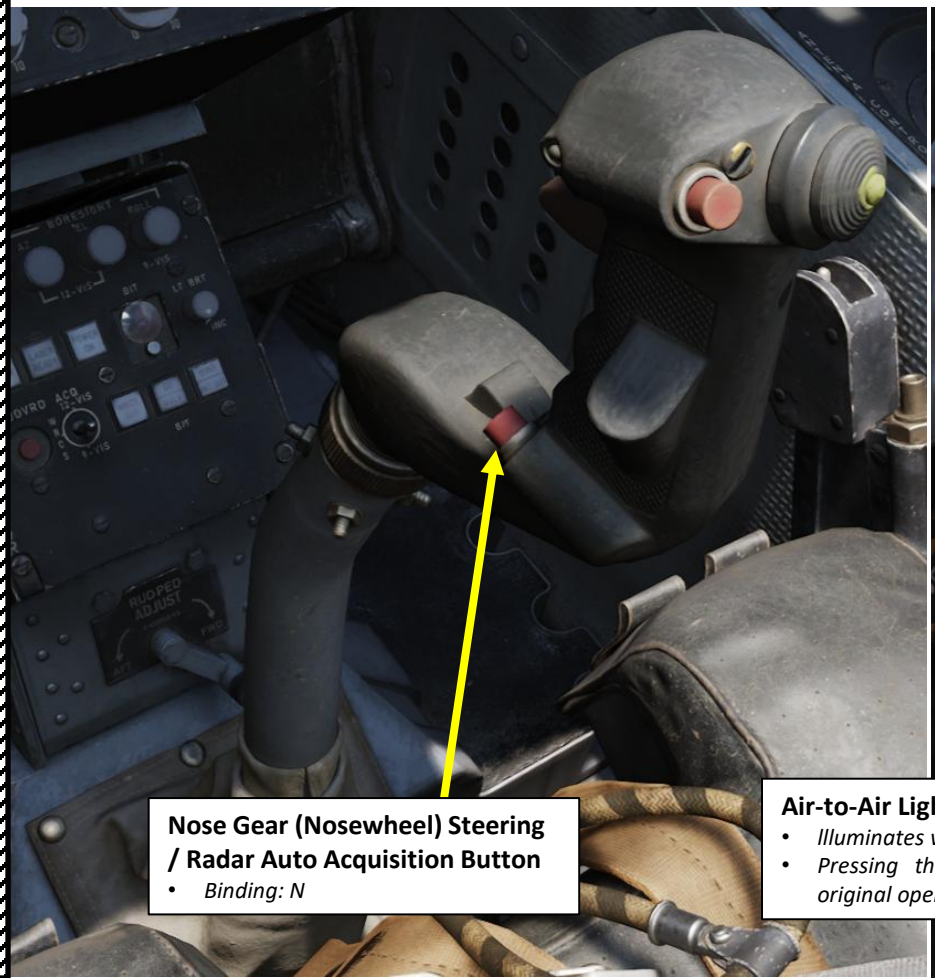
Skin Track Lamp
- *Illuminates when a radar track is attained with range data*

Pulse Switch
- *FWD: SHORT, Narrow pulse width with high PRF for increased close range performance.*
- *MIDDLE: AUTO, uses Power Level Mode Switching to determine best Pulse selection. Selects short pulse for acquiring and tracking targets.*
- *AFT: LONG, Wide pulse width and low PRF (Pulse Repetition Frequency), allowing maximum range detection; no track automatic pulse adjustment.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Overview (WSO)

The **Nose Gear Steering / Radar Acquisition Button** allows the radar to enter an automatic acquisition mode. The **Air-to-Air Light** is used by the WSO to know if the Cage Mode has been activated by the pilot; pressing the push-light will allow the radar to revert to the original operating condition prior to entry into Cage Mode.



Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Overview (WSO)

The **Control Monitor panel** is mainly used to monitor radar diagnostics and control auxiliary functions of the radar like the Vc (Closure Rate Display) and Stab (Antenna Stabilization Mode) switch.

Meter Selector Knob
- *Sixteen position rotary knob used in conjunction with the Test Knob, with each position having two values: an outer SIGNAL value, and an inner VOLT value (selection of which value determined by the Meter Switch).*

Temp Lamp
- *Illuminates when overheat situation in the APQ-120 avionics bays is detected*

Monitor Meter Display
- *Provides voltage, current, and signal indications based on current Meter Switch and Meter Selector Knob settings.*

Radar BIT (Built-In Test) Selector Knob
- *0: Display standard B-scope presentation to confirm all elements functioning correctly.*
- *1: Confirms break lock timing delay, AIM-7 tuning status, and Range lamp status function.*
- *2: Confirms proper AIM-7 head position aim and SHORT pulse function against two targets.*
- *3: Confirms angle tracking performance against a locked target that rotates inside ASE (Allowable Steering Error) circle.*
- *4: Used while lock achieved in another mode, confirms HOJ (Home On Jam) and AOJ (Acquisition On Jam) functionality.*
- *5: Checks range rate, lead angle and CAA (Computer Automatic Acquisition) function.*
- *6: Confirms proper AIM-7 attack display and interlock function.*
- *7, 8, 9, 10: Not Available.*
- *DOT BAL: Confirms AIM dot centering calibration, also used for TIRS data transfer.*

Meter Switch

Determines which set of values are utilized from the Meter Selector Knob for the applicable test sequences.
- *FWD: Signals, selects the outer ring of SIGNAL reference values*
- *AFT: Volts, selects the inner ring of Voltage referencing values*

Vc (Closure Rate) Display Switch

Changes the scale factor of the range rate presentation. DSCG aircraft must leave the switch in 2700, otherwise the Vc presentation will be in error.
- *FWD: 900*
- *AFT: 2700*

STAB (Antenna Stabilization Mode) Switch
- *FWD: STAB OUT, Horizon line removed from scopes and stabilization drift servos are zeroed*
- *MIDDLE: NORMAL operation, inputs of pitch and roll are fed to the antenna stabilization circuit.*
- *AFT: DRIFT OUT, antenna uses direct pitch and roll input tracking, removing INS (Inertial Navigation System) drift compensation in the process.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

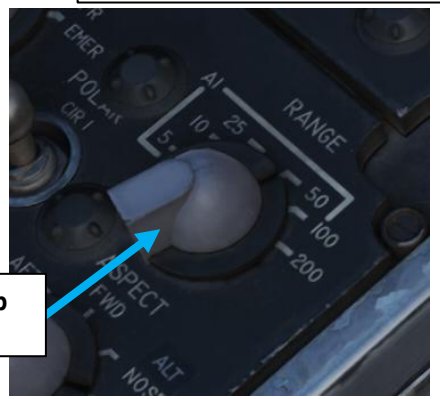
Range Control

The **radar cursor** is controlled in the longitudinal axis (Forward/Aft) with the **Antenna Hand Control** Stick Y Axis (Forward/Aft).

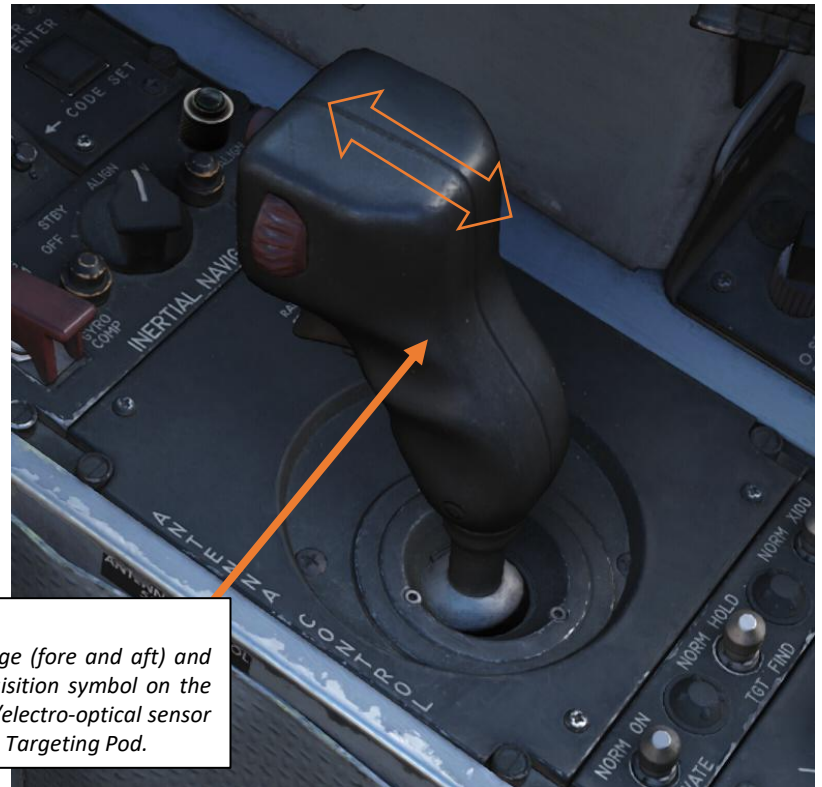
The **range scale** is controlled with the **Radar Range Selector Knob**.

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*

Selected Range Scale (nm)
- *Each horizontal line of the grid marks a scale where the gaps are one fifth of the current range setting of the display.*



Radar Range Selector Knob
- *5, 10, 25, 50, 100 or 200 nm*



Antenna Hand Control Stick
- *This joystick integrates with the radar to perform range (fore and aft) and azimuth (left and right) positional control of the acquisition symbol on the radar display in the air-to-air modes, as well as seeker/electro-optical sensor direction with the AGM-65 Maverick and the Pave Spike Targeting Pod.*



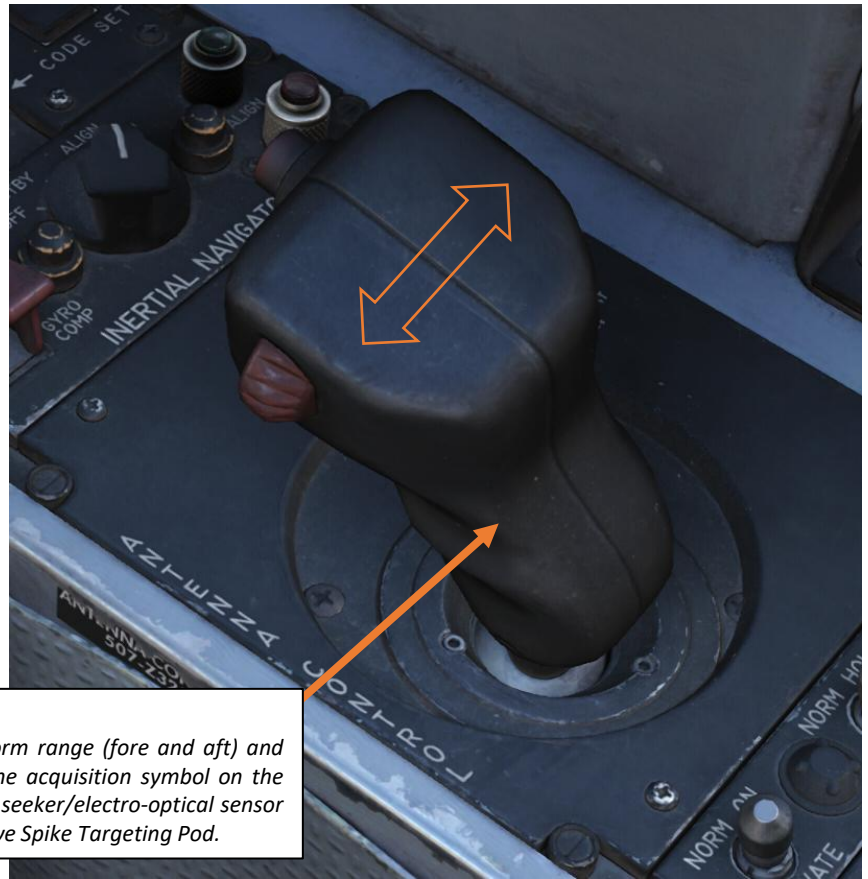
2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Azimuth Control

The **radar cursor** is controlled in the lateral axis (Left/Right) with the **Antenna Hand Control** Stick X Axis (Left/Right).

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*





Antenna Hand Control Stick
- *This joystick integrates with the radar to perform range (fore and aft) and azimuth (left and right) positional control of the acquisition symbol on the radar display in the air-to-air modes, as well as seeker/electro-optical sensor direction with the AGM-65 Maverick and the Pave Spike Targeting Pod.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Antenna Elevation Control

The **radar antenna elevation** is controlled with the **Antenna Elevation Thumbwheel**.

Radar Antenna Elevation Indicator
- *Shows antenna elevation (in degrees) relative to the radar plane, or aircraft if the Stab Switch is set to OUT. This can be moved with the Antenna Hand Control elevation wheel.*

Radar Antenna Elevation Reference Scale (deg)



Antenna Elevation Control Thumbwheel



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Gain Control

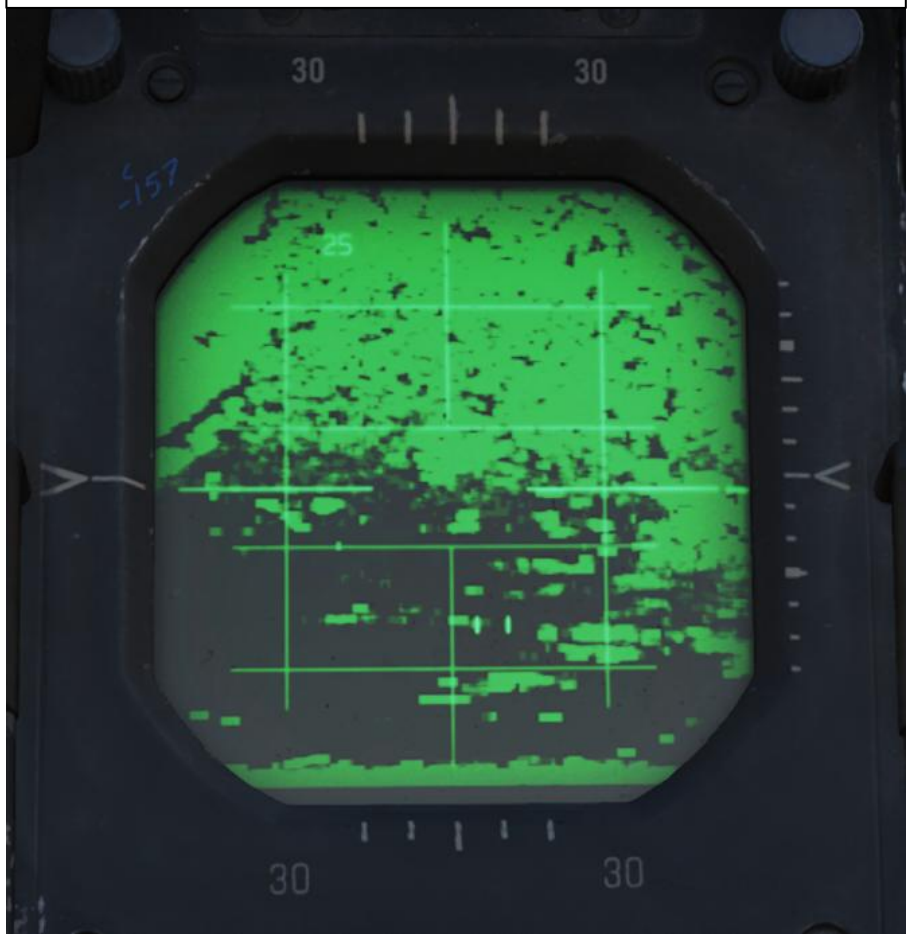
The **radar gain** is manually controlled with the **Receiver Gain knobs**. When the radar locks on a target, the gain control is switched to the Automatic Gain Control Circuit and manual gain control no longer is used.

- Higher gain settings amplify all echoes but can result in noise and saturation resulting in degraded image.
- Lower gain settings will result in better target contrast. However, weaker returns will not be visible, which can degrade detection range.

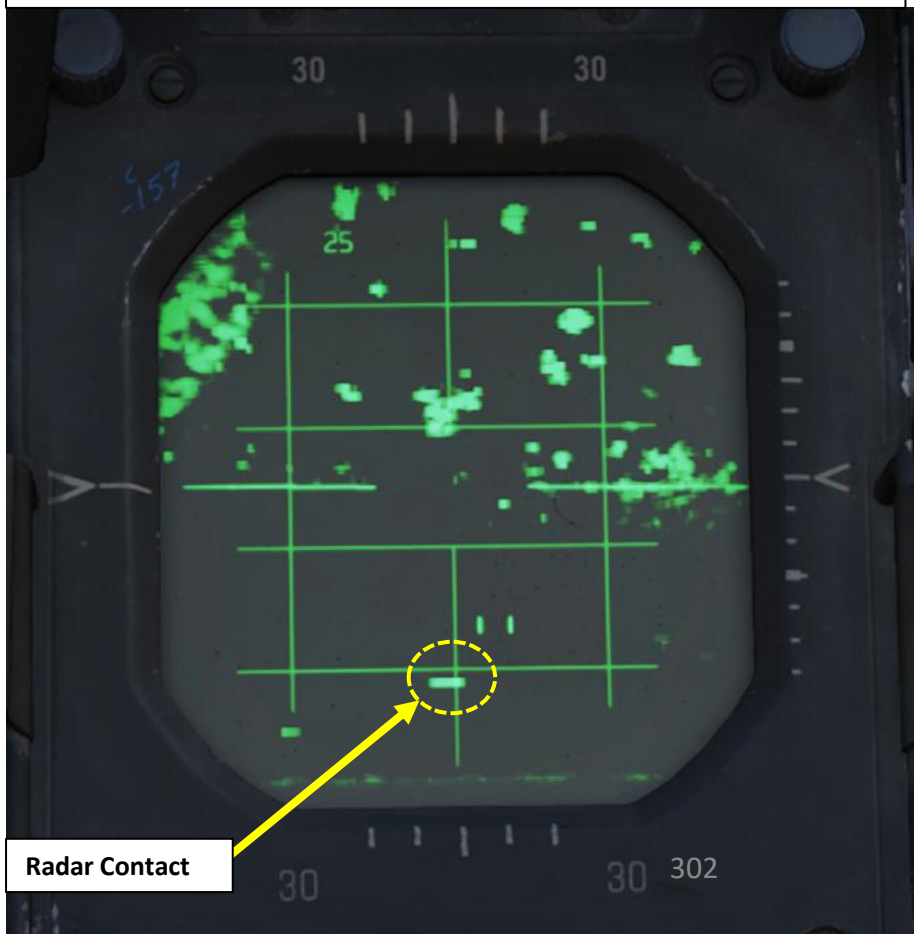
Receiver Gain Knobs
- *INNER KNOB: Fine Gain Tuning*
- *OUTER KNOB: Coarse Gain Tuning*



Radar Gain Setting (Sensitivity) is too high



Radar Gain Setting (Sensitivity) is lowered to filter clutter



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

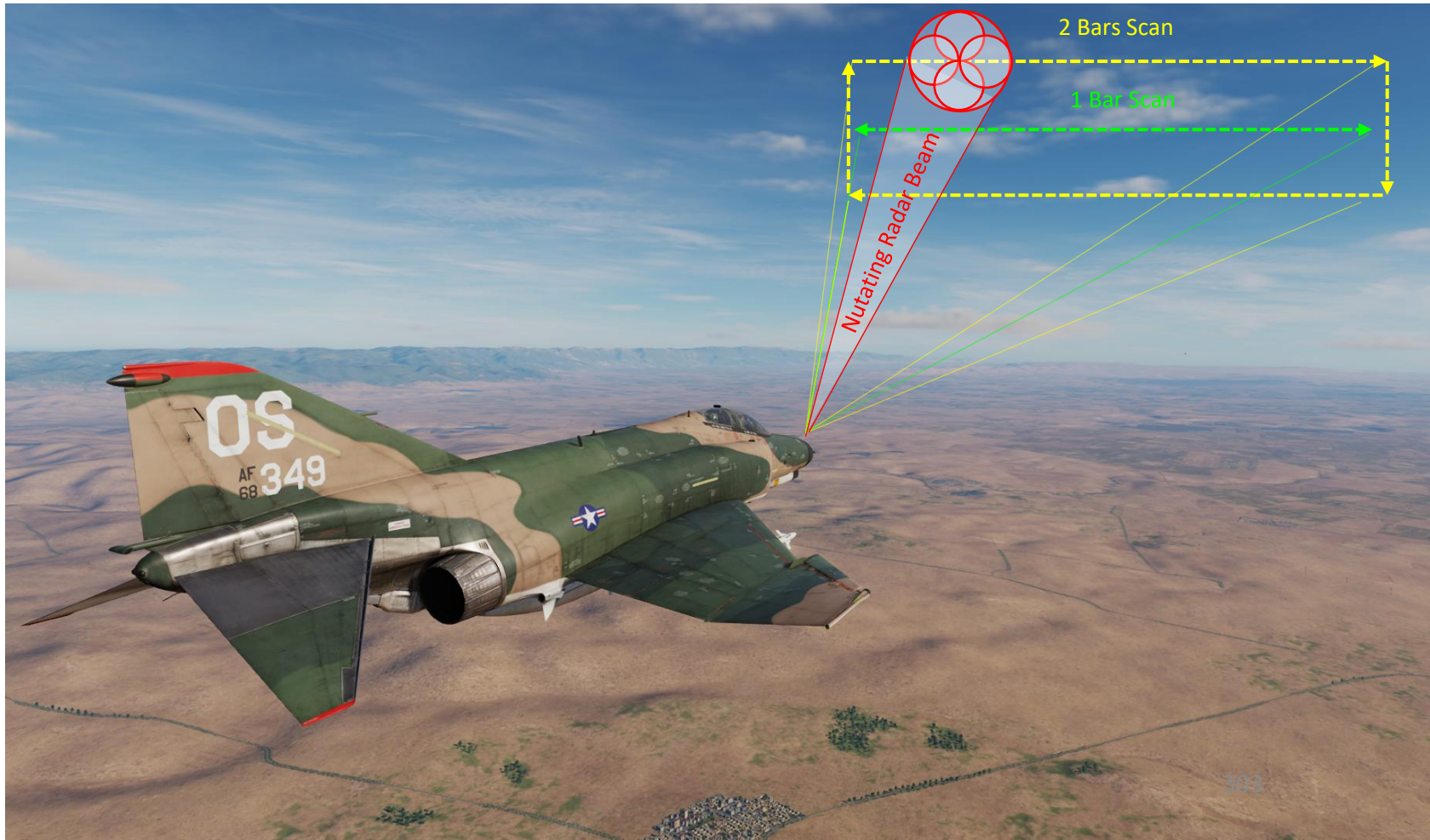
Bar Scan Control

The **Bar Scan Switch** specifies the number of elevation bars used in search. Take note that 1 Bar is automatically selected when selecting MAP Mode.

- 1 Bar: Scans along radar plane (6.7 deg total vertical coverage with nutation, 3.7 deg without nutation)
- 2 Bars: Scan alternates between 1.875 degrees above/below the radar plane (10.45 deg total vertical coverage)

Bar Scan Switch
- *FWD: 1 Bar*
- *AFT: 2 Bars*





2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Aspect Control

The **Aspect Selector switch** controls the display mode of the DSCG numeric output while the radar is tracking a target (radar lock). It also provides the AIM-7 Sparrow missile with a simulated doppler signal when no radar lock is achieved to aid with a Sparrow speed-gate lock-on when it is to be fired in boresight. When the radar is tracking, the calculated (or manually set) closure is used to set a narrow speed gate (+/- 150 kts) around the closure for the Sparrow to search when launched.

Selection	DSCG Display	Sparrow Speed-Gate Setting (Vc)
WIDE	Closure Velocity	Entire Spectrum
NOSE	Altitude	TAS + 450 ±150 kts
FWD	Aspect	TAS + 240 ±150 kts
AFT	Closure Velocity	TAS - 240 ±150 kts
TAIL	Heading	0 ±150 kts



Aspect Selector

- *Used to program the AIM-7 missile with a pre-determined simulated Doppler instead of actual received Doppler, so that the WSO can provide an estimated correct speed-gate for the Sparrow when not tracking.*



TAIL Selected

Locked Target Heading 010



AFT Selected

Locked Target Closure Velocity: -140 kts (opening)



Locked Target Aspect Angle 0

FWD Selected



Locked Target Altitude 0080 = 8000 ft

NOSE Selected



Locked Target Closure Velocity: 180 kts (closing)

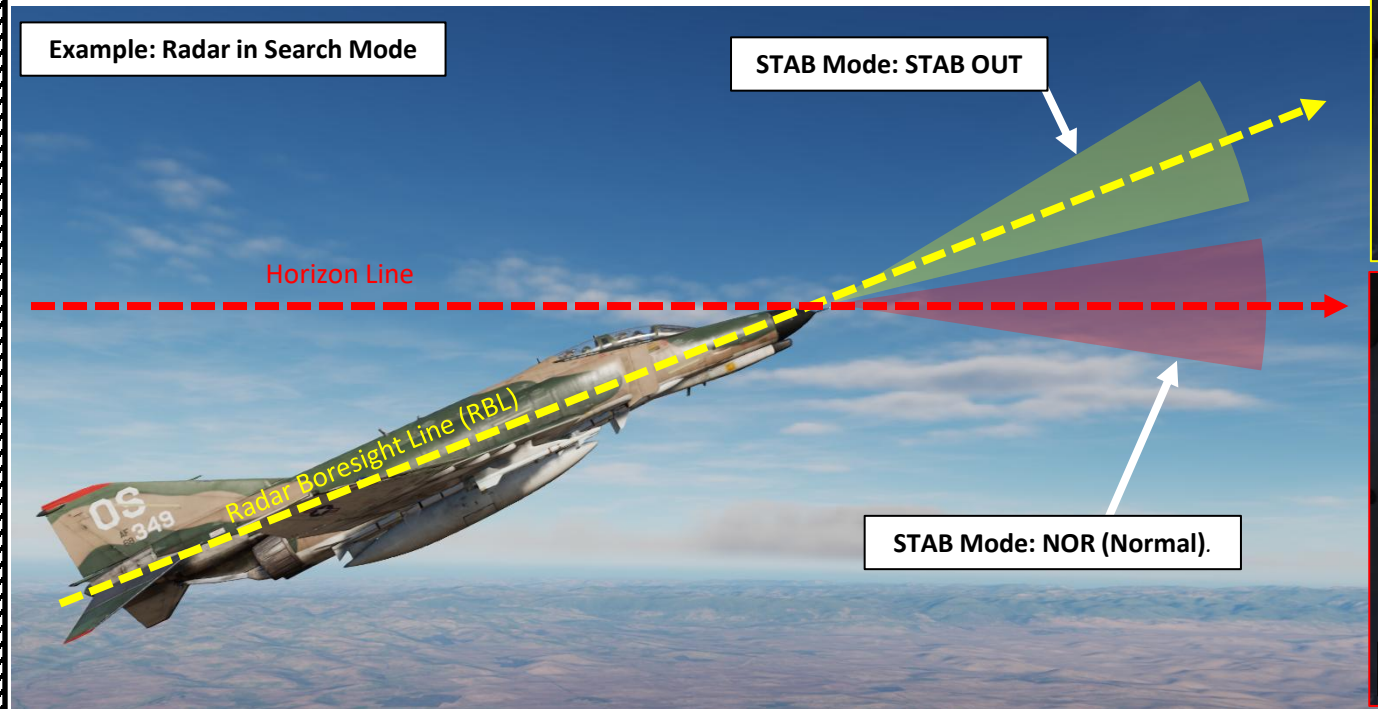
WIDE Selected

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Antenna Stabilization Control

The radar antenna has three stabilization modes, which are controlled by the **STAB (Antenna Stabilization Mode) Switch**.

- **NOR (Normal) Mode**: In Automatic Search (air-to-air), maintains stabilization in pitch and roll axes to the horizon (radar plane). The center of the radar scan is along the heading of the aircraft. In this mode the zero degree mark on the display indicates the horizon. In Air-to-Ground Ranging, the antenna is boresighted to the RBL (Radar Boresight Line) but stabilized in INS (Inertial Navigation System) drift.
- **DRIFT OUT Mode**: Essentially the same as Normal Mode, but INS drift compensation is inactive.
- **STAB OUT (Stabilization Out) Mode**: In Automatic Search (air-to-air), the antenna does not stabilize to the horizon, but instead the aircraft reference. With Air-To-Ground Ranging, the antenna is boresighted to the RBL (Radar Boresight Line) without drift stabilization. In this mode the zero degree mark on the display indicates the radar boresight line.

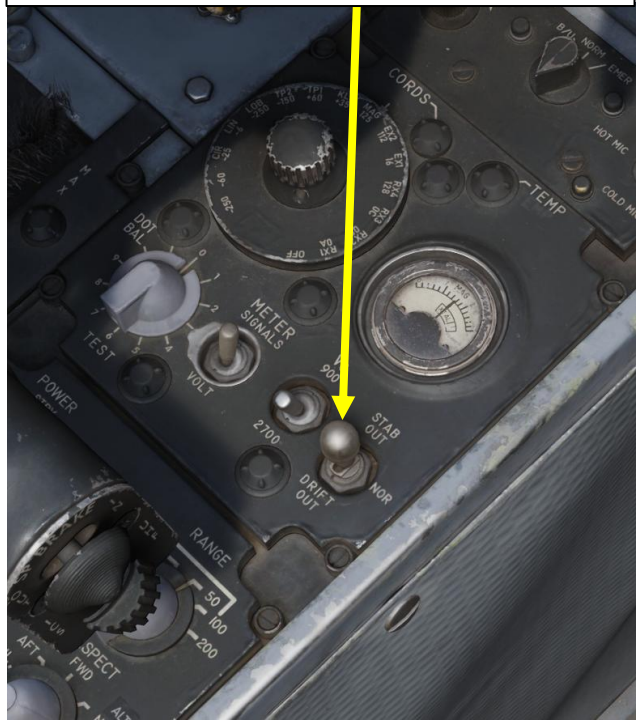






STAB (Antenna Stabilization Mode) Switch

- *FWD: STAB OUT, Horizon line removed from scopes and stabilization drift servos are zeroed*
- *MIDDLE: NORMAL operation, inputs of pitch and roll are fed to the antenna stabilization circuit.*
- *AFT: DRIFT OUT, antenna uses direct pitch and roll input tracking, removing INS (Inertial Navigation System) drift compensation in the process.*



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Pulse Setting Control

The pulse setting determines several characteristics of the radar set. These include the length of the transmitted pulse, which amplifier is used to amplify the signals, and the frequency at which the pulses are emitted (i.e. the pulse repetition frequency, also referred as "PRF"). A higher PRF setting provides a slightly less accurate computed target range but a better sensitivity, while a lower PRF setting can compute a more accurate/unambiguous target range but at a reduced sensitivity.

The pulse setting is controlled with the **Pulse Switch** into either AUTO, LONG or SHORT modes.

- **LONG Mode**: Narrow Band Amplifier, 370 Hz Pulse Repetition Frequency, 2.0 microseconds pulse length.
- **SHORT Mode**: Back Bias Amplifier, 1060 Hz Pulse Repetition Frequency, 0.4 microseconds pulse length.
- **AUTO Mode**: Enables the power-level mode switching (**PLMS**). Power Level Mode Switching (PLMS) automatically selects the LONG or SHORT, and Narrow Band or Back Bias amplifiers depending on several conditions such as target range, echo strength or noise signal.

Note: the Air-to-Ground and Computer Automatic Acquisition (CAA) mode force the pulse setting into SHORT mode.

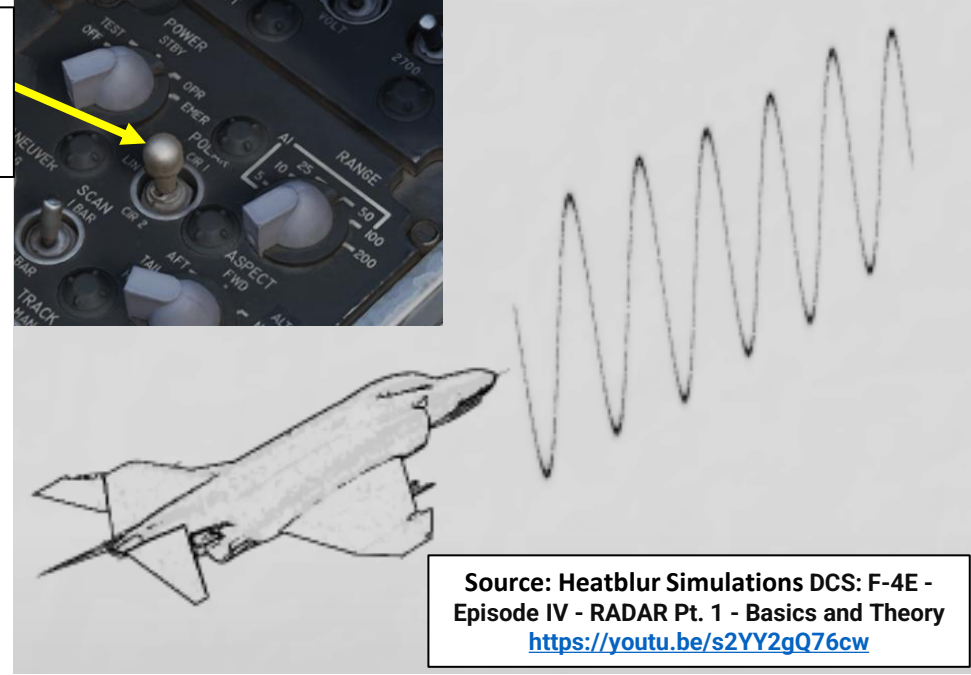


Pulse Switch

- *FWD: SHORT, Narrow pulse width with high PRF for increased close range performance.*
- *MIDDLE: AUTO, uses Power Level Mode Switching to determine best Pulse selection. Selects short pulse for acquiring and tracking targets.*
- *AFT: LONG, Wide pulse width and low PRF (Pulse Repetition Frequency), allowing maximum range detection; no track automatic pulse adjustment.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.2 – Controls

Polarization Switch
- *FWD: CIR 1 (Circularly polarized clockwise)*
- *MIDDLE: LIN (Lineally polarized in a vertical orientation), used in normal conditions*
- *AFT: CIR 2 (Circularly polarized counter-clockwise)*

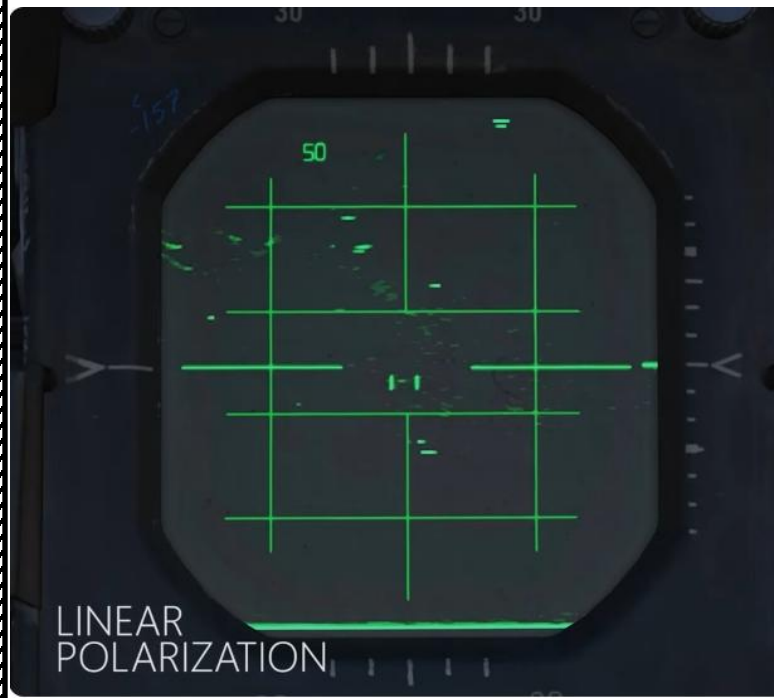


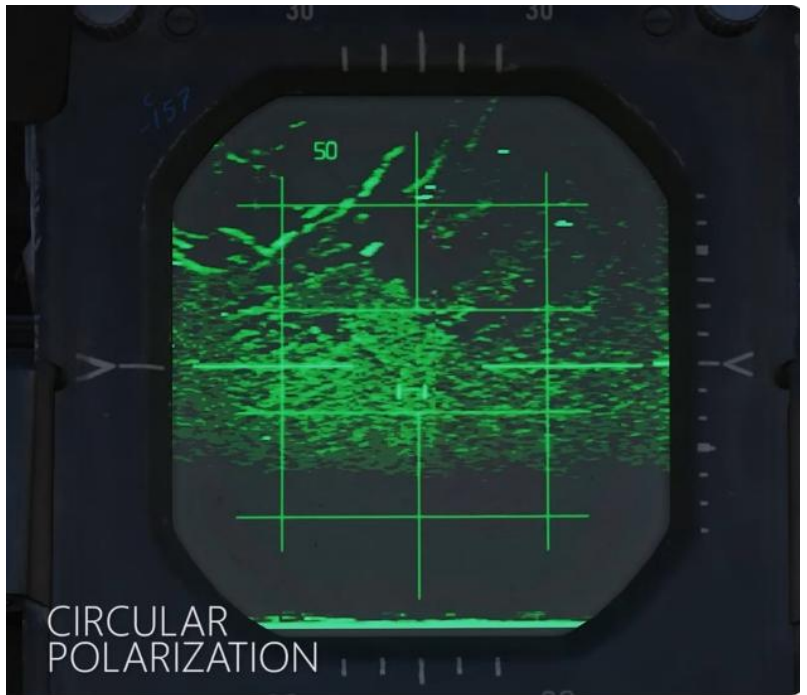
Source: Heatblur Simulations DCS: F-4E - Episode IV - RADAR Pt. 1 - Basics and Theory https://youtu.be/s2YY2gQ76cw

Polarization Control

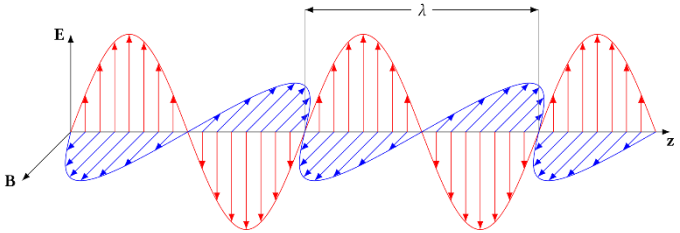
The polarization (orientation of the lines of electric flux in the electromagnetic field) of the radio frequency energy can be changed using the **Polarization Control Switch**.

- **LIN Setting**: In normal operation, the LIN setting is used. It produces linearly polarized RF energy (Radio Frequency) in the vertical direction relative to the antenna. This setting **is compatible with launching AIM-7 Sparrows.** This minimizes ground returns as many types of ground clutter are less reflective to vertically polarized RF energy. However, because the antenna is not roll-stabilized, increased return intensity may be seen when rolling the aircraft.
- **CIR 1 (Circularly polarized clockwise) Setting:** Precipitation is less reflective to circularly polarized RF; this setting can aid in minimizing clutter in rain or fog. This setting **is compatible with launching AIM-7 Sparrows** as the Sparrow rear antenna cannot receive counter-clockwise polarized radio frequency.
- **CIR 2 (Circularly polarized counter-clockwise) Setting:** Precipitation is less reflective to circularly polarized RF; this setting can aid in minimizing clutter in rain or fog. This setting **is not compatible with launching AIM-7 Sparrows** as the Sparrow rear antenna cannot receive counter-clockwise polarized radio frequency.

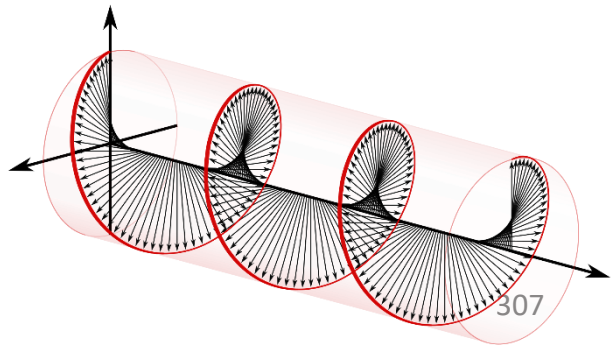




Linear Radar Wave Polarization Representation



Circular Radar Wave Polarization Representation



2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.3 – Performance

The radar's performance varies greatly when it comes to what the aircrew is attempting to do, in what mode and in what conditions. Conditions include aircraft aspect angle, target RCS (radar cross-section), and much more. One must keep in mind that the F-4's radar does not perform as well as modern day radars. Its search capabilities are mainly used in situations where the pilot already knows where the target is while being vectored by an AWACS (Airborne Warning and Control System) aircraft like an E-3 or GCI (Ground Control Intercept) controller. The AN/APQ-120 was to be used mainly as a targeting system to guide missiles at medium to close range.

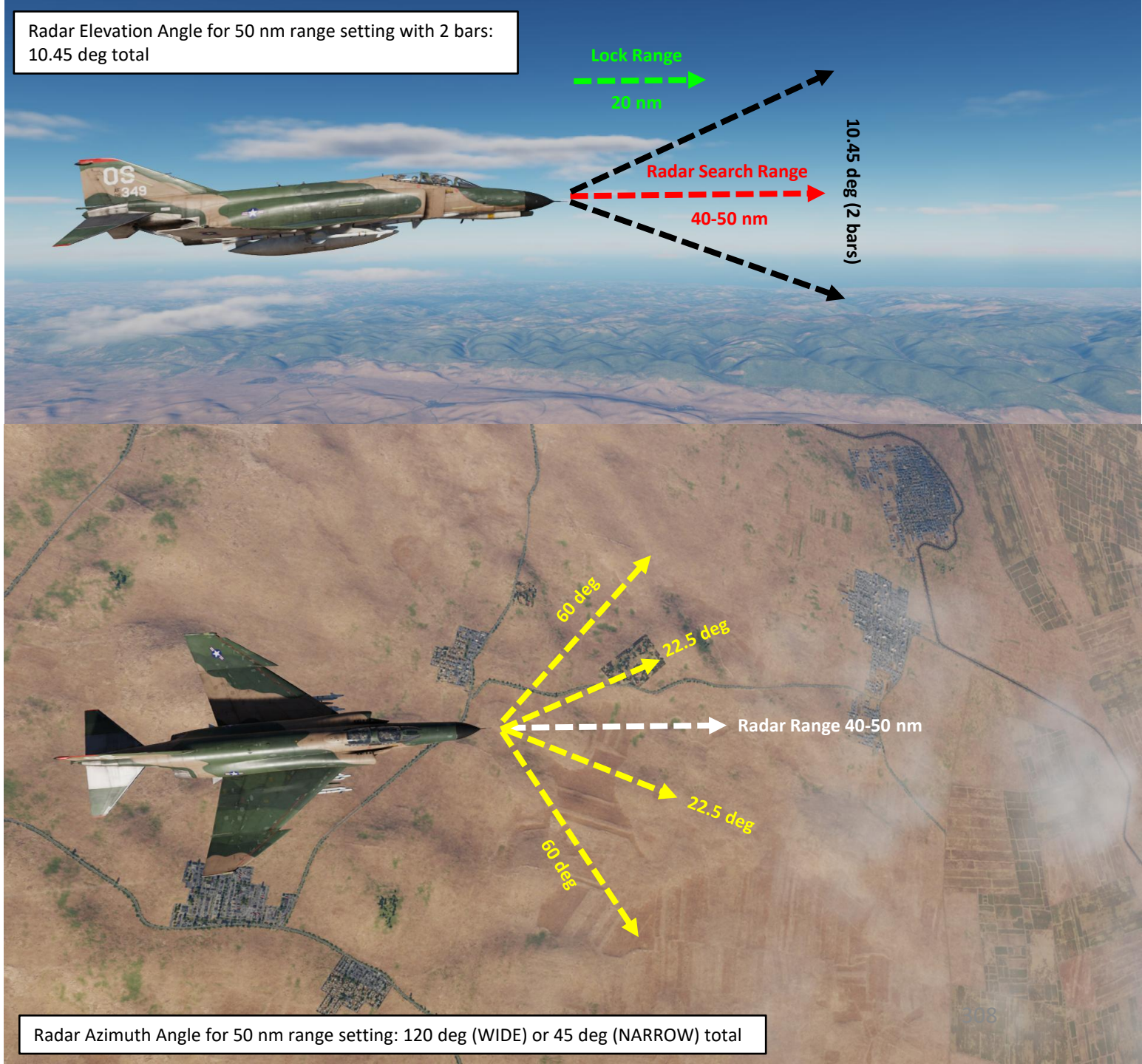
When it comes to searching for air targets, the AN/APQ-120 can detect large aircraft like **bombers** up to a distance of **40 to 50 nm**, while smaller aircraft like **fighter jets** are detected up to a range of **25 nm**. You can typically get a **radar lock** within **20 nm** or less.

In normal operation, the **radar antenna stabilization** is determined by its stabilization mode; Automatic Search (air-to-air) maintains stabilization in pitch and roll axes to the horizon (radar plane).

Search is normally **120 degrees wide** with the display knob in **WIDE** positions, and limited to **45 degrees** in the **NAR** position.

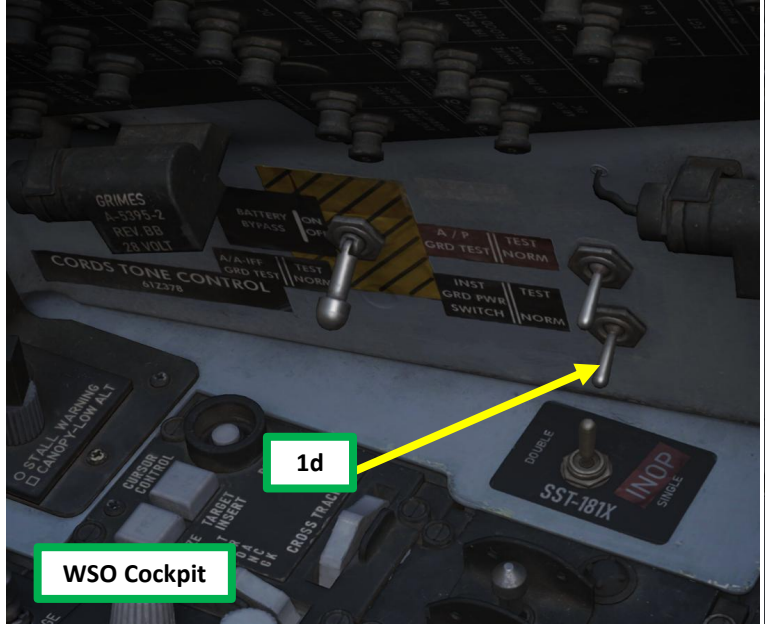
The **radar elevation angle** can be controlled by tilting the radar antenna. However, your radar scanning cone only covers a definite azimuth and elevation angle. Distances and angles are not to scale. The Bar Scan switch allows the radar to perform either a 1-bar scan a 2-bar scan.

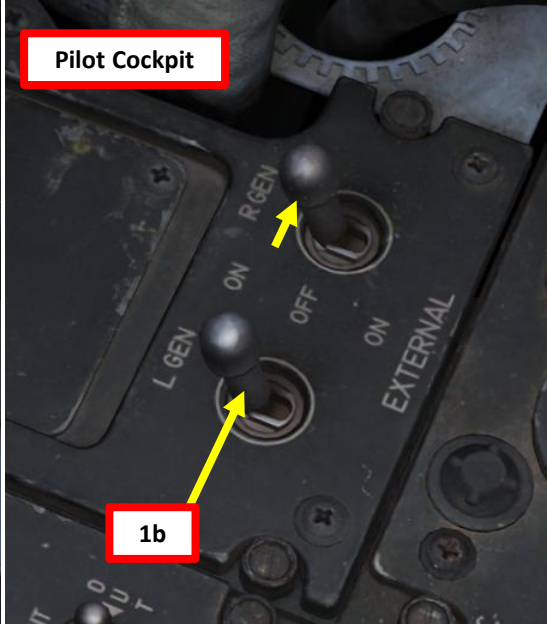
- **1 Bar**: Scans along radar plane (6.7 deg total vertical coverage with nutation, 3.7 deg without nutation)
- **2 Bars**: Scan alternates between 1.875 degrees above/below the radar plane (10.45 deg total vertical coverage)



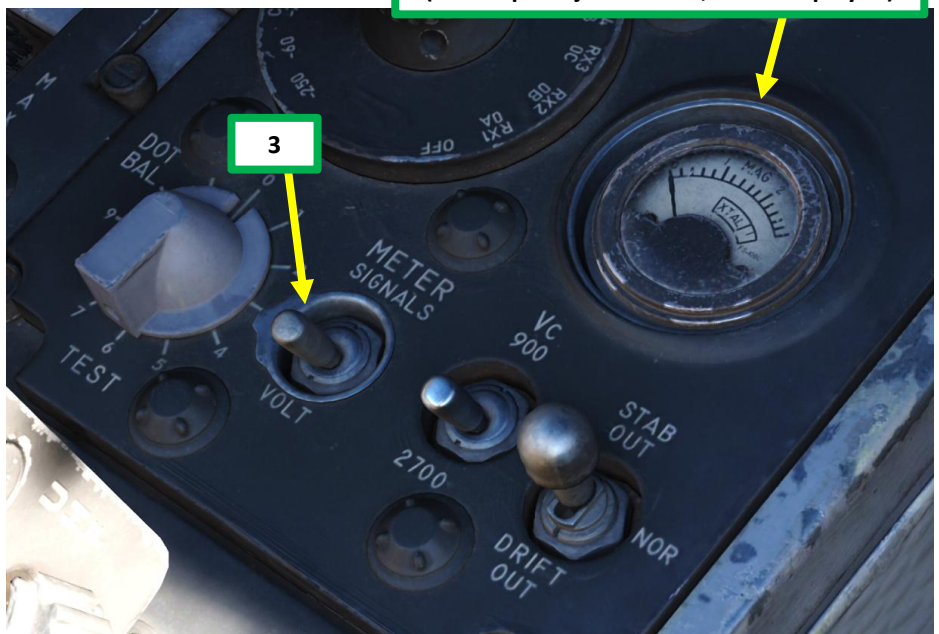
2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.4 – Radar Power-Up

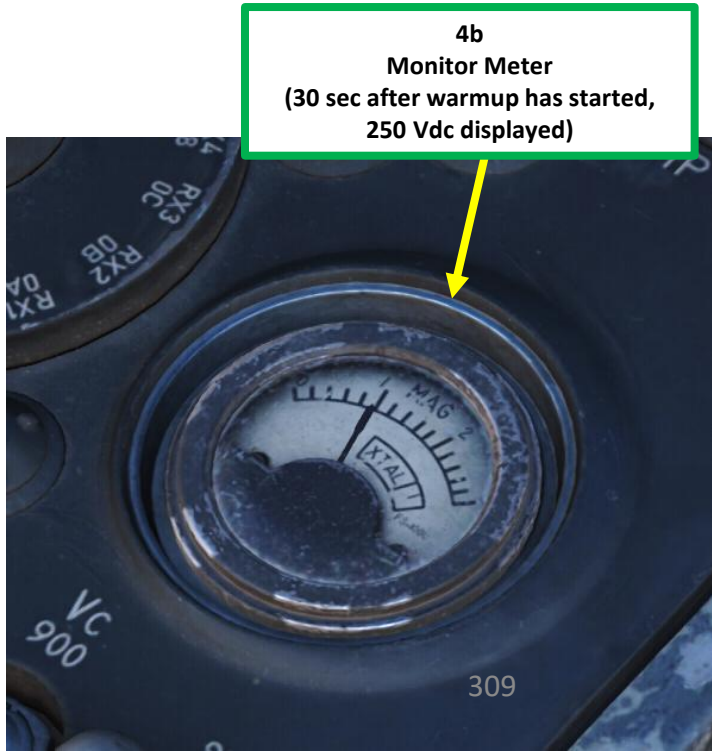
1. *[WSO]* Prior to powering up the radar, check with the pilot to make sure that the following conditions are respected:
    a) Engines are running.
    b) Both Left & Right Generator switches are set to ON (FWD).
    c) INS (Inertial Navigation System) alignment is complete.
    d) Instrument Ground Power Test Switch is set to NORM (DOWN).
2. *[WSO]* Initial powering of the APQ-120 starts by placing the Radar Power Knob into STBY (Standby).
    - The magnetron is not powered until 3 minutes after radar is turned on.
    - The klystron is not powered until 100 seconds after the radar is turned on.
3. *[WSO]* Set Meter Switch – VOLTS (AFT)
4. *[WSO]* The warmup cycle of the radar requires 3 minutes. You can confirm that the warmup process has started via the Control Monitor Meter on the Monitor Panel. The Monitor Meter will display a value of roughly 250 Vdc roughly 30 seconds after cycling radar power from OFF to STBY; from the point the needle shows power at this nominal value, the remainder of the warmup process will take 2 min 30 sec.





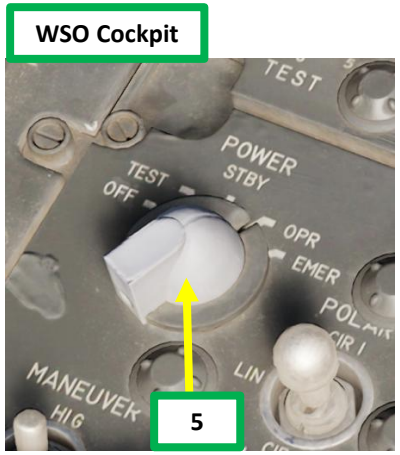


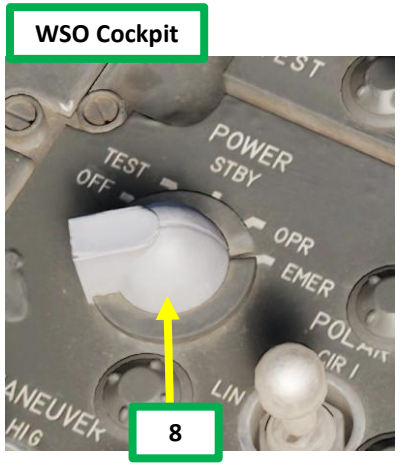




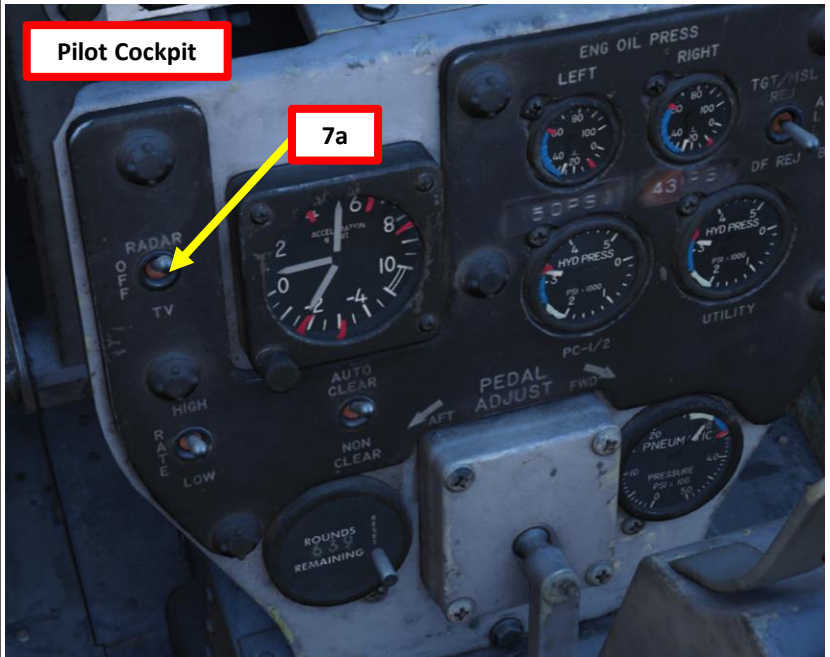
2 – AN/APQ-120 FIRE CONTROL RADAR
2.2 – Radar Interface
2.2.4 – Radar Power-Up

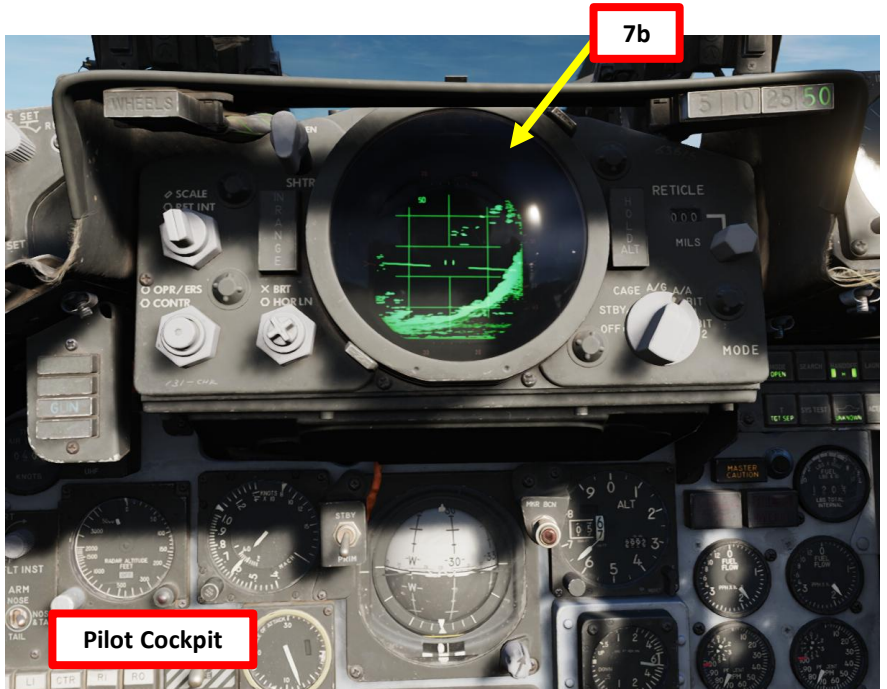
5. *[WSO]* Once the warmup cycle is complete (3 minutes after setting radar mode to STBY), set radar mode into OPR (Operate) for employment.
    - Note: For the safety of crew and others on the ground, only set the radar to OPR while you are airborne.
6. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
7. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).
8. *[WSO]* Note: In the event of an emergency situation requiring immediate operation of the radar, EMER (Emergency) can be selected. This will override the Magnetron to power up in emergency mode. However, keep in mind that operating the magnetron without sufficient warm up (which normally takes 3 minutes) may result in incorrect pulse width and timing and/or degraded pulse power.

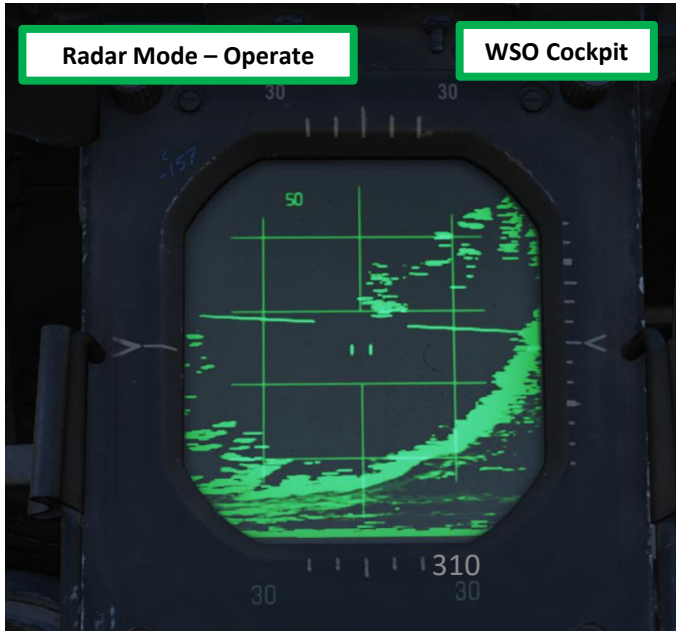












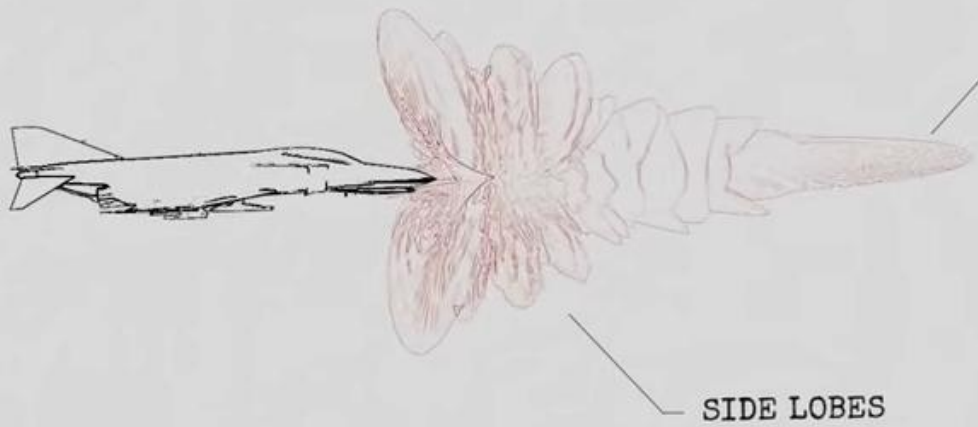
2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.1 – Pulse Radar Basics

A pulse radar transmits a radio pulse focused in one direction. If any obstacle is in that direction (including another aircraft, ground clutter or buildings), it will partly reflect back to the radar. With the time it took the signal to travel back to the radar, the distance to the obstacle can be computed. The radar waves are produced by the magnetron, which are sent to a feedhorn that reflects them onto the radar dish.

Radar beams have different angles, which results in what we call a « **main lobe** » (region of the radiation pattern containing the highest power or exhibiting the greatest field strength) and « **side lobes** » (region of the radiation pattern containing unwanted radiation in undesired directions).

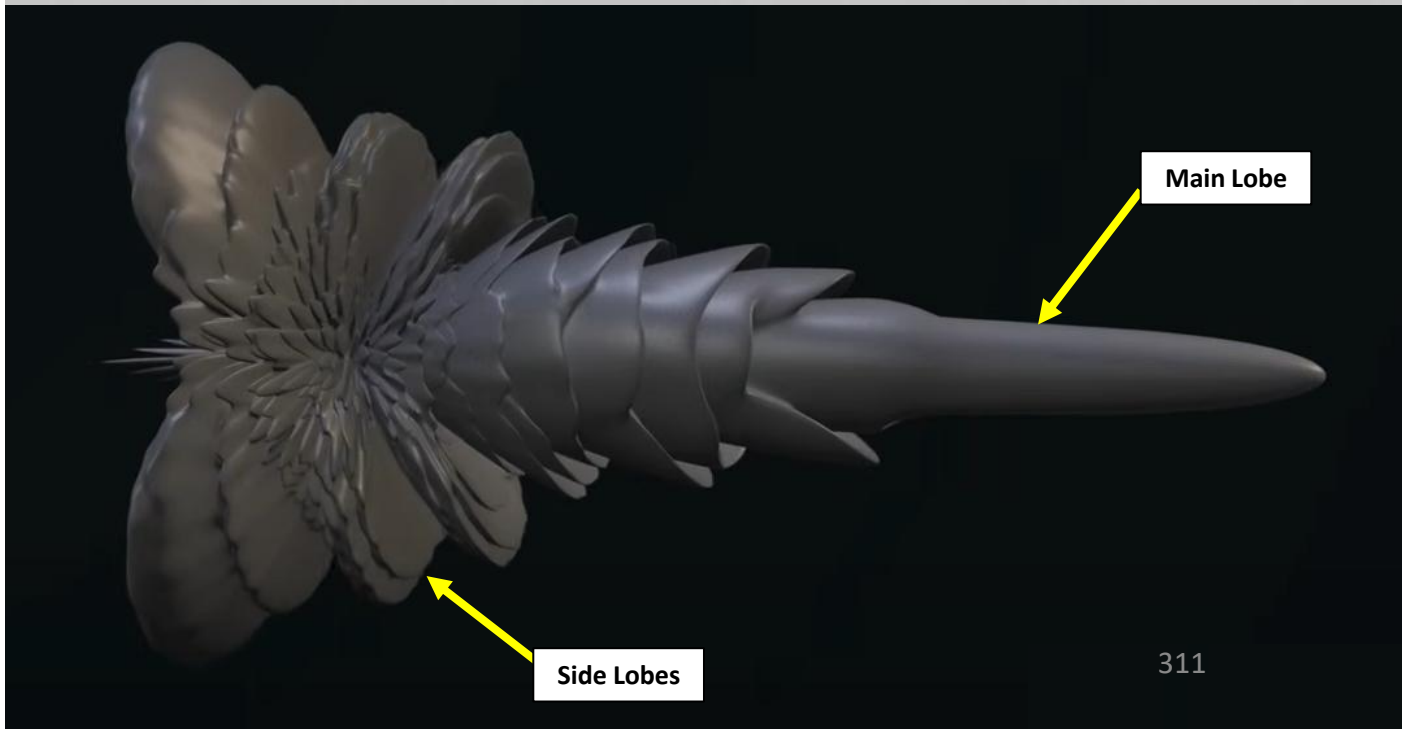
The F-4E's low pulse repetition frequency radar is highly affected by ground clutter. The WSO can try to offset them by adjusting the antenna elevation and the radar gain, but this generation of radar had its own limitations and some level of noise/clutter is still to be expected even in seemingly optimal conditions.

Clutter from the main lobe can easily be identified as ground returns like lakes, rivers, mountains or cities… while clutter from the side lobes pick up "patchy" ground returns that are much easier to mistake for actual aircraft/target returns due to the weaker energy of the reflection.



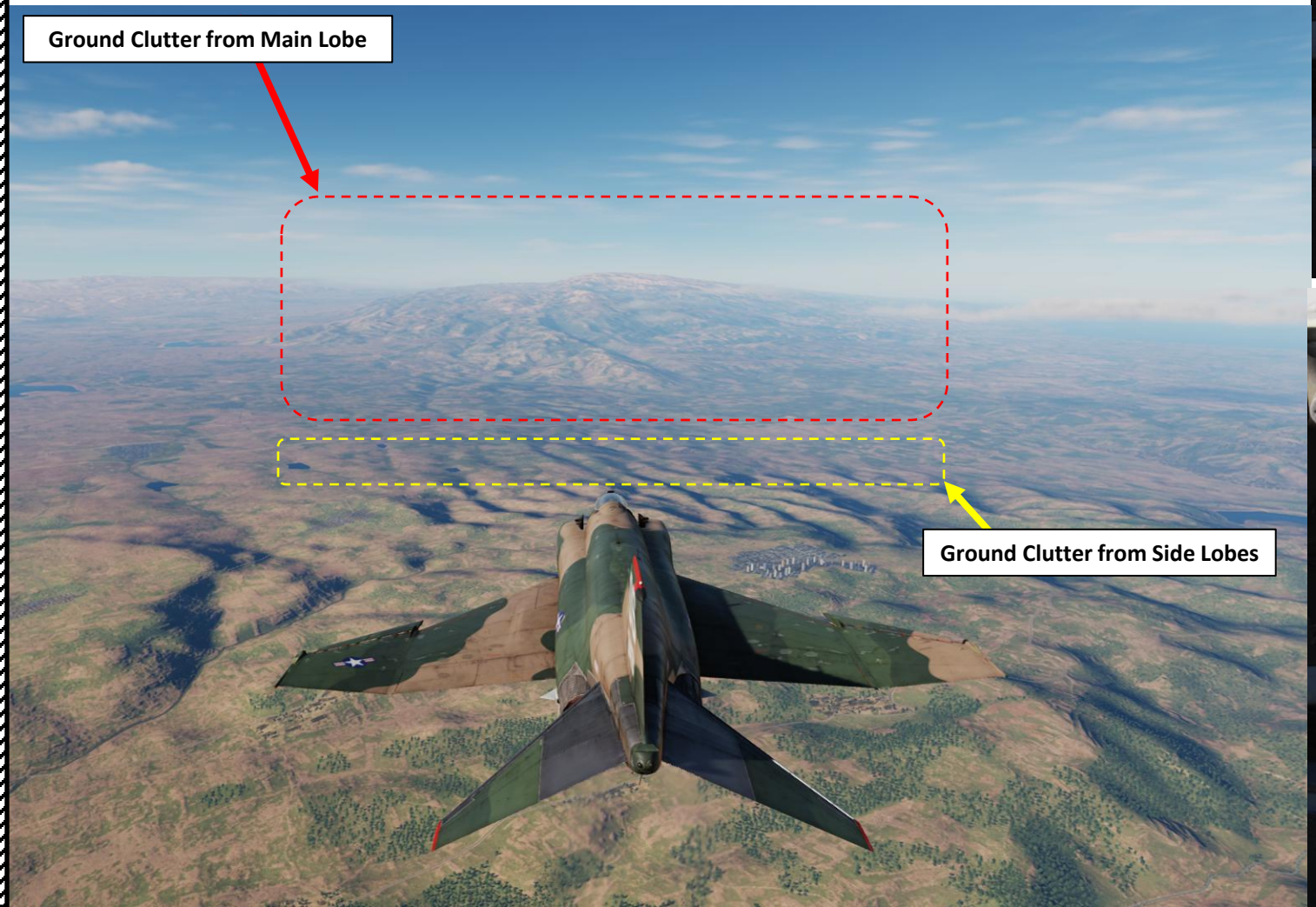
Source: Heatblur Simulations DCS: F-4E - Episode IV - RADAR Pt. 1 - Basics and Theory
https://youtu.be/s2YY2gQ76cw

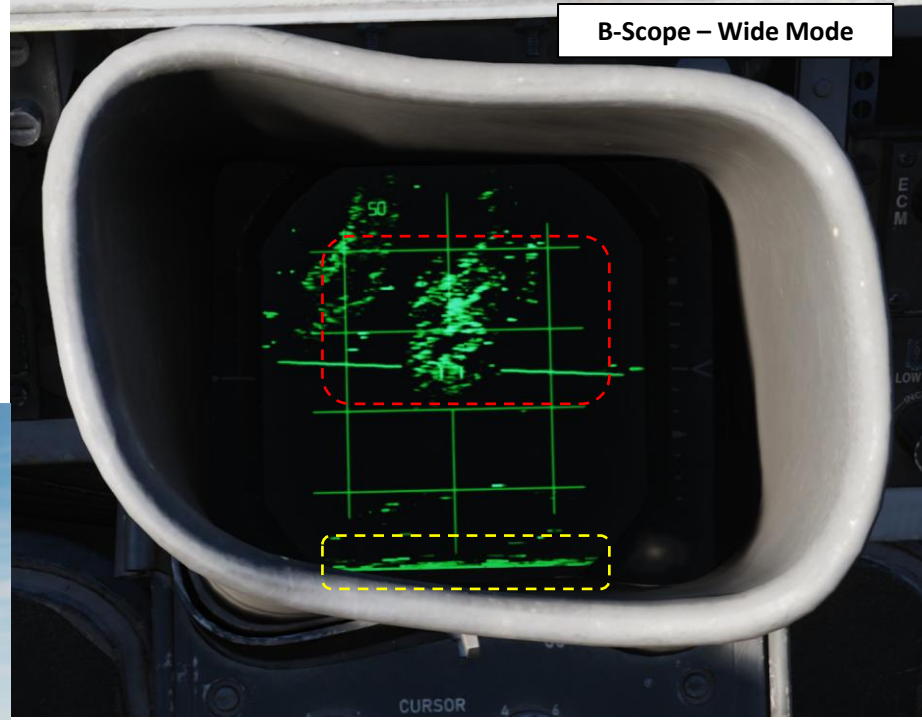
AN/APQ-120 BEAMSHAPE

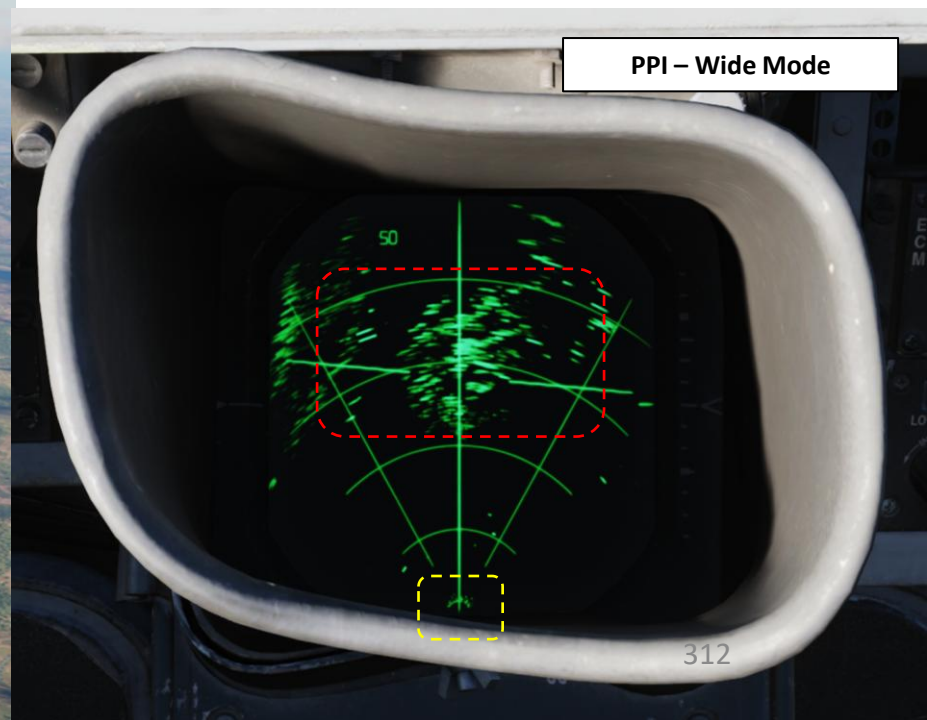


2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.1 – Pulse Radar Basics

In other words, the main difference between a pulse radar like the AN/APQ-120 and modern radars is that the pulse radar captures « everything » both in the air and on the ground without filtering which is which; it is the WSO's job to « filter » what is an air target versus what is a ground return. This filtering process can be done manually by adjusting radar gain, changing radar antenna elevation, etc.

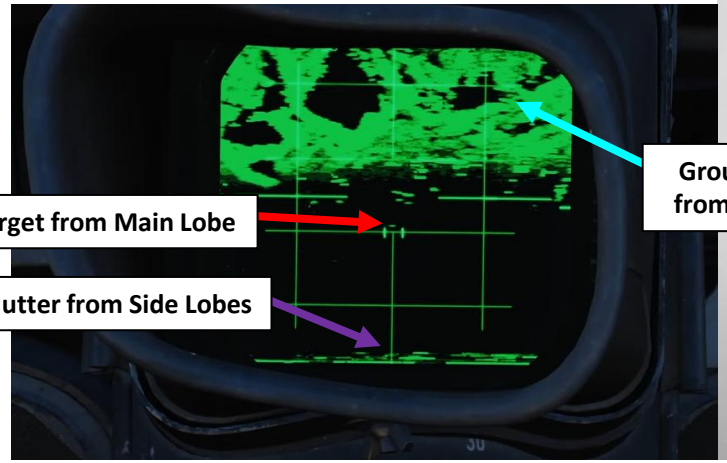


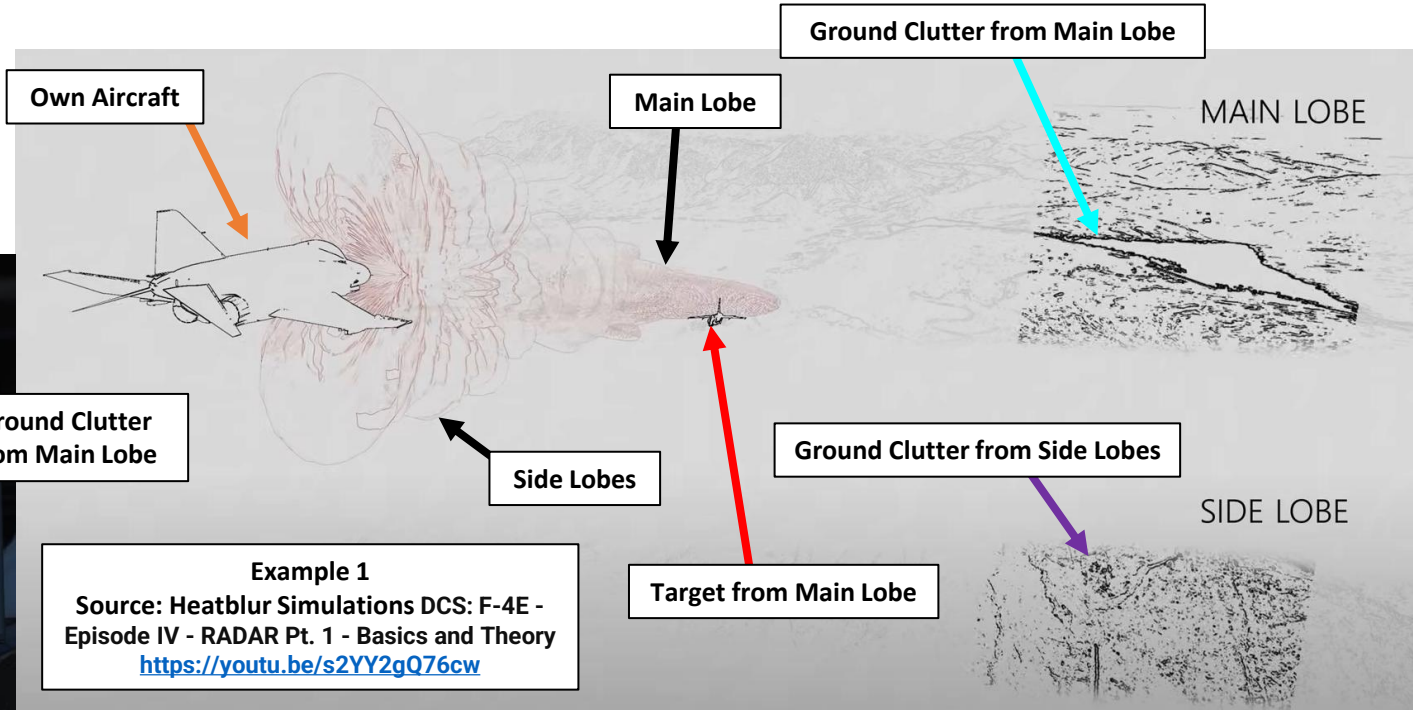




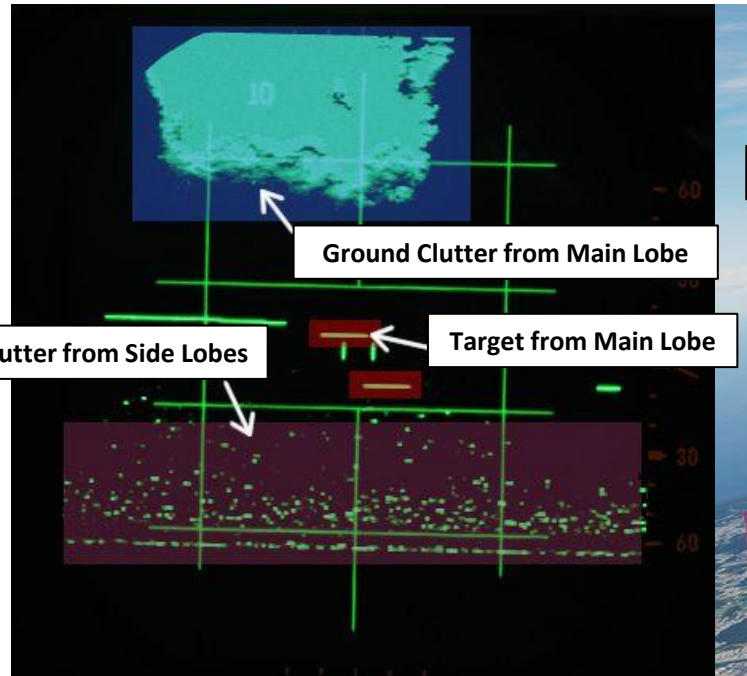
2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.1 – Pulse Radar Basics

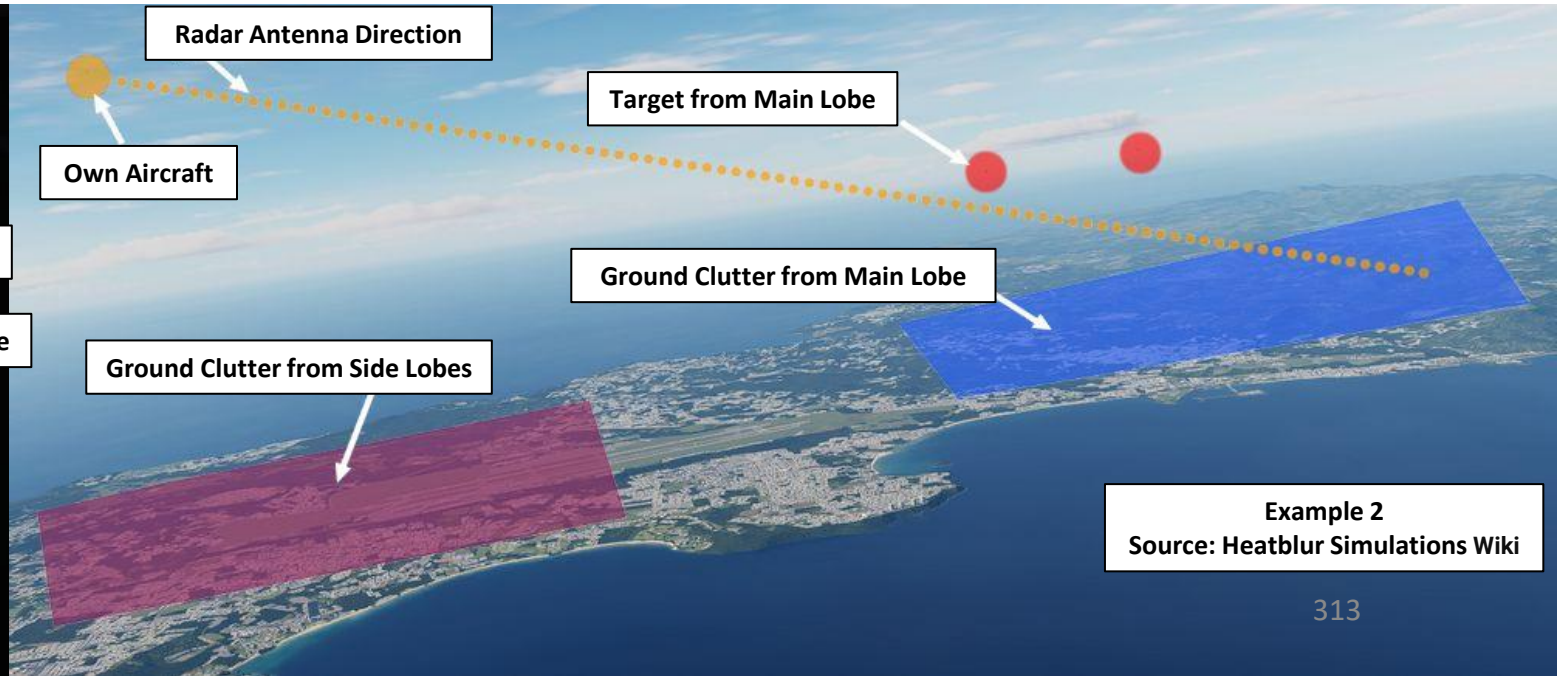
Here are two additional examples of radar returns resulting in a direct and unfiltered representation of the world in front of the aircraft.





Example 1
Source: Heatblur Simulations DCS: F-4E - Episode IV - RADAR Pt. 1 - Basics and Theory
https://youtu.be/s2YY2gQ76cw





Example 2
Source: Heatblur Simulations Wiki

2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.2 – What affects the radar image?

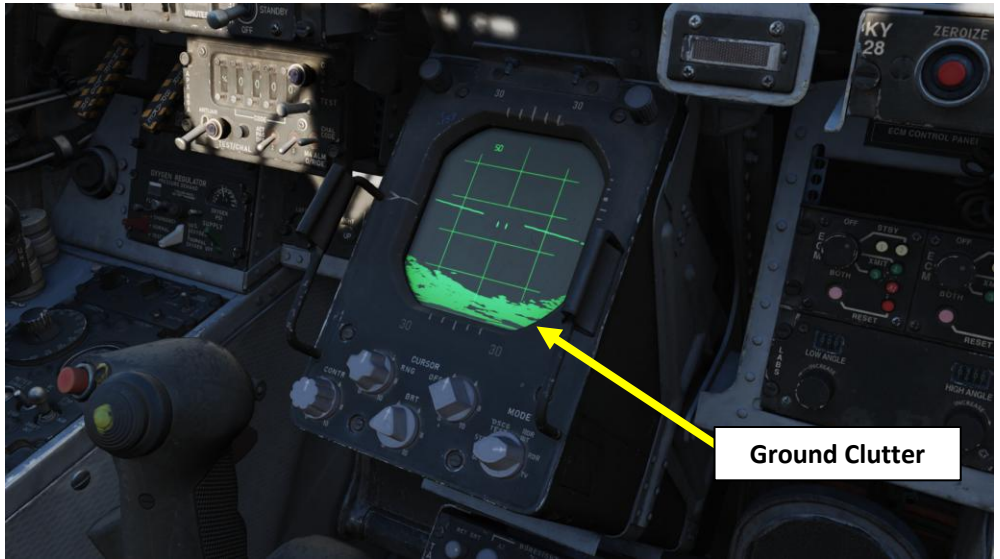
One of the big questions new players ask when operating the radar is… what exactly has an effect on the quality of the radar image? Here is a non-exhaustive list of things that can affect radar returns.

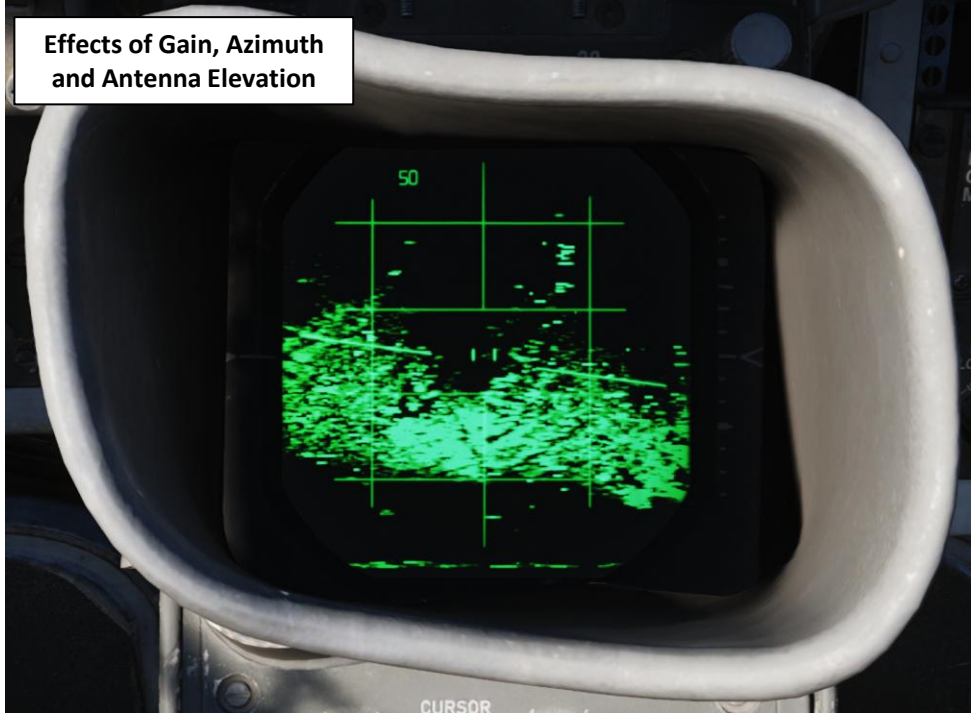
- **Gain, Azimuth and Antenna Elevation:** Not setting up these parameters can have a number of undesired side effects. A gain that is too low can filter out potential targets, while a gain that is too high may give too many returns, making targets too hard to find among the cluttered radar display. An incorrect azimuth and antenna elevation can also cause a number of obvious issues such as scanning the wrong area in front of the aircraft.

- **Thermal Noise at High Gain Settings**: When a radar gain setting is too high, this allows observability for extremely low signals, including thermal noise. These signals can clutter up the display and make it even harder to use.

- **Failing to Adjust Radar Gain**: Radar gain needs to constantly be adjusted in order to get a clear picture. There is no "optimal" gain setting that provides the best coverage every time; an experienced WSO will keep adjusting the gain to take into account changing conditions (weather, terrain, relative aircraft orientation, target distance, target aspect, etc.). As a target approaches the aircraft, radar gain should also be adjusted to keep it visible on the scope.

- **Ground Clutter**: Radar returns from ground obstacles are constantly picked up by the radar at low altitudes by the main lobe and side lobes.

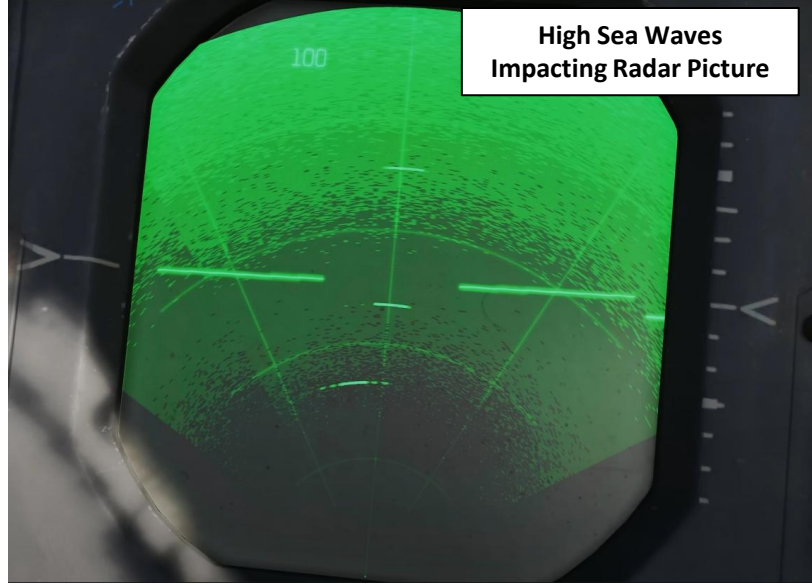






2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.2 – What affects the radar image?

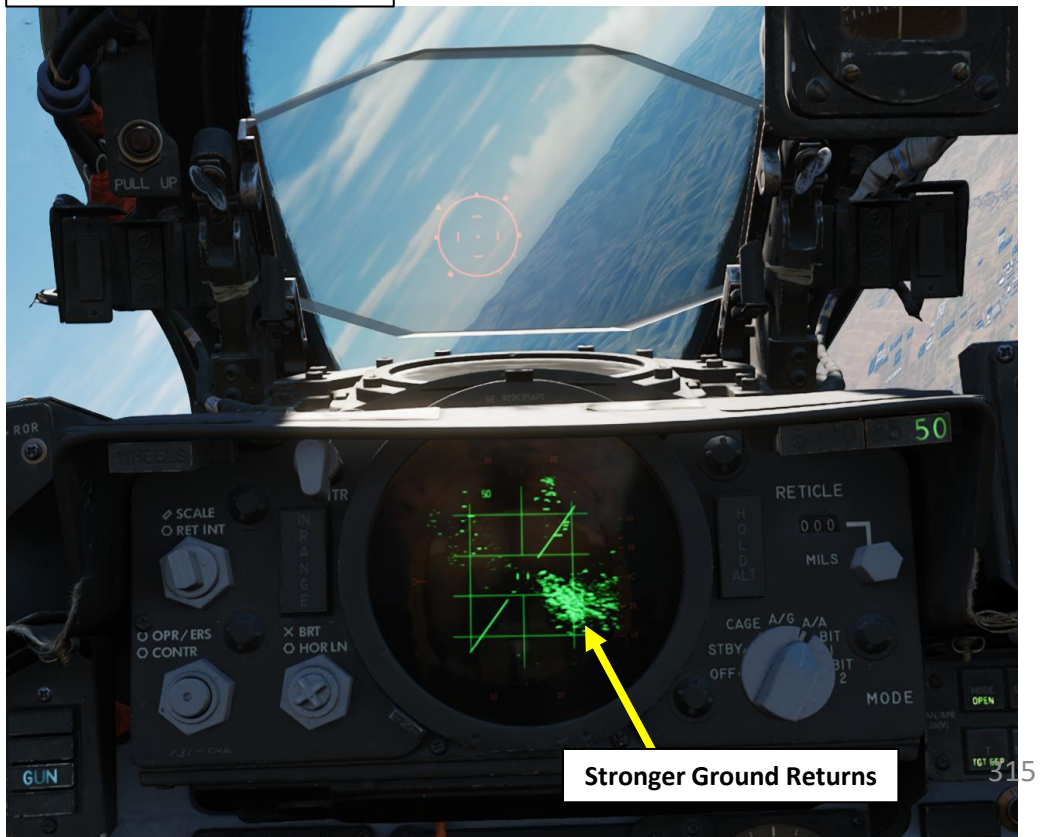
- **Sea Waves Height**: In windy conditions, sea waves reflect radar waves. The ground mapping capabilities of the radar are affected by the height of sea waves.
- **Flying**: The way you fly also impacts the radar picture, believe it or not. When flying banked, radar polarization (property of transverse waves that refers to the geometric orientation of the oscillations of the corresponding radar wave) can result in stronger ground returns.



Radar Picture – Flying Straight and Level



Radar Picture – When Banked



2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.2 – What affects the radar image?

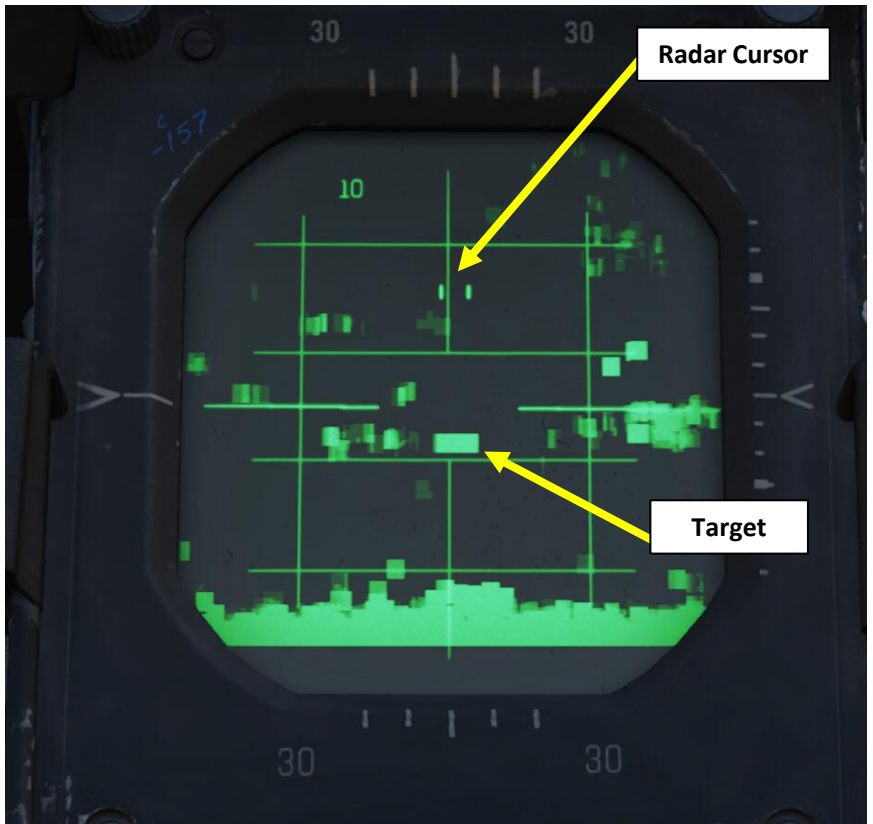
- **Radar Locking with Wrong Range**: If you are locking the target with the radar cursor set to an incorrect range, it is possible that the radar will perform an invalid lock (or lock spurious returns), providing you erroneous information. It is important to use the Aspect Selector switch to verify the information provided makes sense by cross-checking closure velocity, altitude, aspect and heading information.

- **ECM (Electronic Countermeasures)**: If radar jammers are used, a vertical line can appear if the jammer is near the radar's scan volume. This can severely limit the radar's locking ability.

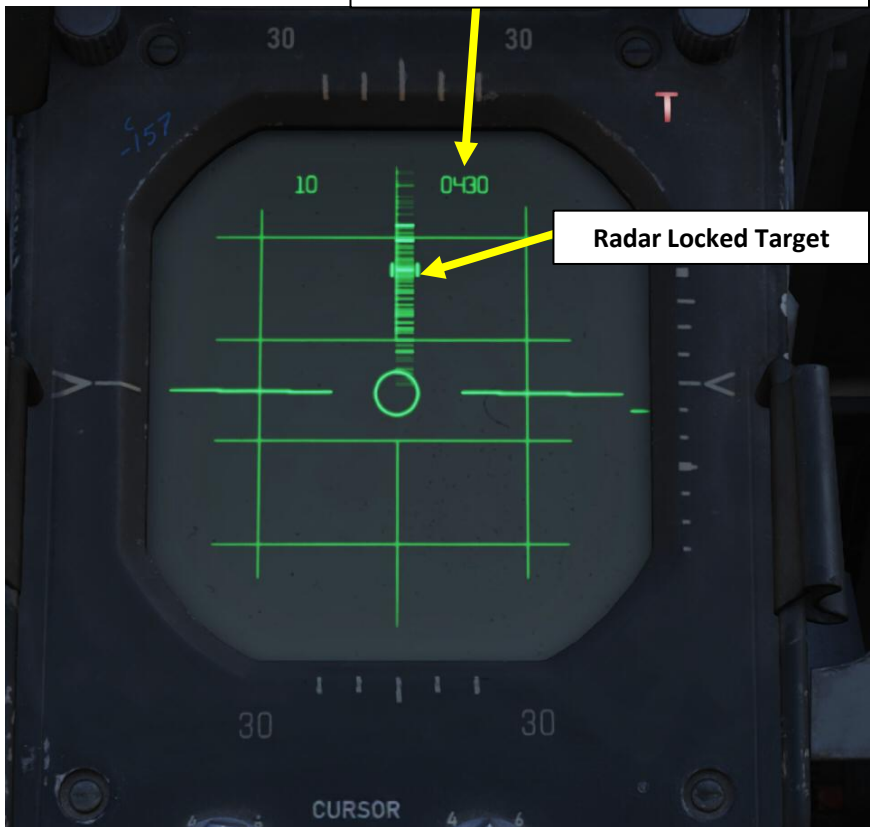
Aspect Selector
- *Used to program the AIM-7 missile with a pre-determined simulated Doppler instead of actual received Doppler, so that the WSO can provide an estimated correct speed-gate for the Sparrow when not tracking.*



Selection	DSCG Display
WIDE	Closure Velocity
NOSE	Altitude
FWD	Aspect
AFT	Closure Velocity
TAIL	Heading



If the closure velocity oscillates between +400 kts and -1000…
Is the lock valid, though? Probably not…



Effect of ECM Jammer



2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.3 – Magnetron, Klystron and Feedhorn Nutation

The AN/APQ-120 radar has a few components that are important to understand: the magnetron, klystron and feedhorn. Both the magnetron and klystron radiation is fed through the antenna and emitted from the feedhorn.

The **magnetron** is the main radio frequency emitter for the radar. It produces pulsed energy which is used to **detect and track targets**. The magnetron is protected by a wave guide pressure switch and a temperature interlock. If either of these interlocks are open (possibly because of battle damage or malfunction) the Radar Power Knob can be moved into EMER (Emergency Mode) to resume operation.

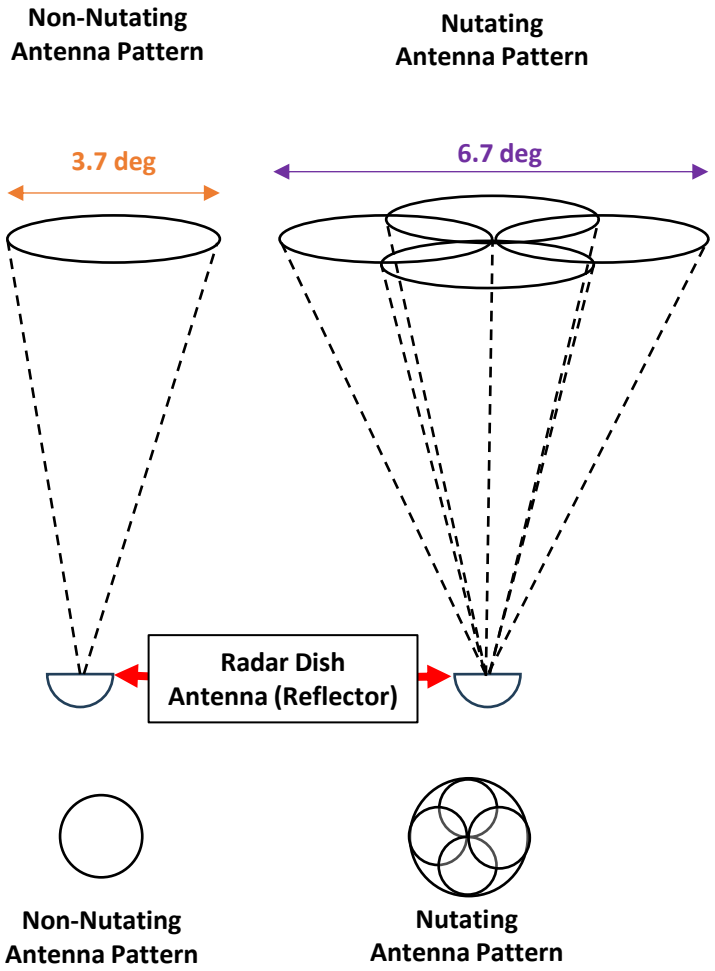
The **klystron** is a specialized linear-beam vaccum tube that acts as a power amplifier. It produces continuous wave radio frequency energy, which is used to **tune and guide the AIM-7 Sparrow missile**. The klystron is protected by two temperature switches, a pressure switch and a surge current switch. If any of these interlocks (with the exception of the surge current switch) are open, the Radar Power Knob can be moved into EMER (Emergency) to resume operation; however, damage to the klystron and feedhorn may result.

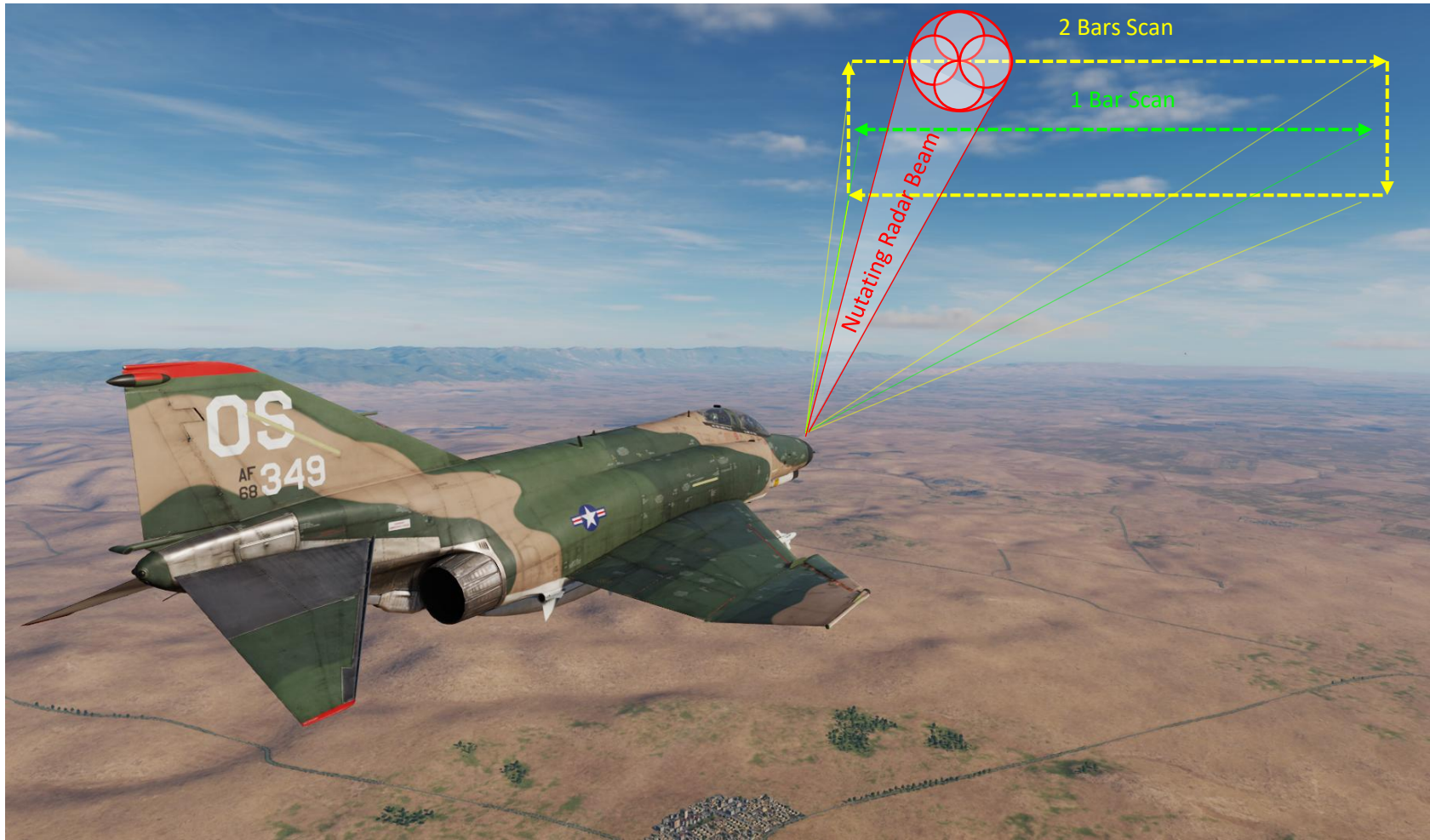
The **feedhorn** is a horn antenna that lies between the transceiver and the antenna radar dish (reflector). It is used to couple the radar dish antenna for reception/transmission of radar waves.



2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.3 – Magnetron, Klystron and Feedhorn Nutation

The feedhorn "nutates" (a fancy way of saying that the feedhorn is "rocking, swaying, or performing a nodding motion in the axis of rotation") to rotate the radiated energy around the antenna axis. This **feedhorn nutation** modulates the radar echoes. Where the echo is strongest, the antenna will steer if tracking, which will drive the antenna back onto a tracked target. A side-effect of this nutation is increasing the radar beam-width from 3.7 degrees (half power) to 6.7 degrees (full power) while reducing the average intensity of the beam. In other words, **feedhorn nutation provides a "bigger" radar beam (meaning a bigger search coverage) while reducing effective radar detection range and discrimination**.





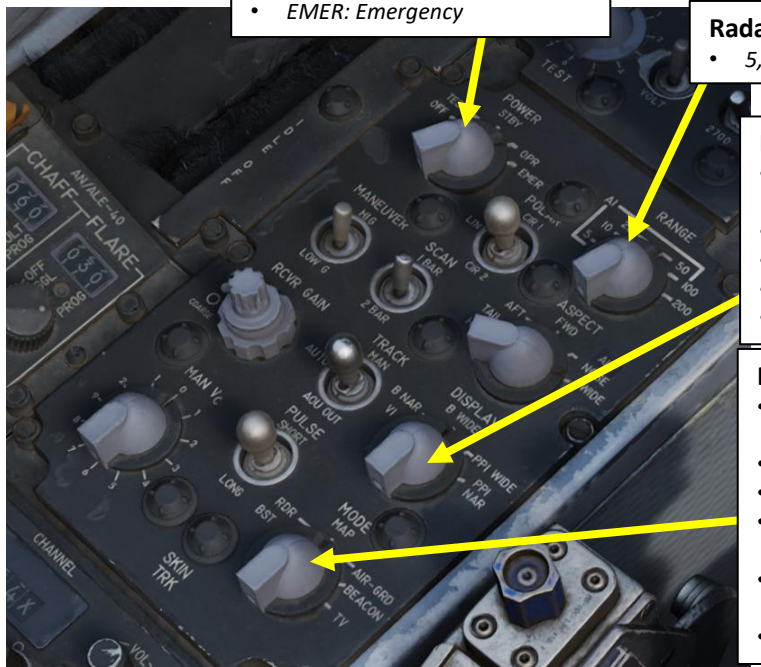
2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.3 – Magnetron, Klystron and Feedhorn Nutation

Feedhorn nutation is required for automatic tracking, but keep in mind that not every radar mode has the feedhorn nutating. Here is a table that lists the various combinations of radar mode, range setting and Action Switch settings and whether feedhorn nutation is activated or not.

Operation Mode	Range Setting (nm)	Action Switch Position	Nutation Active?
RDR, BST, or AIR-GRD	5, 10, 25, 50, 100 or 200	Released	Yes
MAP	5, 10, 25, 50, 100 or 200	Released	No
RDR or MAP (B-Scope Display)	5, 10, 25, or 50	Half-Action or Full-Action	Yes
	100	Half-Action	Yes
		Full-Action	No
	200	Half-Action	Yes
		Full-Action	No
MAP (PPI Display)	5, 10, 25, 50, 100 or 200	Half-Action or Full-Action	No
BST or AIR-GRD	5, 10, 25, or 50	Half-Action or Full-Action	Yes
	100	Half-Action	Yes
		Full-Action	No
	200	Half-Action	Yes
		Full-Action	No

Radar Power Selector Knob
- *OFF*
- *TEST*
- *STBY: Standby*
- *OPR: Operate*
- *EMER: Emergency*

Radar Range Selector Knob
- *5, 10, 25, 50, 100 or 200 nm*

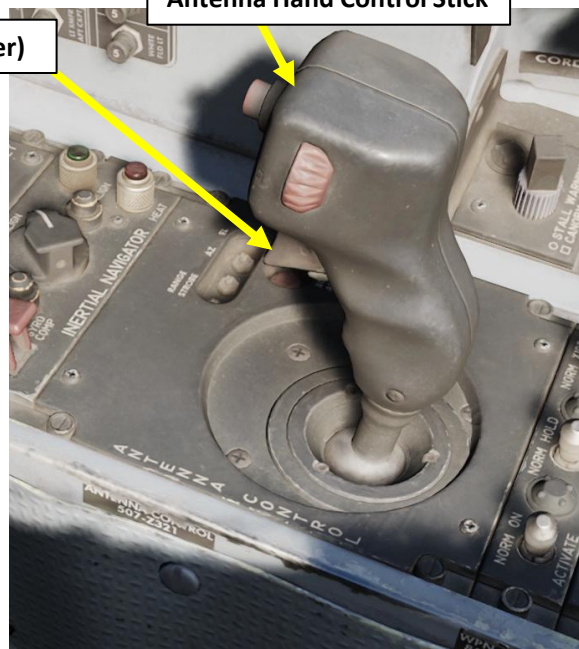


Display Selector
- *VI: provides course guidance for a VISIDENT (visual identification) intercept profile against a locked target.*
- *B NAR: B-Scope display format with Narrow Sweep Setting (45 deg sweep).*
- *B WIDE: B-Scope display format with Wide Sweep Setting (120 deg sweep).*
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*

Radar Operation Mode Selector
- *BST (Boresight): Air-to-Air boresight with antenna aligned radar boresight line and optical sight with sight in A/A*
- *RDR (Radar): Search Mode with Feedhorn Nutation (wider beam-width) mode*
- *MAP: Search Mode without Feedhorn Nutation (narrower beam-width)*
- *AIR GRD (Air-to-Ground): Air-to-Ground boresight, Tracks range of illuminated ground, radar is boresighted to the radar boresight line with drift compensation.*
- *BEACON: Radar receives and displays signals from ground or airborne beacon transponders for navigation.*
- *TV: Not used with DSCG. De-tunes AIM-7 if selected, preventing Sparrows from guiding.*

Action Switch (Two-Stage Trigger)

Antenna Hand Control Stick



2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.4 – Electronic Warfare Interference

FlyAndWire's DCS F-4E APQ-120 - Jamming Effects Video:
https://youtu.be/vWZdx80szrI

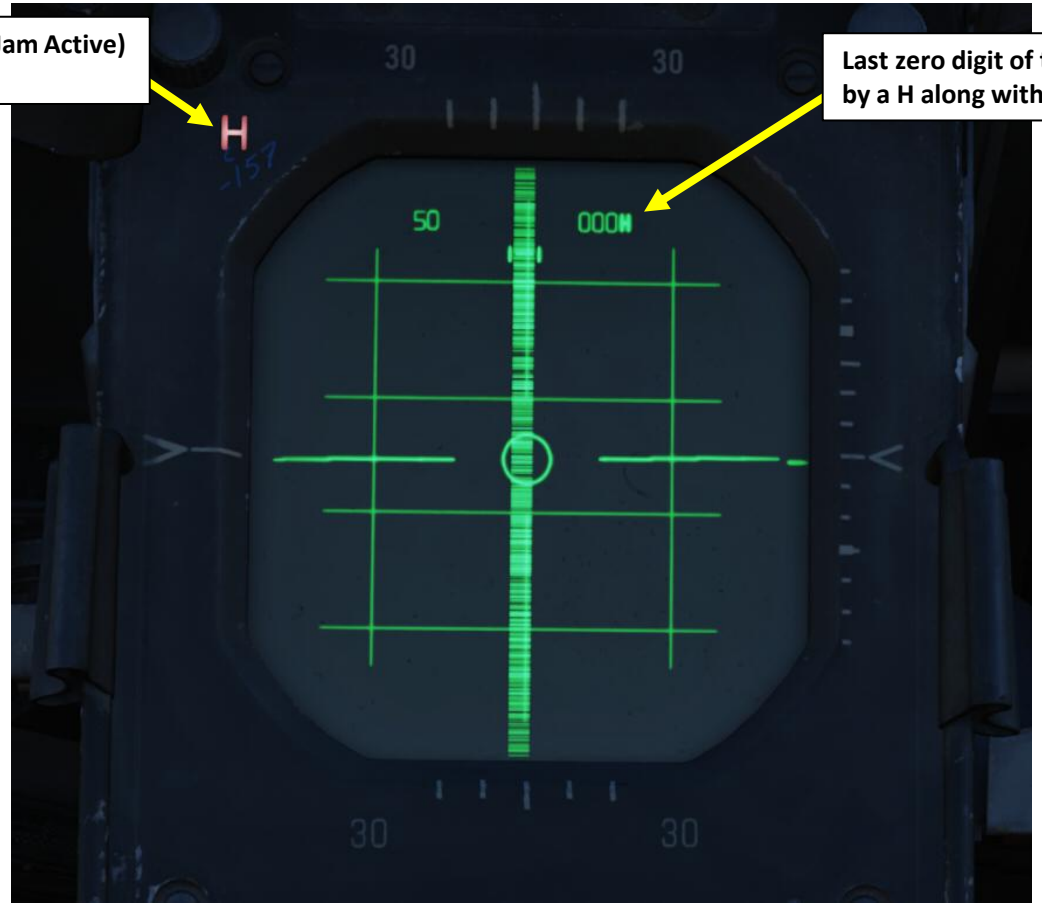
When a jammer is saturating your own radar with noise, you might not be able to get any range information from a jamming target. In such a situation, the target might not be visible on the scope or a vertical noise line will gradually become more visible as you close in the distance. This line indicates the inability of your radar to provide range information on the radar return.

This effect persists until the radar gets close enough, which is often referred as the "burn-through range". Once the jamming target is within burn-through range, After which the radar system can again determine the target's distance.

Although the WSO can manually track the variations in altitude and azimuth, the radar is capable of entering the so-called "Home-On-Jam" mode, where the avionics automatically track angles. For this to happen, the jammer-generated noise must exceed a set threshold.

- Note: The **Track Switch** allows us to select **AOJ (Acquisition On Jam) OUT** mode, which disables Home-On-Jam.

"H" (Home-On-Jam Active) Indicator Light



Last zero digit of the closure velocity is replaced by a H along with the closure rate flashing



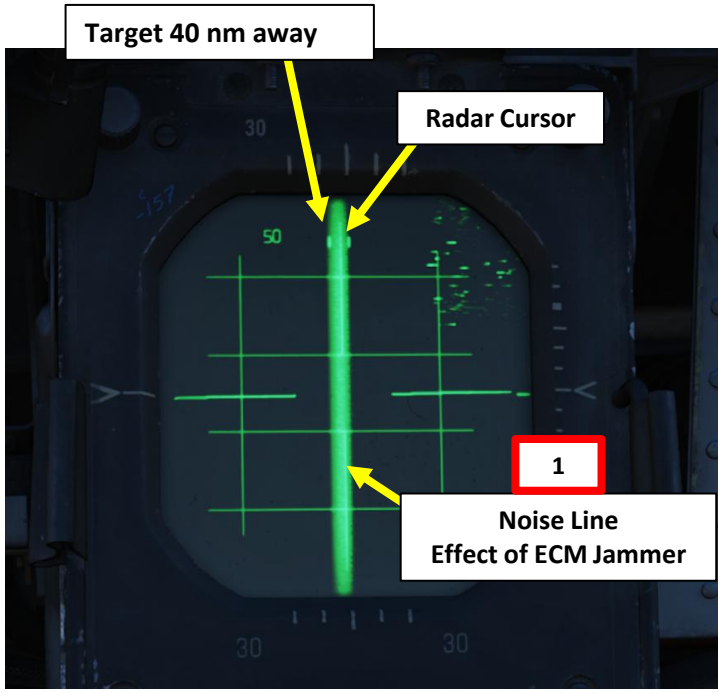
Track Switch

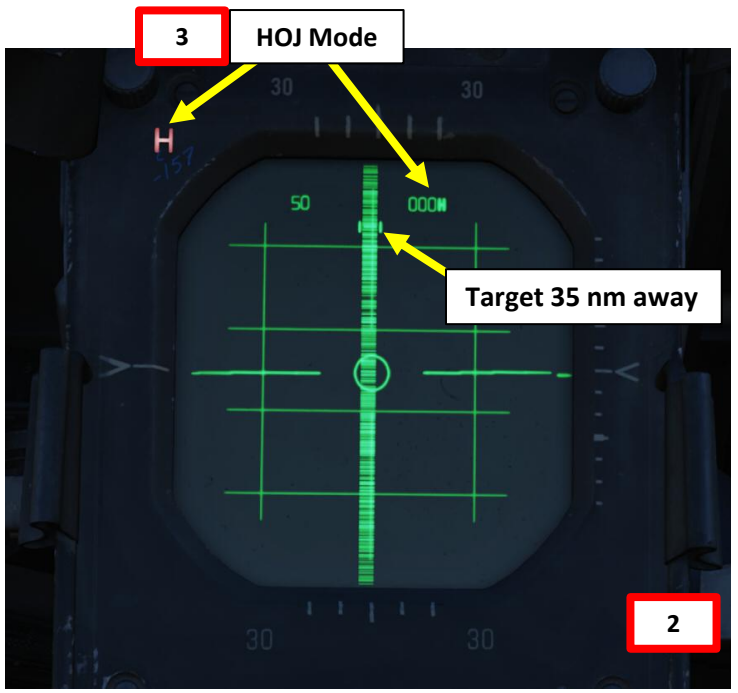
- *FWD: Manual, MAN Vc knob position will be used to set the tracking gate closure velocity*
- *MIDDLE: Auto, operates normal range tracking with Home on Jam (HOJ) if jamming is detected*
- *AFT: AOJ (Acquisition On Jam) OUT, disables Home on Jam in cases where jamming is erroneously detected*

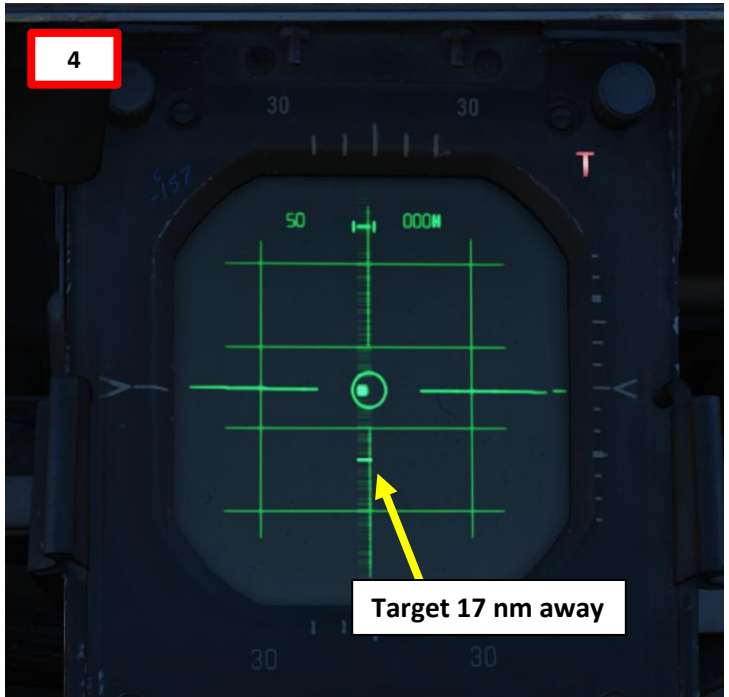
2 – AN/APQ-120 FIRE CONTROL RADAR
2.3 – Radar Theory
2.3.4 – Electronic Warfare Interference

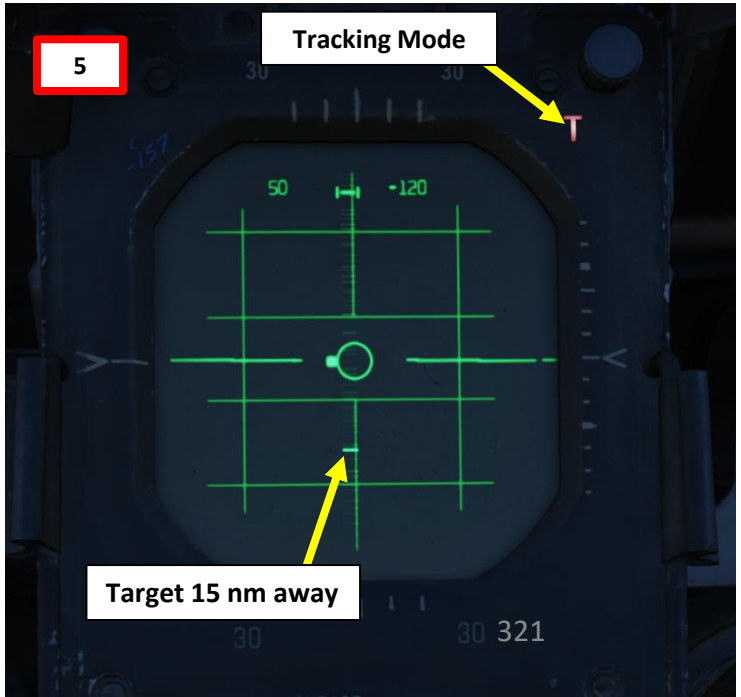
Here is an example of a **HOJ (Home-On-Jam) sequence**:

1. A Tu-22 bomber is using a jammer 40 nm away from us. We have no range information, but the noise line gives us an approximate azimuth information.
2. Using the radar antenna Hand Control Stick, we will slew the radar cursor and attempt to lock on the approximate location of the target even if we have no actual reliable range information.
3. The back bias amplifier in the radar produces a noise signal based on the overall strength of the radar "echoes". Once this noise signal exceeds some threshold, the system will consider it a jamming condition and enter Home-On-Jam (HOJ). In this case, sufficient jammer noise is detected and the radar enters the Home-On-Jam mode. The range track circuit goes into memory mode, the angle track circuit continues to operate and track the jamming target in elevation and azimuth.
    - The Home On Jam condition is also indicated by the engraved H on the WSO DSCG and the last zero digit of the closure velocity is replaced by a H along with the closure rate flashing.
4. As we get closer to the target, we "burn through" the jammer signal until the radar oscillates between Home-On-Jam and Tracking modes. In this example, we see the transition when the target is 17 nm away from us.
5. Once we have burned through the jammer by getting close enough (less than 15 nm), the radar has now entered a proper locking mode.









2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.1 – Air-to-Air Modes Overview

Here is an overview of the different radar air-to-air modes.

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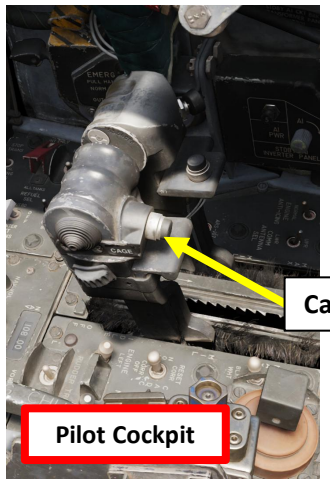
- **RDR-B Mode**: Automatic radar search mode with B-Scope display, with nutation enabled for either 1-bar or 2-bar search pattern.
  - Selected with the Radar Operation Mode Selector to **RDR** and Display Selector to either **B NAR** or **B WIDE**.

- **MAP-B Mode**: Automatic radar search mode with B-Scope display, but nutation is disabled and the 2-bar search pattern is not available.
  - Selected with the Radar Operation Mode Selector to **MAP (Mapping)** and Display Selector to either **B NAR** or **B WIDE**.

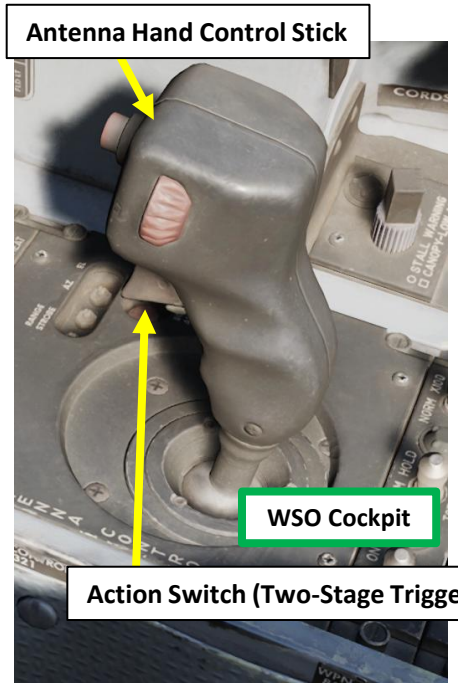
- **BST (Boresight) Mode**: Antenna is fixed along the radar boresight line (RBL) and the radar returns are displayed on the scope as in an acquisition mode.
  - Selected either by setting Radar Operation Mode Selector to **BST** or by depressing the **Cage button** on the pilot's throttle.

- **Track (Radar Lock) Mode**: Automatic tracking can be commanded by first entering acquisition and then, once the target has been bracketed by the acquisition symbol (radar cursor), Full-Action can be depressed on the Antenna Hand Control Stick to enter automatic track.

****



Display Selector
- *VI: provides course guidance for a VISIDENT (visual identification) intercept profile against a locked target.*
- *B NAR: B-Scope display format with Narrow Sweep Setting (45 deg sweep).*
- *B WIDE: B-Scope display format with Wide Sweep Setting (120 deg sweep).*
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*





Radar Operation Mode Selector
- *BST (Boresight): Air-to-Air boresight with antenna aligned radar boresight line and optical sight with sight in A/A*
- *RDR (Radar): Search Mode with Feedhorn Nutation (wider beam-width) mode*
- *MAP: Search Mode without Feedhorn Nutation (narrower beam-width)*
- *AIR GRD (Air-to-Ground): Air-to-Ground boresight, Tracks range of illuminated ground, radar is boresighted to the radar boresight line with drift compensation.*
- *BEACON: Radar receives and displays signals from ground or airborne beacon transponders for navigation.*
- *TV: Not used with DSCG. De-tunes AIM-7 if selected, preventing Sparrows from guiding.*

2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.1 – Air-to-Air Modes Overview

Here is an overview of the different radar air-to-air modes.

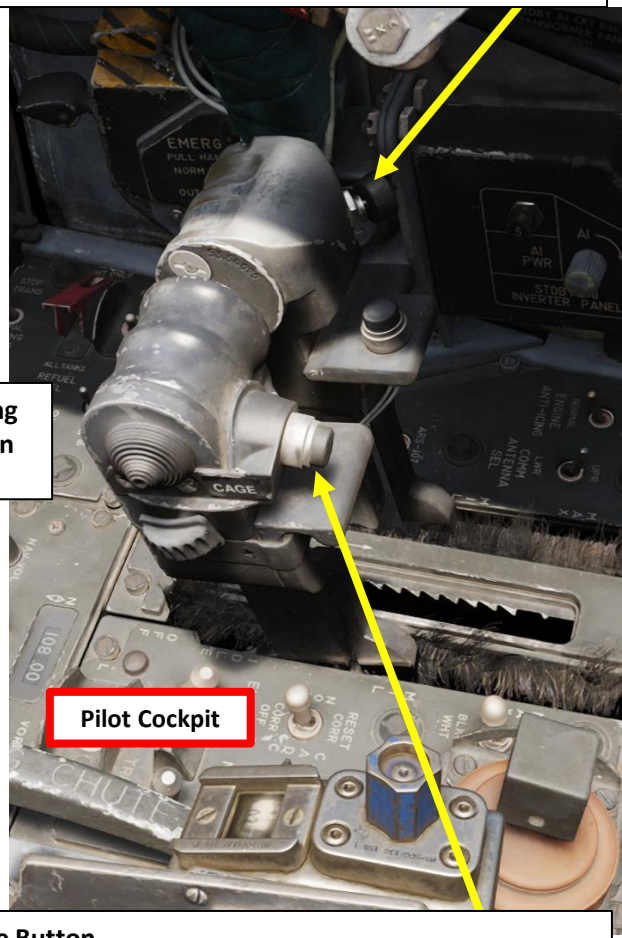


Weapon Selector Knob
- *B: Cancels air-to-air missile CAGE requirement.*

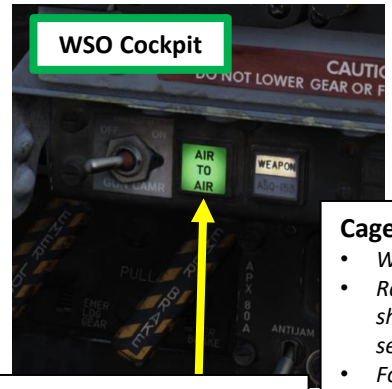


Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Cage Button
- *When pressed, commands Cage Mode.*
- *Radar goes into BST (Boresight) mode with a five mile range, short pulse, and sets the firing circuit for the currently selected air-to-air weapon relative to the Pinky Switch.*
- *For the optical sight, the command activates the respective elevation and azimuth tracking, roll mark, and range functions of the reticle for the chosen weapon, without the pilot having to remove a hand from throttle or stick to swap the sight mode or weapon control panel functions.*



Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

****

- **Cage Mode**: Similar to BST mode, the antenna is fixed along the radar boresight line (RBL) and the radar returns are displayed on the scope as in an acquisition mode. Cage condition **limits the range to 5 nm** and forces the maneuver setting into the HI position. When Cage mode is selected, the Air-To-Air light in the rear pit illuminates, trigger control is transferred to the air-to-air weapons (including when ARM and TV are selected), the Optical sight switches into the A/A mode and Computer Automatic Acquisition mode becomes available.
  - Selected by depressing the **Cage button** on the pilot's throttle.
    - If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch on the throttle is in RADAR or HEAT, the radar breaks track and returns to boresight.
    - If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch is in GUNS, the lock is not broken.
  - Mode can be exited with the pilot's Weapon Select Knob (set into or out of the B position) or with the WSO pressing the Air-to-Air Button.

- **CAA (Computer Automatic Acquisition) Mode**: This mode is **entered from the Cage Mode**. In CAA, the radar enters a vertical-oriented scan pattern 78 degrees in height by 15 degrees wide, the scan is 3 vertical bars wide. Actual radar lock capability within this scan pattern is from +45 degrees above the horizon line to -9 degrees below the horizon line due to radar's software limitation. In the event that the radar finds a suitable target within the scan volume, the target will be locked. Should the flight crew find the locked target not be the one intended, the Nose Gear Steering button can be pressed on either stick grip to return the radar back to the search pattern.
  - Selected by pressing the Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button on either the Pilot or WSO stick.
  - In CAA mode, the radar's search pattern can be shifted left and right utilizing the pinky switch on the throttle.
    - Pinky Switch – AFT (GUNS): Scan Center is 15 deg Left
    - Pinky Switch – CENTER (HEAT): Scan Center is centered (0 deg)
    - Pinky Switch – FWD (RADAR): Scan Center is 15 deg Right
  - To exit CAA, the pilot can select position B on the Weapon Select Knob, or the WSO can push the Air-To-Air button. Should a radar lock be in place at the time of mode exit, it will be retained.

****

2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.1 – Air-to-Air Modes Overview

Here is an overview of the different radar air-to-air modes.

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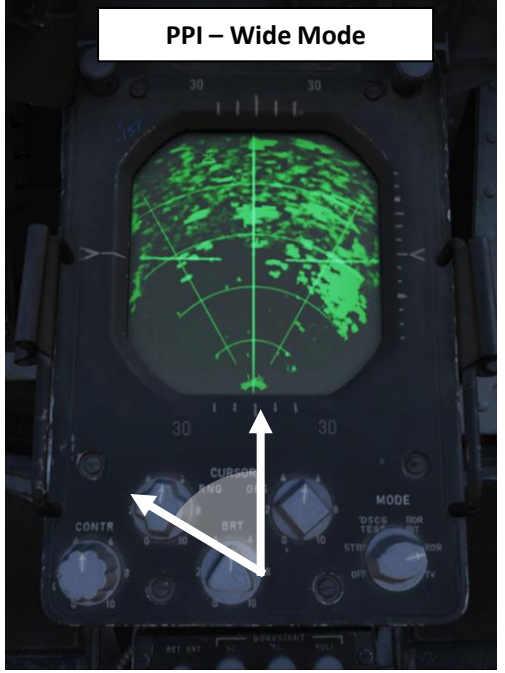
Additional Notes

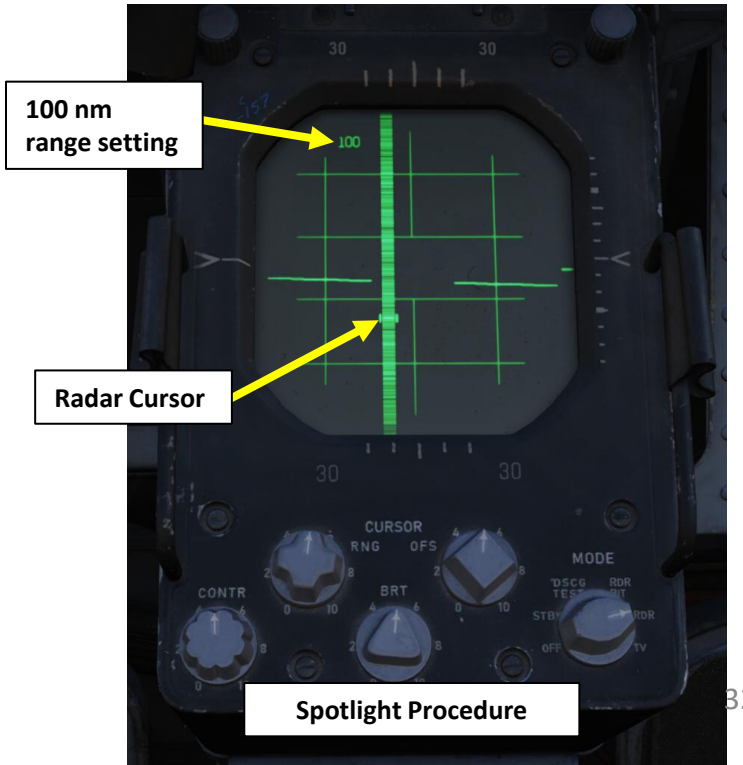
- **PPI vs B-Scope Display Format**: When using the Display Selector switch, take note that the B-Scope display mode allows the WSO to lock targets for weapon employment, while PPI (Plan-Position Indicator) display mode does not.

- **Spotlight Procedure**: In the 100 and 200 nm ranges, a procedure known as “Spotlight” can be used to maintain radar monitoring of a target manually.
    - Spotlighting entails placing the radar cursor over the desired return, then selecting and holding the full-action trigger position of the Antenna Hand Controller. Doing so, the antenna will nutate and revert to the chosen Polar Switch selection to increase target definition, but without attempting the automatic lock-on.
    - The target can be maintained in a well-observable state by holding full action and following the target-return with the Antenna Hand Controller until it reaches a range at which lock-on can be achieved (with the applicable change in range setting; the radar cannot attempt a lock at an incompatible range setting).

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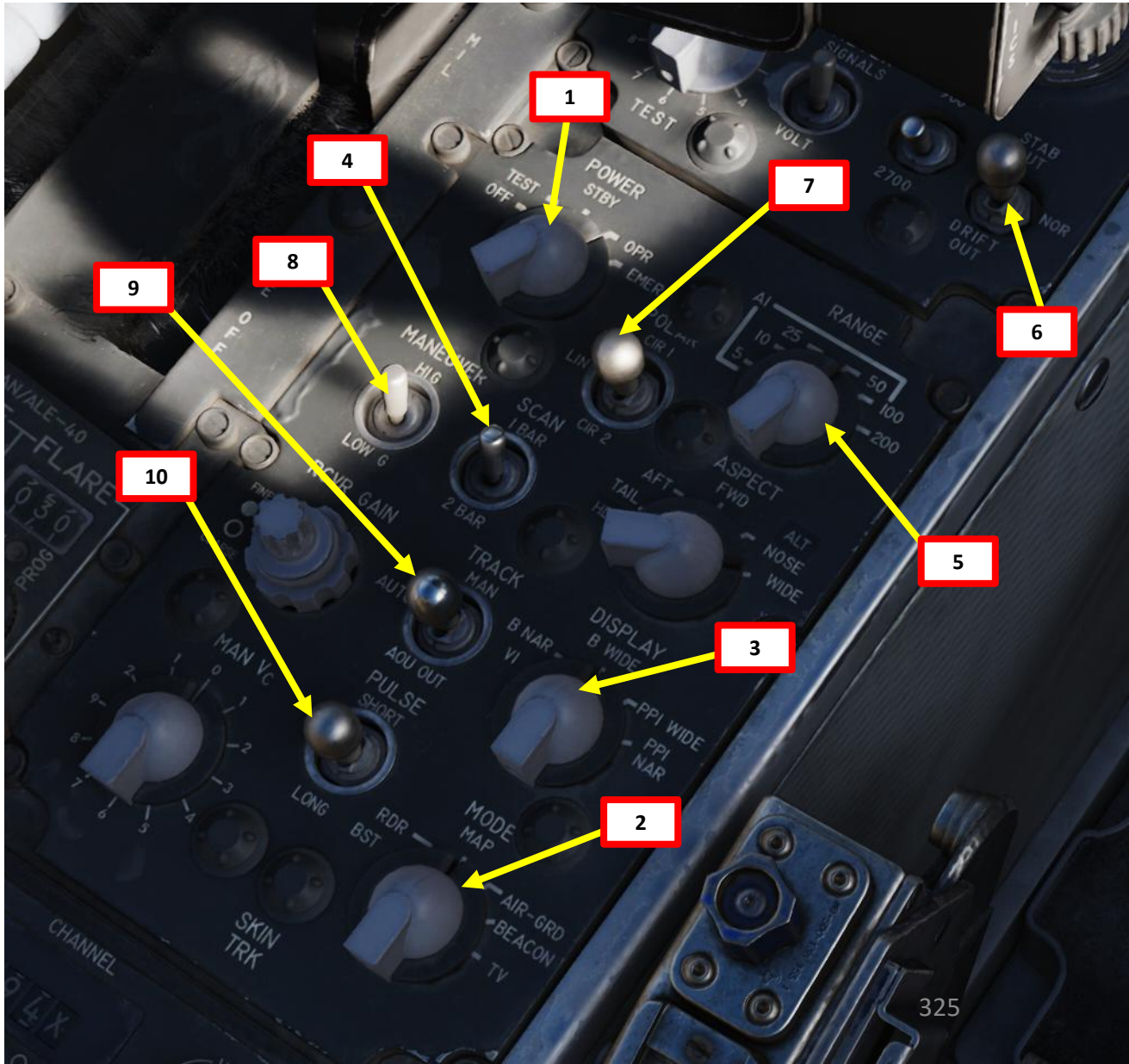




2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.2 – Radar Operation with Multicrew
2.4.2.1 – Beyond Visual Range (BVR) Employment

In order to perform search a track (lock) a target that is beyond visual range, you should have a general idea of where the target is at first since the Phantom's radar search capabilities are quite limited. This information would typically be provided by a ground controller via radio.

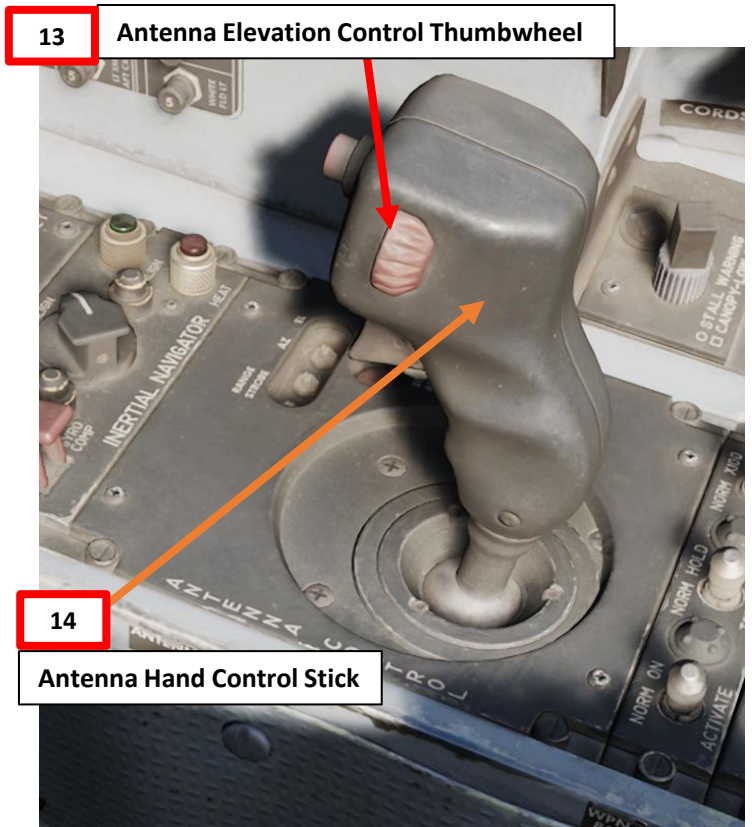
1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[WSO]* Set Radar Operation Mode – RDR (Radar) or MAP, as desired.
    - RDR provides feedhorn nutation, while MAP does not provide feedhorn nutation (narrower beam-width)
3. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE, as desired.
4. *[WSO]* Set Radar Bar Scan Switch – As desired (1 Bar in this example).
5. *[WSO]* Set Radar Range Selector – As desired (50 nm or 25 nm settings are recommended).
6. *[WSO]* Set Stab (Antenna Stabilization Mode) Switch – NORMAL (MIDDLE)
7. *[WSO]* Set Polarization Switch – LINEAR (MIDDLE)
8. *[WSO]* Set Maneuver Switch – HI G (FWD)
9. *[WSO]* Set Track Switch – AUTO (MIDDLE).
    - Since we operate within the DCS environment, electronic warfare is quite simplified and Auto Tracking mode is good enough for our needs.
    - As a side note, Manual Tracking mode would allow you to manually set the range closure rate (Man Vc, in x100 kts). In theory, this could be useful in situations where the radar cannot get a reliable range to a target (likely due to jamming noise drowning your radar returns, making it close to impossible for the radar to get accurate ranging information).
10. *[WSO]* Set Pulse Switch – AUTO (MIDDLE)

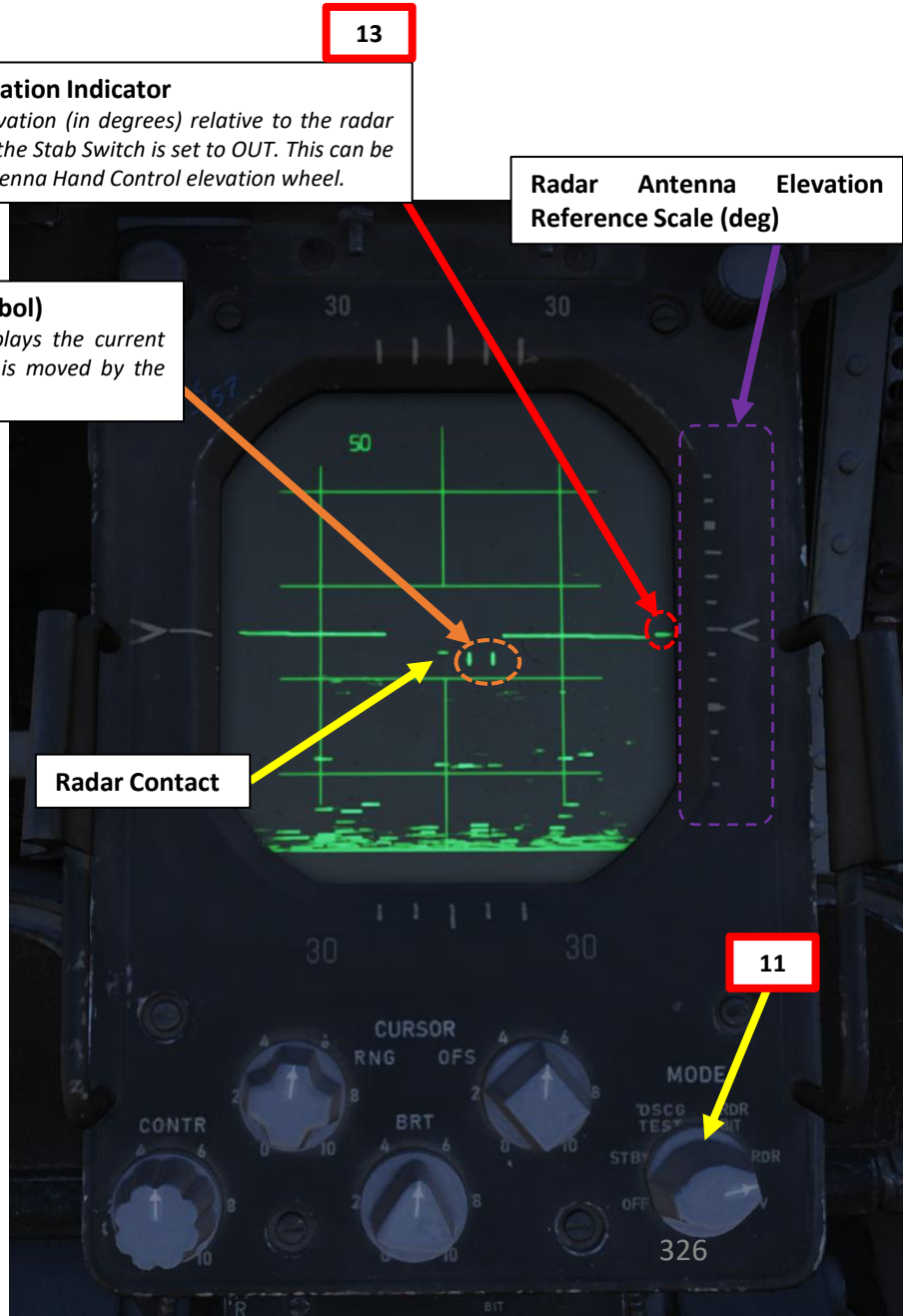


2 – AN/APQ-120 FIRE CONTROL RADAR
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2.4.2.1 – Beyond Visual Range (BVR) Employment

11. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
12. *[WSO]* Adjust Radar Gain using the Outer and Inner Receiver Gain Knobs to filter out radar clutter and discern radar contacts (air targets).
13. *[WSO]* Use the Antenna Elevation Control Thumbwheel to control the antenna elevation if required.
14. *[WSO]* Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the target.







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Note about Target Altitude:

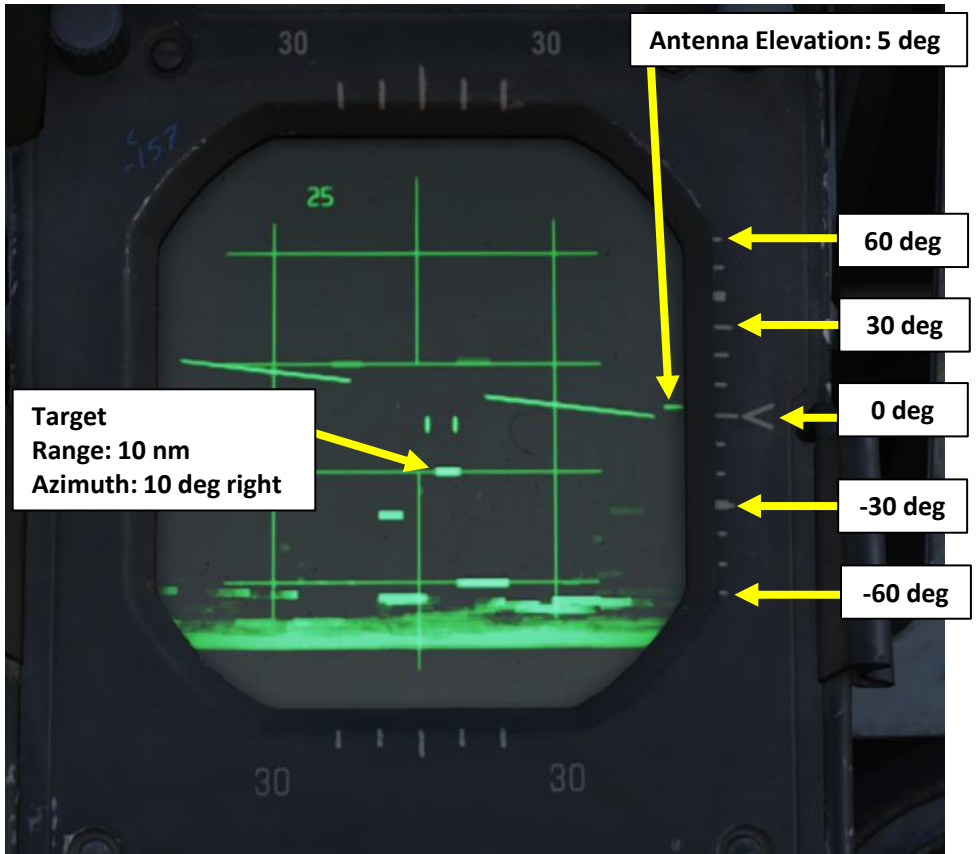
In practice, when you find a radar contact, you should adjust the antenna elevation to ensure you get a reliable « hit ». Realistically, the WSO should provide the pilot with target information via the radio. While the target range is easy to read on the scope, target altitude information should be calculated mentally since the radar does not directly give this information.

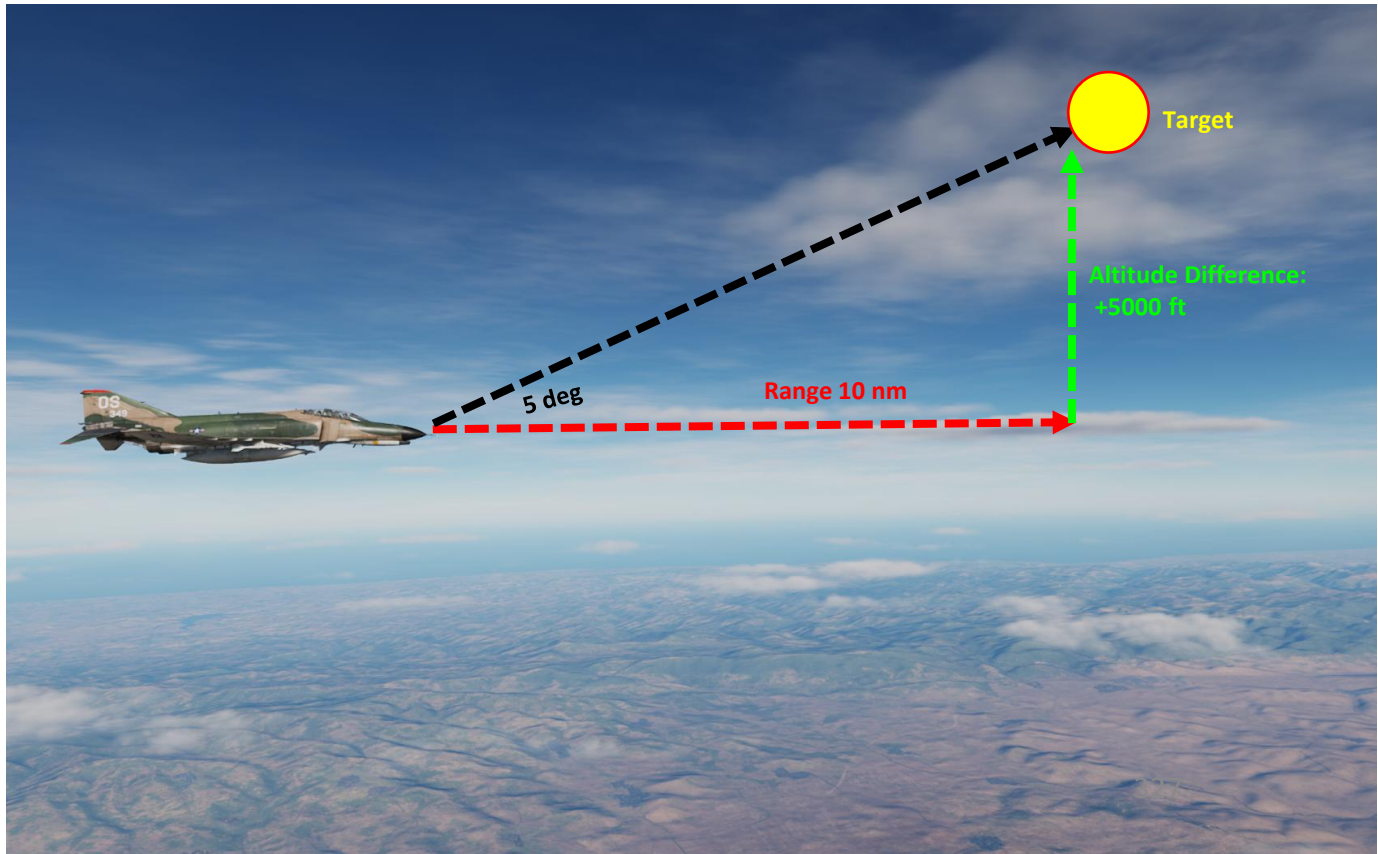
As a quick rule of thumb, here is how to quickly calculate the target altitude from target range and antenna elevation. Keep in mind that contact callouts are approximate and that the pilot should not expect the precision of modern radar systems. In most cases, the pilot should mostly care about targets that are within 30 nm or less.

HOW TO FIND TARGET ALTITUDE IN RELATIONSHIP TO YOU

Difference of Height (in hundreds of ft) = Elevation Angle (deg) x Range (nm)
Example: Target Range at 10 nm, spotted at 5 deg UP
H = 5 deg x 10 nm = 50 x 100 ft = Target is 5000 ft above you

If you are flying at 20000 ft, this means the target is flying at 25000 ft.



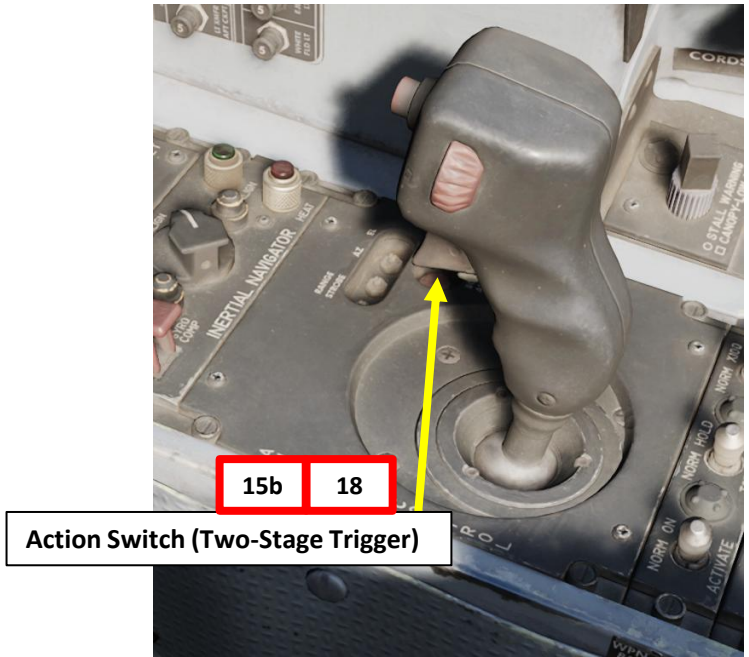


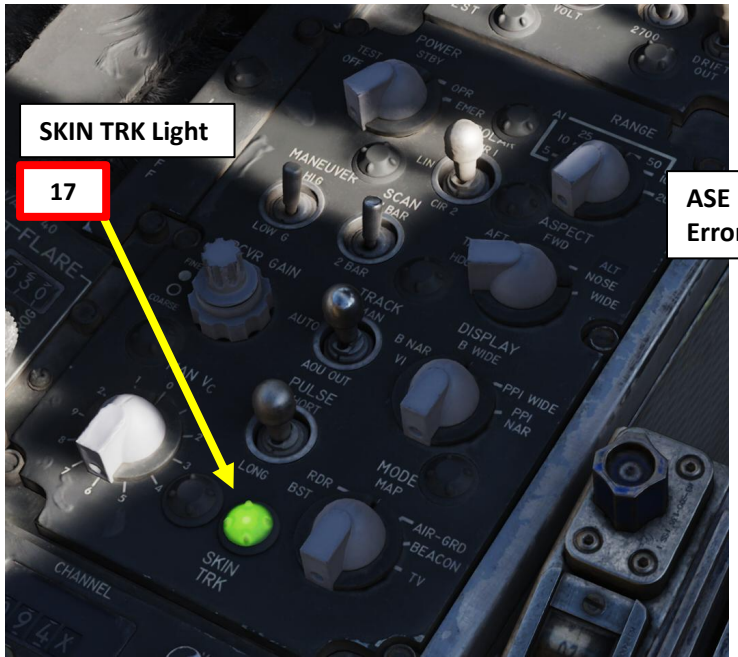
2 – AN/APQ-120 FIRE CONTROL RADAR
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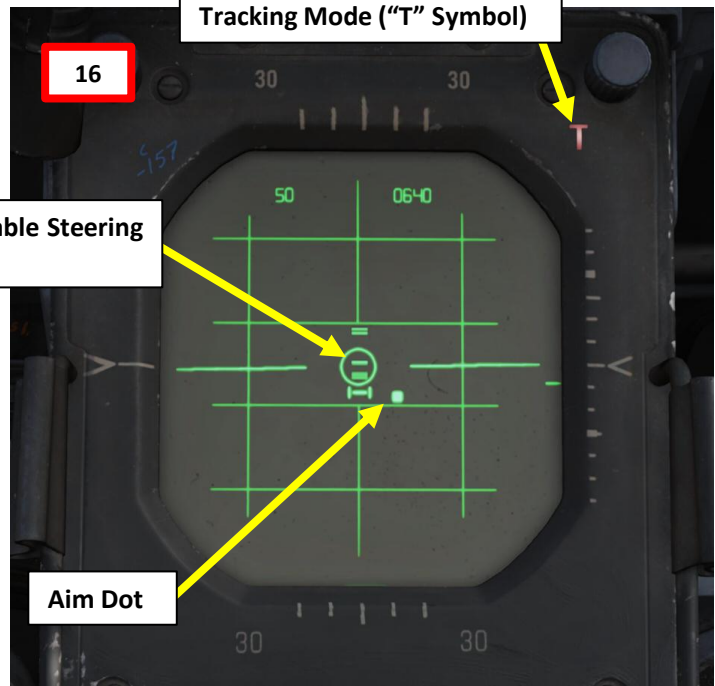
15. *[WSO]* Once the radar cursor is slewed over the target, press the Hand Control Stick Trigger's second detent (Full-Action).
    - Note: the first stage of the trigger (referred as "**half-action**") will initiate the visibility of the range strobe and allow positioning of the antenna in azimuth. The second stage of the trigger (referred as "**full-action**") will attempt an automatic lock-on if the range is set to 50 nm or less and the range strobe is positioned over the desired target.
16. *[WSO]* The radar will enter "acquisition mode" and automatically attempt to track (radar lock) the target.
17. *[WSO]* Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
        - If the target is manually tracked, or AOJ (Angle-On-Jam) or HOJ (Home-On-Jam) track conditions are effective, the SKIN TRK light will not illuminate
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears, which indicates the maximum lead or lag at which the missile can be launched and will still retain a high probability of hit
    - The Aim Dot appears, which provides steering commands to the pilot
18. *[WSO]* If you want to "unlock" the target, press the Hand Control Stick Trigger's second detent (Full-Action).

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*









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2.4.2.1 – Beyond Visual Range (BVR) Employment

19. *[WSO]* Adjust gain and range accordingly to ensure good target visibility.
20. *[WSO]* Verify the validity of the target lock by using the Aspect Selector. I recommend alternating the selector to the WIDE, NOSE and TAIL position and checking that the values displayed on the scope make sense.
    - WIDE Setting: Target Closure Velocity is displayed (kts)
    - NOSE Setting: Target Altitude is displayed (in hundreds of ft)
    - FWD Setting: Target Aspect Angle is displayed
    - AFT Setting: Target Closure Velocity is displayed (kts)
    - TAIL Setting: Target Heading is displayed



Aspect Selector – WIDE Setting
- *Displays Closure Velocity (kts)*





Selection	DSCG Display
WIDE	Closure Velocity
NOSE	Altitude
FWD	Aspect
AFT	Closure Velocity
TAIL	Heading



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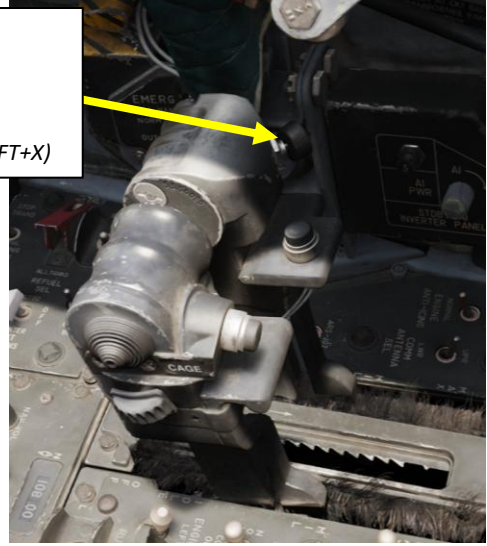
21. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).





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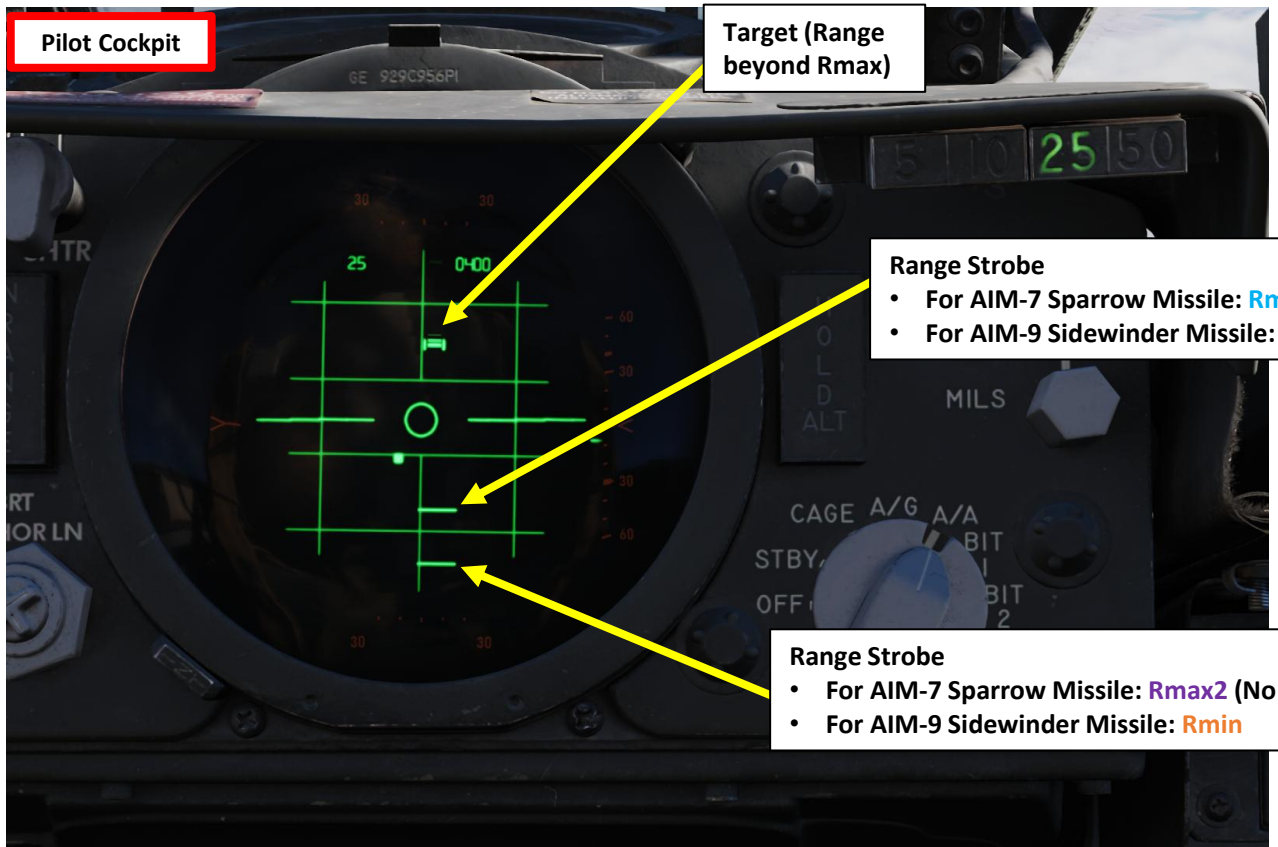
Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

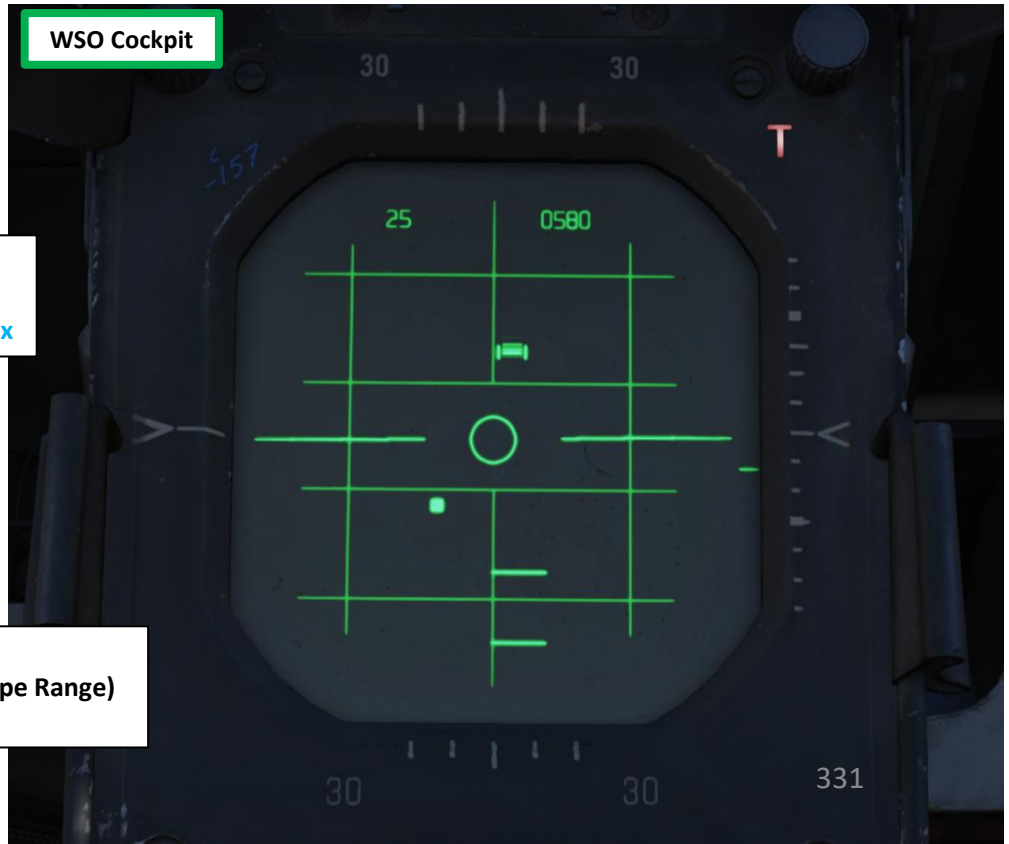


Note about Range Strobes:

If Sparrows are selected and ready for employment, take note that the radar display will also show two range strobes.

- If an AIM-9 Sidewinder Missile is selected: range strobes display **Rmin** (Minimum range capability of the missile) and **Rmax** (Maximum range capability of the missile provided the target continues flying on current heading and course).
- If an AIM-7 Sparrow Missile is selected: range strobes display **Rmax** (Maximum range capability of the missile provided the target continues flying on current heading and course) and **Rmax2** (Maximum range capability of the missile provided the target performs the shortest high-G turn to tail aspect, also referred as the "no escape range").
  - Note: **Rmax2** rate is based on altitude (8G up to 20000 ft, 6G to 35000 ft, and 4G above 35000 ft).





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22. *[P]* If the pilot sets the Sight Mode Selector to A/A (Air-to-Air), the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target, displaying ranges up to 20,000 ft (top) to 3000 ft (bottom), with 12,000 ft signified at the 3 o-clock position. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time).



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2.4 – Air-to-Air Operation
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Note about Aspect Selector Switch:.

- The **Aspect Selector switch** controls the display mode of the DSCG numeric output while the radar is tracking a target (radar lock), but its use is not always intuitive.
- The **default setting** should always be **closure speed** (Vc), which requires the Aspect switch in **WIDE** or **AFT**. I recommend using AFT because it potentially provides a faster and more accurate missile speedgate lockon than WIDE after missile launch.
- **After a radar lock**, time permitting or at the request of the pilot, the WSO can check the target's **altitude** (Aspect switch set to **NOSE**), **heading** (Aspect switch set to **TAIL**), or **aspect** (Aspect switch set to **FWD**)… however this process takes a long time and you may very well not have enough. Checking target altitude/heading/aspect can be done in a relaxed environment (when looking for a tanker for instance) but more often than not… "ain't nobody got time for that".
- The main takeaway? It is crucial to return the Aspect switch to the WIDE or AFT position because Vc (Closure Velocity) is the primary information used for an intercept. The WSO knows the **target altitude from the antenna elevation strobe** and the **target speed/aspect** from the **Vc (Closure Velocity)**. In a hot tactical intercept, WSO will likely not have time to fumble with the Aspect switch and just leave it in WIDE or AFT.



Aspect Selector

Selection	DSCG Display	Sparrow Speed-Gate Setting (Vc)
WIDE	Closure Velocity	Entire Spectrum
NOSE	Altitude	TAS + 450 ±150 kts
FWD	Aspect	TAS + 240 ±150 kts
AFT	Closure Velocity	TAS - 240 ±150 kts
TAIL	Heading	0 ±150 kts



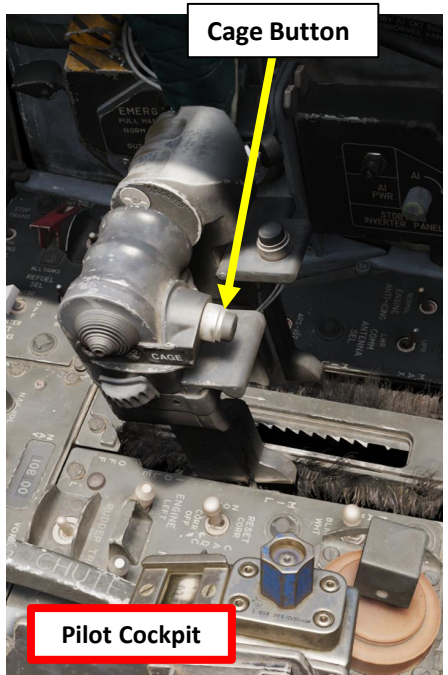
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Note about BST (Boresight) Mode:.

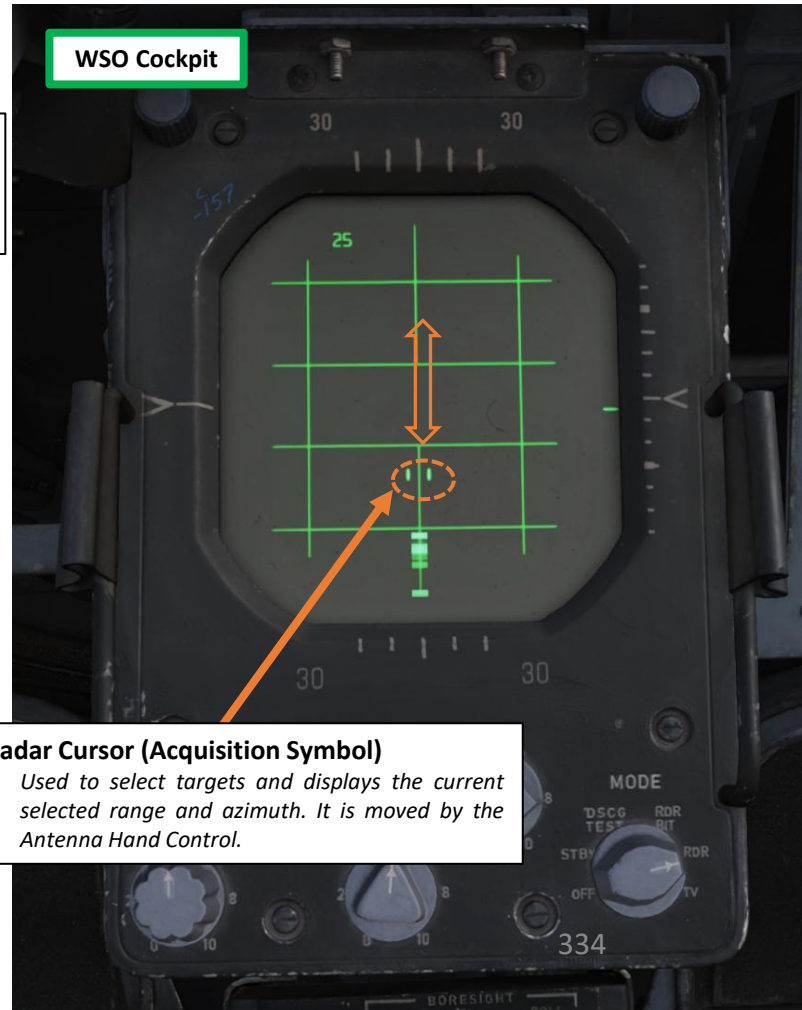
- When searching for a target, you may use BST (Boresight) Mode if you know the target is lined up with the aircraft's radar boresight line (RBL).
- In BST, the Radar Antenna is fixed along the radar boresight line (RBL) and the radar returns are displayed on the scope as in an acquisition mode. The WSO can only move the radar cursor in the FWD/AFT direction using the Antenna Hand Control Stick. Radar lock-on is performed the same way as in RDR-B or MAP-B modes with the Action Switch, as shown previously. Targets need to be within a 5 degree zone or an attempted lock will likely result in a bad lock.
- BST Mode can be selected either by setting **Radar Operation Mode Selector** to **BST** or by depressing the **Cage button** on the pilot's throttle.











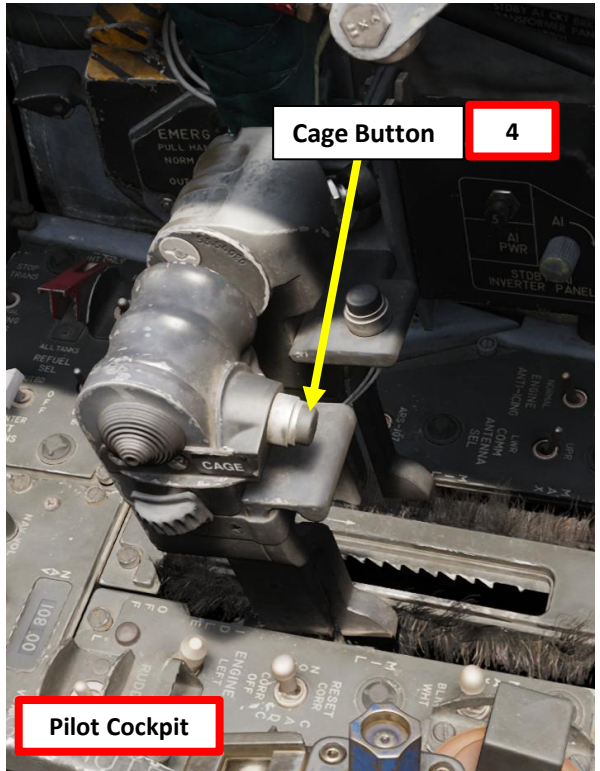
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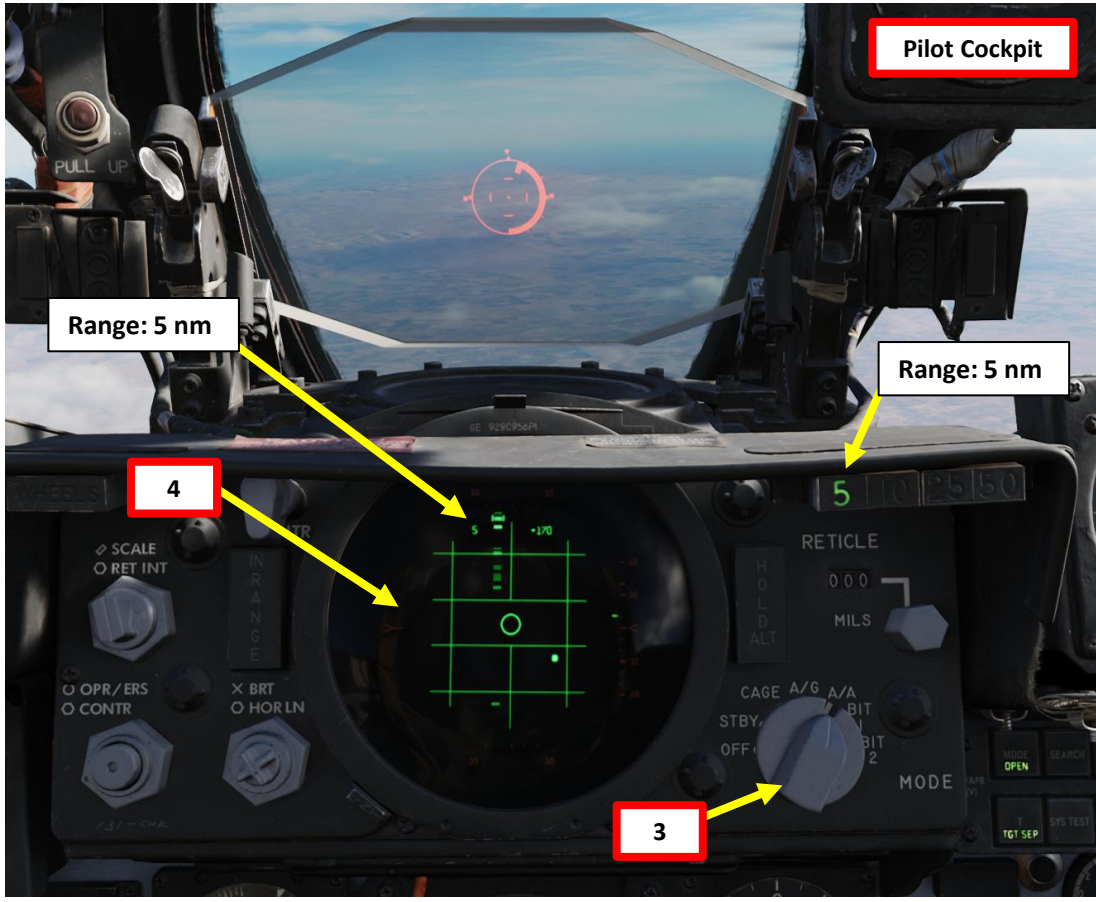
In order to perform search a track (lock) a target that is within visual/close range, the pilot is typically better positioned to perform the radar lock. Be aware not to confuse “Cage Mode” and “CAA (Computer Automatic Acquisition) Mode” since they are related but serve different functions.

1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).
3. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
4. *[P]* Select **Cage Mode** by depressing the Cage button on the pilot’s throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.





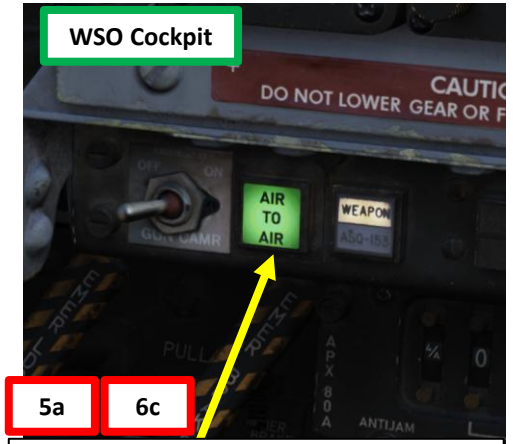




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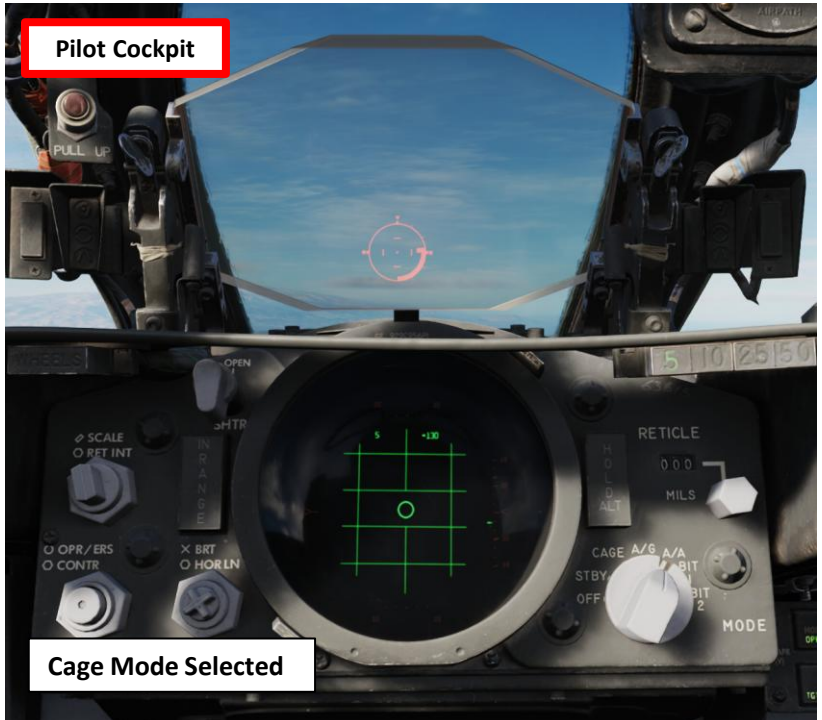
5. *[P]* When Cage mode is selected:
   a) The Air-To-Air light in the rear pit illuminates
   b) Trigger control is transferred to the air-to-air weapons (including when ARM and TV are selected)
   c) The Optical sight switches into A/A mode
   d) CAA (Computer Automatic Acquisition) mode becomes available for selection.
6. Additional Notes about Cage Mode:
   a) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch on the throttle is in RADAR or HEAT, the radar breaks track and returns to boresight.
   b) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch is in GUNS, the lock is not broken.
   c) Cage Mode can be exited with the pilot's Weapon Select Knob (set into or out of the B position) or with the WSO pressing the Air-to-Air Button.

Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



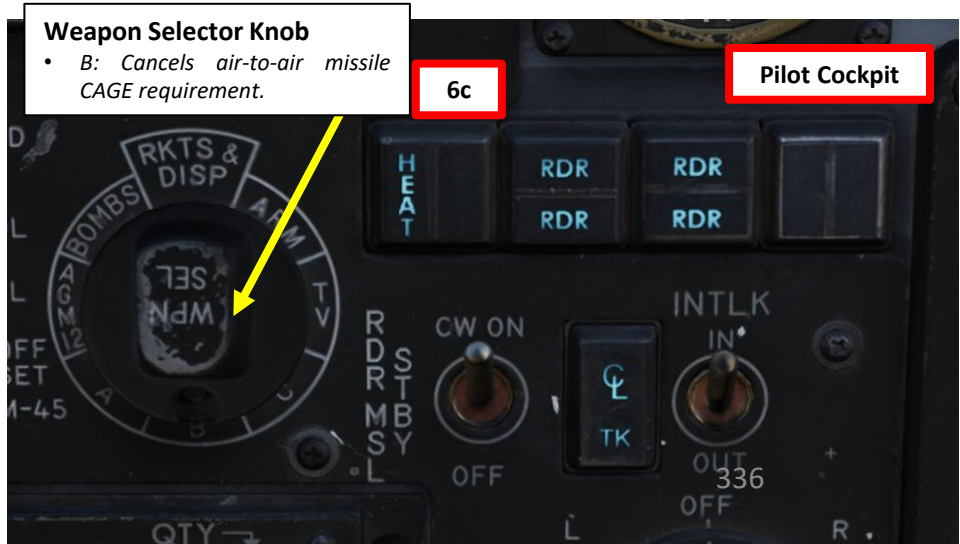


Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*





Weapon Selector Knob
- *B: Cancels air-to-air missile CAGE requirement.*

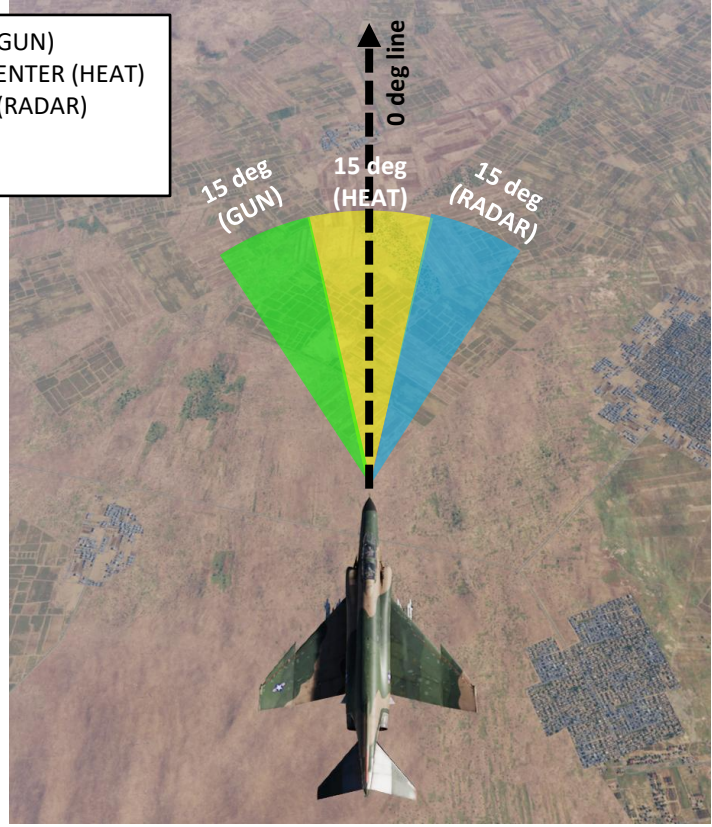


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7. *[P]* Select **CAA (Computer Automatic Acquisition) Mode** by pressing the Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button on either the Pilot (or WSO stick).
8. *[P]* When CAA Mode is selected:
   a) The radar enters a vertical-oriented scan pattern 78 degrees in height by 15 degrees wide, the scan is 3 vertical bars wide.
   b) Actual radar lock capability within this scan pattern is from +45 degrees above the horizon line to -9 degrees below the horizon line due to radar's software limitation.
   c) In the event that the radar finds a suitable target within the scan volume, the target will be automatically locked.
   d) Should the flight crew find the locked target not be the one intended, the Nose Gear Steering button can be pressed on either stick grip to return the radar back to the search pattern.
9. *[P]* In CAA mode, the radar's search pattern can be shifted left and right utilizing the pinky switch on the throttle.
   - Pinky Switch – AFT (GUNS): Scan Center is 15 deg Left
   - Pinky Switch – CENTER (HEAT): Scan Center is centered (0 deg)
   - Pinky Switch – FWD (RADAR): Scan Center is 15 deg Right

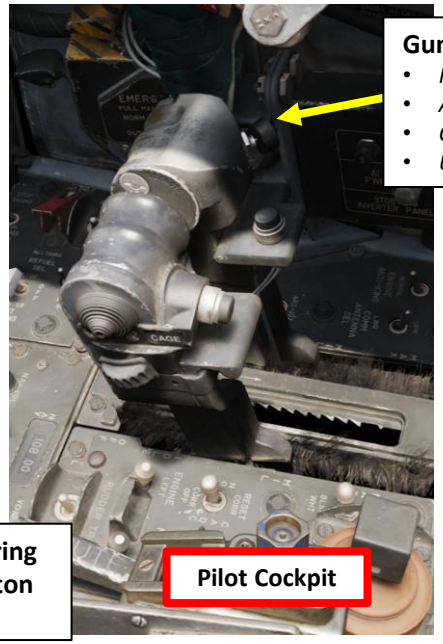
Green Arc: Left Corridor (Gun/Missile Pinky Switch AFT (GUN)
Yellow Arc: Center Corridor (Gun/Missile Pinky Switch CENTER (HEAT)
Blue Arc: Right Corridor (Gun/Missile Pinky Switch FWD (RADAR)

Note: Distances/Angles are not to scale

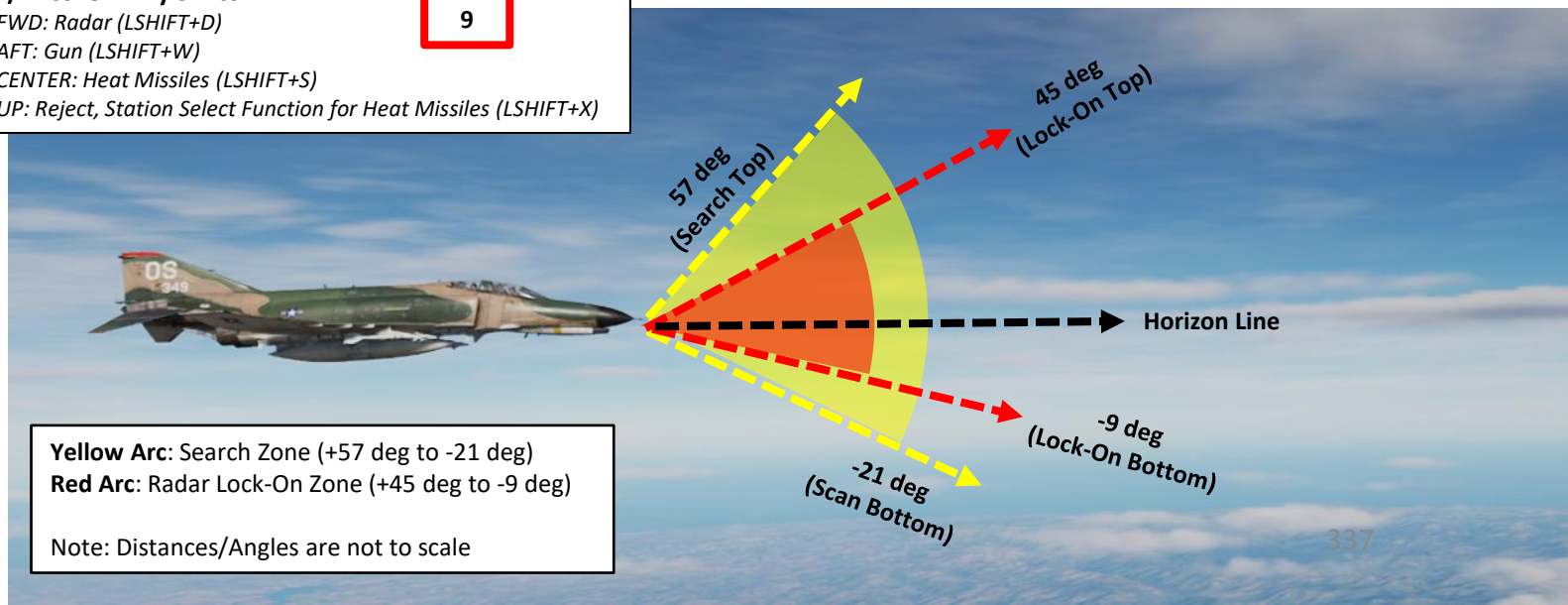




Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Gun/Missile Pinky Switch 9
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



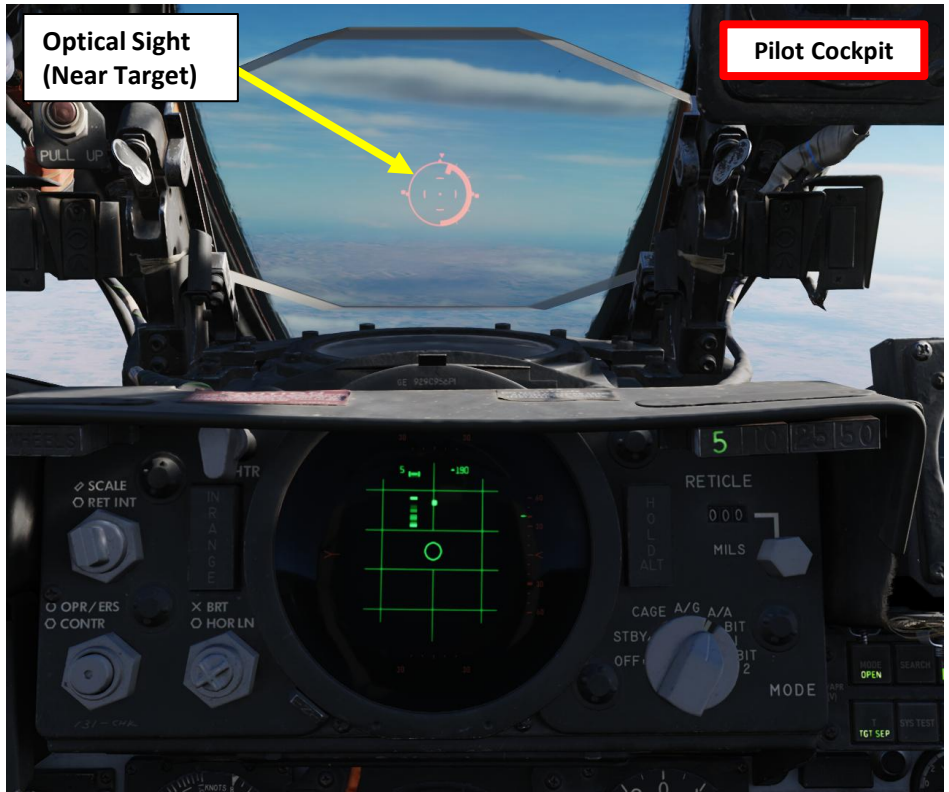
Yellow Arc: Search Zone (+57 deg to -21 deg)
Red Arc: Radar Lock-On Zone (+45 deg to -9 deg)

Note: Distances/Angles are not to scale

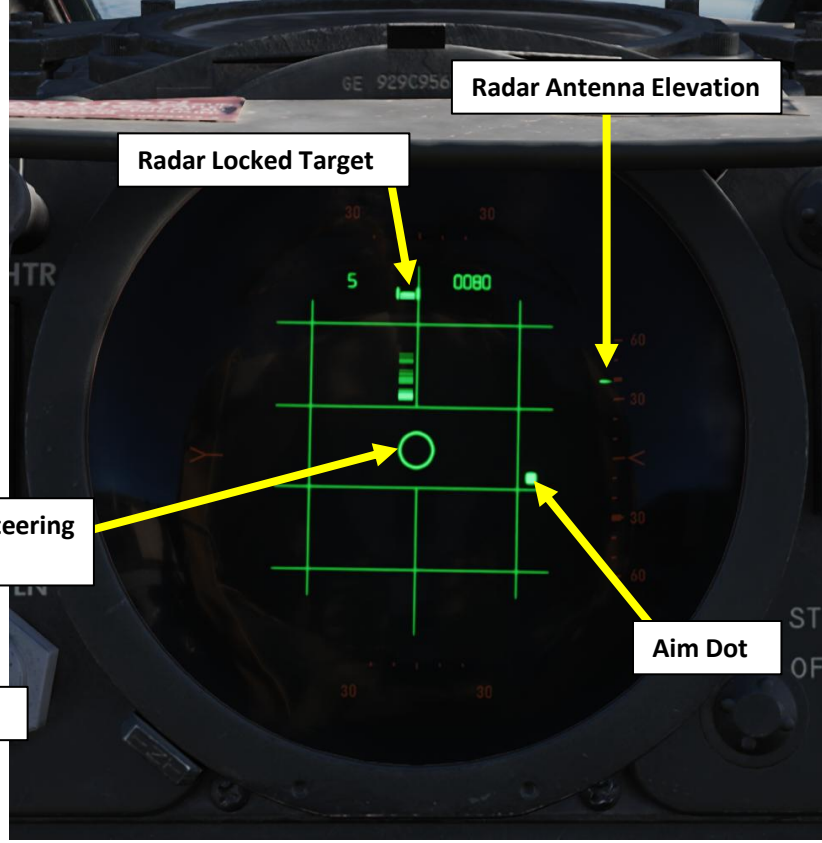
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10. [P] The pilot should visually line up the optical sight near the target. When the radar finds a suitable target within the scan volume and a 5 nm range, the target will be locked.

11. Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears, which indicates the maximum lead or lag at which the missile can be launched and will still retain a high probability of hit
    - The Aim Dot appears, which provides steering commands to the pilot





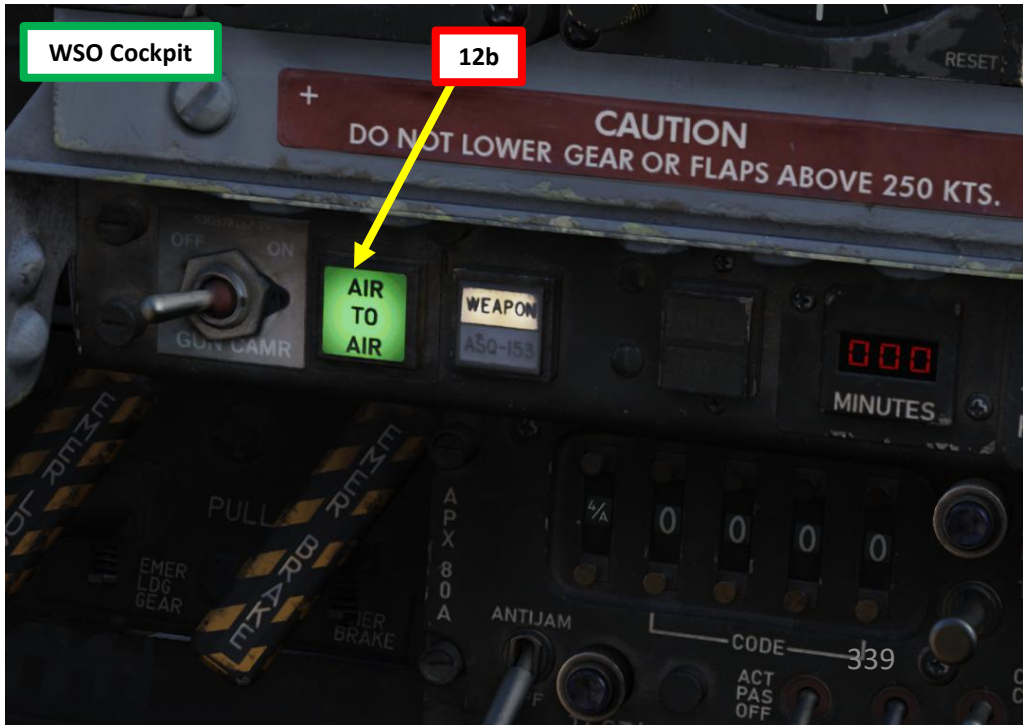




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12. If you want to exit CAA mode, you can either:
    - *a) [P]* Select position B on the Weapon Select Knob, or
    - *b) [WSO]* Push the Air-To-Air button.
    - Note: Should a radar lock be in place at the time of CAA mode exit, it will be retained.





2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.2 – Radar Operation with Multicrew
2.4.2.3 – Advanced Topics: Angle Track & Range Track

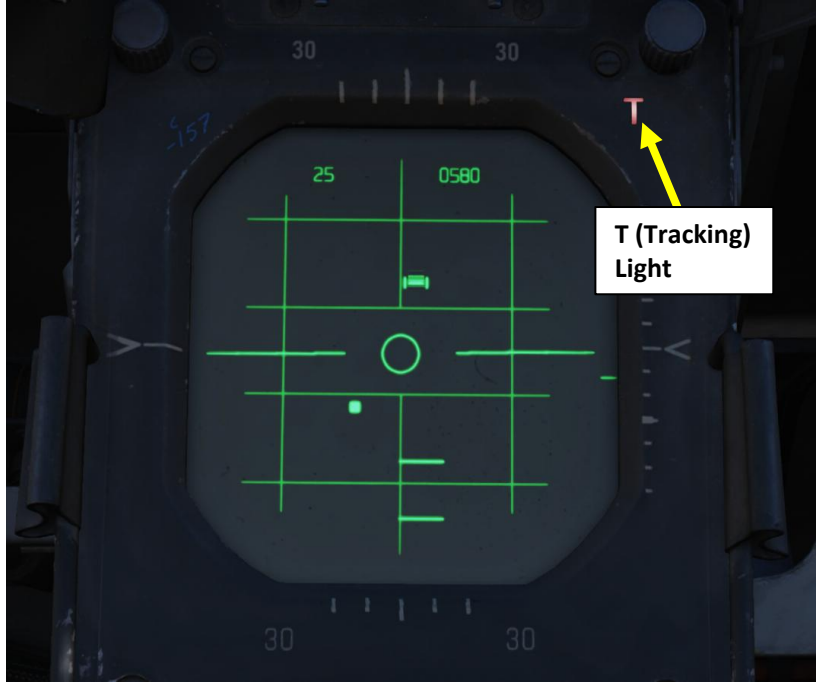
When performing an automatic radar lock/track, there are two types of tracking circuits available:

Angle tracking:

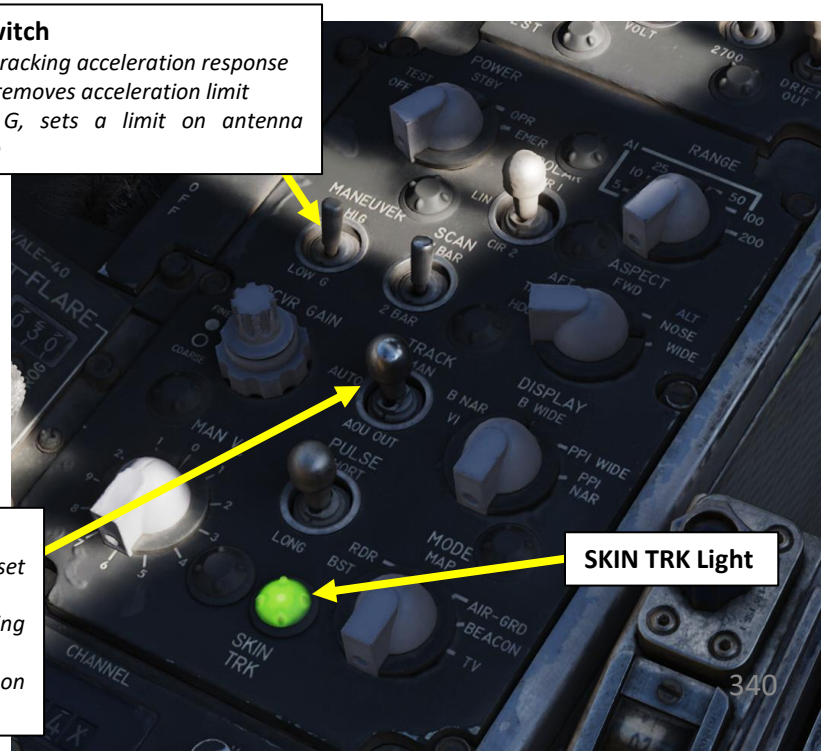
- The Angle Tracking circuit **steers the antenna to keep the target centered**. It does so by making use of feedhorn nutation (conical scan). The antenna steers towards the direction of highest amplitude in the nutation scan pattern. As a result, angle tracking cannot be achieved without nutation (MAP-B begins nutation when using acquisition).
- Angle Tracking has two settings set by the **Maneuver Switch**, HI G and LOW G. These set limits on the acceleration in the angle tracking circuits.
- Antenna steering has several important functions:
  - Tracking target location in elevation and azimuth
  - Providing head aiming angles to the Sparrow for a seeker lock-on.
  - Illuminating the target with continuous wave radio frequency energy for Sparrow guidance.

Range tracking:

- The radar **uses a range gate to select a target in range**. This uses only radar returns within the range gate for its circuits. This helps eliminate clutter and other targets, and allows angle tracking circuits to accurately track the target of interest without erroneous signals.
- In Range Track, the range gate uses the radar echoes to automatically correct any error between the range gate and the target echo. This causes the range gate to move; the rate at which the gate moves is the closure velocity and displayed on the screen. This is also used to supply the Sparrow with a closure velocity to set its speed-gate for target tracking.
- Range Track can operate in **memory mode**. When in memory mode the range gate will continue to move down at the last calculated closure velocity. When this occurs the **SKIN TRK** and **T light** on the DSCG will go out and the range rate digits will begin to flash. If memory mode was entered because the target was lost, the system will drop the lock if the target does not reappear within 5 seconds.
- **Memory Mode** will be entered under several conditions:
  - Manual Search is selected (**Track Switch**)
  - Target is lost
  - Jamming condition is detected



Maneuver Switch
Controls radar tracking acceleration response
- *FWD: HI G, removes acceleration limit*
- *AFT: LOW G, sets a limit on antenna acceleration*



Track Switch
- *FWD: Manual, MAN Vc knob position will be used to set the tracking gate closure velocity*
- *MIDDLE: Auto, operates normal range tracking with Home on Jam (HOJ) if jamming is detected*
- *AFT: AOJ (Acquisition On Jam) OUT, disables Home on Jam in cases where jamming is erroneously detected*

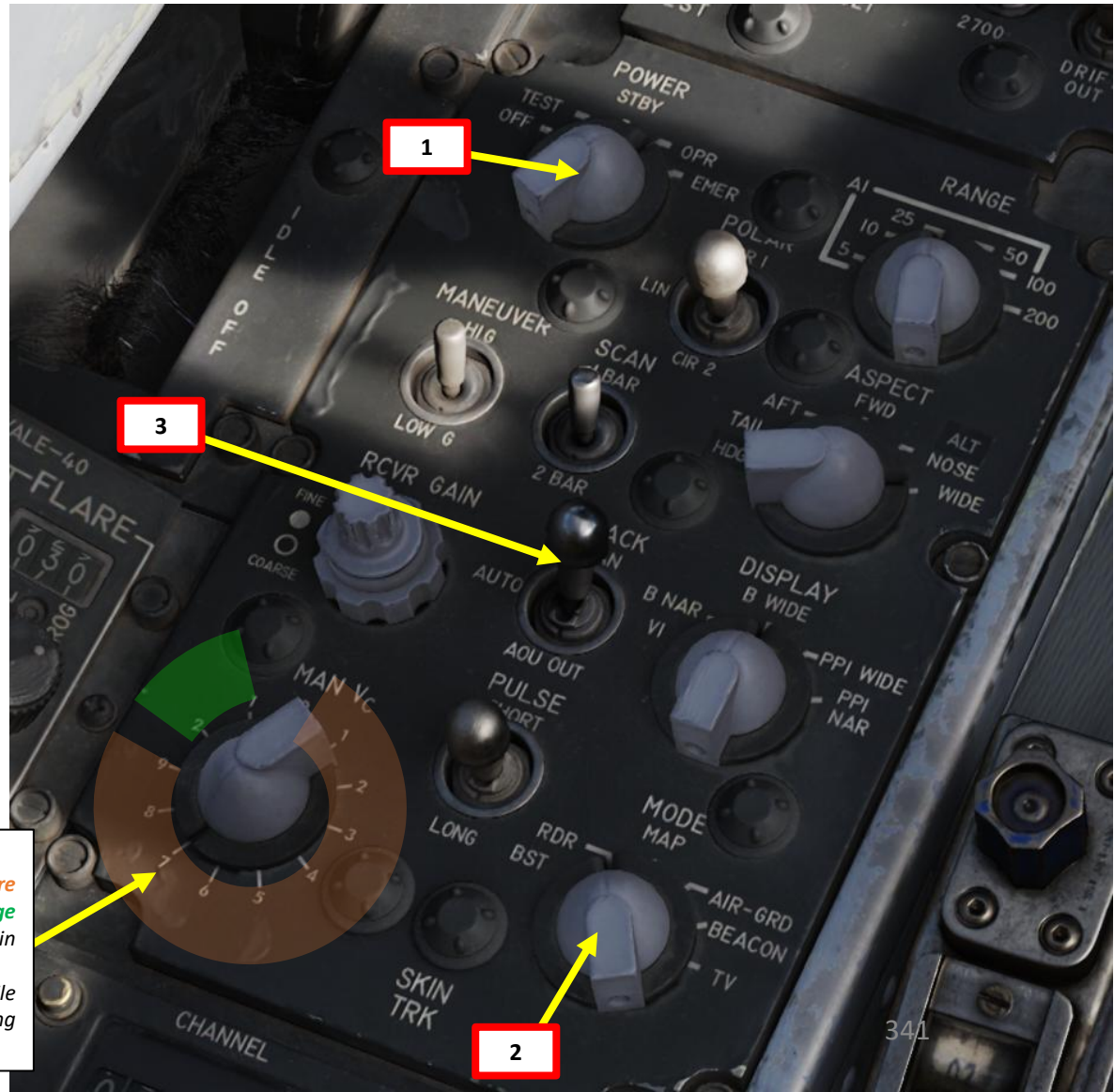
2 – AN/APQ-120 FIRE CONTROL RADAR
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2.4.2.3 – Advanced Topics: Manual Tracking

FlyAndWire Video: Manual Tracking and AIM-7
https://youtu.be/SeymRq0CygY

As we have seen in the previous topic, the radar can track targets using "angle tracking" and "range tracking" circuits. This means that when performing a radar lock, the radar will be able to keep "updating" the position of the target. However, there are situations where the radar is unable to automatically update the position of the target (i.e. electronic warfare due to jamming noise drowning your radar returns, making it close to impossible for the radar to get accurate ranging information).

Manual Tracking mode would allow you to "tell" the radar how to track a target. How? By manually setting the range closure rate (Man Vc, in x100 kts). FlyAndWire covers this topic in-depth, but here is a quick demo on how to use Manual Tracking.

1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[WSO]* Set Radar Operation Mode – RDR (Radar).
3. *[WSO]* Set Track Switch – MANUAL (FWD).
4. *[WSO]* Set Man Vc (Closure Rate) Knob – Estimated target closure rate or opening rate. In this example, we estimate the target closure rate to 700 kts.



4

Man Vc (Closure Rate) Knob

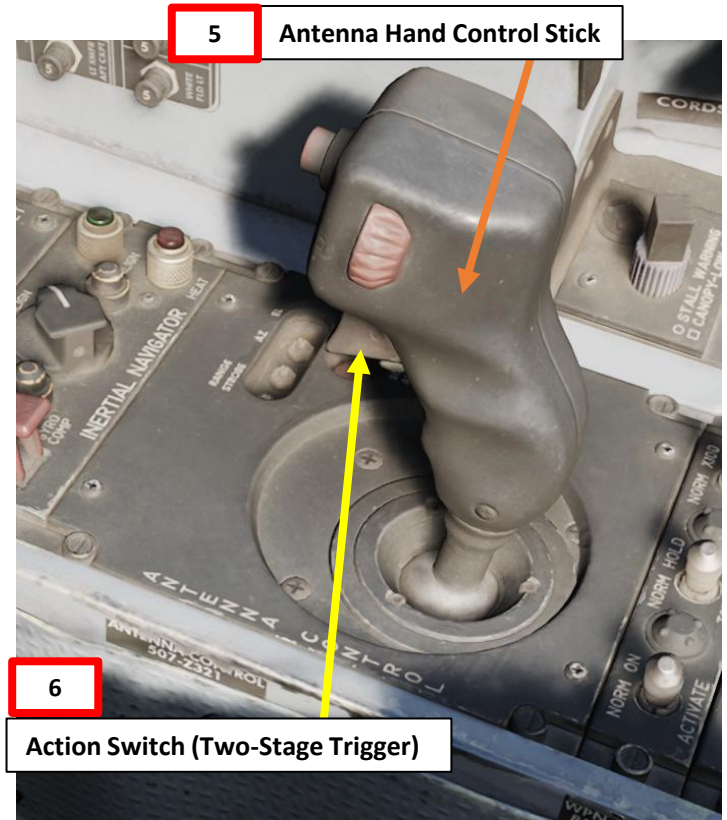
- *Used to apply estimated range rate of closure (clockwise, 0-9), or estimated opening of range (counterclockwise, 0-2) against a target in manual track mode.*
- *The numbers are multiplied by 100 knots while closure means closing in to the F-4 and opening means the target is flying away from the F-4*

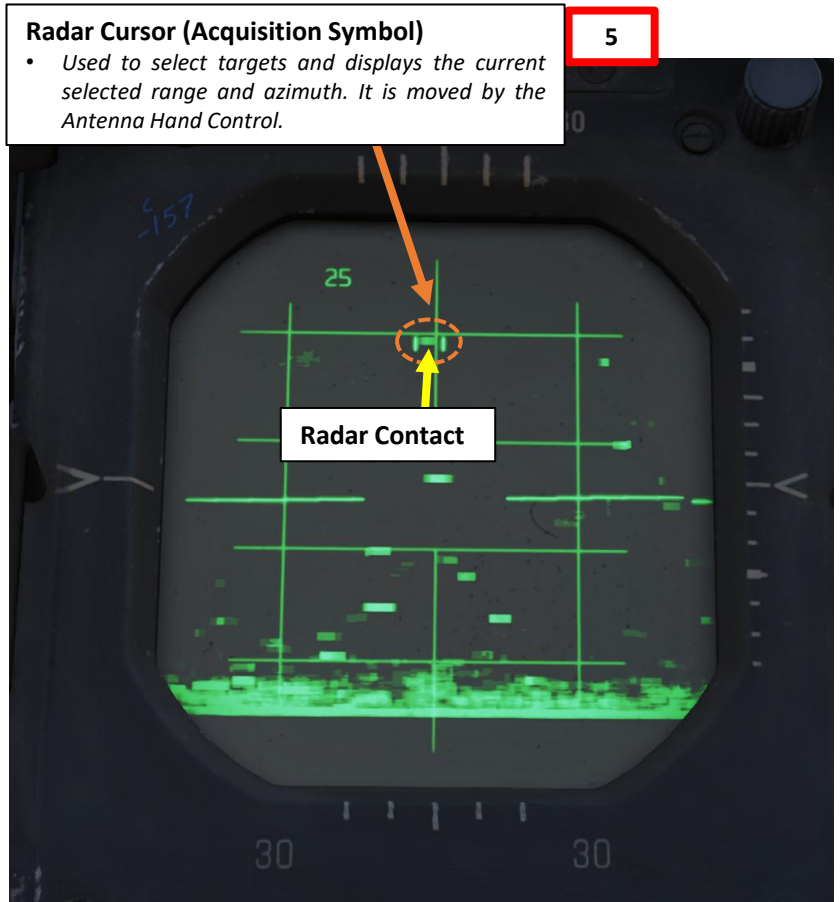
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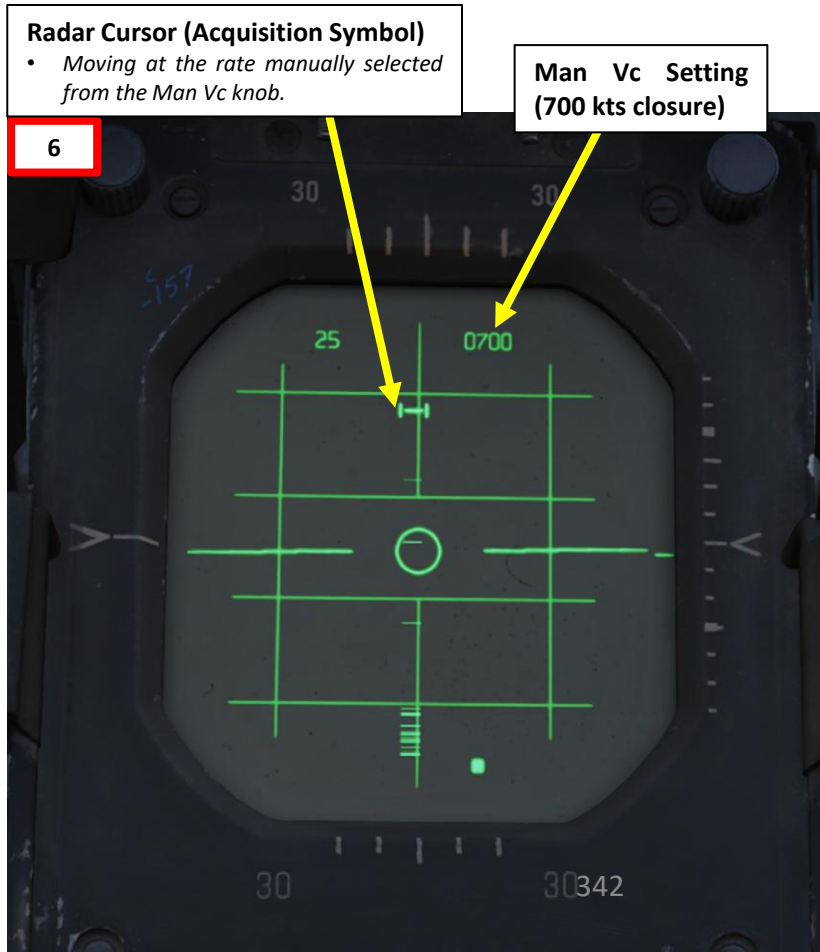
5. *[WSO]* Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the target.
6. *[WSO]* Once the radar cursor is slewed over the target, press the Hand Control Stick Trigger's second detent (Full-Action).
7. *[WSO]* The cursor will move at the range rate specified by the Man Vc knob (700 kts closure rate in our case). Verify if the cursor "follows" the radar contact. If the cursor descends or rises too quickly (drifting apart from the radar contact), this means the Man Vc setting needs to be adjusted to another speed until the cursor and radar return "follow" each other.

Note: If a target **is using electronic jamming**, the HOJ (Home-On-Jam) radar mode provides angle tracking capability but you might still require manual tracking. If a target **is not using electronic jamming**, there is **no automated angle tracking even when using manual tracking.**

Keep in mind that angle tracking provides the following capabilities:
- Tracking target location in elevation and azimuth.
- Providing head aiming angles to the Sparrow for a seeker lock-on.
- Illuminating the target with continuous wave radio frequency energy for Sparrow guidance.







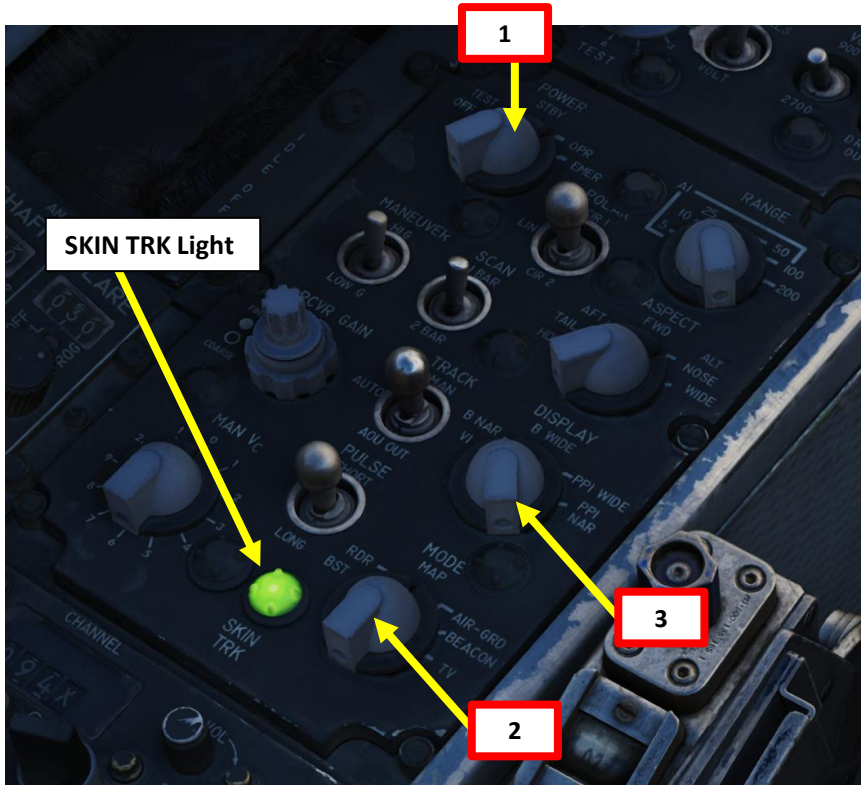
2 – AN/APQ-120 FIRE CONTROL RADAR
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2.4.2.3 – Advanced Topics: VISIDENT (Visual Identification)

FlyAndWire Video: VISIDENT
https://youtu.be/aWU3PS4AcgQ

If you have radar locked/tracked a target, you can switch the radar to "VI" (Visual Identification, also referred as VISIDENT). This will provide steering command symbology (aim dot) on the radar scope to guide the aircraft to a pure pursuit trajectory to fly behind the radar locked target in order to visually identify it. This is very useful in cases where you need to fly behind a tanker at night for air-to-air refueling.

Here is an example that showcases how VISIDENT works.

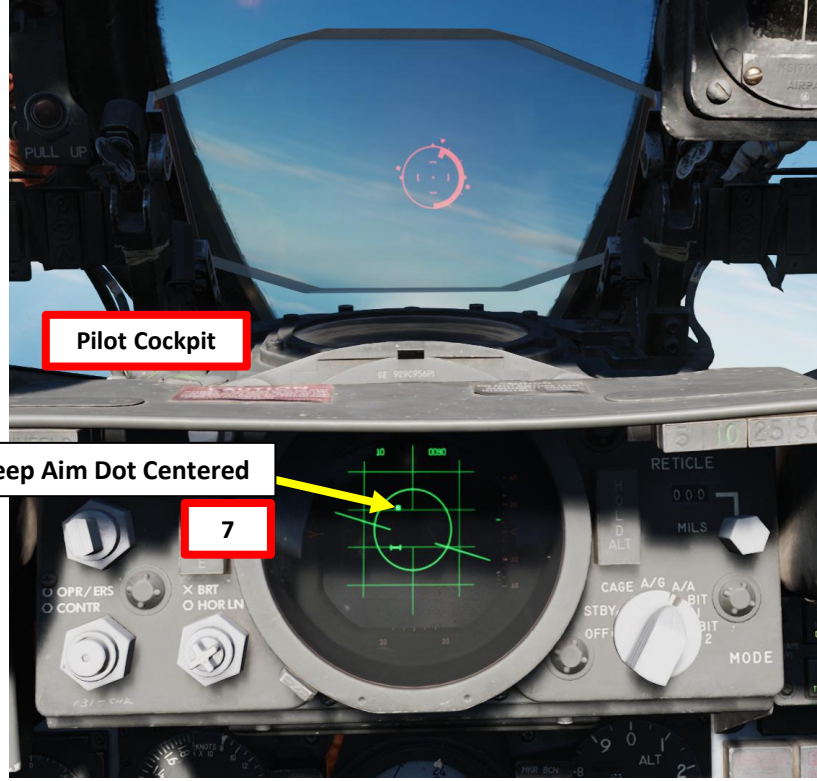
1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[WSO]* Set Radar Operation Mode – RDR (Radar).
3. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE, as desired.
4. *[WSO]* Perform a radar lock on the target.





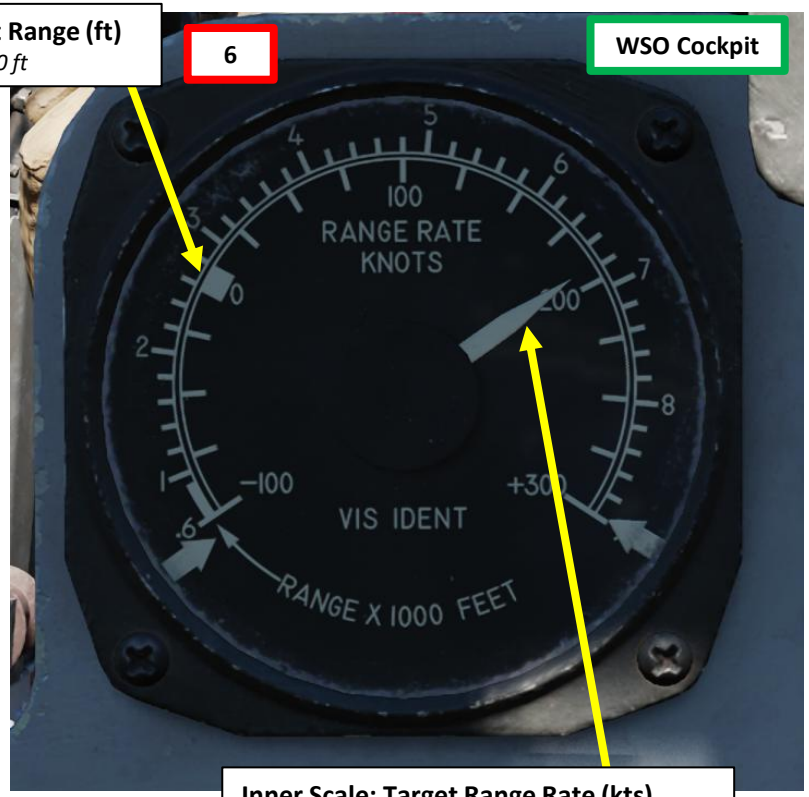
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5. *[WSO]* Set Display Selector – VI (Visual Identification)
6. *[WSO]* The VISIDENT indicator provides ranging information for close range interceptions (closer than 2 nm or 12000 ft) and range rate information (kts). A trajectory to intercept the radar-locked target will be computed.
7. *[P]* Steer the aircraft to keep the Aim Dot centered. Following this steering command, VI Mode will provide a pure pursuit trajectory to help the pilot get behind the radar-locked target.





Outer Scale: Target Range (ft)
- *From 600 ft to 9000 ft*

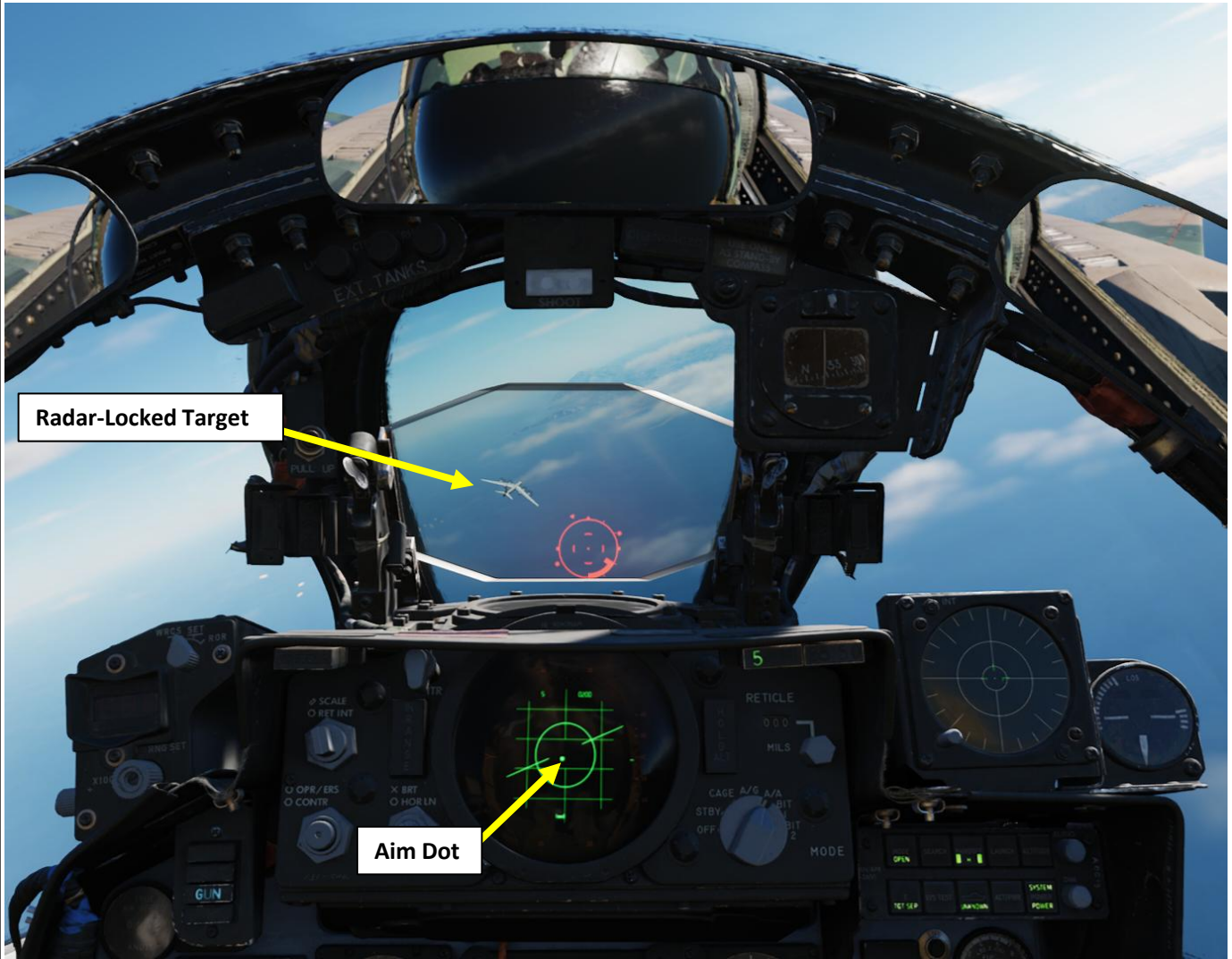


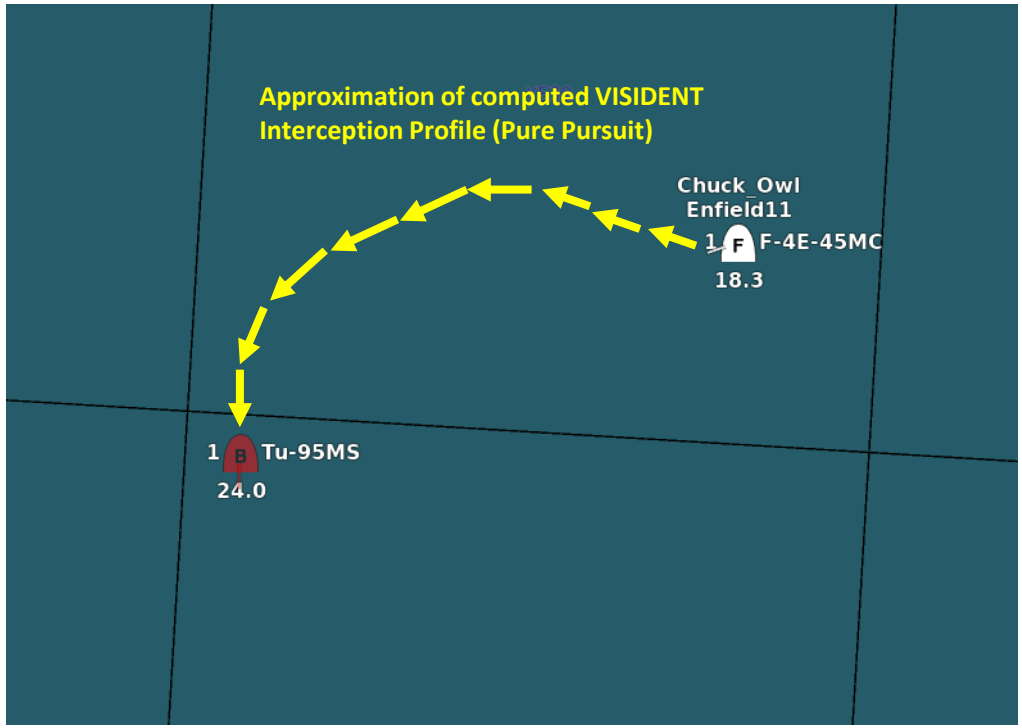
Inner Scale: Target Range Rate (kts)
- *From -100 kts to +300 kts (positive values indicate the target is closing in)*



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8. *[P]* As you fly the aircraft and keep the Aim Dot centered, you will eventually end up behind the radar-locked target and be able to visually identify it.



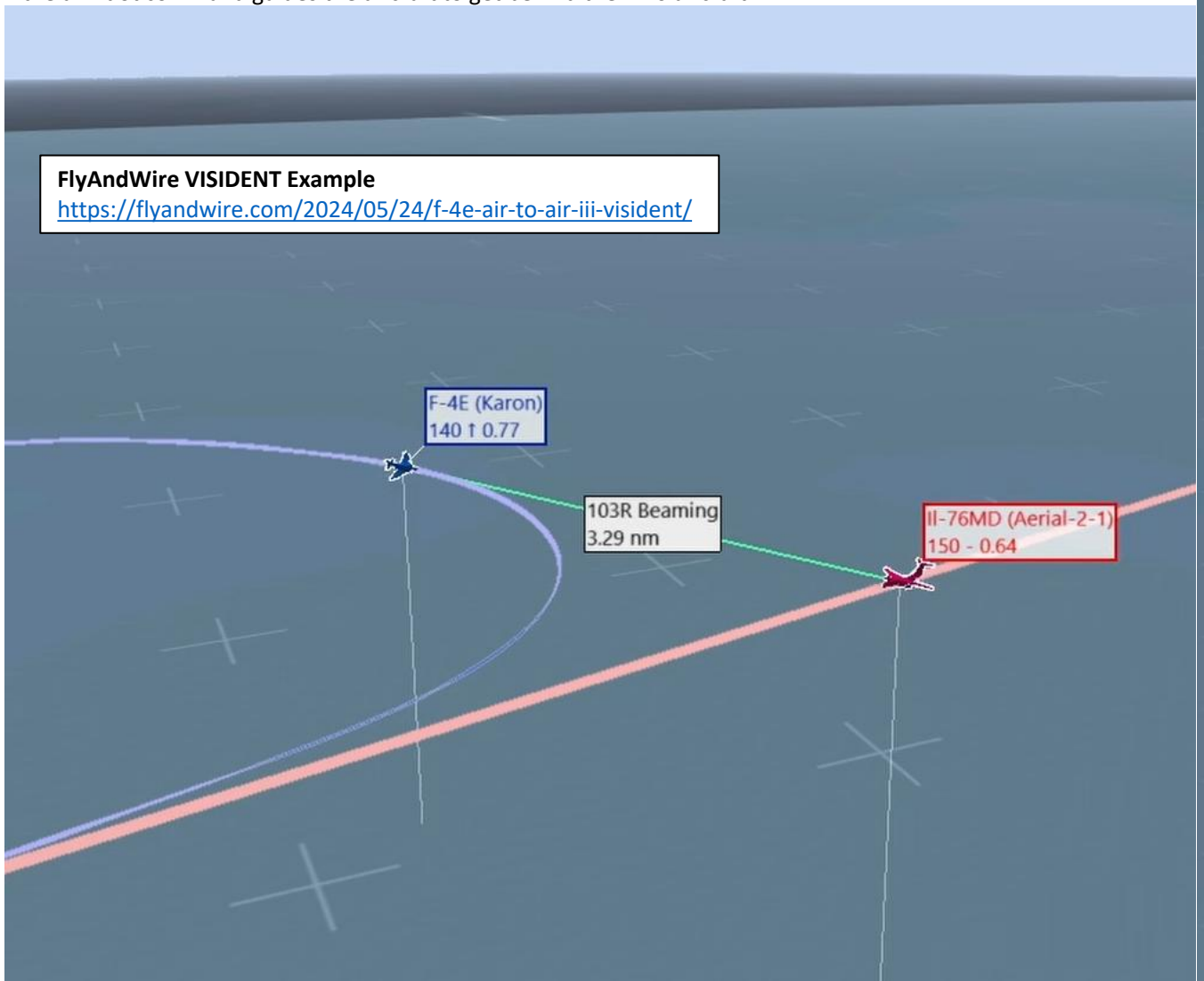


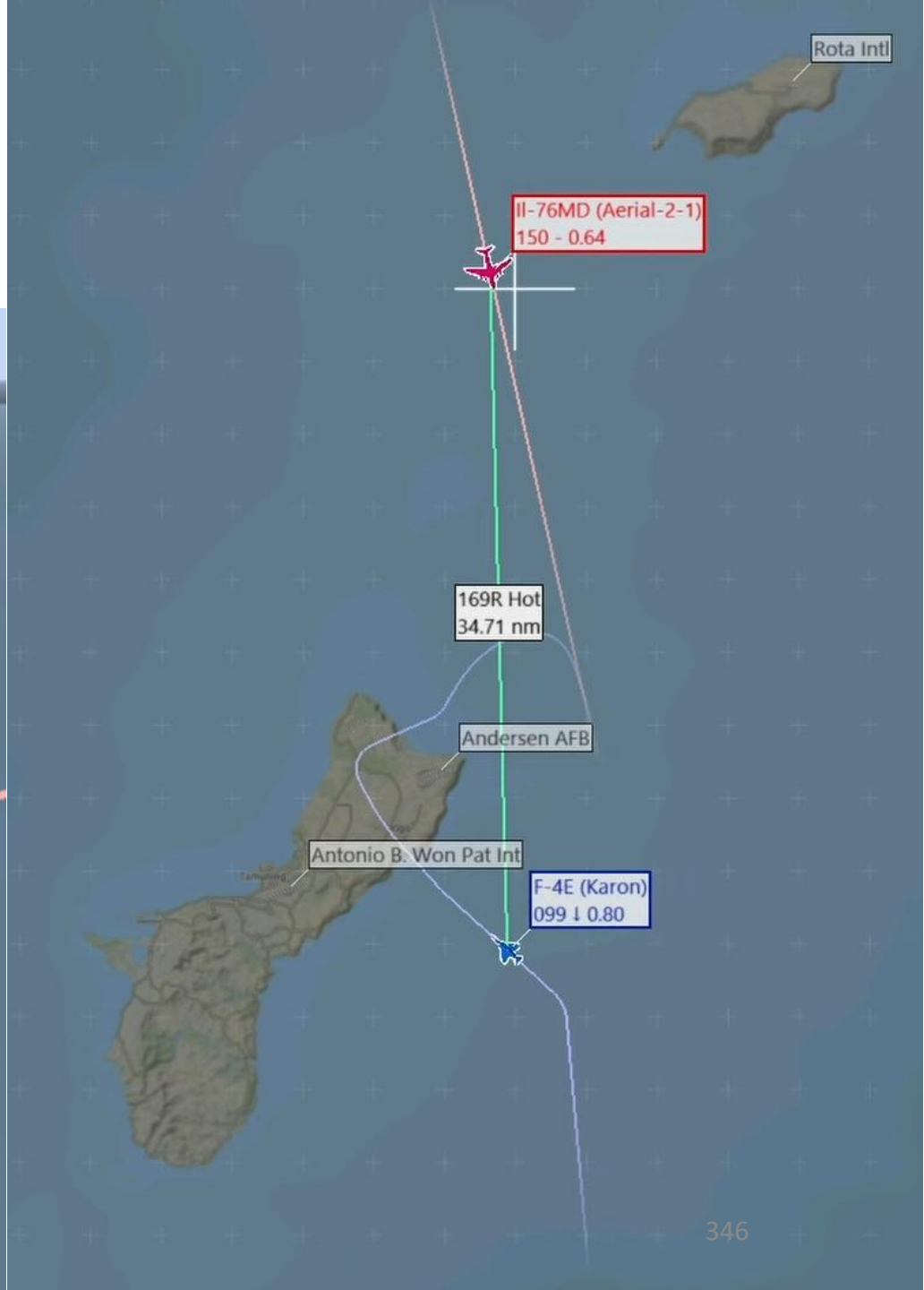


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Here is an example from FlyAndWire of the trajectory VISIDENT mode can command you to fly. As you can see, the aim dot command guides the aircraft to get behind the Il-76 aircraft.

FlyAndWire VISIDENT Example
https://flyandwire.com/2024/05/24/f-4e-air-to-air-iii-visident/

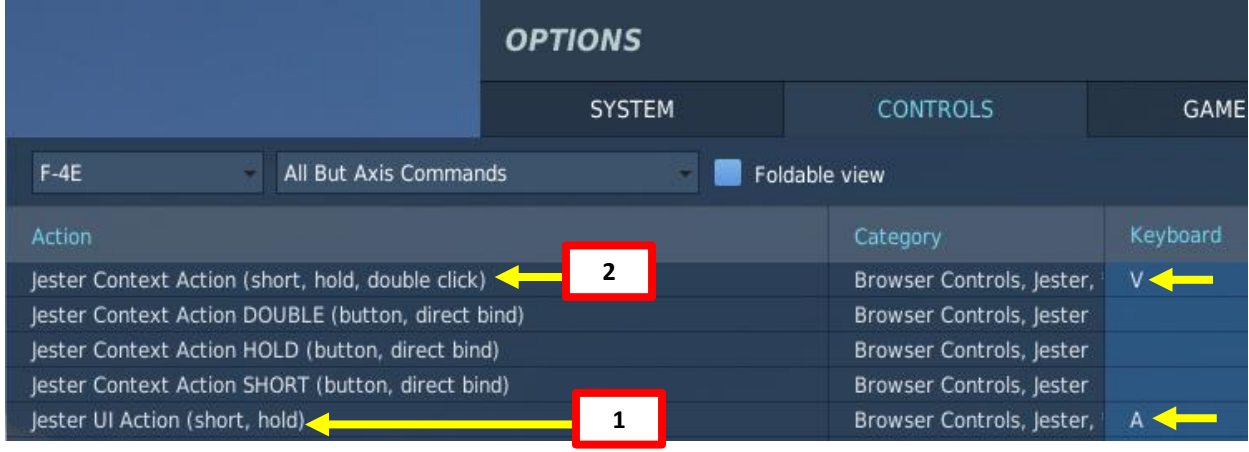




2 – AN/APQ-120 FIRE CONTROL RADAR
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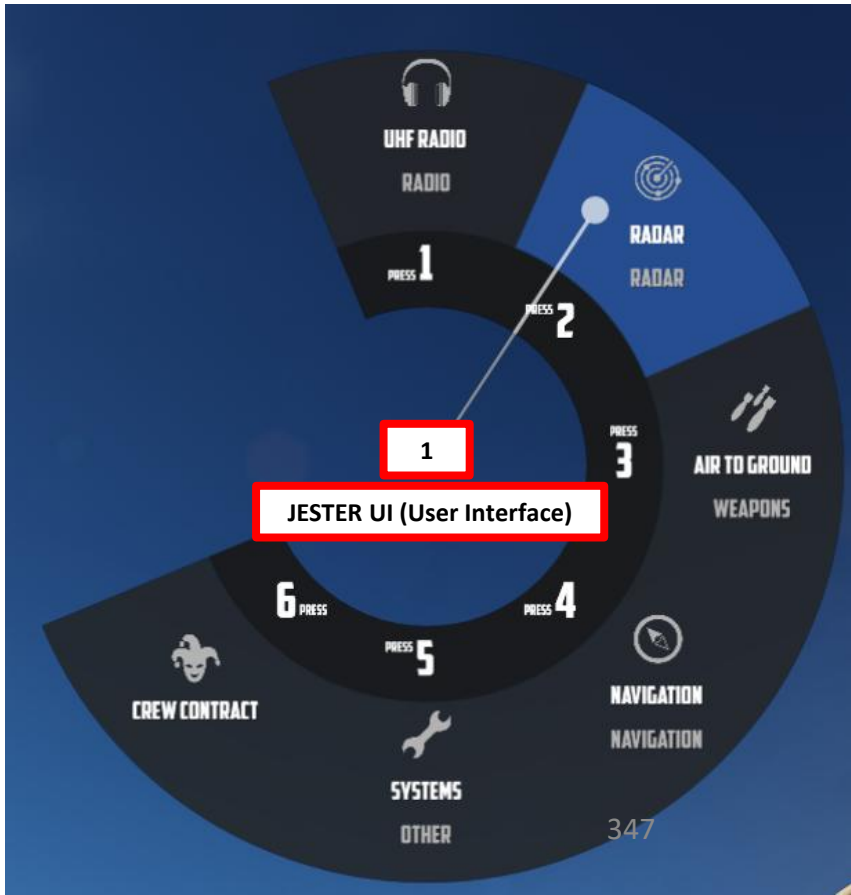
When you are flying in the pilot position and the JESTER AI takes over WSO tasks, JESTER will operate the radar by himself. There are two very important bindings you should set in the Controls tab in order to control JESTER.

1. To open JESTER AI wheel, short-press "**A**" (**JESTER UI Action binding**).
2. Make sure to map a binding for the **JESTER Context Action** (short, hold, double-click). In my case, I have it set to "**V** ". The JESTER Context Action does different things based in what context you are (d'uh!).



The table below lists what the JESTER Context Action (V) binding does in which condition.

JESTER Context Action (« V » binding)		
Radar in SCAN/SEARCH Phase (JESTER searching for targets)	**Radar in LOCK/TRACK Phase** (JESTER performing a radar lock)	**Radar in CAGE or BORESIGHT (BST) Mode** (JESTER is in a dogfight situation)
Condition: Normal flight situation, JESTER has not been issued commands	**Condition:** Pilot has already asked JESTER to radar lock a target.	**Condition:** Pilot must press Cage Button or ask JESTER to select BORESIGHT (BST) Mode.
Short Press: Commands JESTER to focus/select the next target visible on the radar scope.	**Short Press:** Commands JESTER to drop the target's radar lock but keep the target in focus.	**Short Press:** Commands JESTER to select Next Target Aspect
Long Press: Commands a radar lock on the target currently selected by JESTER (or the target with the highest priority).	**Long Press:** Commands JESTER to drop the target's radar lock but keep the target in focus.	**Long Press:** Commands JESTER to radar lock or unlock the closest target (radar contact) ahead. Note: Targets have to be within 5 degrees of his boresight or a lock attempt can result in a bad lock. JESTER expects the pilot to place the target within that zone first before being asked to perform the lock.
Double-Press: Resets currently selected target and returns JESTER to his standard behavior of automatically selecting the highest priority threat.	**Double-Press:** Commands JESTER to drop both the target's radar lock and focus (meaning JESTER will focus his attention on other targets).	**Double-Press:** Commands JESTER to exit CAGE or BORESIGHT Mode.

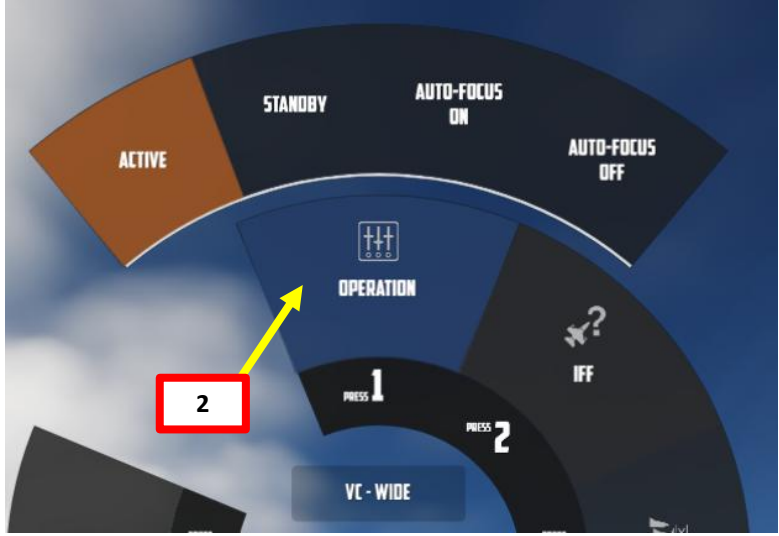


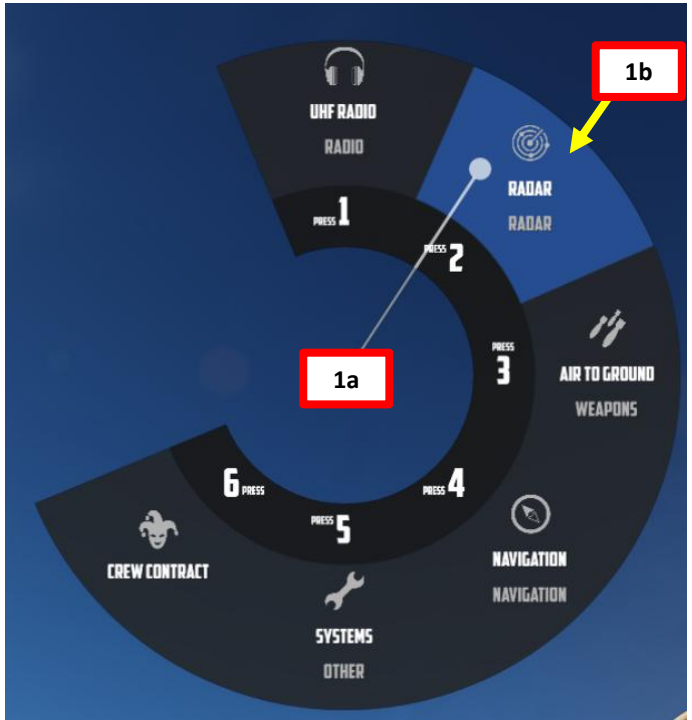
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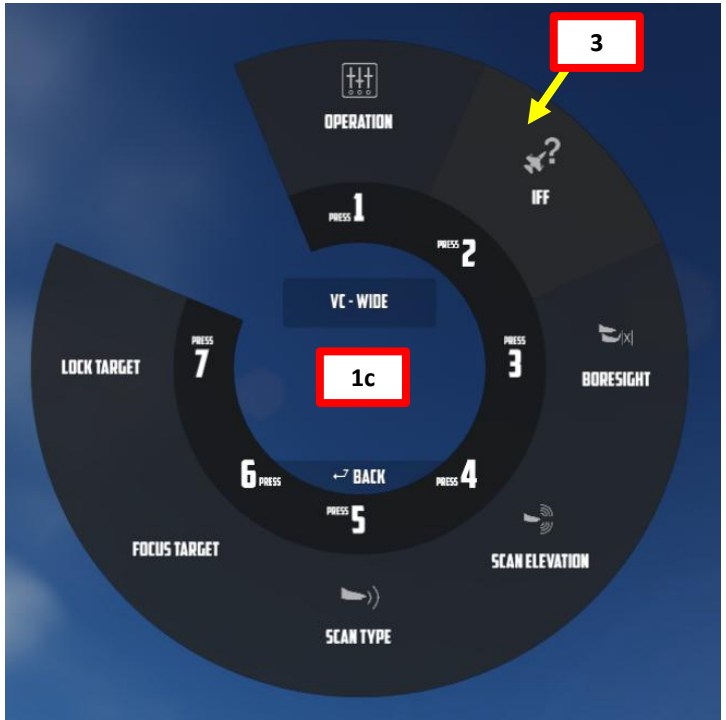
JESTER User Interface (UI) Functions

To open JESTER AI wheel, short-press "A" (JESTER UI Action binding). Consult the Heatblur Simulations wiki for more information.

1. From the **RADAR** menu, you will access all radar-related JESTER commands.
2. From the **OPERATION** menu, you can select the way JESTER operates the radar:
   - ACTIVE: Radar is active.
   - STANDBY: Radar is in Standby mode (inactive).
   - AUTO-FOCUS ON: JESTER will automatically choose what target to focus (select) before being asked to perform a radar lock/track.
   - AUTO FOCUS OFF: JESTER will have to be manually asked to choose what target to focus (select) before being asked to perform a radar lock/track.
3. Selecting "**IFF**" commands JESTER to identify whether a selected radar contact is friendly or foe.
4. From the **BORESIGHT** menu, you can command JESTER to select BST (Boresight) radar mode and tell him what target aspect (Wide, Nose, Forward, Aft or Tail Aspect) to set in order to enable no-lock "flood" shots with the Sparrow.









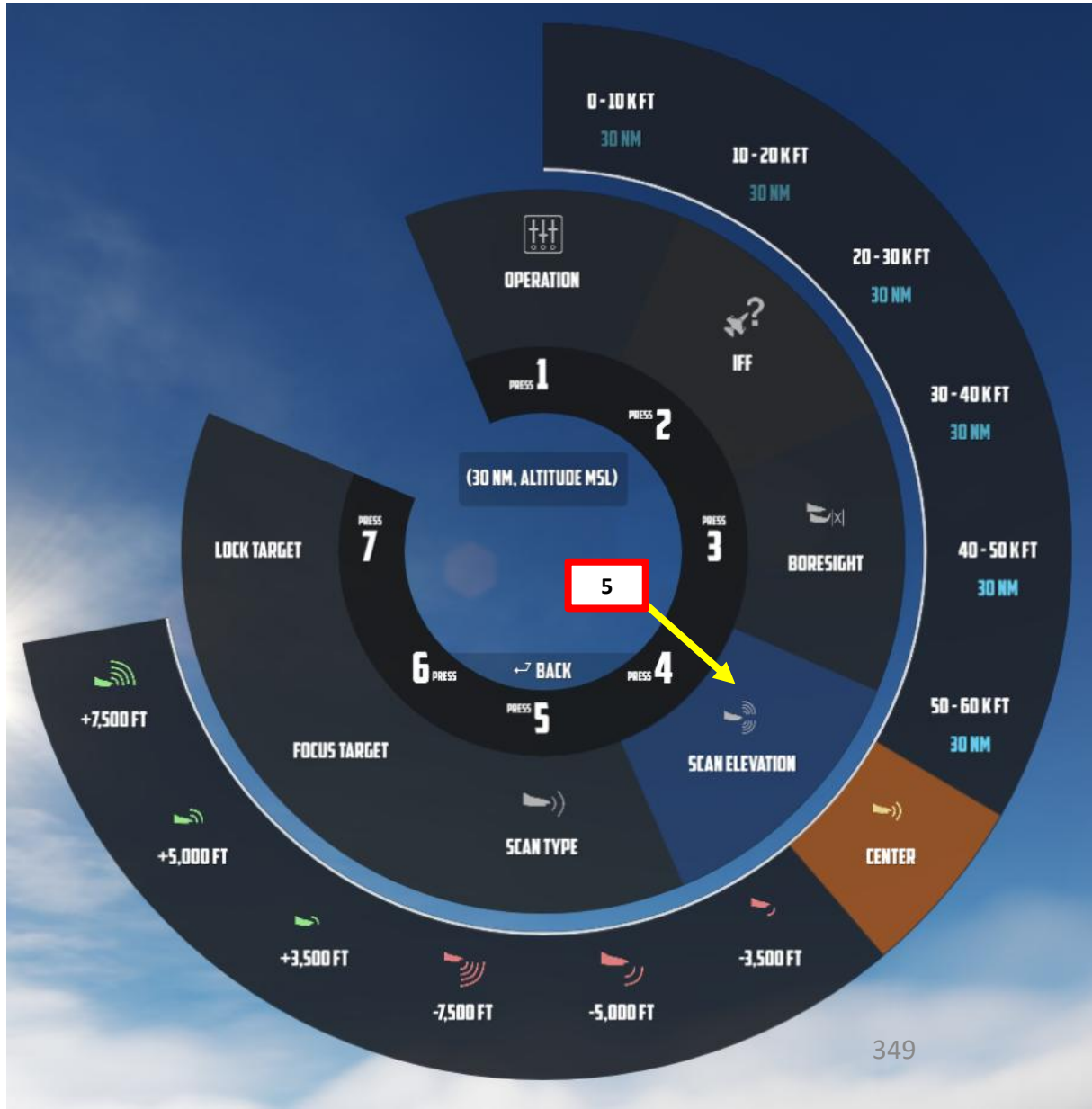
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JESTER User Interface (UI) Functions

To open JESTER AI wheel, short-press “A” (JESTER UI Action binding).

5. From the **SCAN ELEVATION** menu, you can select a number of antenna elevation settings.
6. From the **SCAN TYPE** menu, you can select the display range (distance in nm) settings and Narrow/Wide azimuth coverage settings.



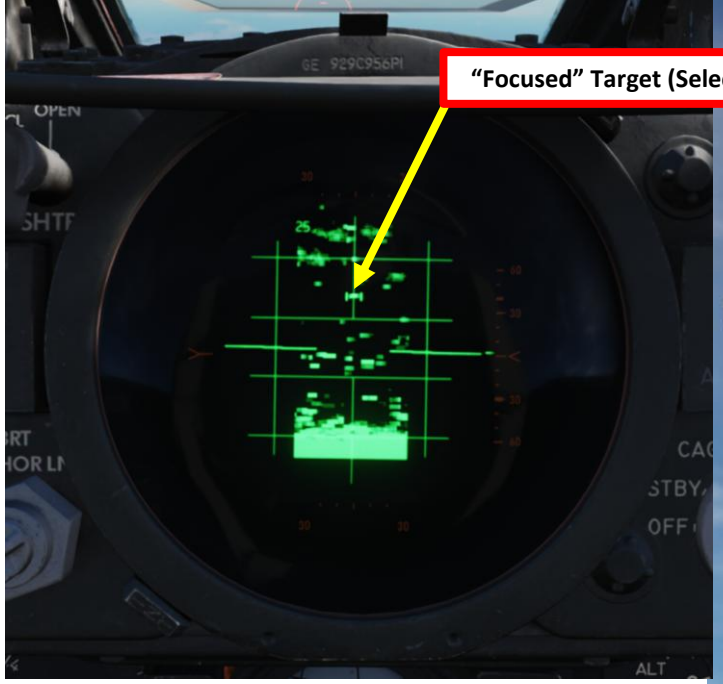


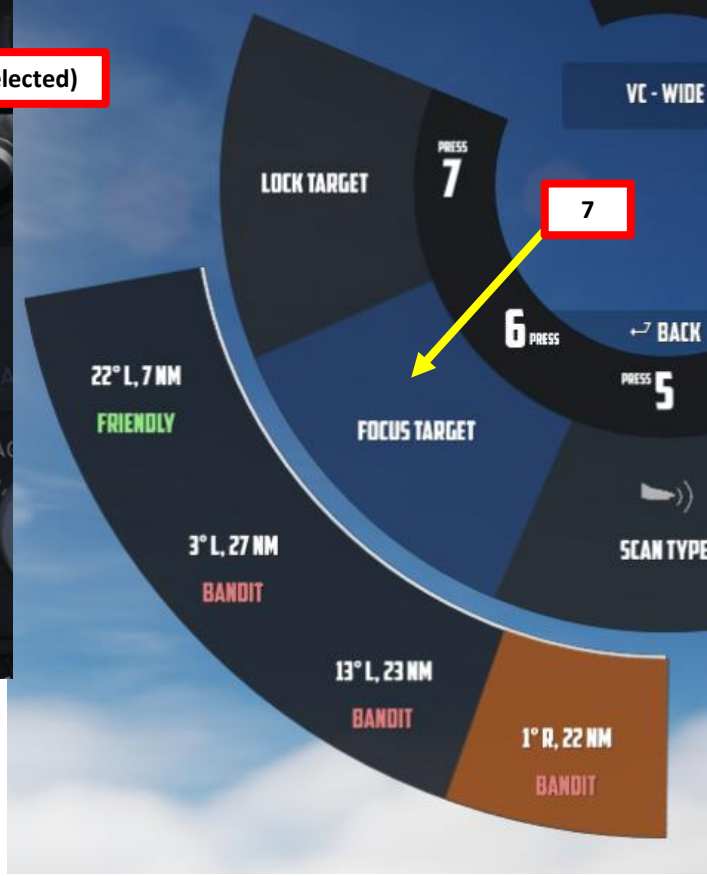
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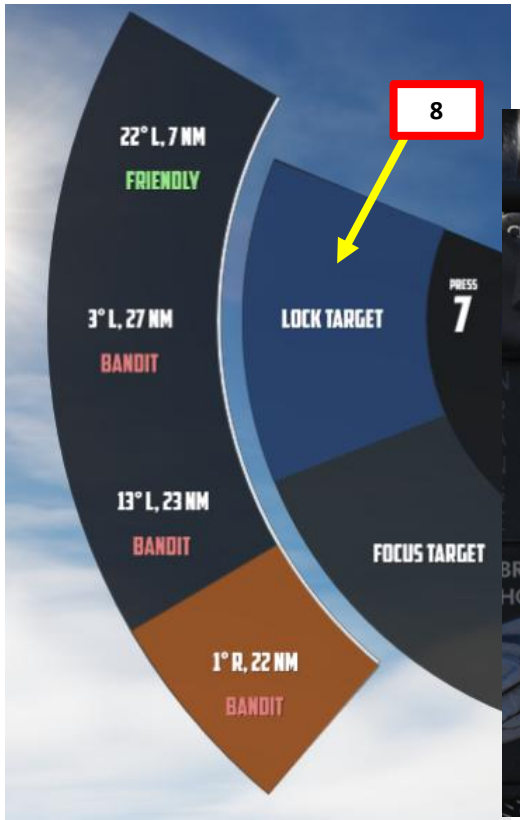
JESTER User Interface (UI) Functions

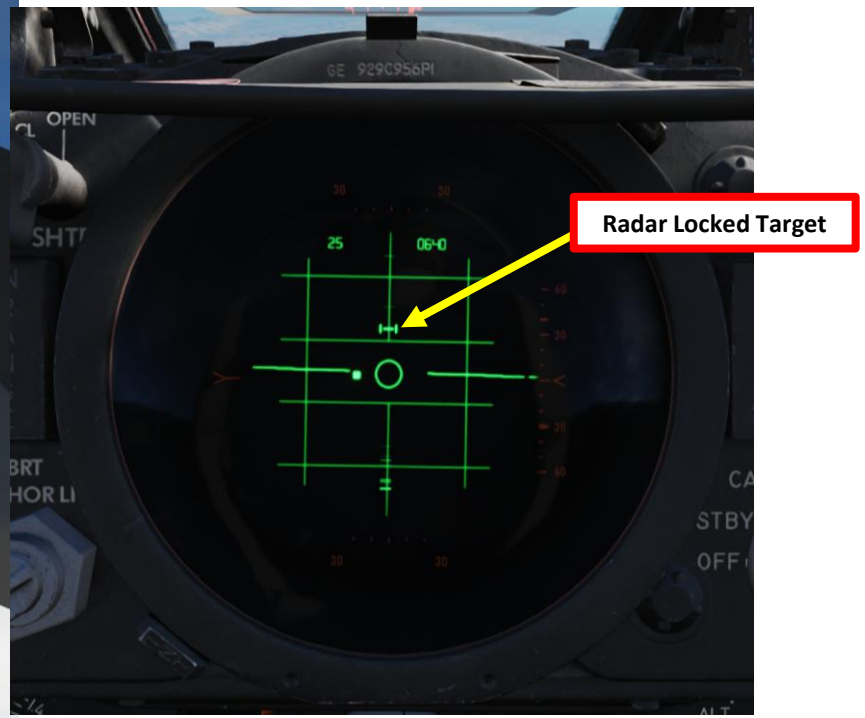
To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).

7. From the **FOCUS TARGET** menu, you can command JESTER to focus on a specific radar contact/target. In this context, "focus" means that JESTER will put the radar cursor on the target but not perform a radar lock/track yet.
    - This is a way for the pilot to tell his WSO what target to keep his attention on since the pilot cannot select targets by himself.
8. From the **LOCK TARGET** menu, you can command JESTER to perform a radar lock/track on the selected/focused radar contact/target.







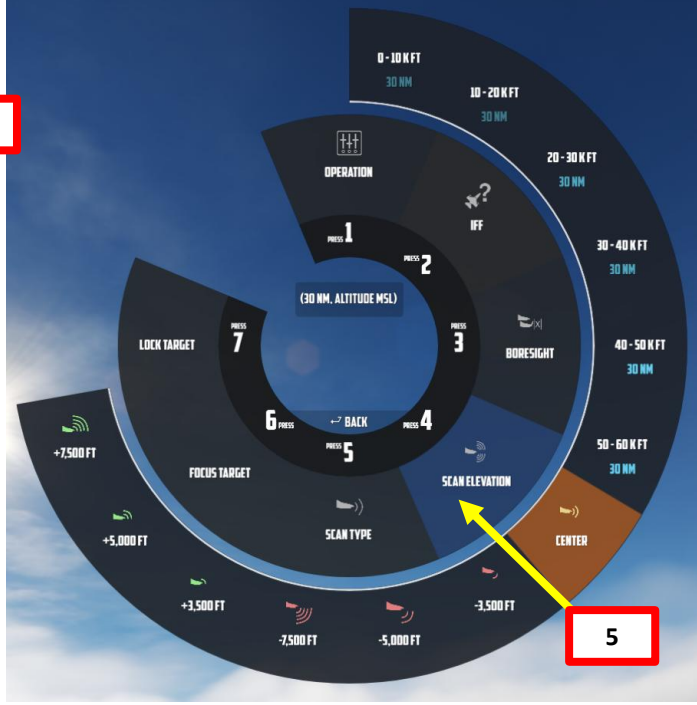


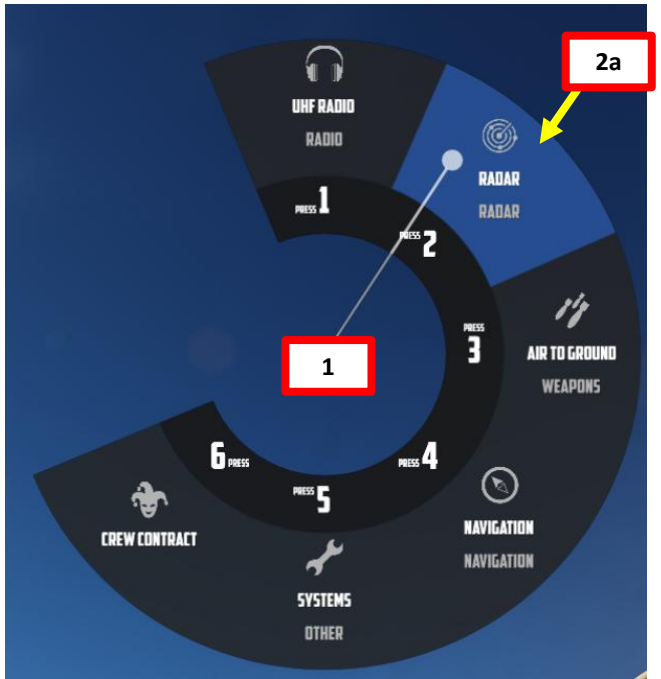
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JESTER AI Demonstration *(BVR, Beyond Visual Range)*

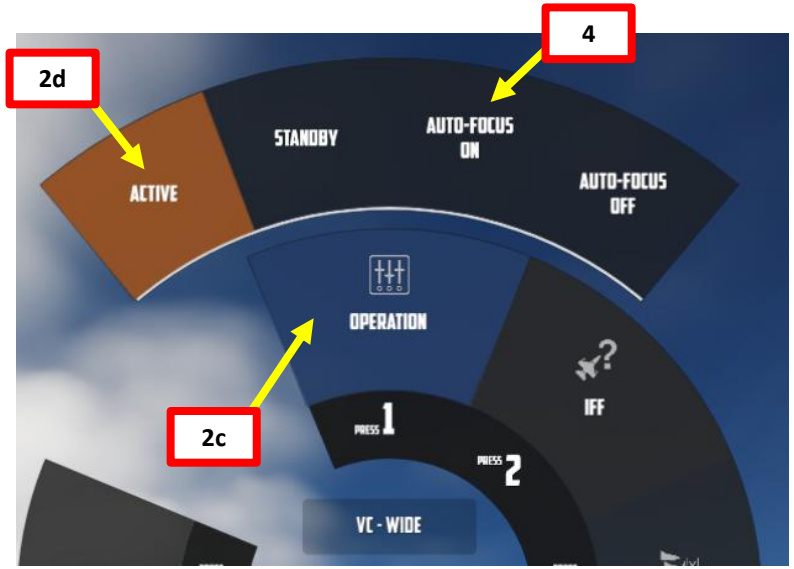
1. *[P]* To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).
2. *[P]* By default, JESTER should already have automatically set the radar to ACTIVE by himself once you are up in the air.
    - In certain situations, such as during landing, on the ground or when performing air-to-air refueling, the radar will be in Standby mode.
3. *[P]* JESTER will start scanning for targets automatically (SCAN/SEARCH Phase). This is the default phase Jester will be in. He will automatically point the antenna at different altitudes and ranges in order to scan the entire space ahead of the aircraft. Jester will automatically identify any new contact and call them out.
4. *[P]* Command Auto-Focus to ON from the OPERATION menu. JESTER will automatically focus on the highest priority target when spotted on the radar scope.
5. *[P]* If desired, use the **SCAN ELEVATION** menu to command specific antenna elevation settings.
6. *[P]* If desired, use the **SCAN TYPE** menu to command a specific display range (distance in nm) setting and Narrow/Wide azimuth coverage setting.







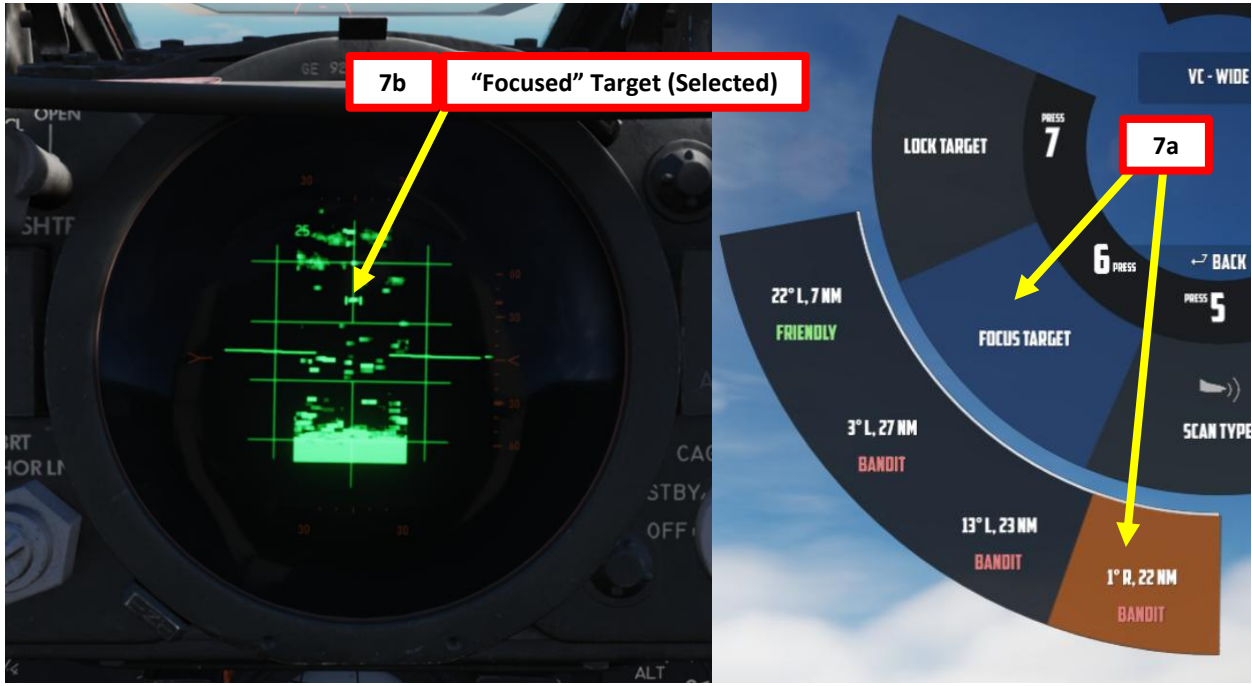


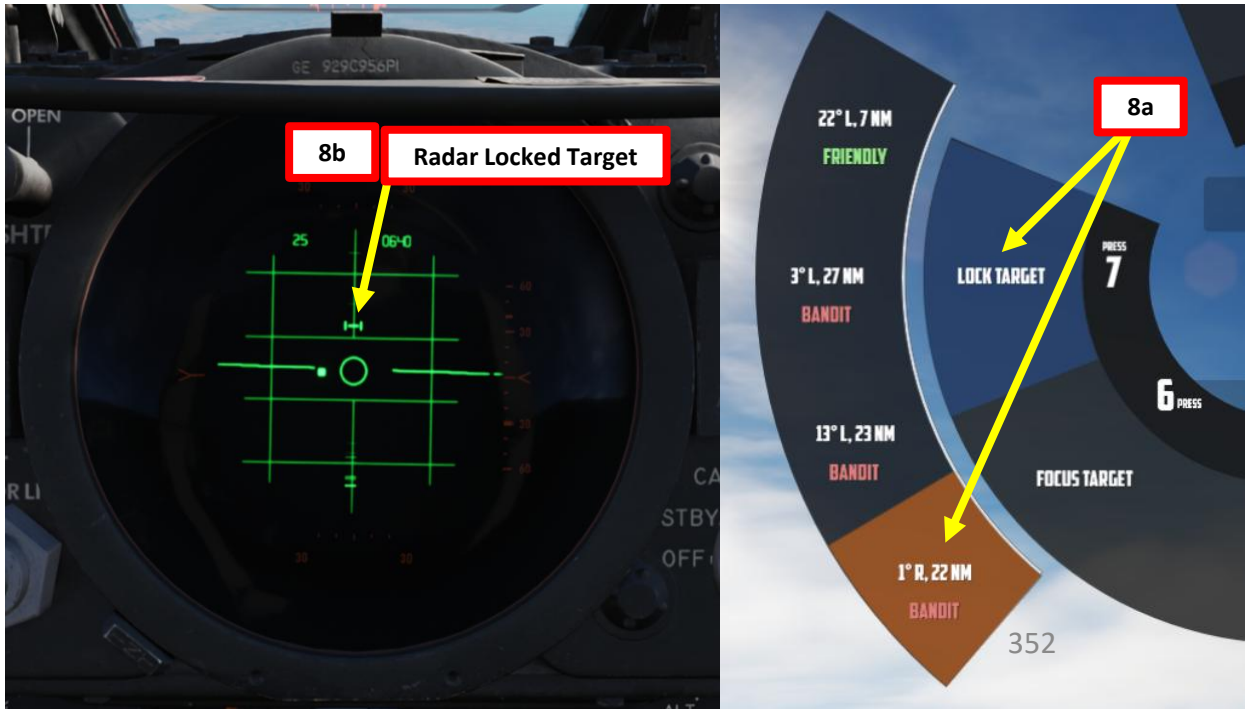


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2.4 – Air-to-Air Operation
2.4.3 – Radar Operation with JESTER AI

JESTER AI Demonstration (BVR, Beyond Visual Range)

7. *[P]* When radar is in the Scan/Search phase, you can command JESTER to focus his attention on a specific target. In other words, "select but without performing a radar lock". You can either use the JESTER UI Menu (which is a bit more cumbersome) or use the quicker JESTER Context Action binding ("V").
    a) From the **JESTER UI ("A")**: Select FOCUS TARGET menu, then select desired target (includes bearing and distance information).
    Or;
    b) Using the **JESTER Context Action binding ("V"):**
        - **Short Press**: Commands JESTER to focus/select the next target visible on the radar scope.
        - **Double-Press**: Resets currently selected target and returns JESTER to his standard behavior of automatically selecting the highest priority threat.
8. *[P]* To command a radar lock/track, you can either use the JESTER UI Menu (which is a bit more cumbersome) or use the quicker JESTER Context Action binding ("V").
    a) From the **JESTER UI ("A")**: Select LOCK TARGET menu, then select desired target (includes bearing and distance information).
    Or;
    b) Using the **JESTER Context Action binding ("V"):**
        - **Long Press**: Commands a radar lock on the target currently selected by JESTER (or the target with the highest priority).
9. *[P]* If desired, you can issue additional commands to JESTER when radar is in the Lock/Track phase, including "radar unlock".
    - Using the **JESTER Context Action binding ("V"):**
        - **Short or Long Press**: Commands JESTER to drop the target's radar lock but keep the target in focus.
        - **Double-Press**: Commands JESTER to drop both the target's radar lock and focus (meaning JESTER will focus his attention on other targets).

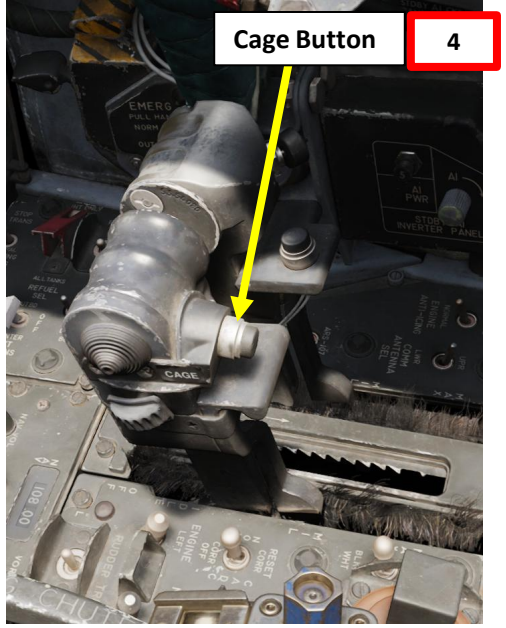


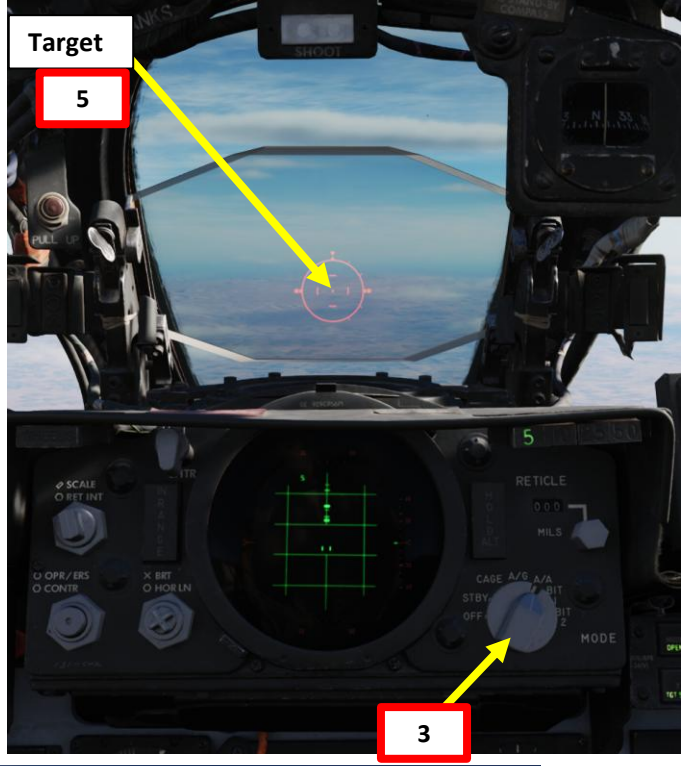


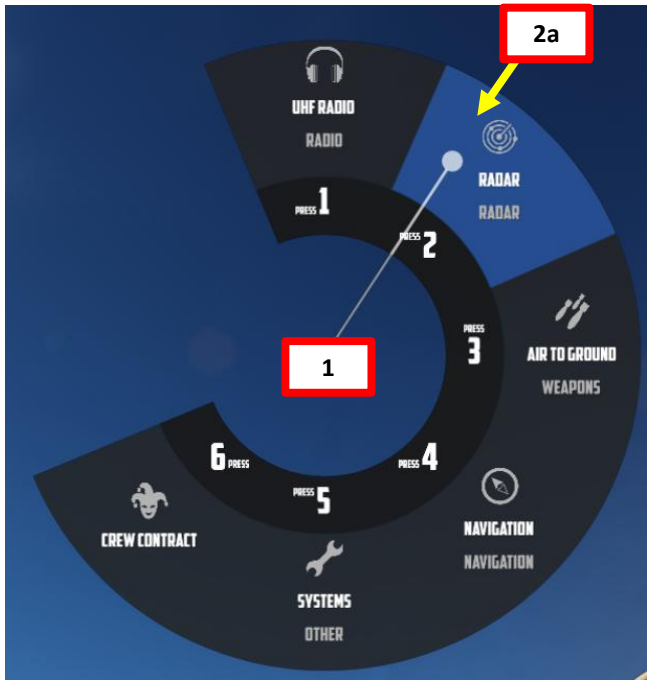
2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.3 – Radar Operation with JESTER AI

JESTER AI Demonstration (ACM, Close-Range)

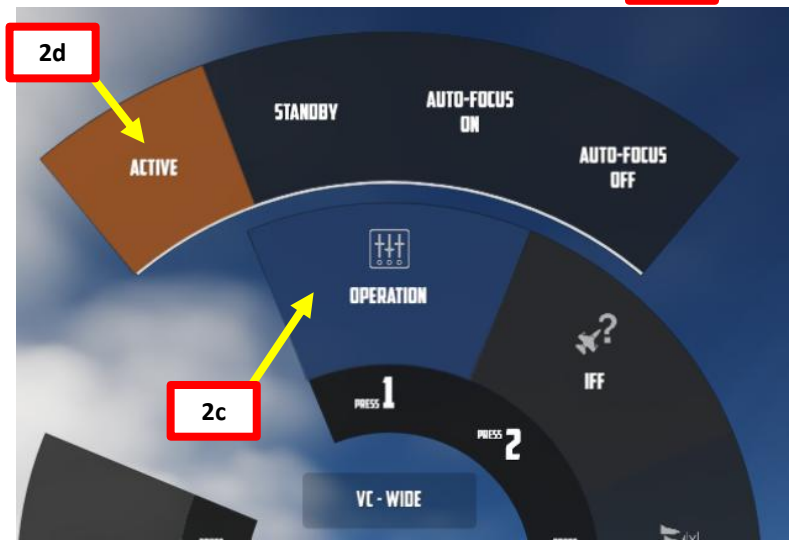
1. *[P]* To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).
2. *[P]* By default, JESTER should already have automatically set the radar to ACTIVE by himself once you are up in the air.
    - In certain situations, such as during landing, on the ground or when performing air-to-air refueling, the radar will be in Standby mode.
3. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
4. *[P]* Select **Cage Mode** by depressing the Cage button on the pilot's throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.
5. *[P]* Visually line up the optical sight near the target.







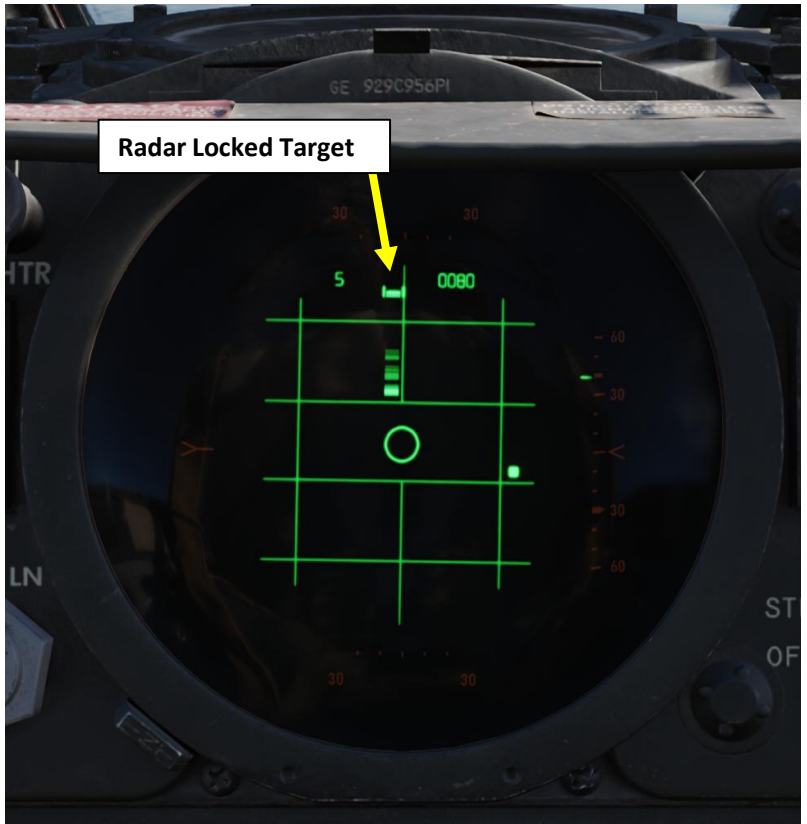


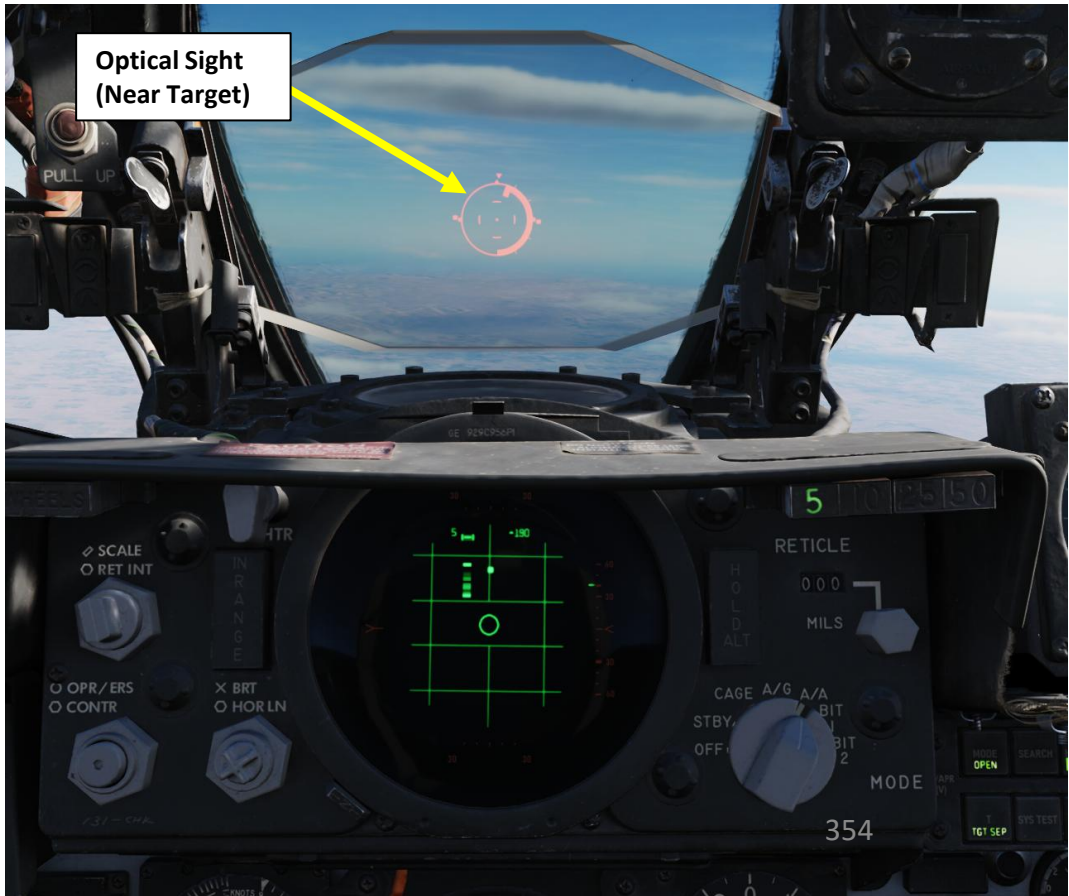


2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.3 – Radar Operation with JESTER AI

JESTER AI Demonstration (ACM, Close-Range)

6. *[P]* To command a radar lock/track from JESTER while in Cage Mode, use the JESTER Context Action binding (“V”).
    - Use the **JESTER Context Action binding (“V”):**
        - **Long Press**: Commands JESTER to radar lock (or unlock) the closest target (radar contact) ahead. Targets have to be within 5 degrees of his boresight or a lock attempt can result in a bad lock. JESTER expects the pilot to place the target within that zone first before being asked to perform the lock
7. *[P]* If desired, you can issue additional commands to JESTER when radar is in the Lock/Track phase, including “radar unlock”.
    - Using the **JESTER Context Action binding (“V”):**
        - **Short Press:** Commands JESTER to select Next Target Aspect (in case you want to enable no-lock "flood" shots with the Sparrow).
        - **Long Press**: Commands JESTER to unlock target (if locked).
        - **Double-Press**: Commands JESTER to exit CAGE or BORESIGHT Mode.





2 – AN/APQ-120 FIRE CONTROL RADAR
2.4 – Air-to-Air Operation
2.4.4 – External Resources

While the Heatblur Simulations wiki is a great resource for the basics of radar operation, there is also another **amazing** resource from **FlyAndWire**, which I highly recommend when it comes to understanding various radar-related topics.

Phantom Phamiliarisation Series
- Radar Basics & Controls: https://flyandwire.com/2023/07/23/radar-basics-controls-phantom-phamiliarisation/
- Radar Quirks & Features: https://flyandwire.com/2023/08/03/radar-quirks-features-phantom-phamiliarisation/
- F-4E Air-to-Air Intercepts – Theory: https://flyandwire.com/2023/08/17/f-4e-air-to-air-intercepts-theory-phantom-phamiliarisation-vi/
- F-4E Air-to-Air Intercepts – Practice: https://flyandwire.com/2023/08/31/f-4e-air-to-air-intercepts-practice-phantom-phamiliarisation-vii/

F-4E AN/APQ-120 Series
- Elevation, Range, Azimuth: https://flyandwire.com/2024/05/16/f-4e-apq-120-elevation-range-azimuth/
- Radar Cross-Section (RCS) and Detection Range: https://flyandwire.com/2024/05/20/f-4e-apq-120-radar-cross-section-rcs-and-detection-range/
- Jamming Effects: https://flyandwire.com/2024/05/21/dcs-f-4e-apq-120-jamming-effects/
- Chaff Effects: https://flyandwire.com/2024/05/23/dcs-f-4e-apq-120-chaff-effects/

F-4E Avionics Applications & Weapons Series
- Boresight Mode, AIM-7 and Speedgates: https://flyandwire.com/2024/05/27/f-4e-boresight-mode-aim-7-and-speedgates/
- Manual Tracking and AIM-7: https://flyandwire.com/2024/06/01/f-4e-manual-tracking-and-aim-7-sparrow/
- F-4E: Stop struggling in Air-to-Air: https://flyandwire.com/2024/06/10/f-4e-stop-struggling-in-air-to-air/

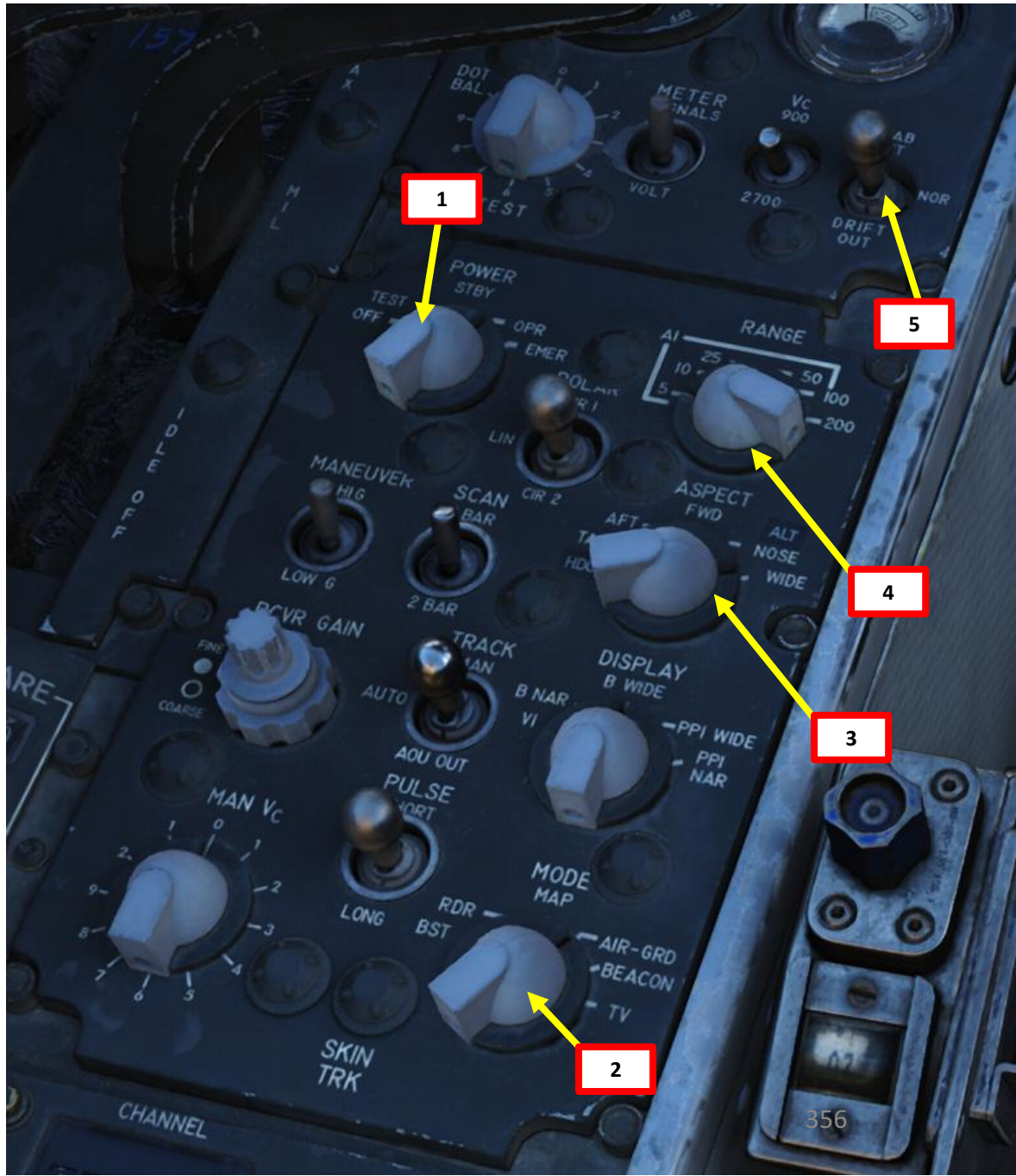
F-4E Air-to-Air Tactics Series
- First Steps: https://flyandwire.com/2024/05/18/f-4e-air-to-air-i-first-steps/
- Aim Dot Intercepts: https://flyandwire.com/2024/05/22/f-4e-air-to-air-ii-aim-dot-intercepts/
- VISIDENT Mode: https://flyandwire.com/2024/05/24/f-4e-air-to-air-iii-visident/
- SYNC-Z-TURN Intercept Technique: https://flyandwire.com/2024/08/02/f-4e-air-to-air-v-sync-z-turn-essential/
- Assess CATA (Collision Antenna Train Angle) & Bandit Heading: https://flyandwire.com/2024/09/04/f-4e-air-to-air-vi-assess-cata-bandit-heading-essential/
- “40 deg Cold of CATA” Intercept Technique: https://flyandwire.com/2024/09/18/f-4e-air-to-air-vii-40-cold-of-cata-intercept-technique/

2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.1 – Air-to-Ground Radar Ranging

It is possible to use the radar for air-to-ground ranging by using the AIR-GRD Mode. This functionality, which is only available if a distance setting of 5 or 10 nm is selected, is used by the WRCS (Weapon Release Computer Set) for Dive Toss bombing. This ranging information can be used by the pilot to know when to release a bomb if a specific profile is required.

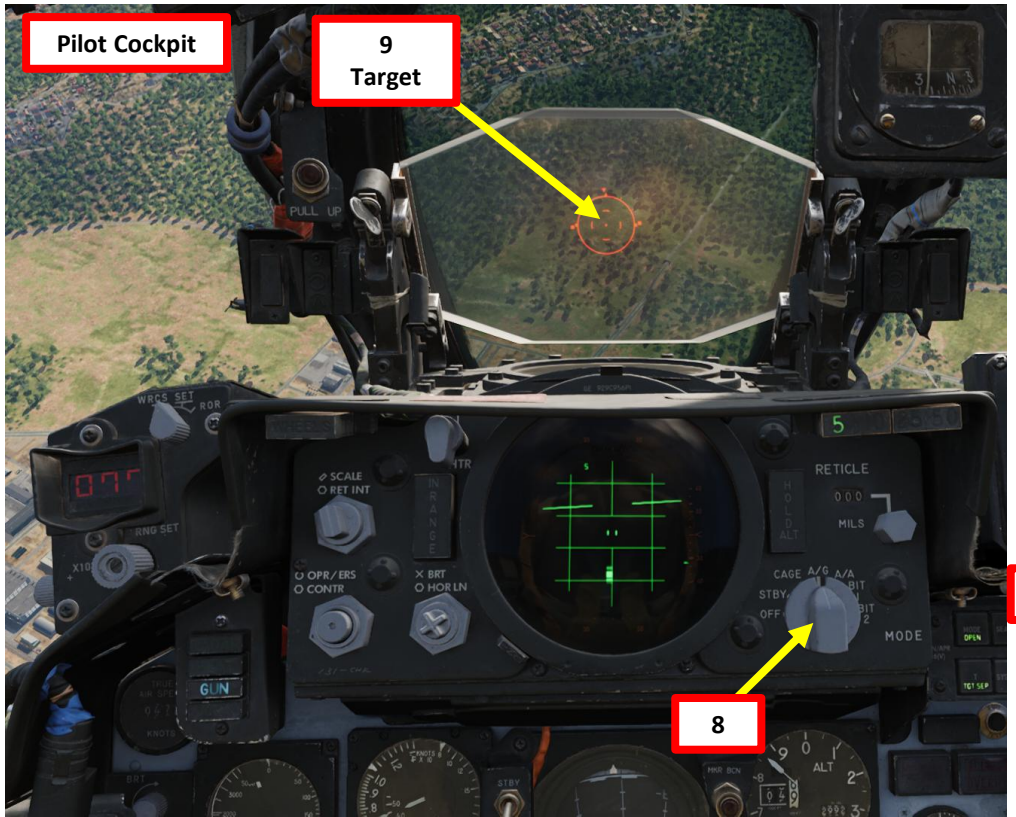
Here is an example about how to perform air-to-ground ranging.

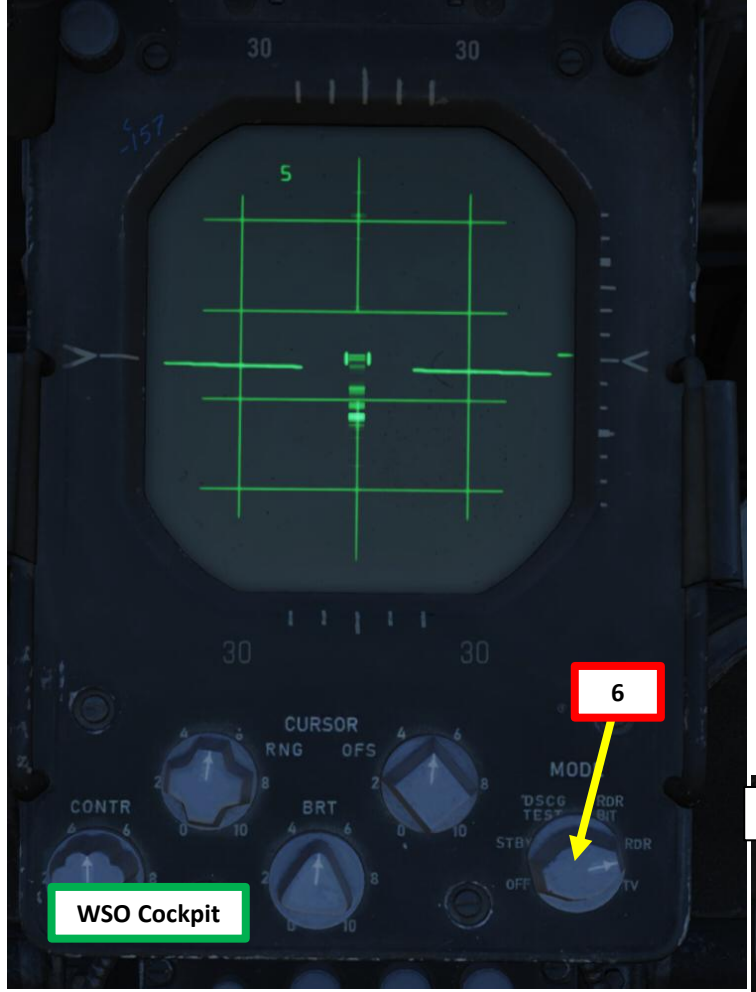
1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[WSO]* Set Radar Operation Mode – AIR-GRD (Air-to-Ground).
    - In this mode, the radar antenna is fixed to the radar boresight while also being stabilized in drift. AIR-GRD mode disables Angle Track operation and only uses Range Track. Once locked on the main lobe clutter (ground radar echo), it will be tracked in range.
3. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE.
4. *[WSO]* Set Radar Range Selector – 5 nm or 10 nm settings only. In this example, we will select 5 nm.
5. *[WSO]* Set Stab (Antenna Stabilization Mode) Switch – NORMAL (MIDDLE)
    - In case of an INS (Inertial Navigation System) failure, you can remove the drift correction by setting the Stab Switch to DRIFT OUT (AFT).

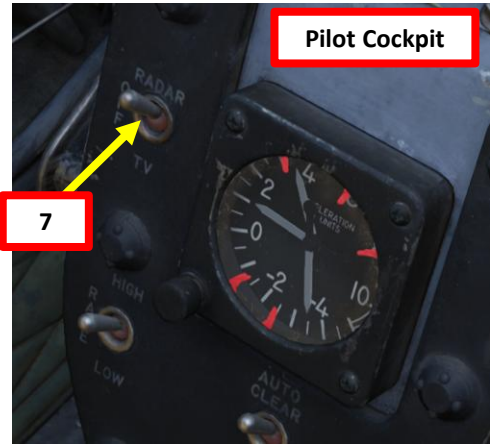


2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.1 – Air-to-Ground Radar Ranging

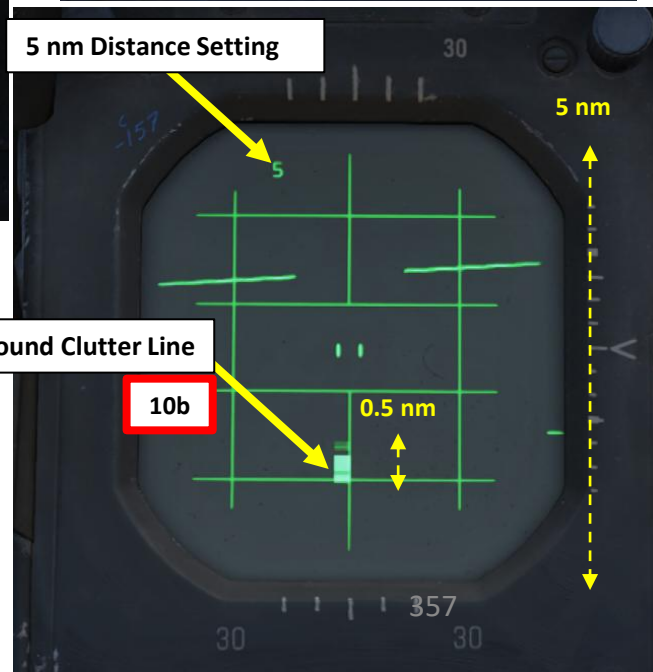
6. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
7. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Once the target has been identified, the pilot should make a 10 to 40-degree dive towards the target.
10. *[WSO]* Adjust receiver gain to reduce clutter signal to 0.5 nm. This is done to prevent erroneous track of sidelobes which would result in incorrect ranging information.
    - In this example, we have a distance setting of 5 nm, therefore the ground clutter "line" should be as shown.









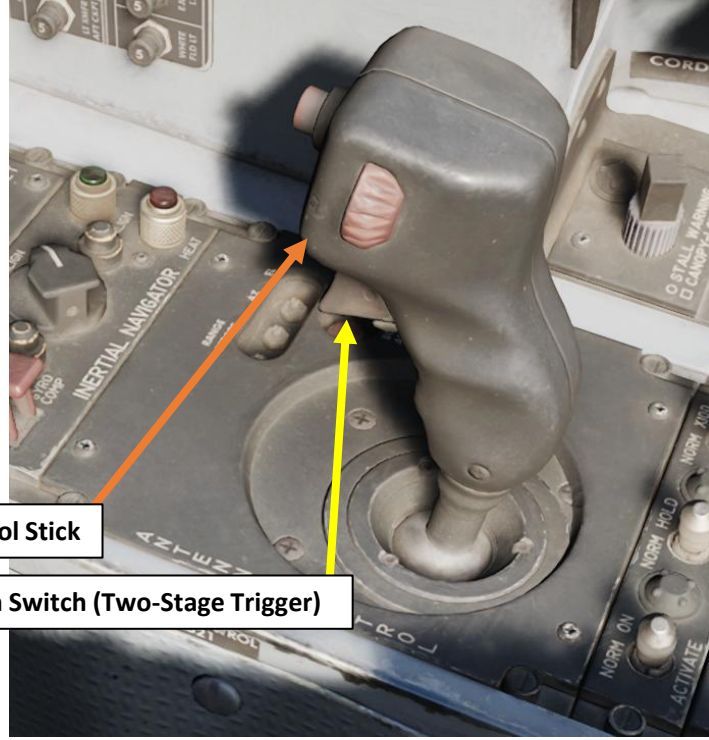


2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.1 – Air-to-Ground Radar Ranging

11. *[WSO]* Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the center of the ground clutter signal.
12. *[WSO]* Once the radar cursor is slewed over the ground clutter, press the Hand Control Stick Trigger's second detent (Full-Action). Release once the ASE (Allowable Steering Error) Circle becomes visible.
13. *[WSO]* Confirm radar lock-on.
    - Note: The radar can track ground clutter from beyond 25000 ft.

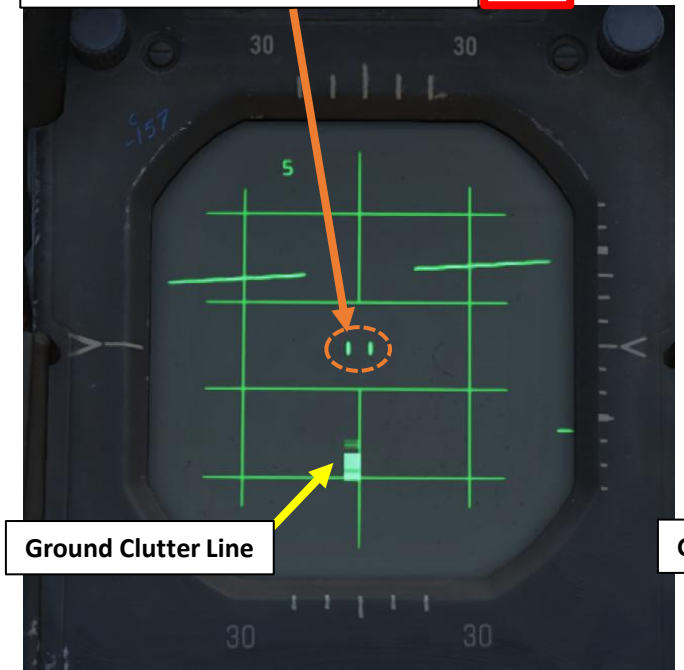


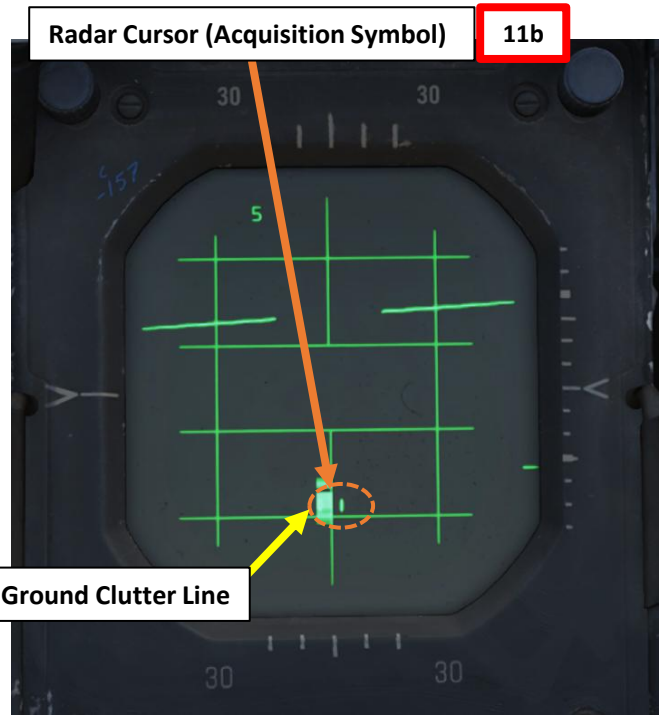
13 SKIN TRK Light

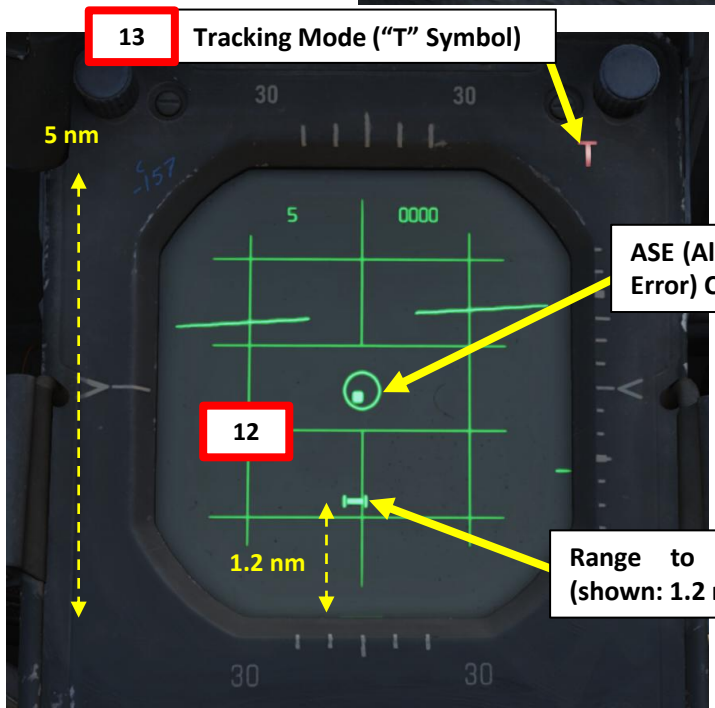


11b Antenna Hand Control Stick

12 Action Switch (Two-Stage Trigger)

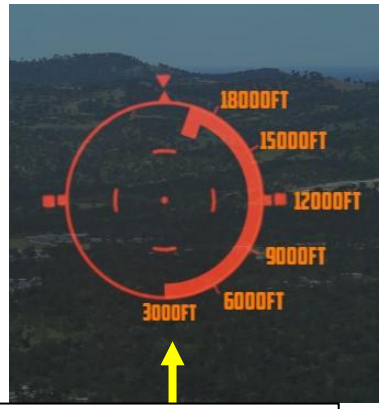






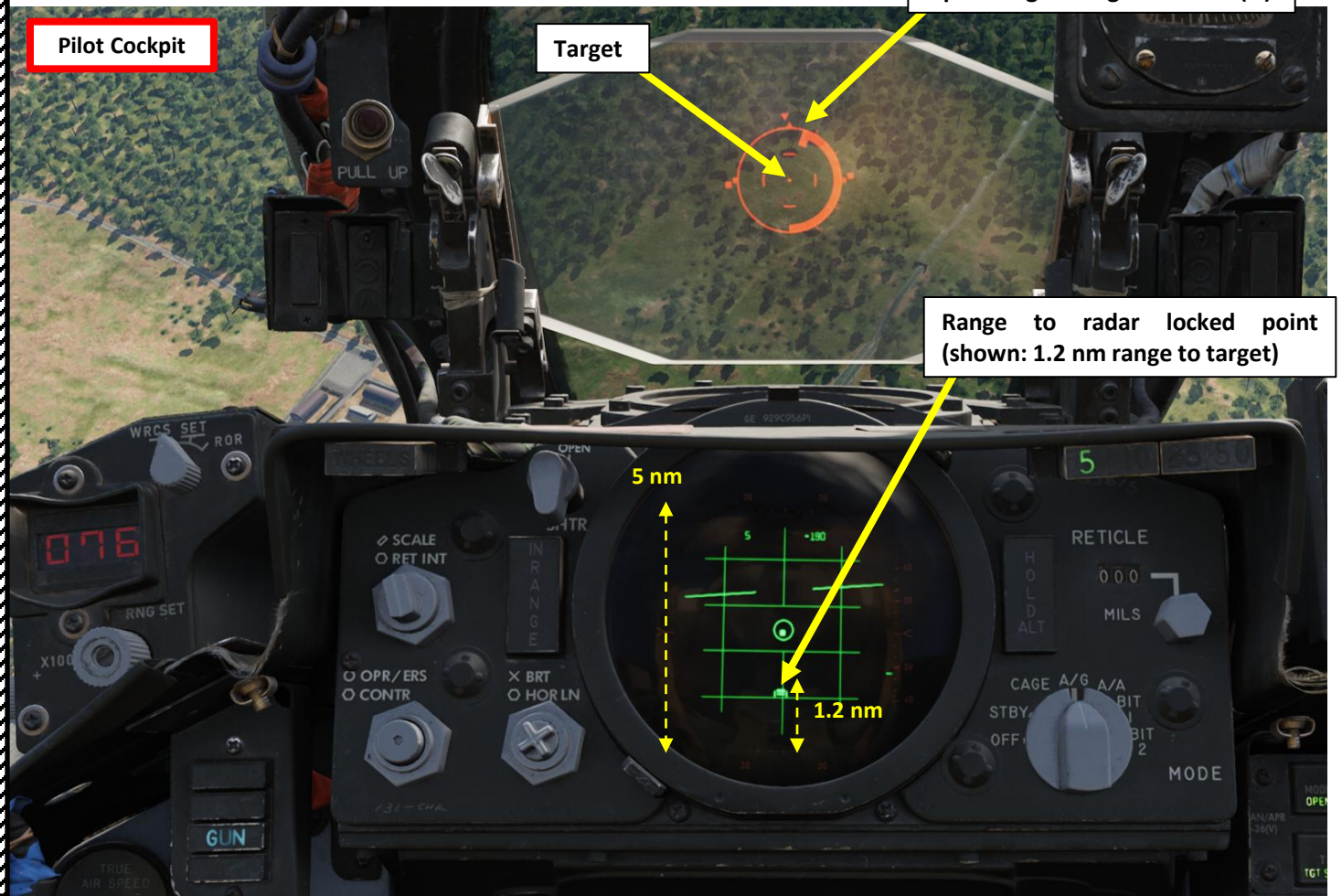
2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.1 – Air-to-Ground Radar Ranging

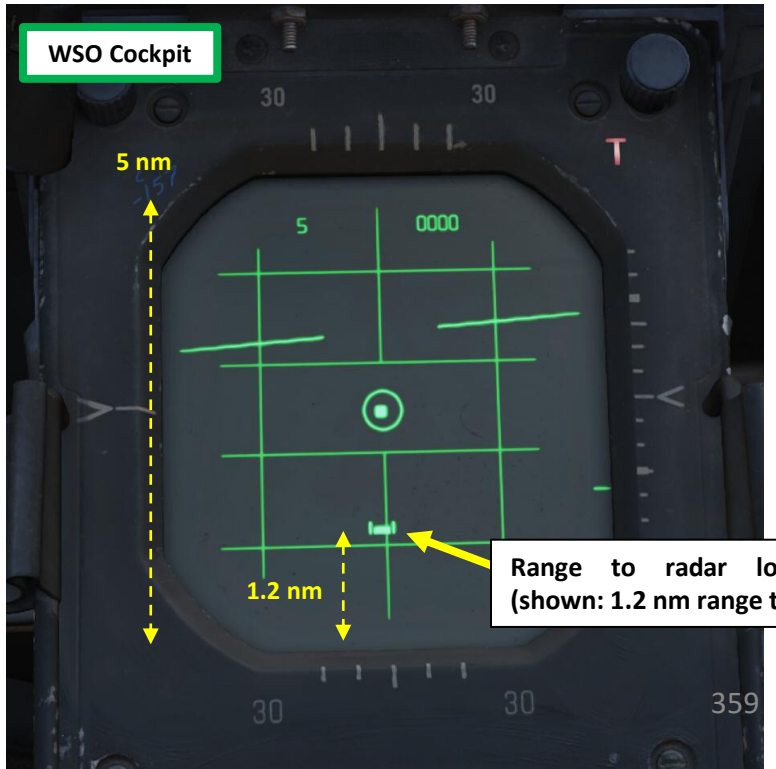
14. Range is now provided by the radar on the radar scope and on the optical sight as well.
15. Sometimes, false tracking can occur, which is indicated by a rapid decrease in slant range displayed on either the pilot's optical sight or the radar display. To correct this condition the following actions can be taken:
    a) Press Action Switch to half action, then release.
    b) Begin acquisition process again.



Optical Sight Range Indicator (ft)



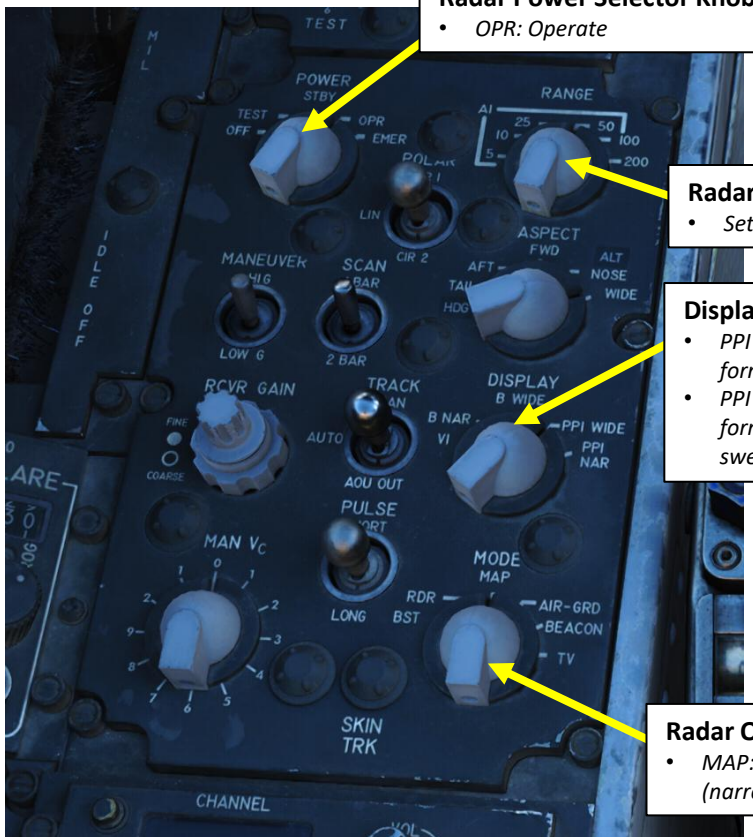




2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

The Map PPI (Plan-Position Indicator) mode is a display which shows radar returns plotted with their real position relative to the aircraft. The aircraft position is at the bottom center of the display, lines parallel to the vertical axis of the display are parallel to the aircraft track. Lines parallel to the horizontal axis of the display are offset from the track up to a maximum of half the current display range.

PPI Mode can be accessed by changing the **Display Knob** into **PPI-WIDE** or **PPI-NAR** (with the exception of **the 5 nm Distance Setting** which is always displayed in B-Scope interpretation).



Radar Power Selector Knob
- *OPR: Operate*

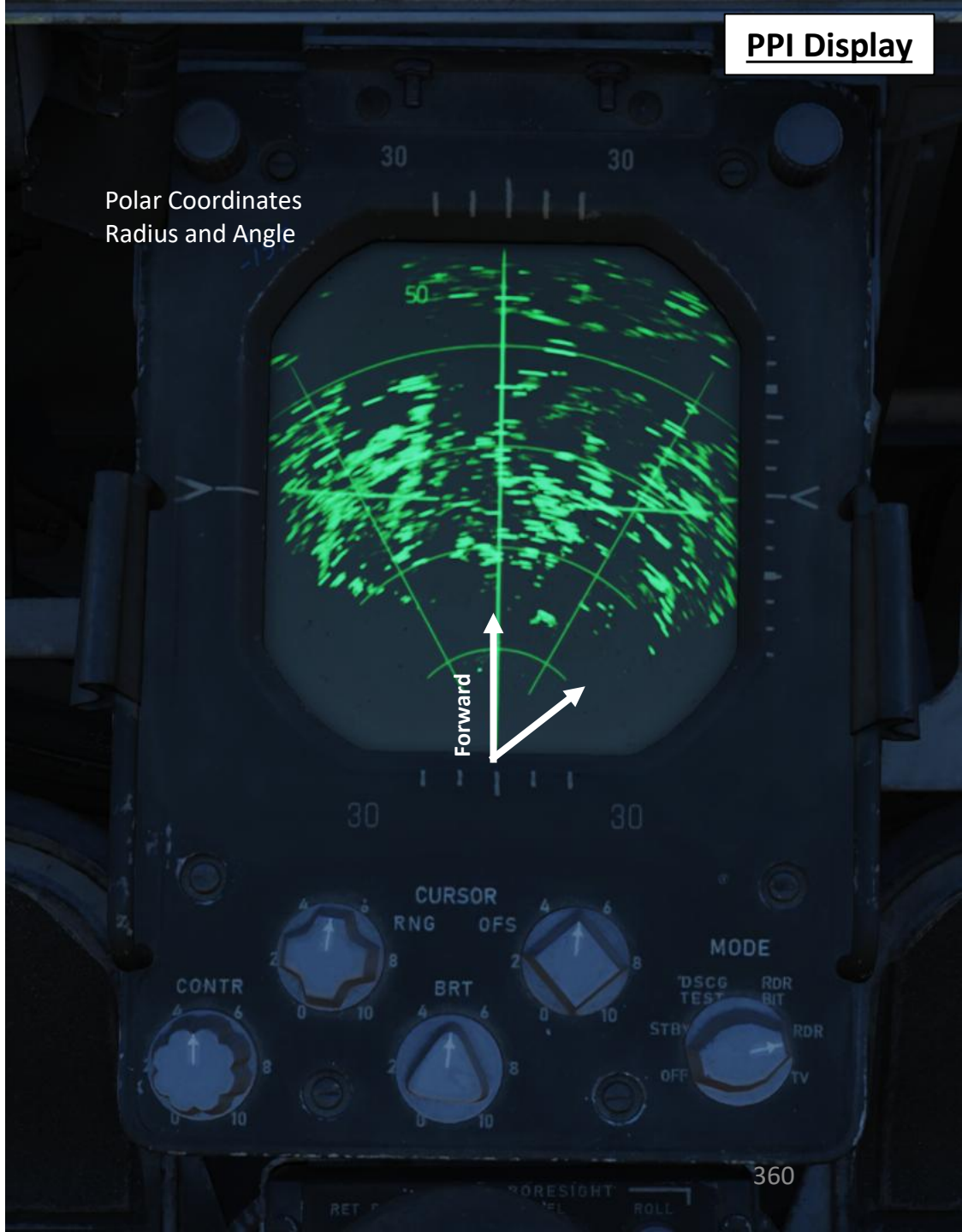
Radar Range Selector Knob
- *Set to either 10, 25, 50, 100 or 200 nm*

Display Selector
- *PPI WIDE: Plan Position Indicator (PPI) display format with Wide Sweep Setting (120 deg sweep).*
- *PPI NAR: Plan Position Indicator (PPI) display format with Narrow Sweep Setting (45 deg sweep).*

Radar Operation Mode Selector
- *MAP: Search Mode without Feedhorn Nutation (narrower beam-width)*

PPI Display

Polar Coordinates
Radius and Angle



2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

In other words, MAP PPI mode is a raster scan of terrain ahead of the aircraft. Image intensity is a function of the strength of a radar return. Certain ground features will have higher intensity (e.g., buildings or vehicles) and others will have lower intensity (e.g., water). Terrain or tall structures will impede the radar beam from traveling further, creating distinctive shadows, giving the resulting image the appearance of an elevation relief map. Radar gain can be tuned using the Gain Knobs.

Receiver Gain Knobs
- *INNER KNOB: Fine Gain Tuning*
- *OUTER KNOB: Coarse Gain Tuning*

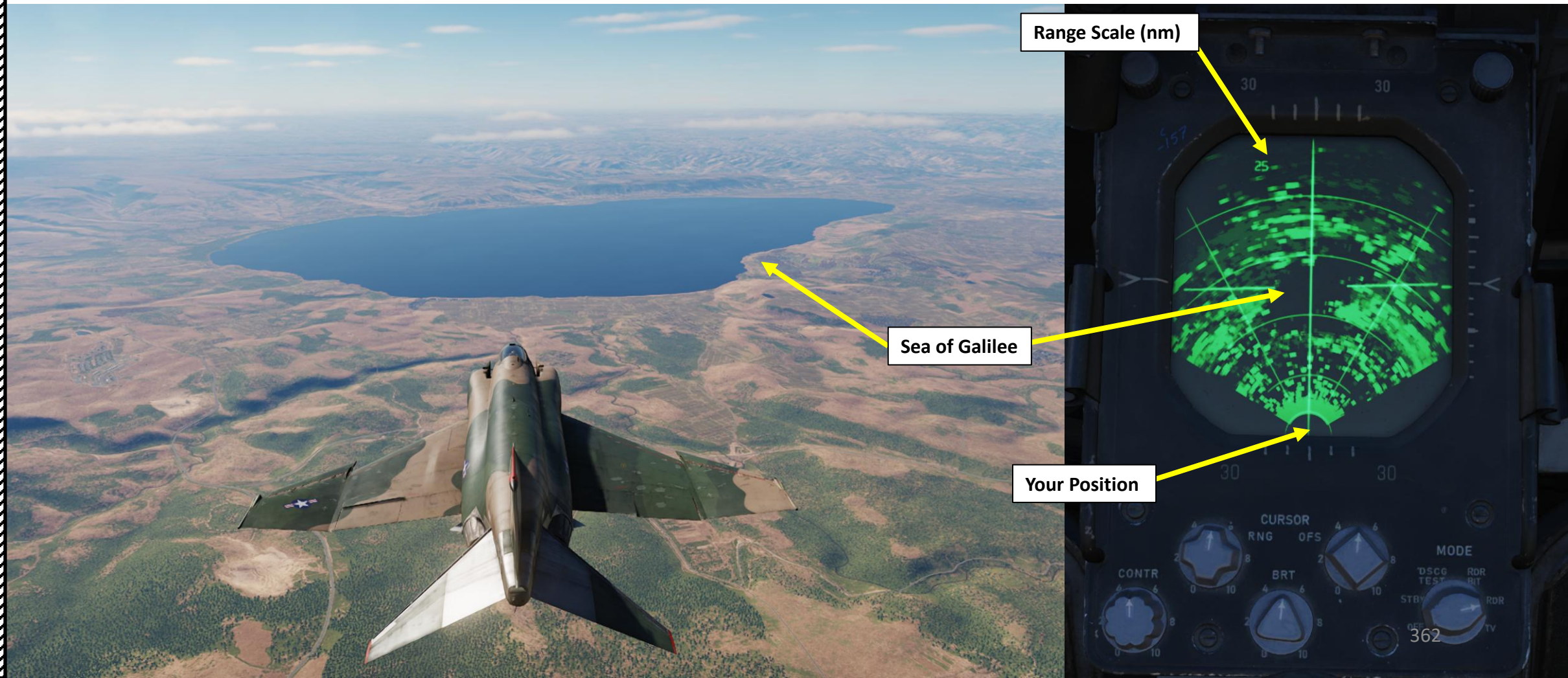






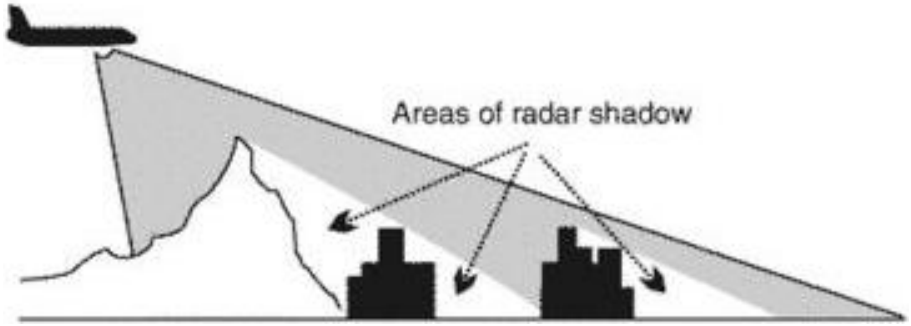
2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

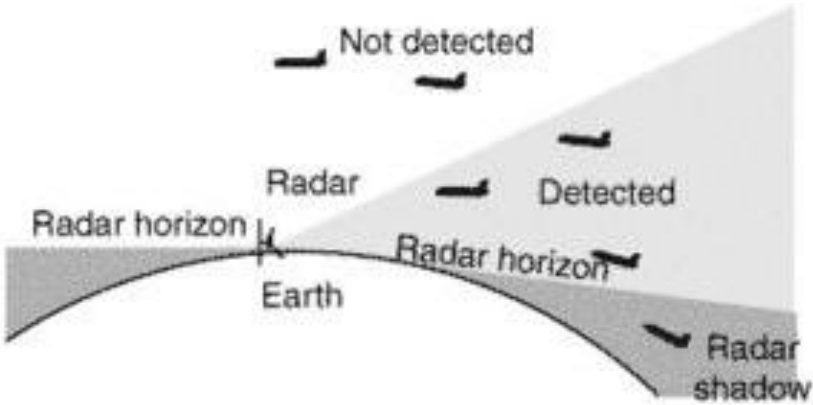
Regions that do not provide radar returns are black (such as water). The bright/green regions are generally man-made structures (buildings, power lines, roads, etc.) or mountains.



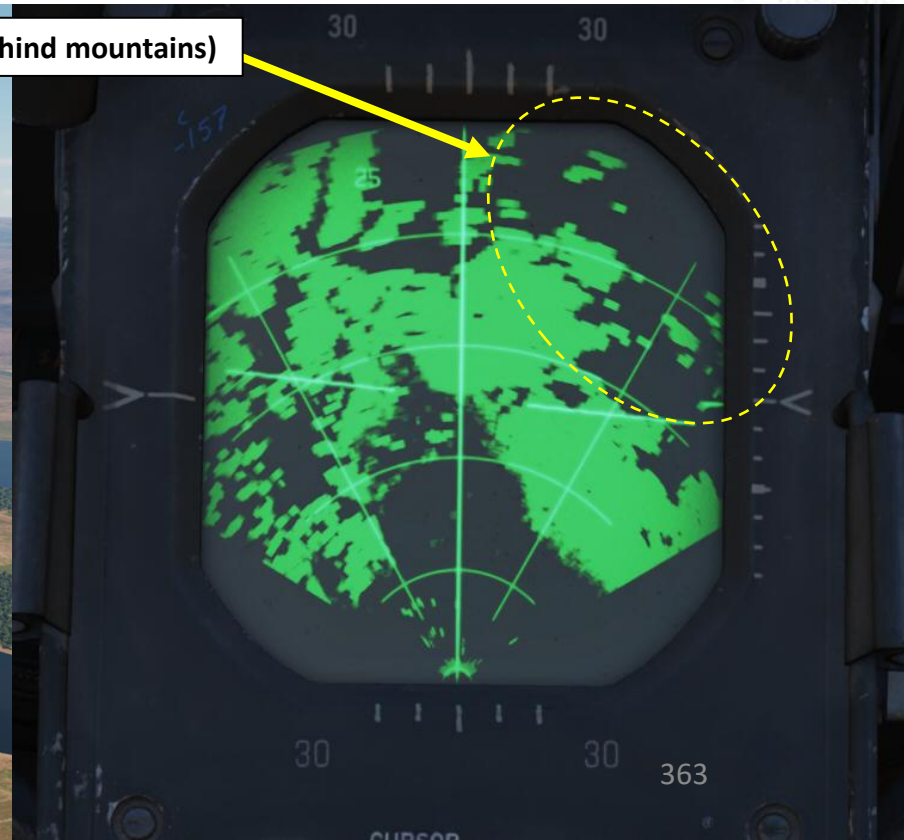
2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

Some of the black areas on the scope are part of the radar shadow, which are regions behind hills or mountains that the radar cannot see behind.









2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

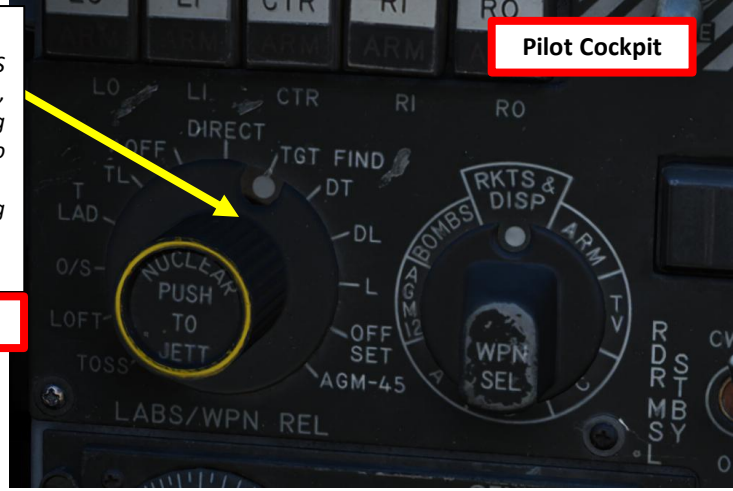
To designate a target in Map PPI Mode with the air-to-ground radar:

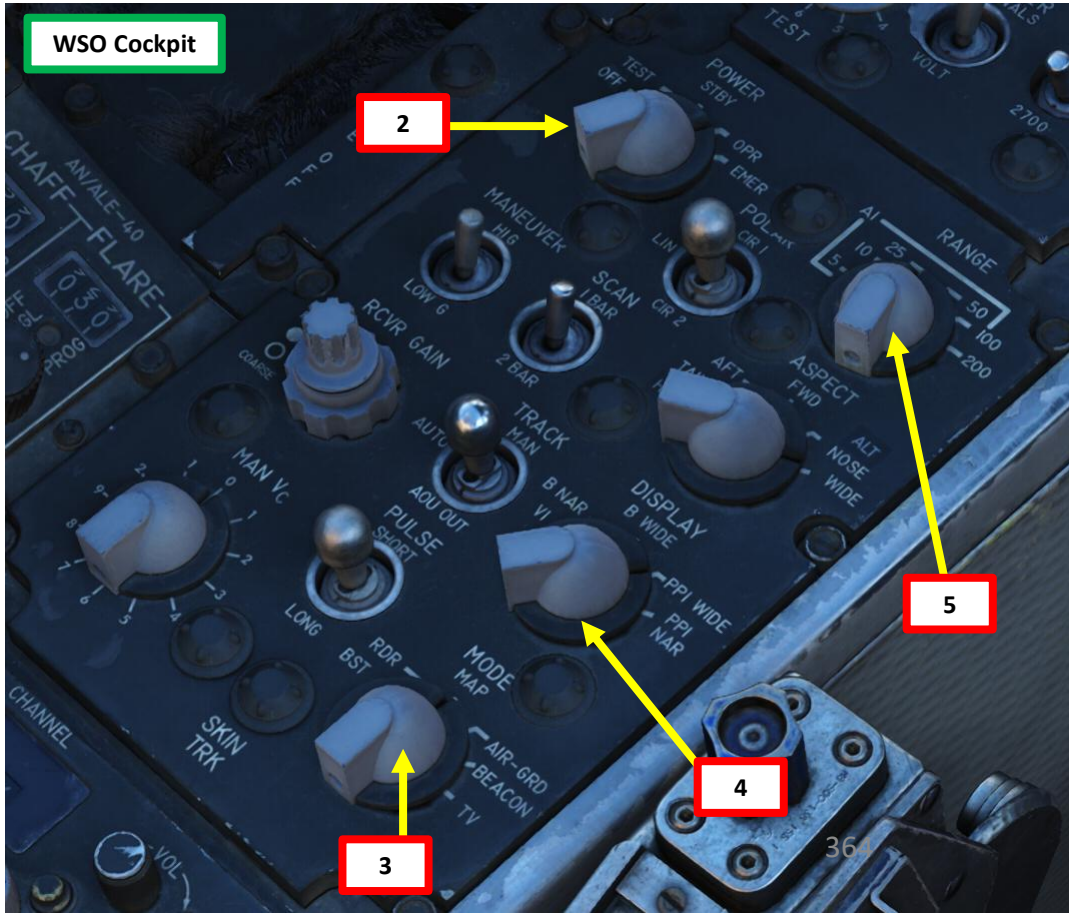
1. *[P]* Select Air-to-Ground Weapon Delivery Mode Knob – TGT FIND (Target Find) or OFF SET (Offset bombing).
2. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
3. *[WSO]* Set Radar Operation Mode – MAP
4. *[WSO]* Set Display Selector – PPI NAR (Narrow) or PPI WIDE.
5. *[WSO]* Set Radar Range Selector – As desired.
    - Take note that **the 5 nm Distance Setting** is always displayed in B-Scope interpretation.

Air-to-Ground Weapon Delivery Mode Knob

Split into two halves, the left side of the dial references ARBCS (Attitude Reference and Bombing Computer Set) delivery modes, while the right side provides automated release functions using the WRCS (Weapon Release Computer Set) with possible tie-in to the navigation computer, depending on mode.

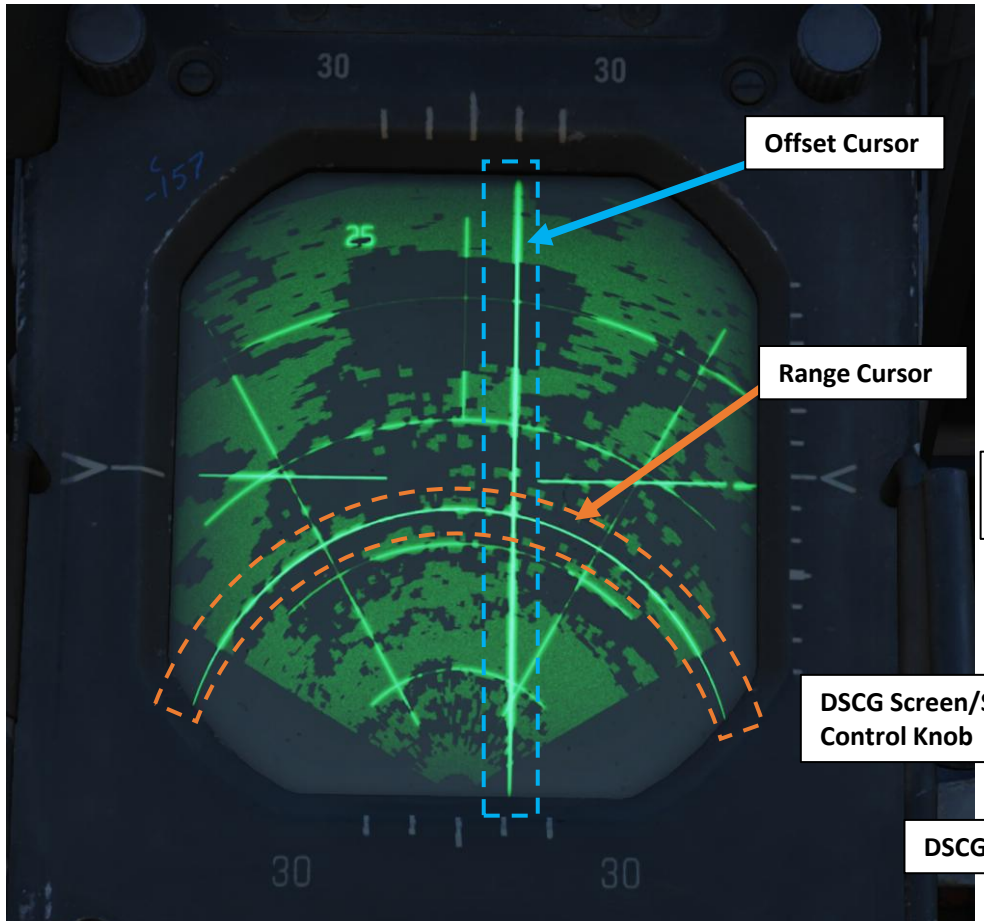
- *TGT FIND: Target Find (Nav Mode and Pave Spike Targeting Pod bombing only)*
- *OFF SET: Offset Bombing*

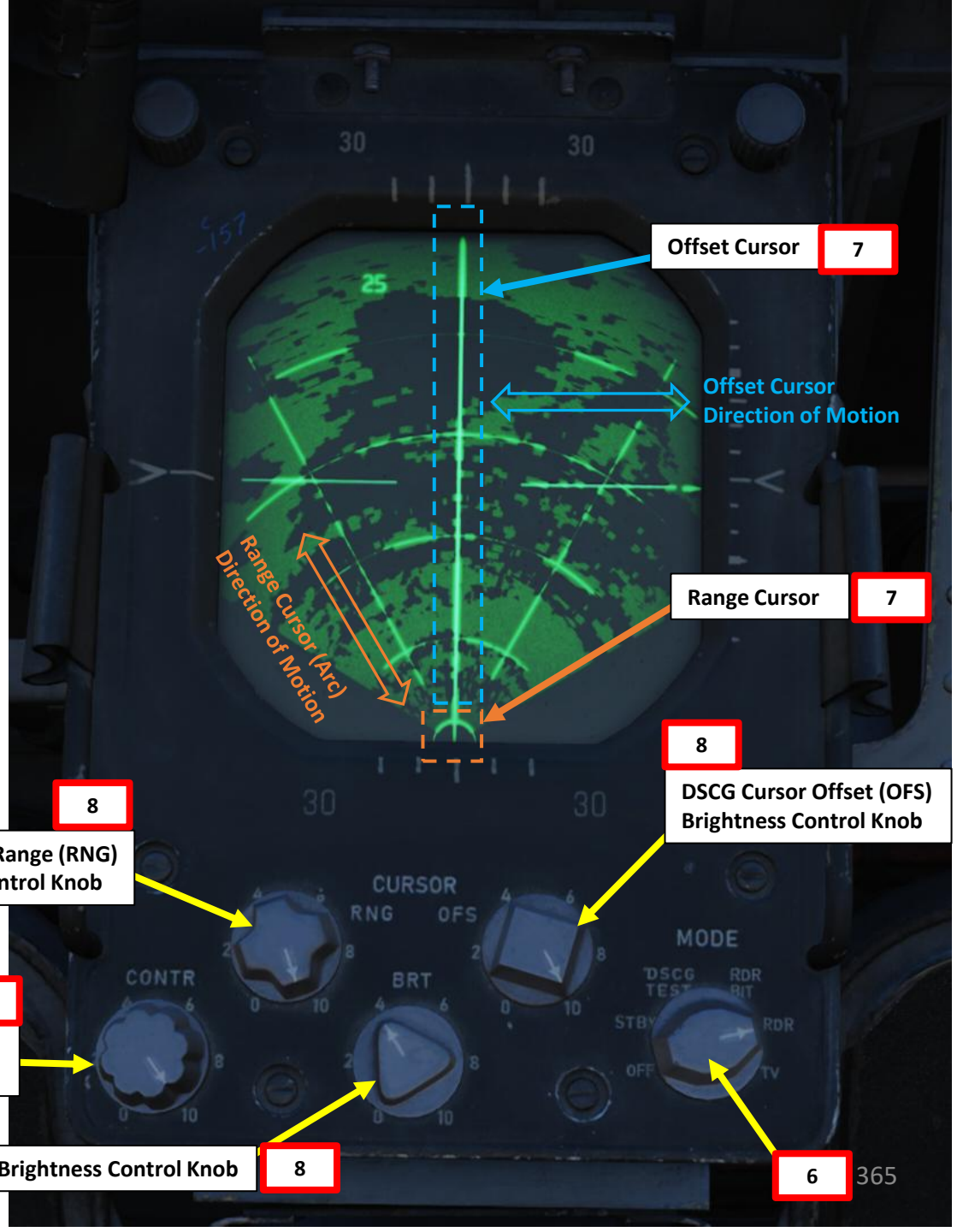




2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

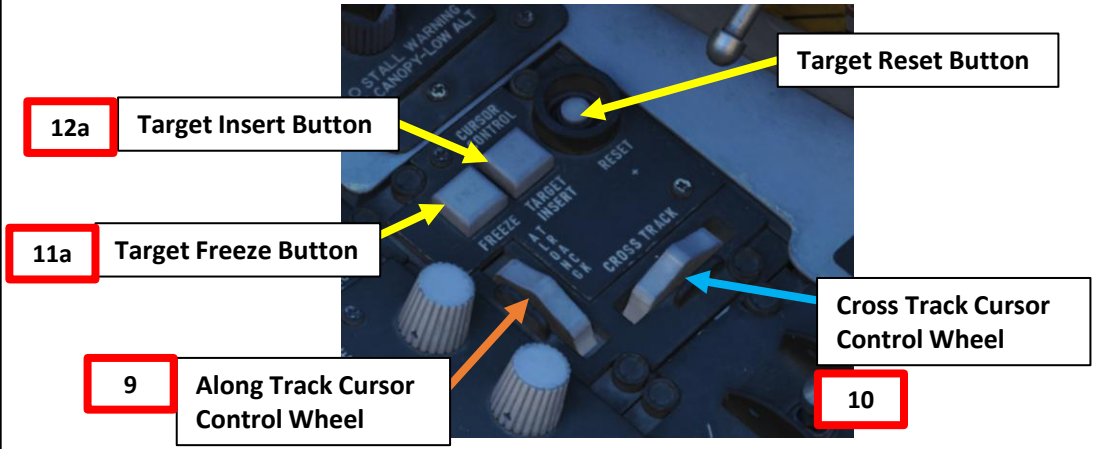
6. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
7. *[WSO]* There are two symbols that will interest us: the **Range Cursor** and the **Offset Cursor**. Both cursors can only be displayed in PPI modes.
    - The **Range Cursor** is an arc of constant range from the aircraft, which can be moved closer or away from the aircraft.
    - The **Offset Cursor** is an offset parallel to the drift of the aircraft, which can be offset left or right of the aircraft's current track.
8. *[WSO]* Adjust Cursor Range Brightness, Cursor Offset Brightness, Screen/Scope Contrast and Screen/Scope Brightness to ensure the range cursor and offset cursor are both visible.

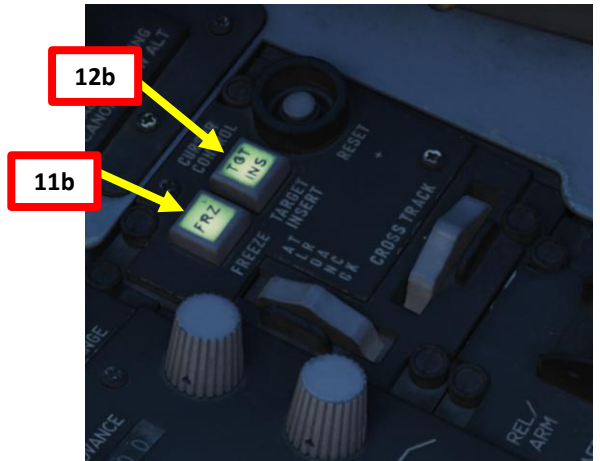


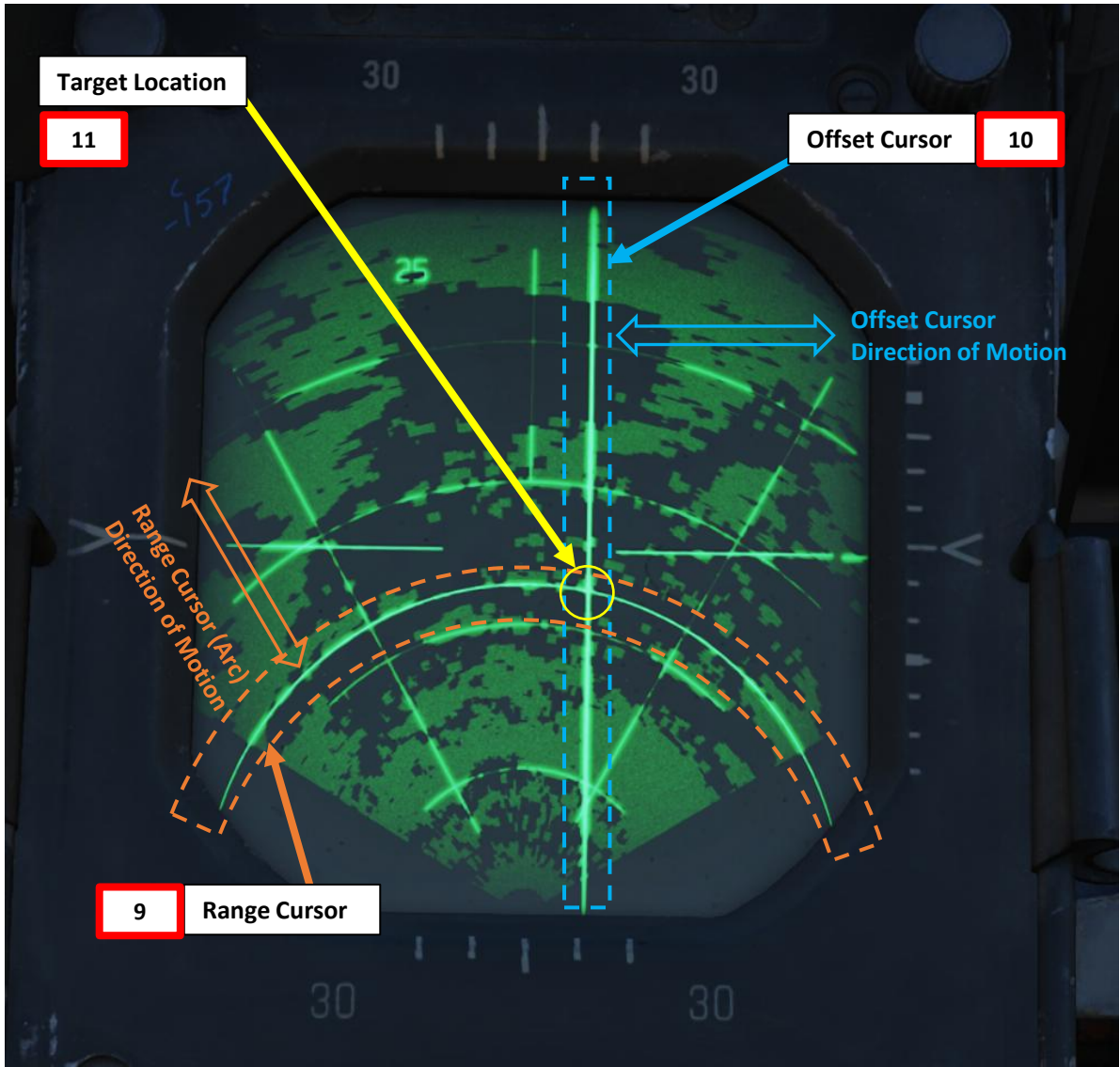


2 – AN/APQ-120 FIRE CONTROL RADAR
2.5 – Air-to-Ground Operation
2.5.2 – Map PPI (Plan-Position Indicator) Mode

9. *[WSO]* The Along Track Control is used to increase and decrease the current setting for the range cursor.
10. *[WSO]* The Cross Track Control is used to move the offset cursor to the left and right of the aircraft's track.
11. *[WSO]* Once a target is at the meeting point between the range cursor and the offset cursor, press the Target Freeze Button to memorize this position.
12. *[WSO]* Press the Target Insert Button.
13. *[WSO]* The target is now designated.







2 – AN/APQ-120 FIRE CONTROL RADAR
2.6 – Radar Lingo & Terminology

- BANDIT: Identified Enemy Aircraft
- BOGEY: Unidentified Aircraft
- SPIKE: Air-to-Air radar is locked on you
- BUDDY SPIKE: Friendly radar is locked on you
- NAILS: RWR contact, which emits radar waves but does not have a radar lock on you
- FOX 1: semi-active radar missile (Super S530F + R530F + 27R/ER + AIM-7)
- FOX 2: heat-seeking infrared missile (R550 Magic I + R550 Magic II + 27T/ET + AIM-9 + R-73/60)
- FOX 3: active radar missile, meaning the missile tracks to an aircraft's radar up to a certain distance, then its internal radar activates (pitbull) (AIM-120/R-77)
- RIFLE: AGM-65 Air-to-Ground missile
- RAYGUN: When locking a target with your radar, it is good practice to say "RAYGUN" so your teammates are aware that you are locking someone. It is often used to identify a contact as friend or foe. If a person yells "BUDDY SPIKE!", it's very likely that you are locking a friendly contact.
- SHOTGUN: AGM-45 Shrike anti-radiation missile (ARM) is launched.
- IFF: meaning "Is he friendly or bandit (enemy)?"
- PITBULL: Any FOX 3 (active radar) missile that starts using its onboard radar for tracking



FOX1
Semi-active radar homing missile
e.g. AIM-7, AA-10,
Super S530F, R530F

FOX2
Passive IR homing missile
e.g. AIM-9, AA-11, IRIS-T,
R550 Magic I, R550 Magic II

FOX3
Active radar homing missile IR homing missile
e.g. AIM-120, AA-12, Meteor

No equipment for F-4E Phantom

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.1 – Introduction

The AN/AVQ-23 “Pave Spike” targeting pod provides a slewable TV image for spotting ground targets and can fire laser for determining range information and to guide laser guided weapons. It does not have modern infrared imagery, which limits its use during low visibility or night conditions.

It is the successor of the AN/AVQ-10 Pave Knife and predecessor of the AN/AVQ-26 Pave Tack pod. The Pave Spike entered service in 1974 and was replaced from 1982 to 1989 by the Pave Tack pod.





AN/AVQ-23 Pave Spike Targeting Pod

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.1 – Introduction

The targeting pod is operated by the WSO (Weapon Systems Officer), but communication between the WSO and the pilot is essential since the pod itself and its modes are highly dependent on the manner the aircraft is flown.



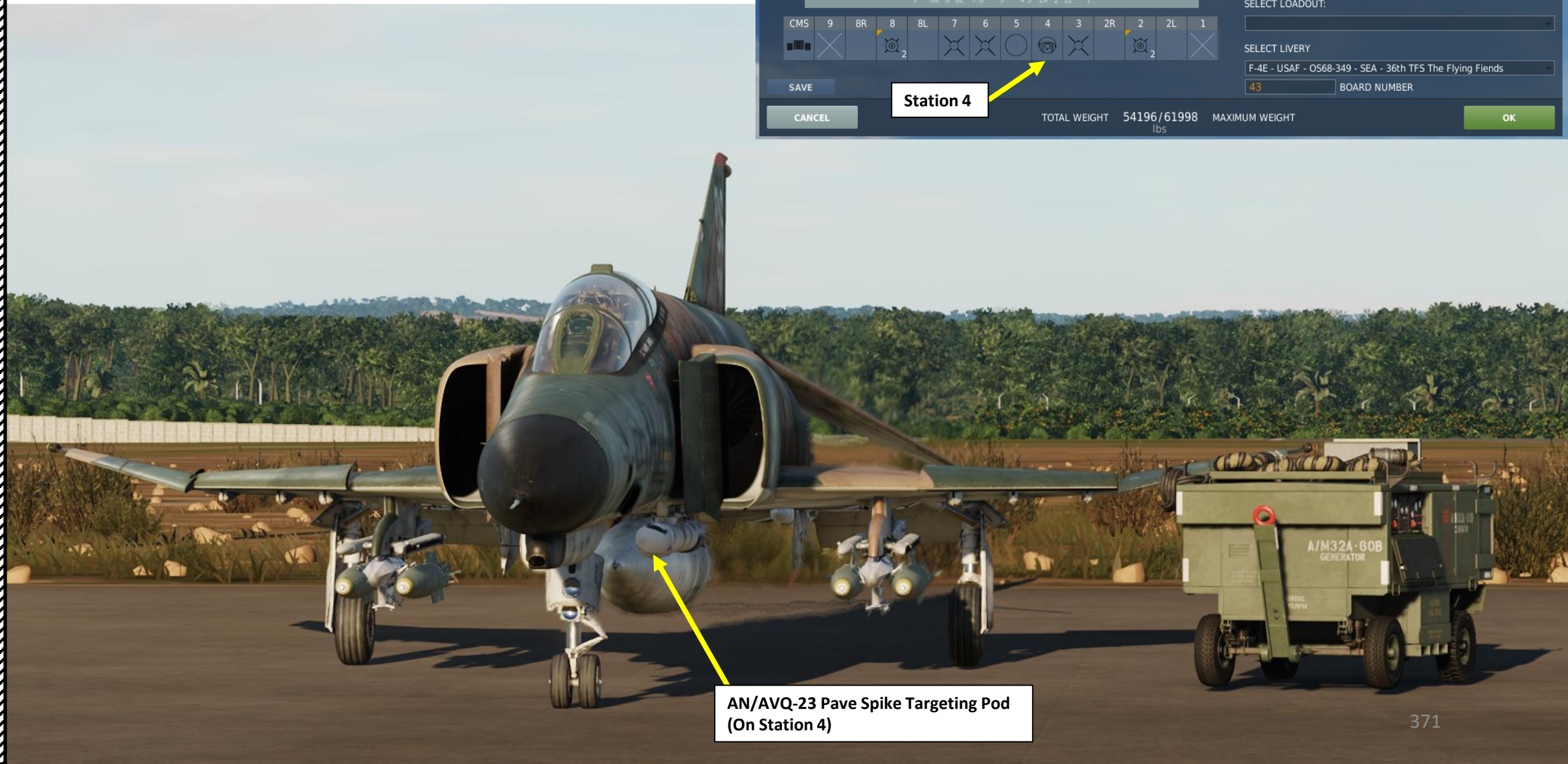
I strongly recommend that you consult Redkite's "Pave Spike + Laser guided bombs Tutorial" Video: https://youtu.be/FZNtAqOZGgA

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.1 – Introduction

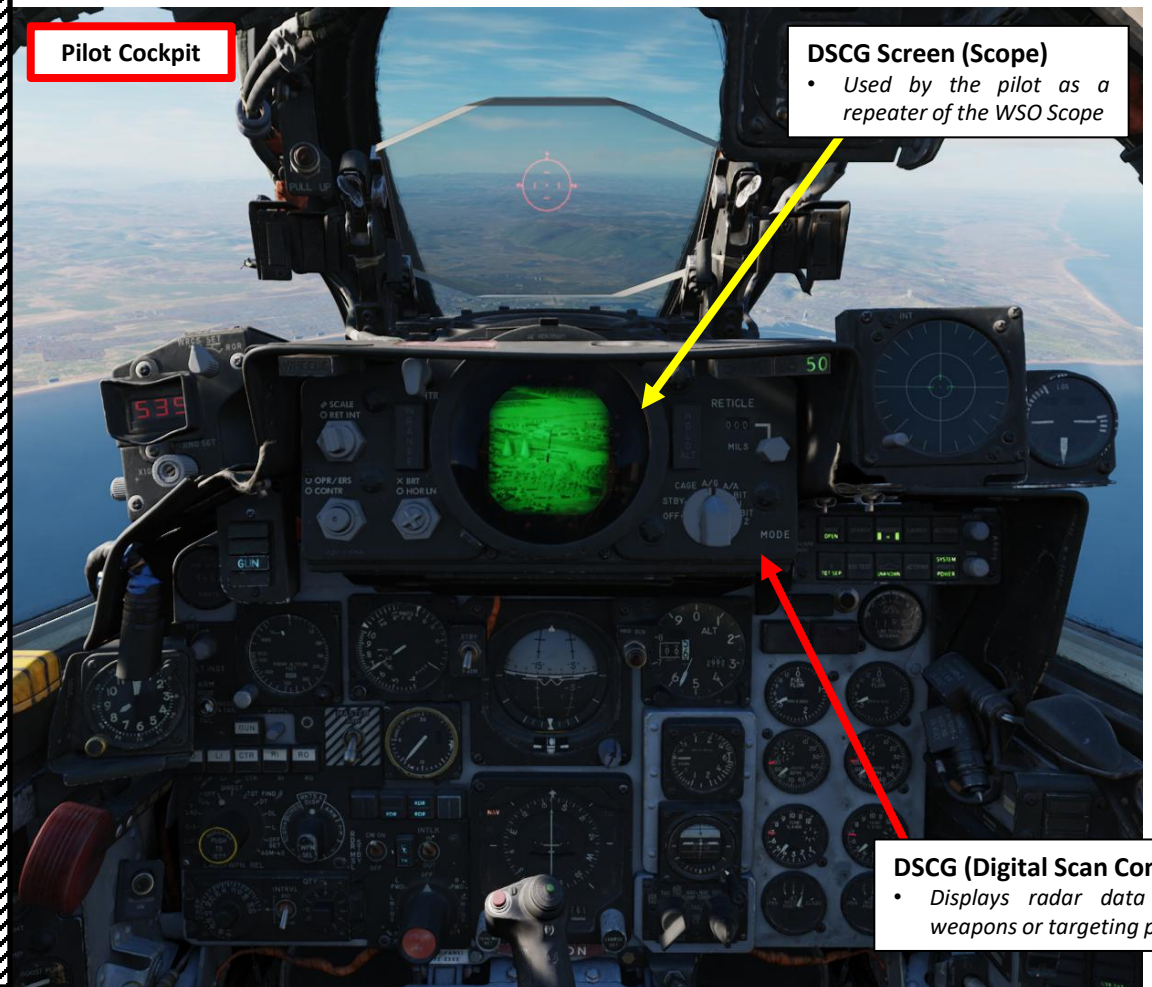
It is important to note that the targeting pod can only be equipped on Station No. 4. This affects the pod's visibility limits.





3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.2 – Display

In the F-4, targeting pod information is displayed on a scope referred as the **DSCG (Digital Scan Converter Group) Screen**.



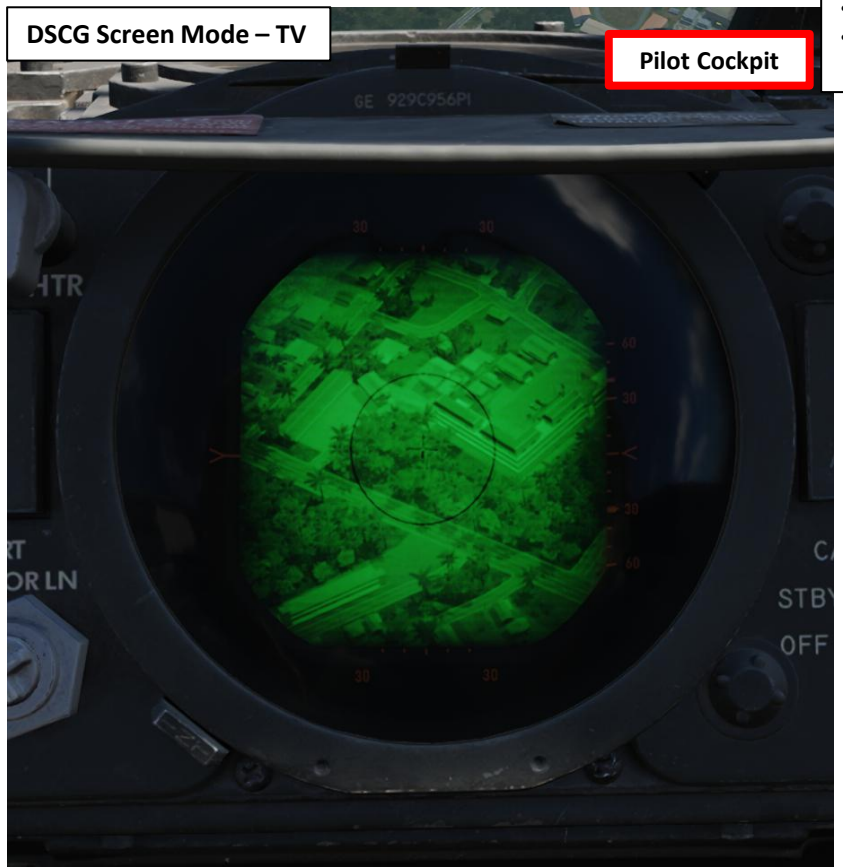


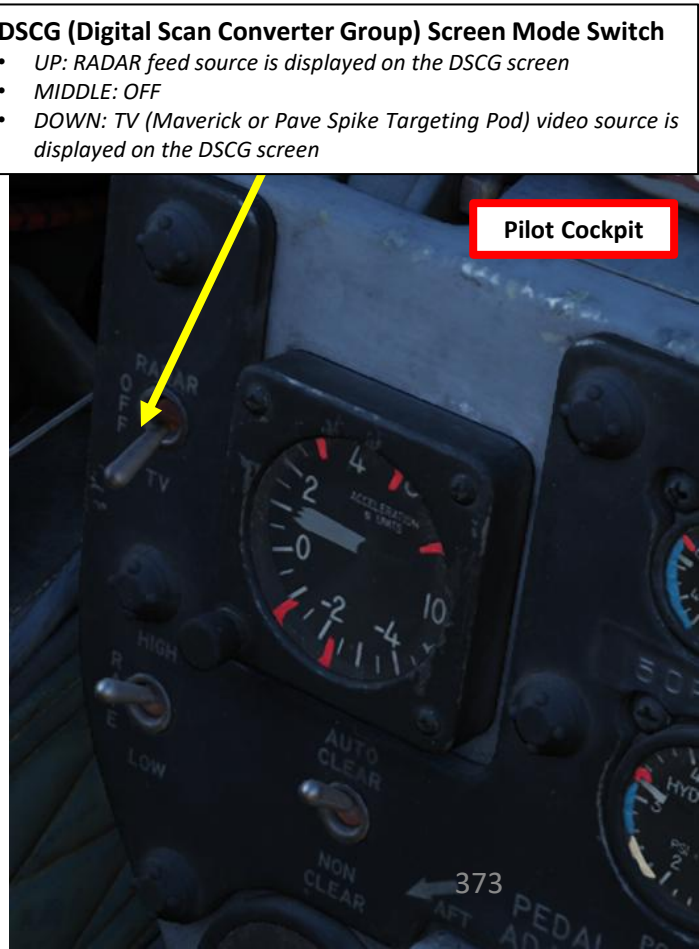
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.2 – Display

The **DSCG Screen Mode Switch** is used to determine which feed will appear on the scope screen. The **Video Select Button** in the WSO cockpit controls if the TV feed comes from the targeting pod or the Maverick missile.









3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.2 – Display (WSO)

Reticle Brightness Control Knob
- *Controls contrast of the TV reticle from black (full counter-clockwise) to green (full clockwise).*

Targeting Pod Reticle
- *The reticle rotates clockwise to indicate the pod's current elevation.*

WSO Cockpit

TTG (Time-to-Go) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is firing laser and target range is accepted*
- *Flashing Quickly: Pod is not firing laser or target is too far away*
- *Flashing Slowly: Pod is firing laser, but target range is rejected*

T0 (Release) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is commanded to fire laser (Hand Control Stick Trigger to FULL ACTION)*
- *Flashing Quickly: Pod is not commanded to fire laser*

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

DSCG Screen/Scope Brightness Control Knob

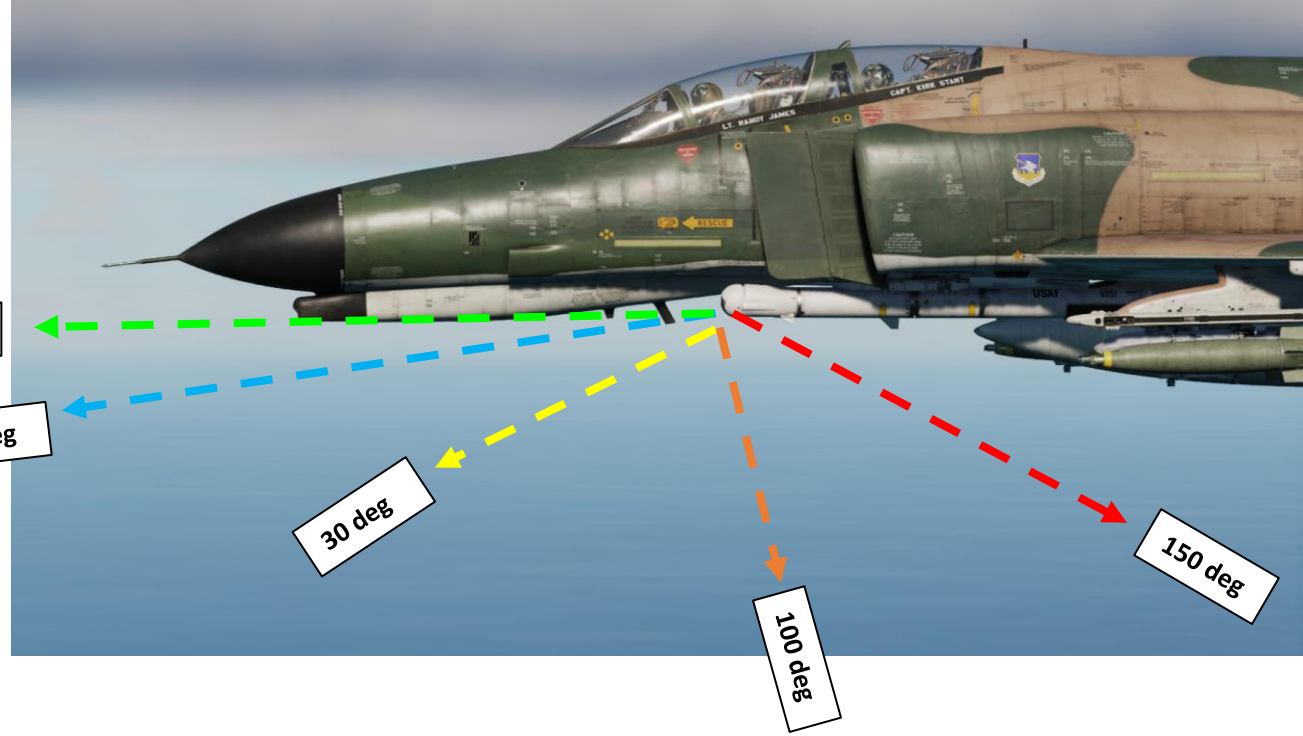
DSCG Screen/Scope Contrast Control Knob

DSCG (Digital Scan Converter Group) Screen Mode Selector
- ***OFF***
- ***STBY****: Standby mode, used for takeoff and landing.*
- ***DSCG TEST****: Displays a test search display image with 8 shades of grey to confirm normal operation. Select Range 10 for proper sizing.*
- ***RDR BIT****: Radar Built-In Test*
- ***RDR****: Used for radar display functionality in all employment modes.*
- ***TV****: Used for TV raster imagery with EO (electro-optical) weapons, as well as the Pave Spike targeting pod.*

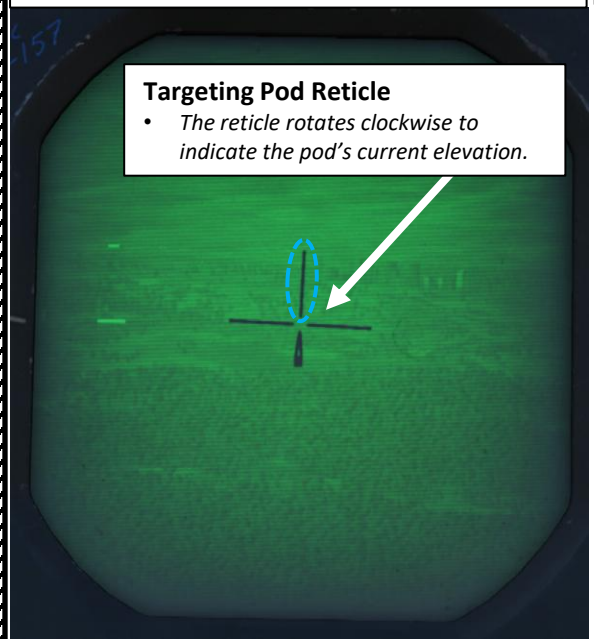
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (WSO)

The TV image mainly consists of a reticle. The reticle rotates clockwise to indicate the pods current elevation. At a 90 deg rotation, the pod is looking straight down. If the reticle is almost upside down, the pod reached its gimbal limit for the elevation (160 degrees).



Targeting Pod Line-of-Sight: 10 deg



Targeting Pod Line-of-Sight:30 deg



Targeting Pod Line-of-Sight: 100 deg



Targeting Pod Line-of-Sight: 150 deg

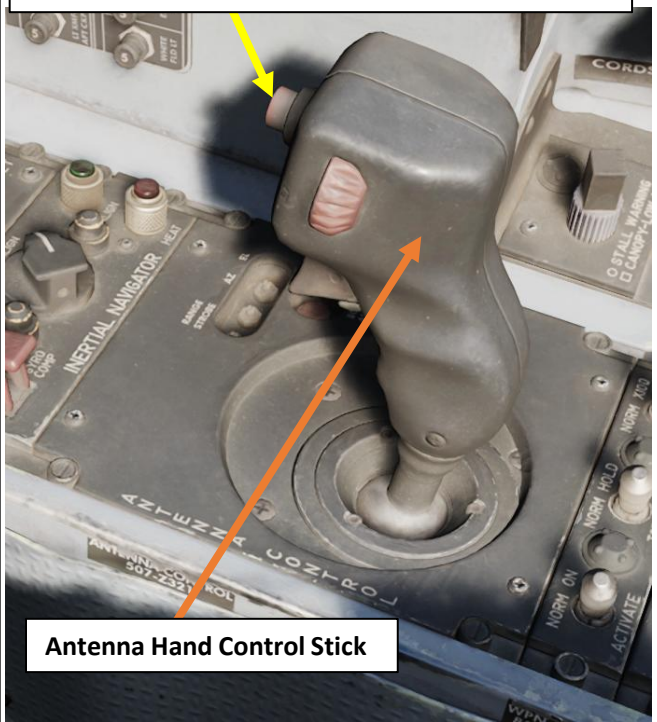


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (WSO)

The targeting pod's field-of-view is toggled using the **Challenge Button** on the **Antenna Hand Control Stick.**
The wide field of view is indicated by a circle around the reticle.

Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*



Antenna Hand Control Stick

Targeting Pod Reticle
- *Wide Field-of-View*



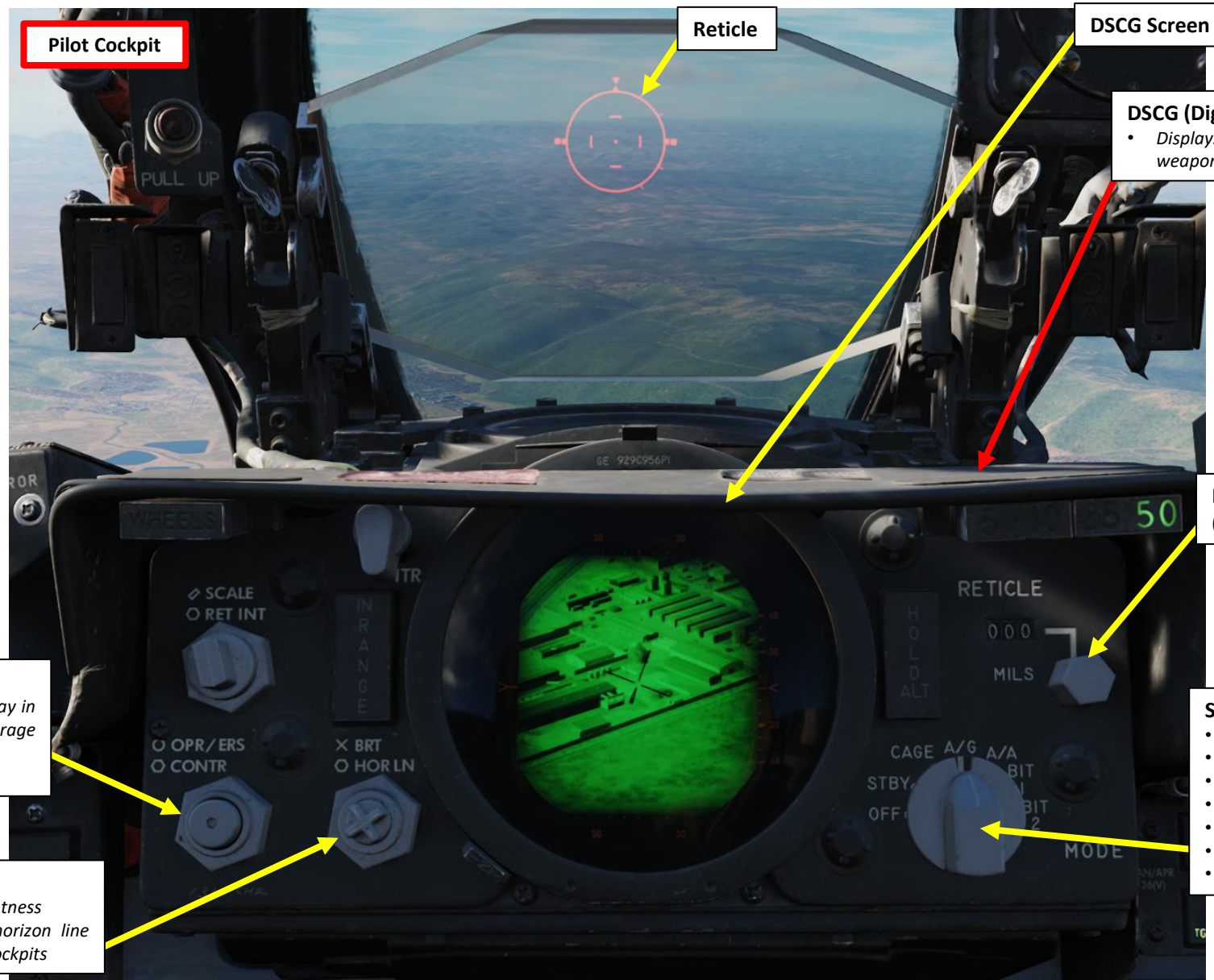
Targeting Pod Reticle
- *Narrow (4x) Field-of-View*



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (Pilot)

The pilot has no control over the targeting pod itself; the screen/scope is mainly used to provide information in a passive manner.



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (Pilot)

The range indicator panel provides the pilot with a readout of the slant range measured by the Pave Spike.

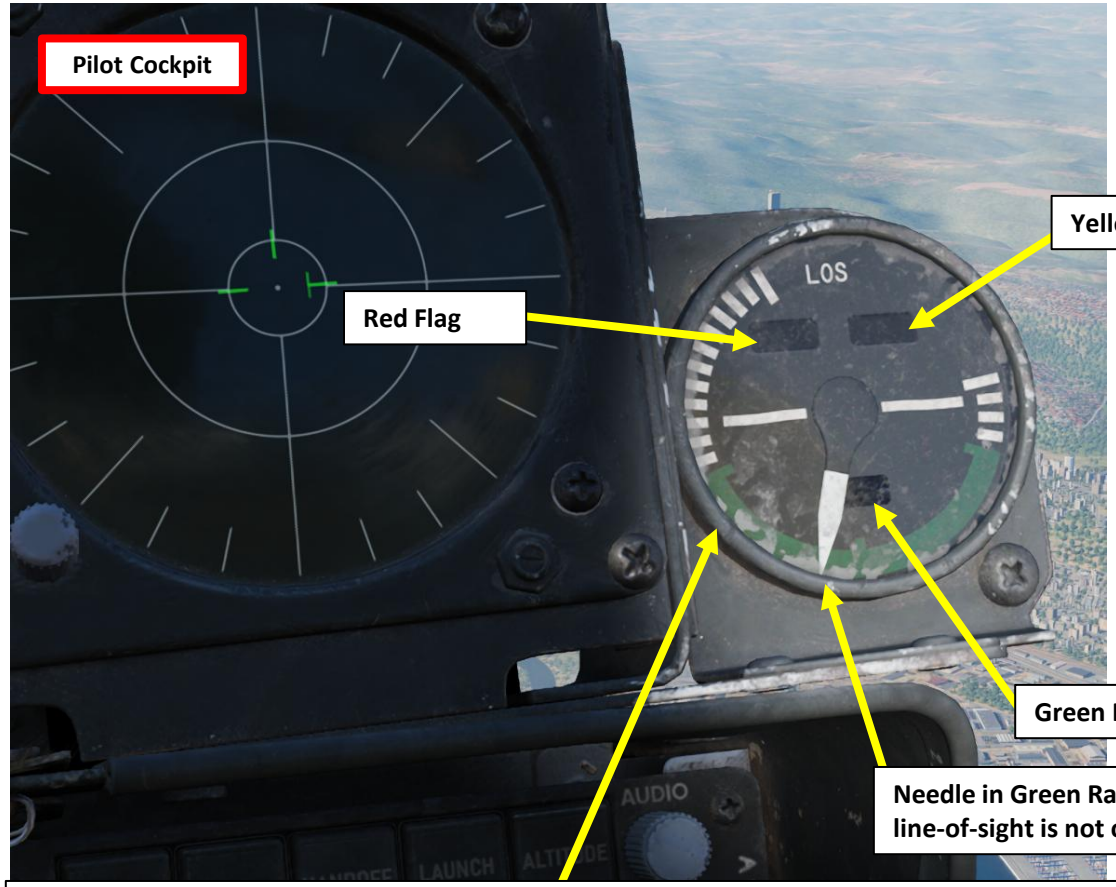


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (Pilot)

The Azimuth-Elevation / Line-of-Sight (LOS) Indicator is an instrument used by the pilot in order to know where the targeting pod is pointing in terms of roll and elevation. This is mainly used to avoid exceeding the Pave Spike's gimbal limits.

If the needle is kept within the green labelled range and neither the yellow or red flag are shown, the view will not be obstructed by the pod of the aircraft.

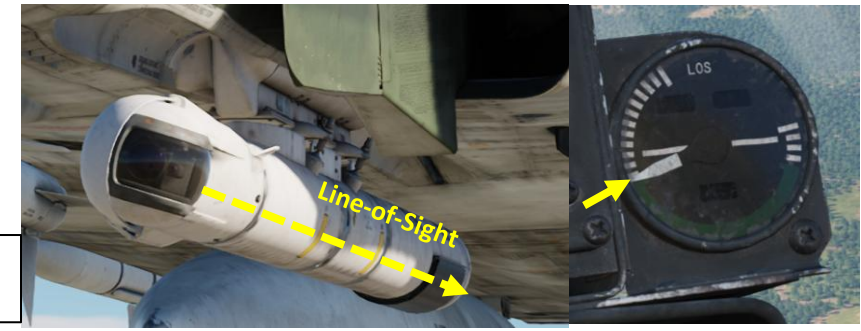


Azimuth-Elevation / Line-of-Sight (LOS) Indicator

- *Main instrument for the pilot to assess the current attitude of the Pave Spike Targeting Pod in order to keep the line of sight within the operational limits.*
- *The needle shows the pods roll position from -160° (CW) to +110° (CCW).*
- *Three flags indicate the elevation: Green (-120° to -155°), Yellow (-155° to -160°) and Red (-160° or beyond).*



Roll Angle:
-160 deg Left



Roll Angle:
-80 deg Left



Roll Angle:
0 deg



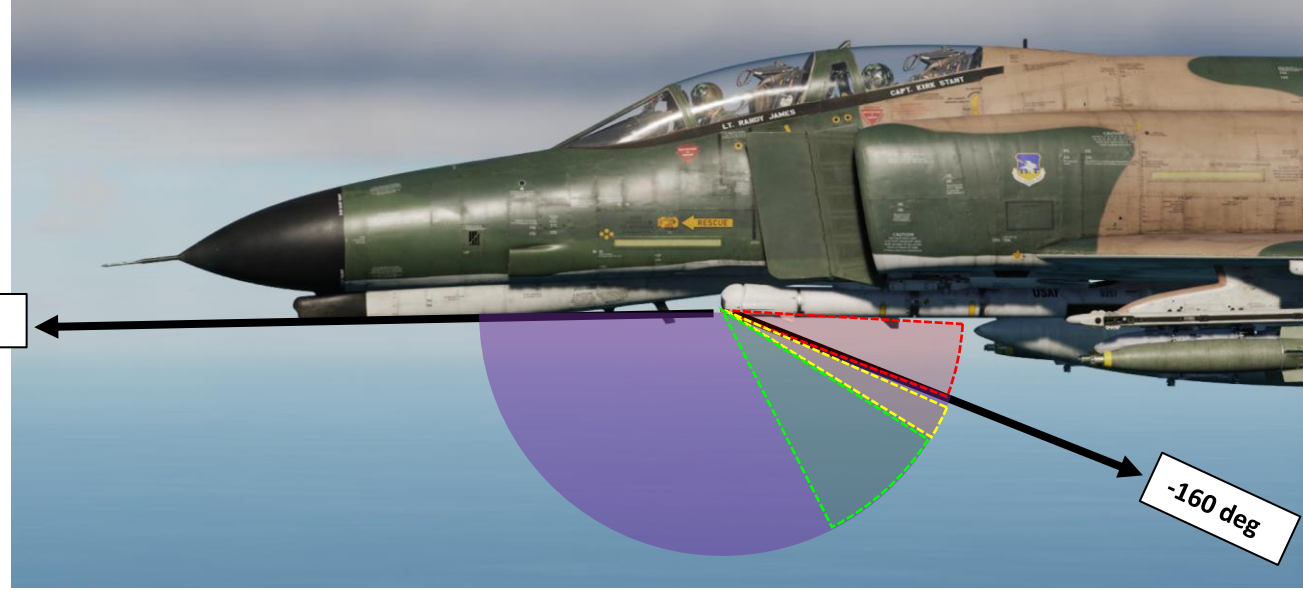
Roll Angle:
+80 deg Right

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (Pilot)

The three flags indicate the pod's elevation:

- **Green: from -120 deg to -155 deg**
- **Yellow from -155 deg to -160° deg**
- **Red: from -160° or beyond**





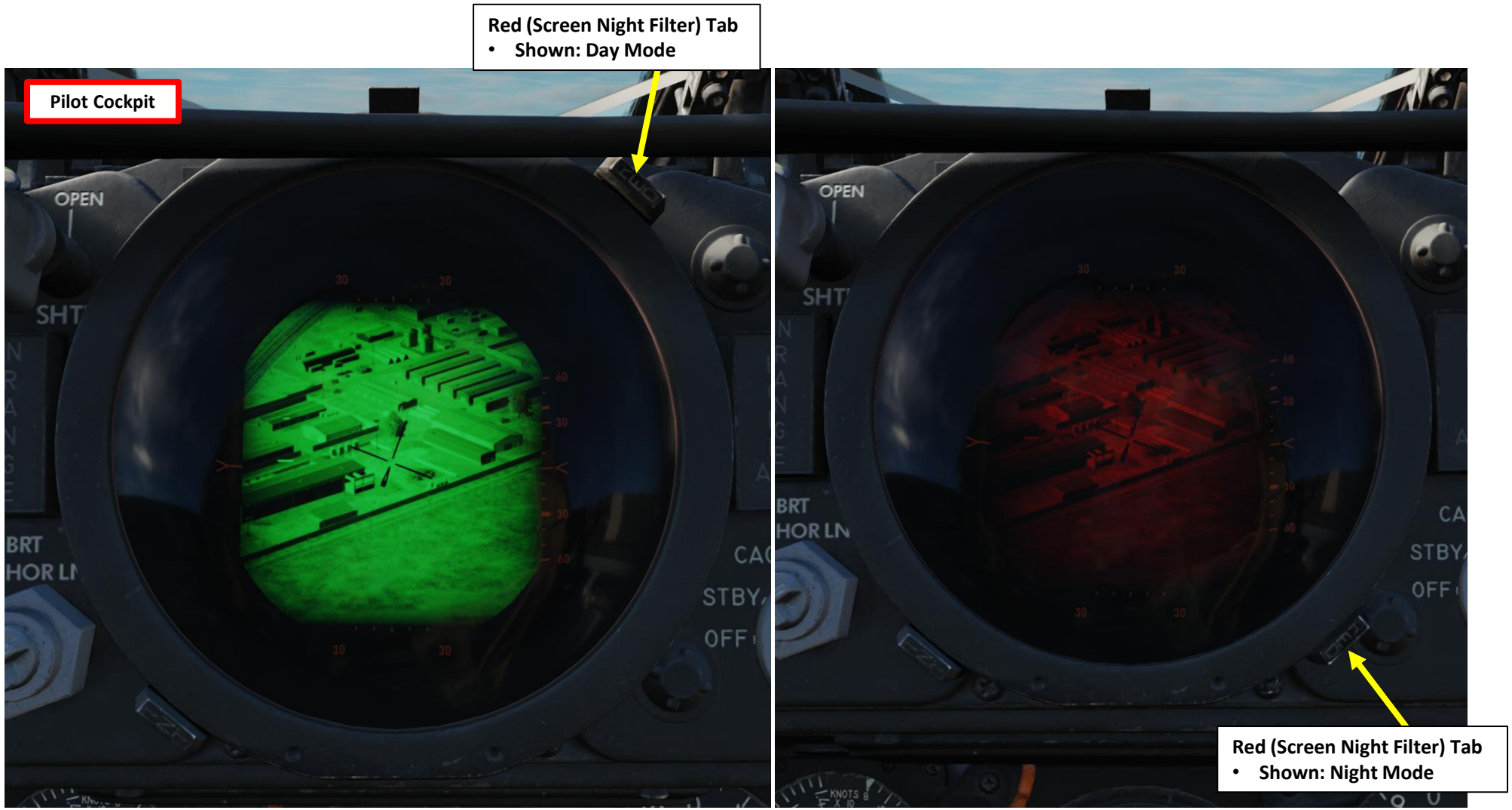




3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.2 – Display (Pilot)

The **Red (Screen Night Filter) Tab** can be rotated to provide a red scope display for night flying.



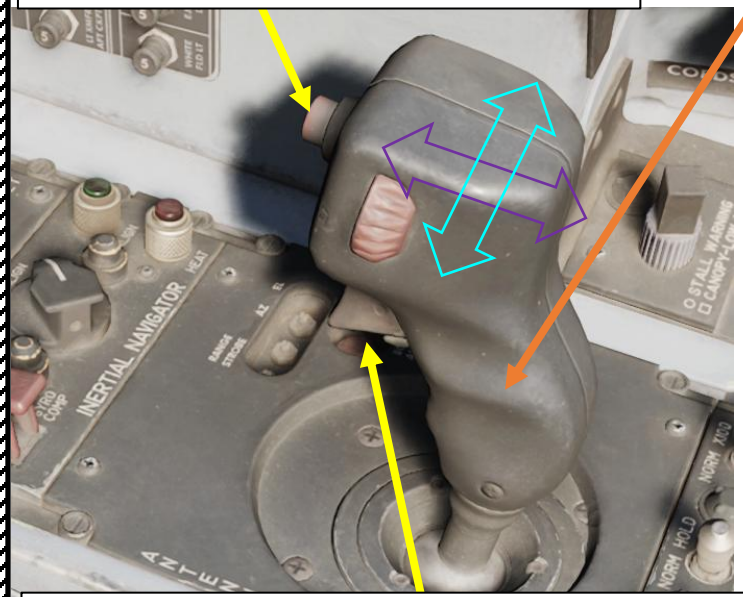
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.3 – Controls (WSO)

The **Hand Control Stick** is used to slew and correct the pod's line of sight. Moving the stick FWD moves the pod's line-of-sight UP, while moving it AFT moves the pod's line-of-sight down.

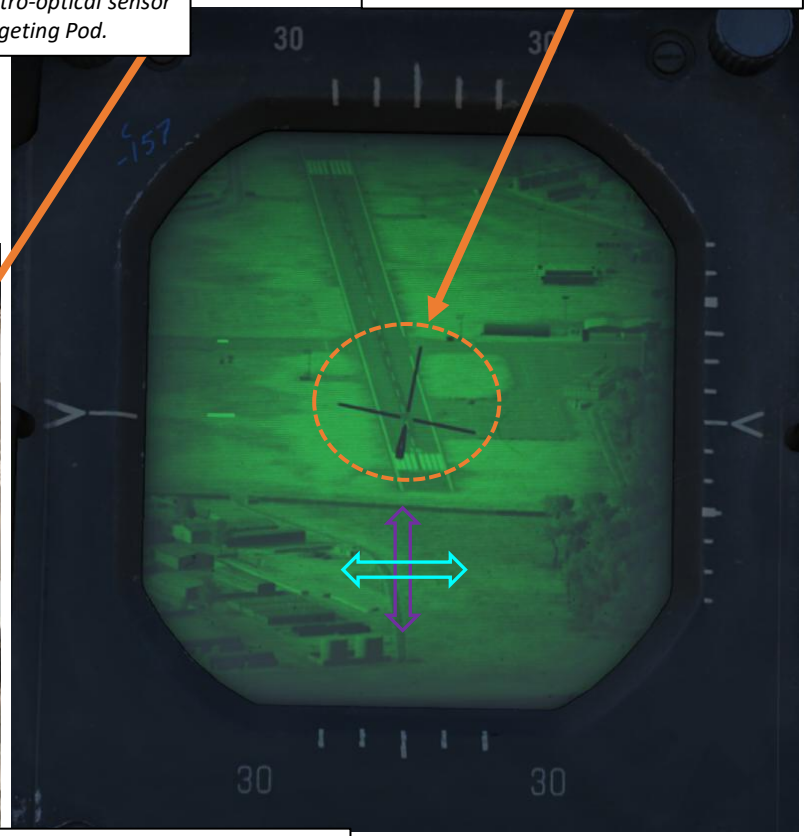
Antenna Hand Control Stick
- *This joystick integrates with the radar to perform range (fore and aft) and azimuth (left and right) positional control of the acquisition symbol on the radar display in the air-to-air modes, as well as seeker/electro-optical sensor direction with the AGM-65 Maverick and the Pave Spike Targeting Pod.*

Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*



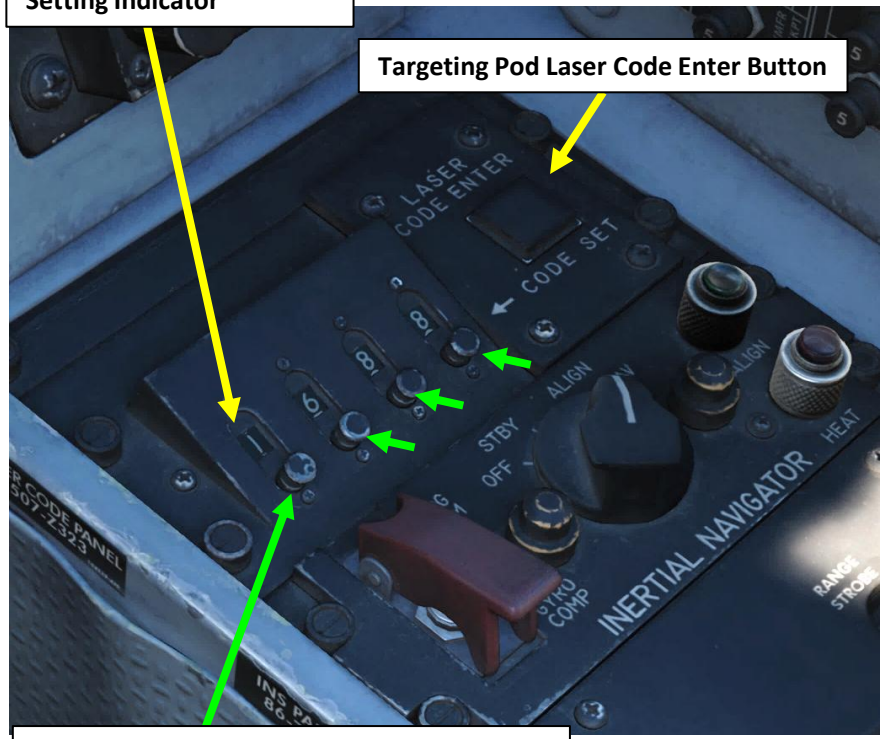
Action Switch (Two-Stage Trigger)
- *To enter track mode, one has to complete the sequence Released to Half Action and back to Released. Holding the trigger at any point will not actuate the linked action.*
- *To fire the laser, instead of perhaps holding the trigger down, one has to complete the sequence and move the trigger through all its stages forth and back, i.e. from Released to Half Action, to Full Action, back to Half Action and Released. Completing this sequence will toggle the laser on or off.*

Targeting Pod Reticle
- *The reticle rotates clockwise to indicate the pod's current elevation.*



Targeting Pod Laser Code Setting Indicator

Targeting Pod Laser Code Enter Button

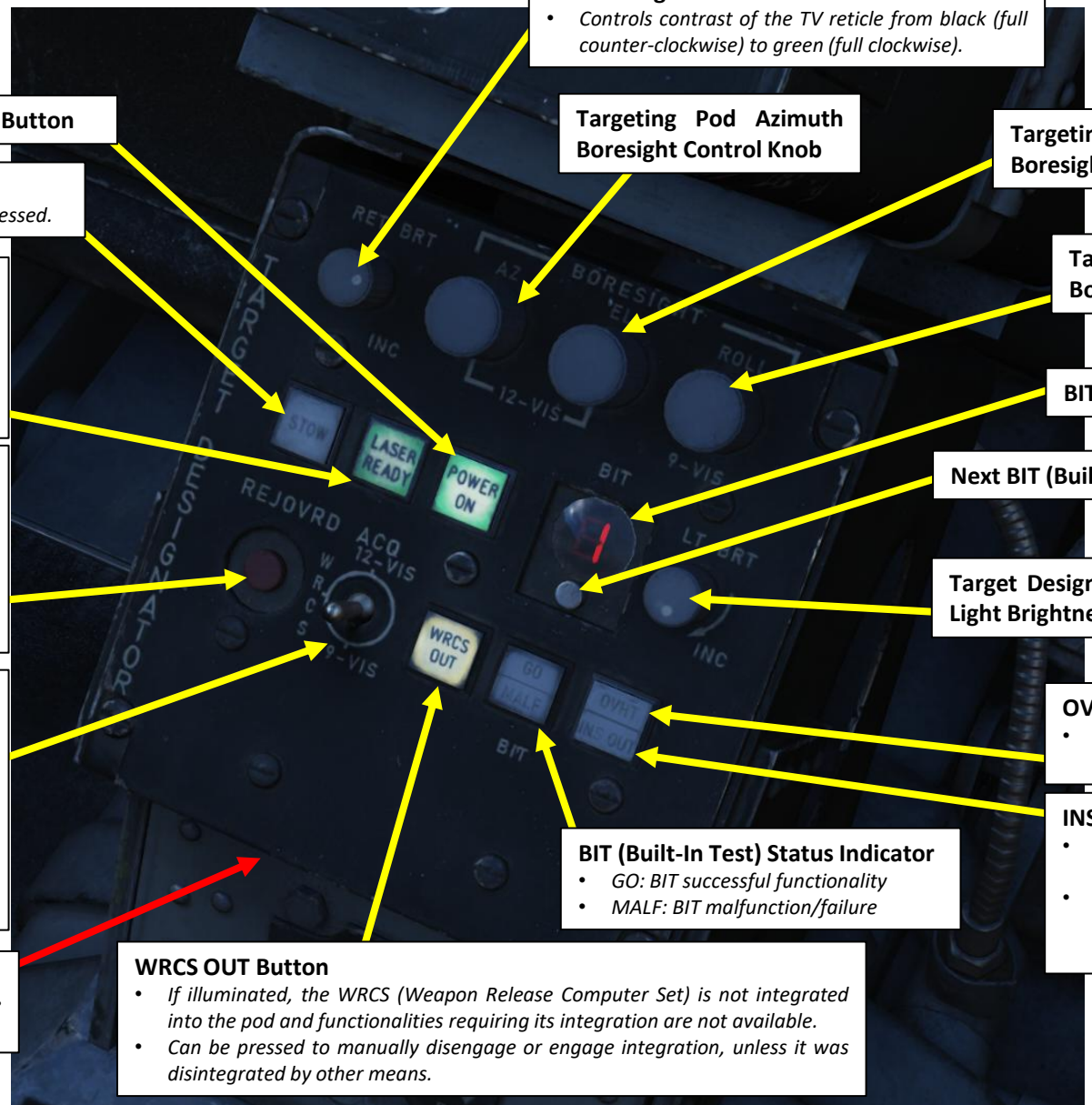


Targeting Pod Laser Code Setting Controls

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.3 – Controls (WSO)

The **Target Designator Control Set panel** is primarily used to power up the targeting pod.



Reticle Brightness Control Knob
- *Controls contrast of the TV reticle from black (full counter-clockwise) to green (full clockwise).*

Targeting Pod Power On Button

Targeting Pod Azimuth Boresight Control Knob

Targeting Pod Elevation Boresight Control Knob

Stow Button
- *Stows/Un-stows targeting pod when pressed.*

Targeting Pod Roll Boresight Control Knob

Laser Ready Select Button
- *Enables designator laser firing if illuminated after pressing.*
- *Light remains off if interlocks (nose gear up and all pod functions working) inhibit use. Subsequent press deactivates laser system.*

BIT (Built-In Test) Number Indicator

Next BIT (Built-In Test) Button

Reject/Override Button
- *When the targeting pod detects a too great discrepancy between the laser measured slant range and the INS based computed ranged, it automatically rejects the former and prefers the latter.*
- *This button forces the use of the laser measured slant range.*

Target Designator Control Set Panel Light Brightness Control Knob

Acquisition Mode Selector Switch
- *UP: 12-VIS, slaves pod line-of-sight parallel to the optical sight pipper.*
- *MIDDLE: WRCS, slaves pod line-of-sight to the WRCS cursor unless WRCS integration is deactivated; reverts to 12-VIS otherwise.*
- *DOWN: 9-VIS, slaves pod line-of-sight to 90 degrees below FRL (Fuselage Reference Line) and rolled 90 degrees left.*

OVHT (Overheat) Light
- *Illuminated in case of targeting pod overheat condition.*

INS OUT Light
- *Illuminated in case of inertial navigation system failure.*
- *Button can be pressed to manually disengage or engage INS-integrated functions, unless it was disintegrated by other means.*

BIT (Built-In Test) Status Indicator
- *GO: BIT successful functionality*
- *MALF: BIT malfunction/failure*

Target Designator Control Set
- *Main panel to interact with the Pave Spike Targeting Pod.*

WRCS OUT Button
- *If illuminated, the WRCS (Weapon Release Computer Set) is not integrated into the pod and functionalities requiring its integration are not available.*
- *Can be pressed to manually disengage or engage integration, unless it was disintegrated by other means.*

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.3 – Controls (Pilot)

The **Air-to-Ground Weapon Delivery Mode Knob** and the **Weapon Release Mode Selector** allow the selection of a weapon release mode, which is integrated with the targeting pod.

Weapon Release Mode Selector

- *WRCS: Weapon Release Computer Set, also known as Automatic Delivery*
- *SET: Display shows the desired release range used in the ROR mode*
- *ROR: Release On Range Mode*





Air-to-Ground Weapon Delivery Mode Knob

Split into two halves, the left side of the dial references ARBCS (Attitude Reference and Bombing Computer Set) delivery modes, while the right side provides automated release functions using the WRCS (Weapon Release Computer Set) with possible tie-in to the navigation computer, depending on mode.

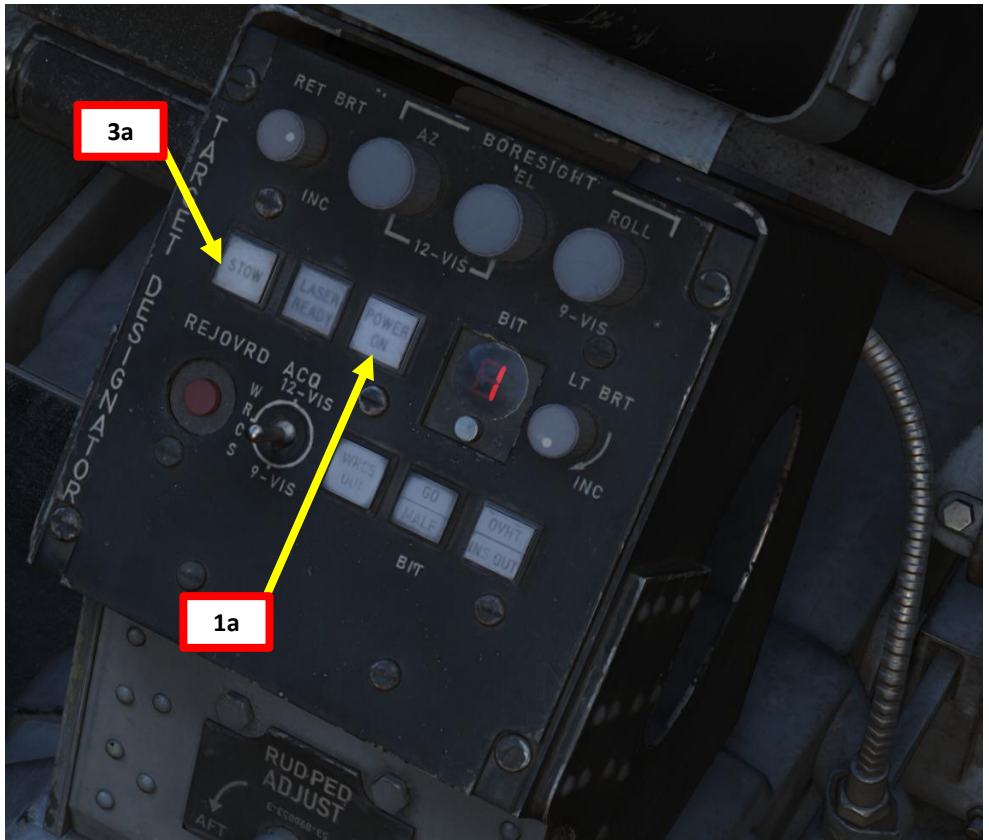
- *INST O/S: Instantaneous Over the Shoulder Bombing*
- *LOFT: Loft Bombing*
- *O/S: (Timed) Over the Shoulder Bombing*
- *T LAD: Timed LADD (Low Angle Drogue Delivery) Bombing*
- *TL: Timed Level Bombing*
- *OFF: OFF (Air-to-Air)*
- *DIRECT: Manual Direct Bombing*
- *TGT FIND: Target Find (Nav Mode and Pave Spike Targeting Pod bombing only)*
- *DT: Dive Toss Bombing*
- *DL: Dive Laydown Bombing*
- *L: Laydown Bombing*
- *OFF SET: Offset Bombing*
- *AGM-45: Used for AGM-45 Shrike missile*

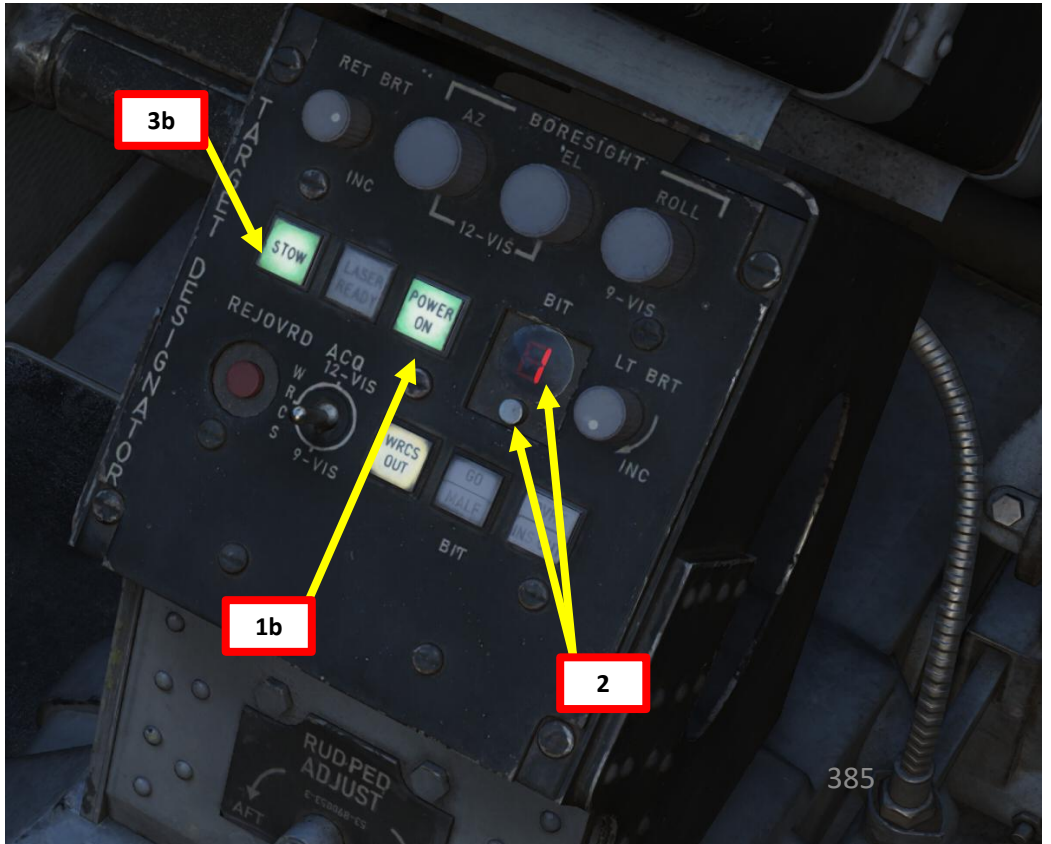
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

The power-up sequence of the targeting pod should be initiated on the ground prior to taxi and takeoff since flying while the pod is unpowered will allow the gimbals to move freely and potentially damage the pod itself.

1. *[WSO]* Set Target Designation Power On Button – ON
2. *[WSO]* Verify that the BIT (Built-In Test) indicator is set to "1".
    - Note: BIT "0" illuminates all lights on the Target Designator Set Panel and will inhibit pod operation.
3. *[WSO]* Set Target Designation Stow Button – ON.
    - The pod's head is stowed when the button is illuminated.







3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

4. *[WSO]* Set laser designation code – As desired. We will select 1688.
5. *[WSO]* Press and hold the Laser Code Enter Button.
    - If the laser code is valid, the NO GO light will momentarily illuminate, then extinguish.
    - If the laser code is invalid, the NO GO light will remain illuminated.
6. *[WSO]* Release the Laser Code Enter Button.
7. *[WSO]* Set Target Designation Stow Button – OFF. This will un-stow the targeting pod.
    - The pod's head is un-stowed when the button is extinguished. Un-stowing the targeting pod takes about 5 seconds.
8. *[WSO]* Press the Laser Ready Button and ensure the LASER READY light is illuminated.

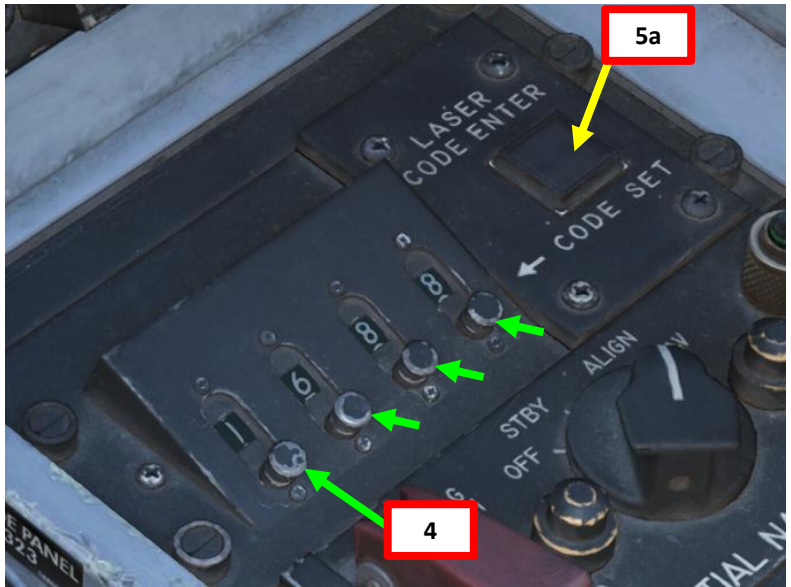


Pod Stowed

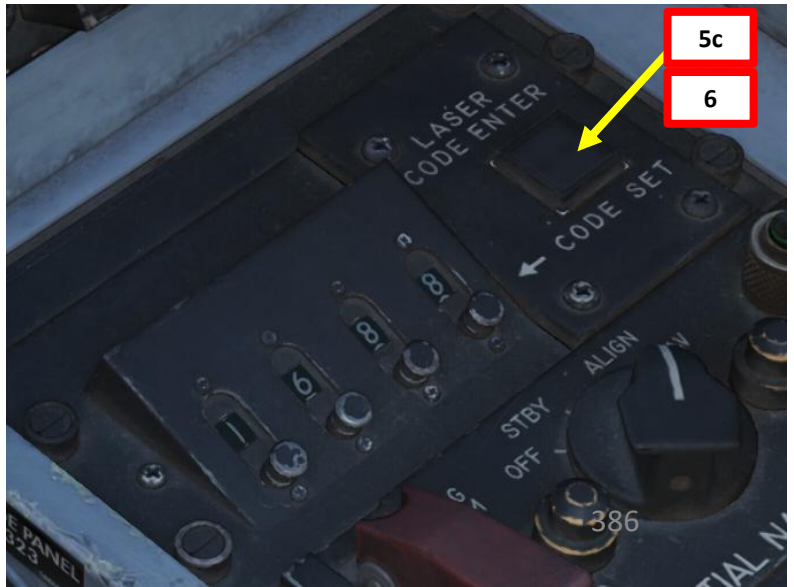


Pod Un-Stowed



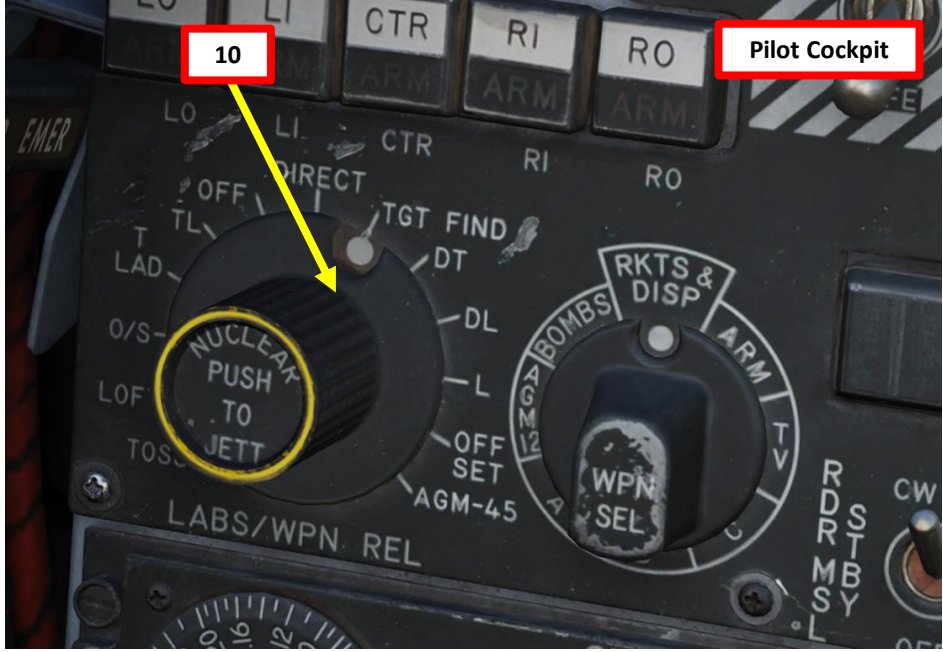


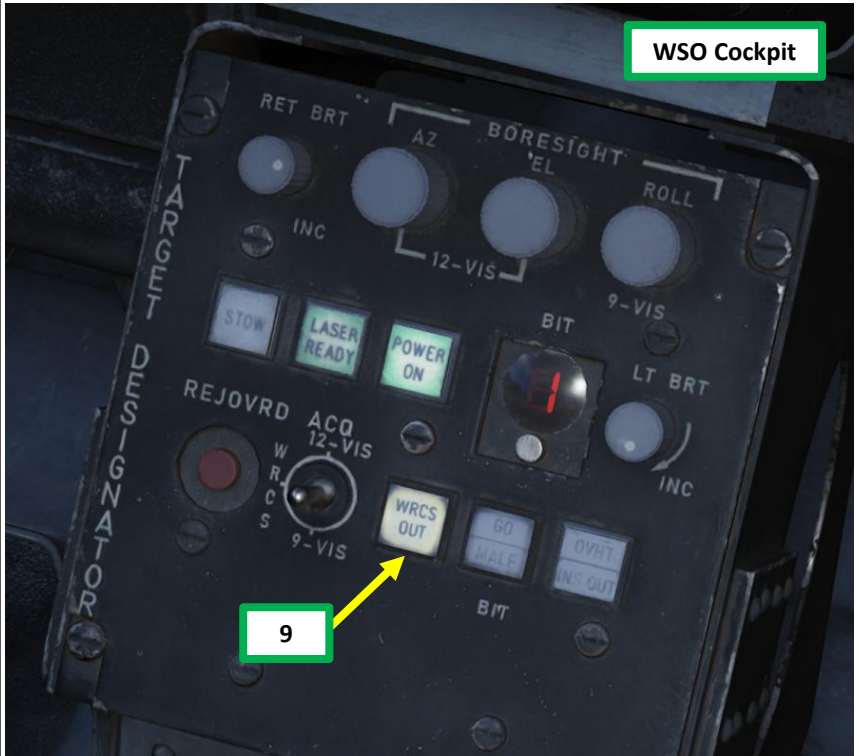


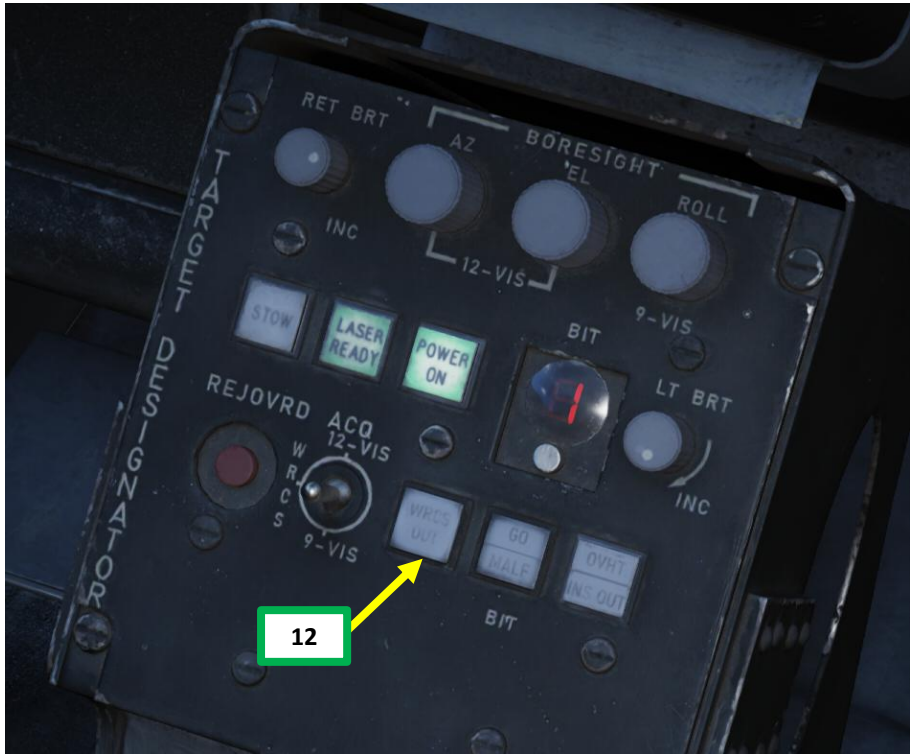


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

9. *[WSO]* Verify that the WRCS OUT button is pushed OUT.
    - Note: If the WRCS OUT light is still illuminated, this might simply be because the Air-to-Ground Weapon Delivery Mode Knob is not set to DIRECT or TGT FIND yet, meaning that the targeting pod functionality is not yet coupled with the Weapon Release Computer Set.
10. *[P]* Set Air-to-Ground Weapon Delivery Mode Knob – TGT FIND (Target Find).
11. *[P]* Set Weapon Release Mode Selector – WRCS (Weapon Release Computer Set, also known as "Automatic Delivery")
12. *[WSO]* Verify that the WRCS OUT light is extinguished.







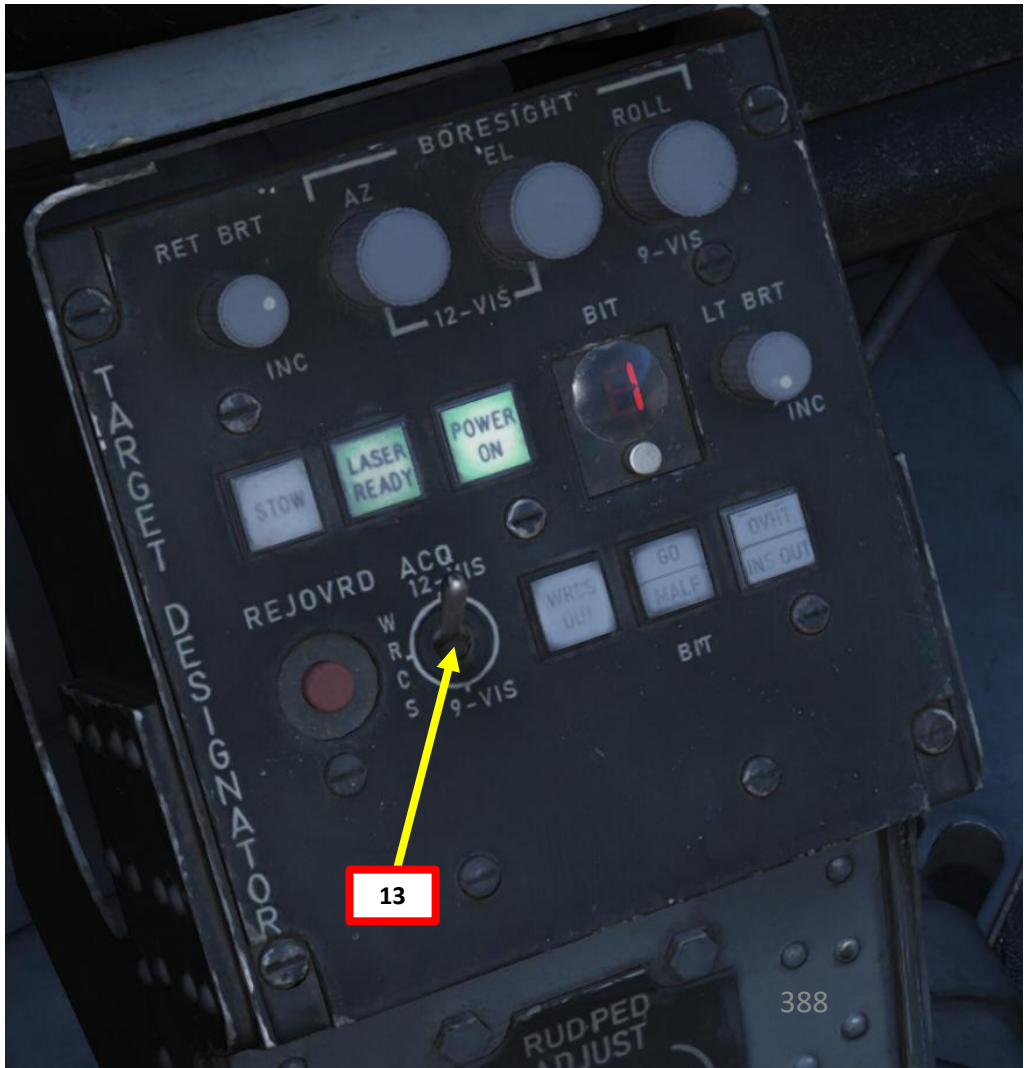


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

13. [WSO] Select desired acquisition mode using the Acquisition Mode Selector Switch. We will use 12-VIS (UP).

- **12-VIS** (switch UP): visual line-of-sight of the pod is set to the 12 o'clock (front) position; 0 degrees roll, -2 degrees elevation, looking slightly nose down.
- **WRCS** (switch MIDDLE): Enables the crew to spot a target by using the radar or entering known coordinates and then slewing the pod to this destination. If no specific target has been inserted, the WRCS usually defaults to the aircraft position, resulting in the pod looking straight down.
    - Note: WRCS mode automatically falls back to the 12-VIS mode in case the WRCS integration is deactivated.
- **9-VIS** (switch DOWN): visual line-of-sight of the pod is set to the 9 o'clock (left) position; -90 degrees roll clockwise, -90 degrees elevation (down), looking left.

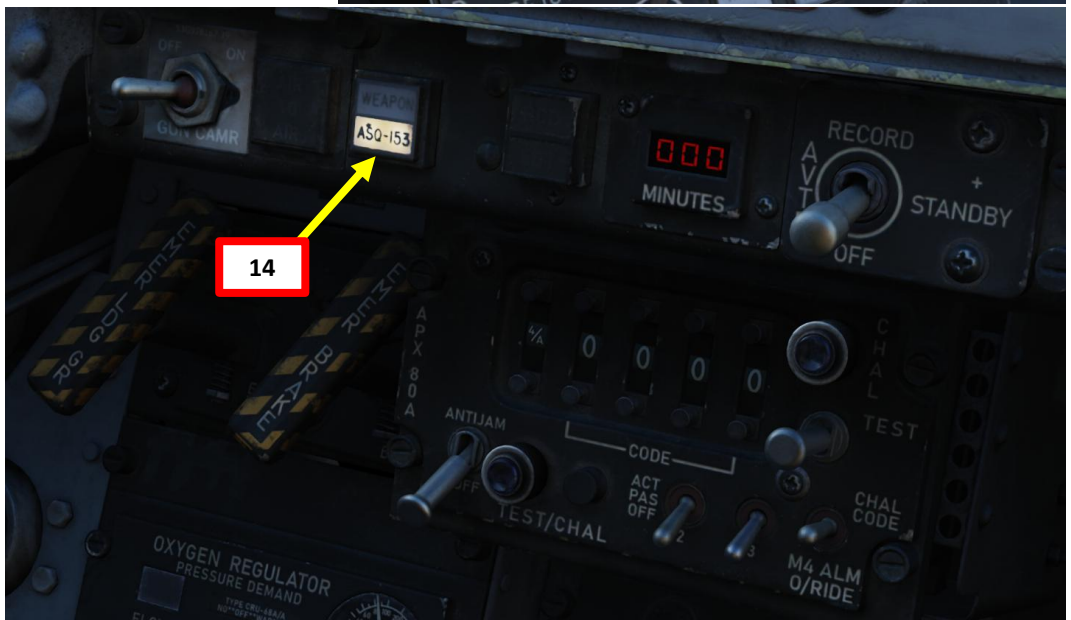


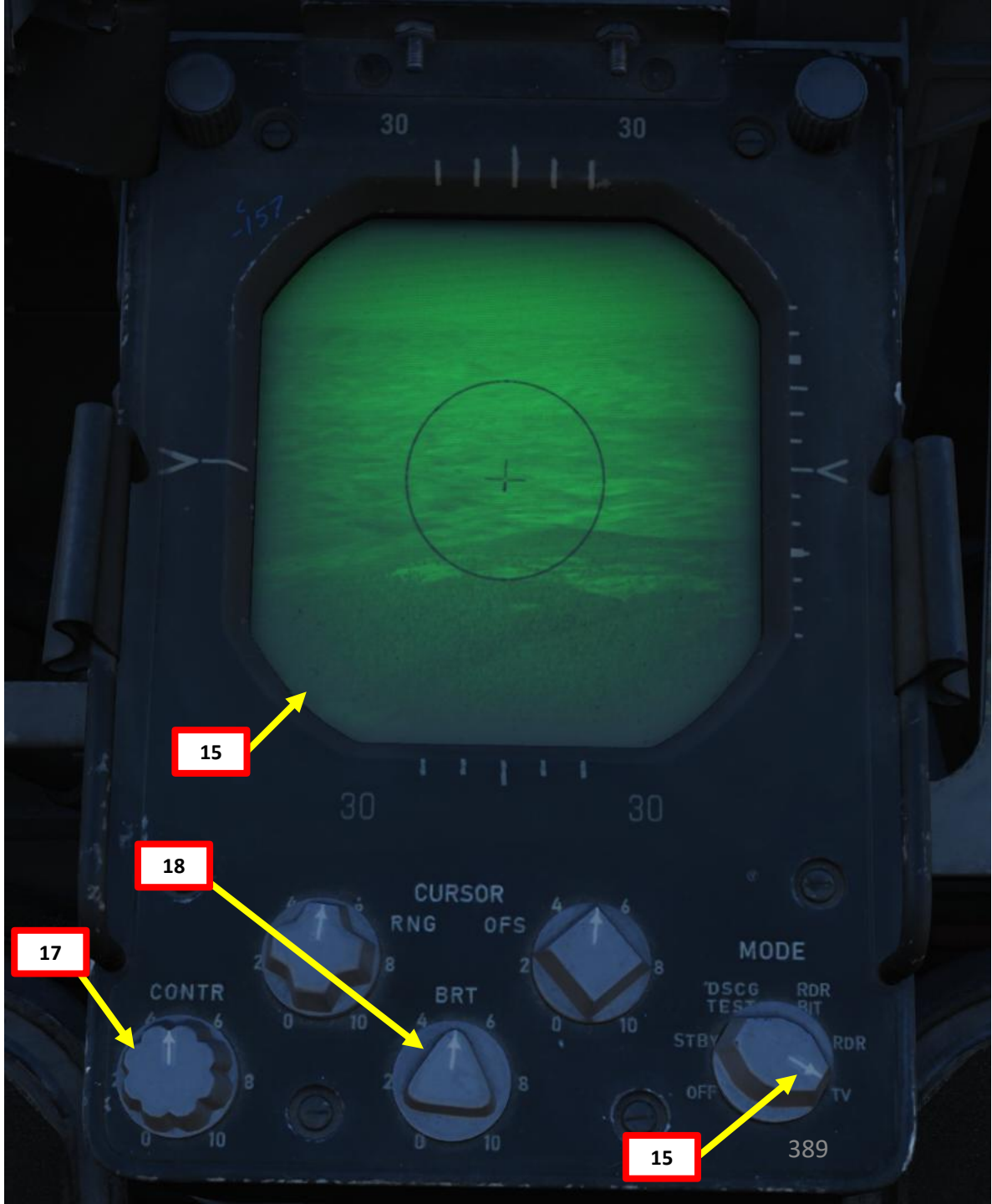


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

14. *[WSO]* Set Video Select Button – ASQ-153.
15. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – TV
16. *[WSO]* Set Reticle Brightness – As desired.
    - Full counter-clockwise: reticle is black.
    - Full clock-wise: reticle is green.
17. *[WSO]* Adjust Screen Contrast – As desired.
18. *[WSO]* Adjust Screen Brightness – As desired.



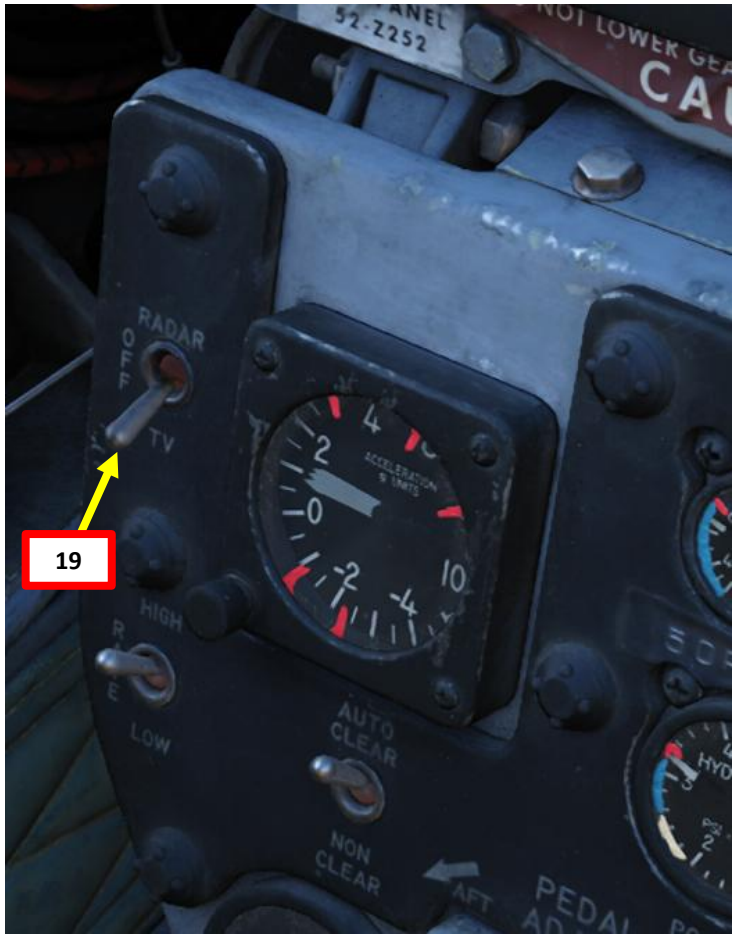


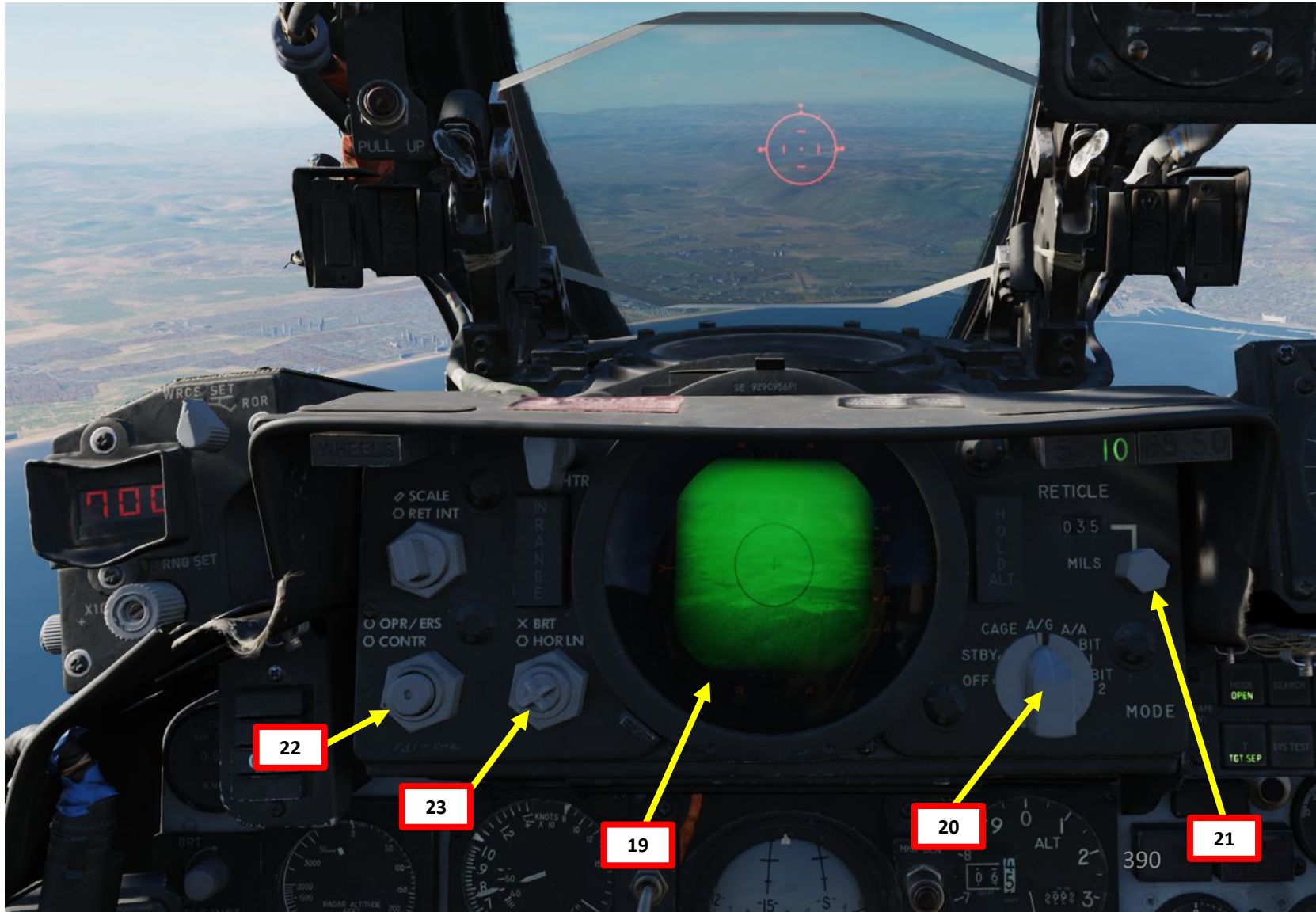


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)

3.4 – Start-Up & Lasing Procedure

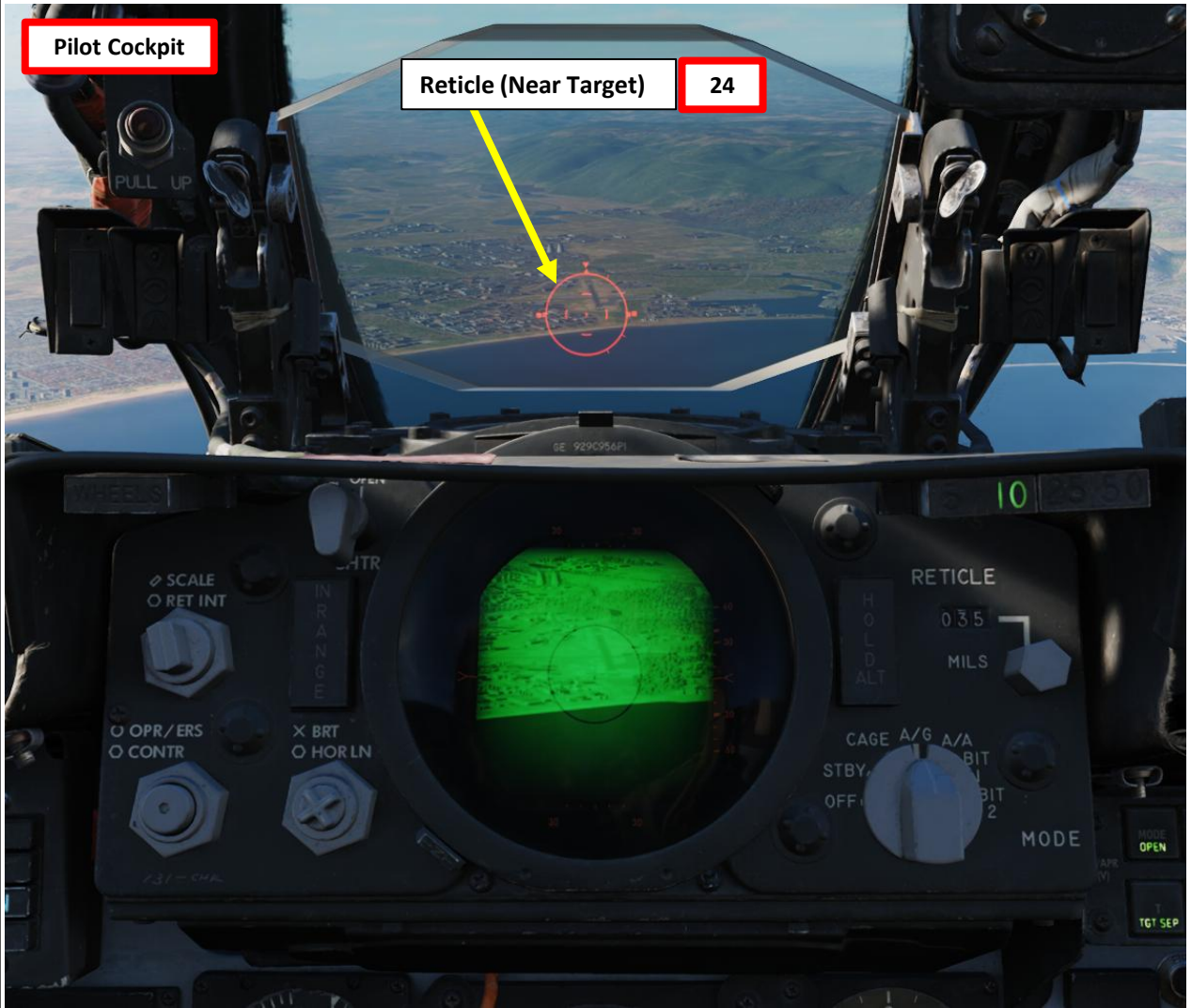
19. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – TV (DOWN). This will display the targeting pod display repeater (provided the pod is set up from the WSO seat).
20. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
21. *[P]* Set Reticle Depressing Setting – 35 Mils.
22. *[P]* Adjust Screen Contrast – As desired (Outer knob)
23. *[P]* Adjust Screen Brightness – As desired (Inner knob).





3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

24. *[P]* Fly the aircraft to put the reticle roughly near the target since we are using the 12-VIS acquisition mode.
25. *[P]* Once the reticle is on the target, call out “Tracking” to the WSO to confirm the target is being held in sight.

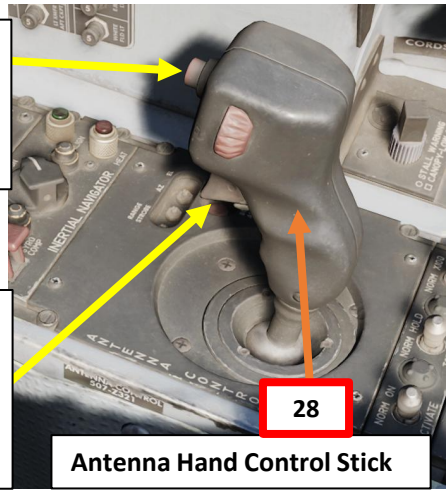




3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

26. *[WSO]* Use the Challenge Button to toggle between WIDE and NARROW field-of-views.
27. *[WSO]* Press the Hand Control Stick Trigger's first detent (Half-Action), then release trigger. This will toggle between 12-VIS acquisition mode and Tracking Mode.
28. *[WSO]* Slew the targeting pod's reticle with the Hand Control Stick over the target.
29. *[WSO]* Both the TTG (Time-to-Go) Cue and T0 (Release) Cue should be flashing, meaning that the pod is in tracking mode (stabilized) but laser is not firing the laser yet.
    - Note: ground stabilization is rudimentary and needs constant correction with the stick for the target to be kept centered.
30. *[WSO]* Once the targeting pod is stabilized in tracking mode on the target, the WSO calls out to the pilot "Capture" to indicate that the pod is stabilized in tracking mode.
31. *[WSO]* Press the Hand Control Stick Trigger's second detent (Full-Action), then release trigger. This will toggle command firing the laser.
    - The laser has a maximum range of approximately 11 nm.
32. *[WSO]* When the target is within range and the laser is firing, both the TTG (Time-to-Go) Cue and T0 (Release) Cue should be steady, meaning that the pod is in tracking mode (stabilized) and that the laser is firing.
33. *[WSO]* Once a good target solution is acquired, the WSO calls out to the pilot "Acceptance" to indicate that the target is acquired.

26 **Challenge Button**
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*



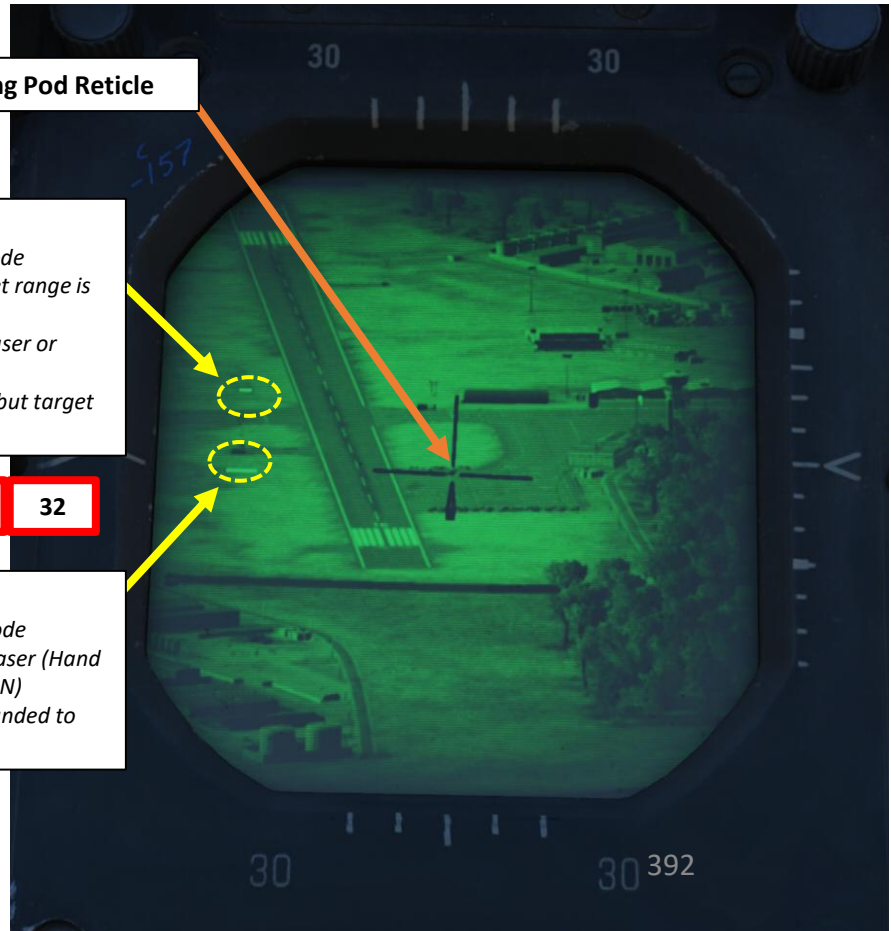
27 **31** **Action Switch (Two-Stage Trigger)**
- *Half-Action and Release: Toggles between Acquisition Mode (12-Vis, 9-Vis, WRCS) and Tracking Mode*
- *Full-Action and Release: Toggles firing the laser*
- *If in Memory Mode or Acquisition Mode (12-Vis, 9-Vis, WRCS), Full-Action and Release will enter tracking mode and fire the laser.*





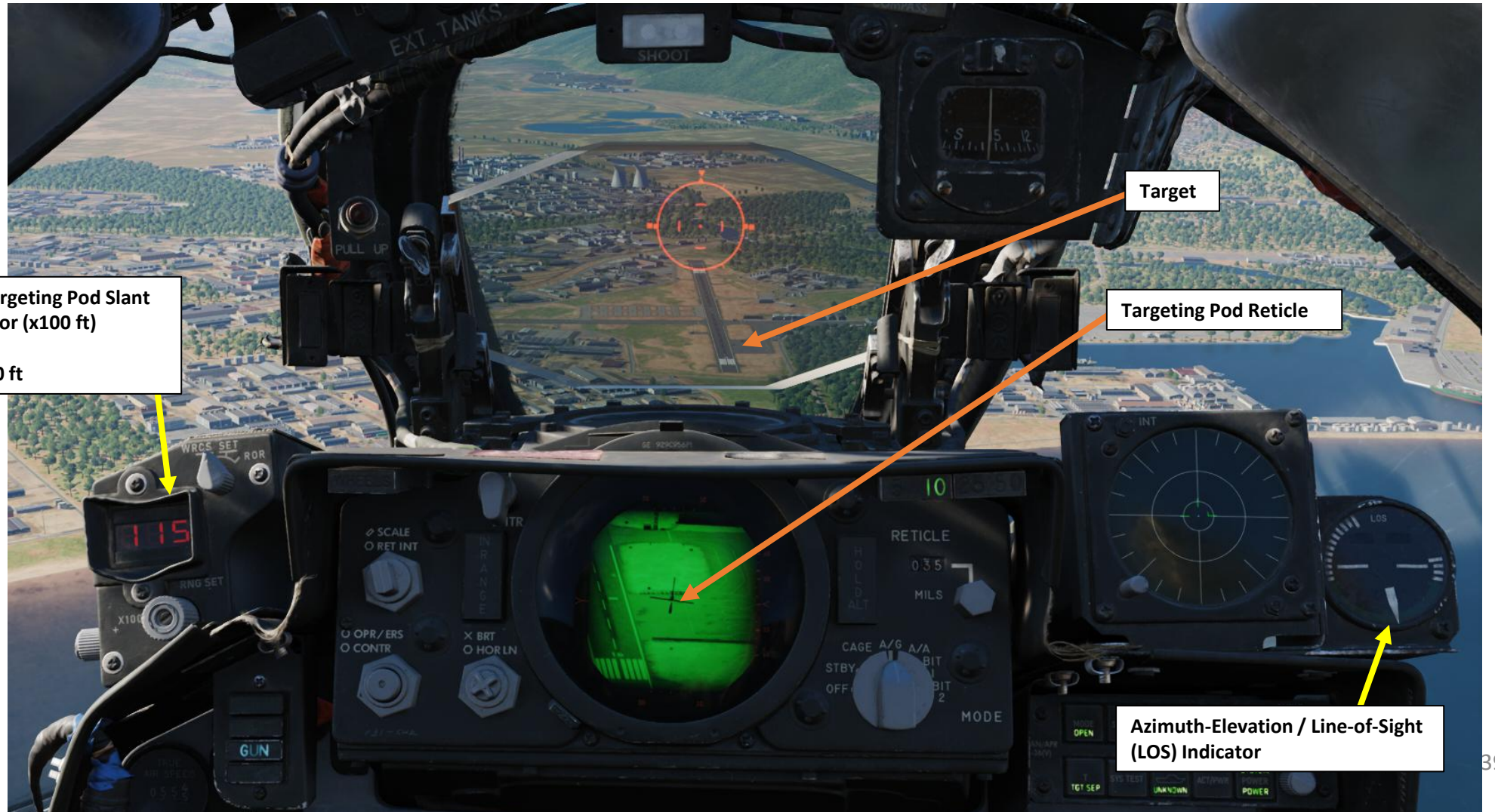
TTG (Time-to-Go) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is firing laser and target range is accepted*
- *Flashing Quickly: Pod is not firing laser or target is too far away*
- *Flashing Slowly: Pod is firing laser, but target range is rejected*

29 **32** **T0 (Release) Cue**
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is commanded to fire laser (Hand Control Stick Trigger to FULL ACTION)*
- *Flashing Quickly: Pod is not commanded to fire laser*



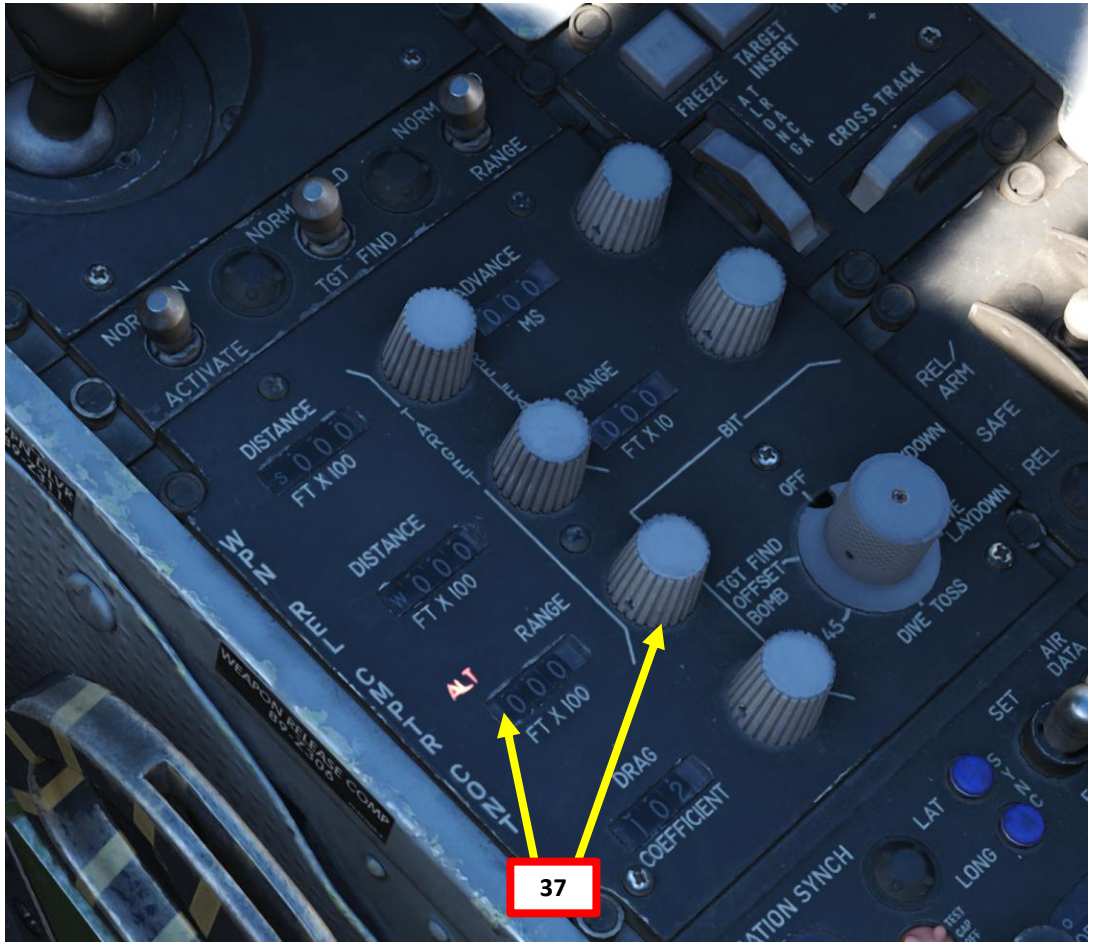
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

34. *[P]* The pilot should now fly the aircraft in order to keep the target within the targeting pod's line-of-sight and release ordnance based on what delivery mode is selected.
    - Keep in mind that the pod is located on the left side of the aircraft and that it will restrict the way the aircraft has to be flown.
35. *[WSO]* Both crew members should communicate to ensure the targeting pod stays on target. Here are a few brevity terms that may come in handy:
    - **Blanking**: Stores installed on the aircraft (like external fuel tanks) are masking the view.
    - **Ease Off**: Informs the pilot that the targeting pod is approaching masking limits.
    - **Bunt Left/Right**: Command to roll aircraft left/right to maintain or regain target line-of-sight.



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

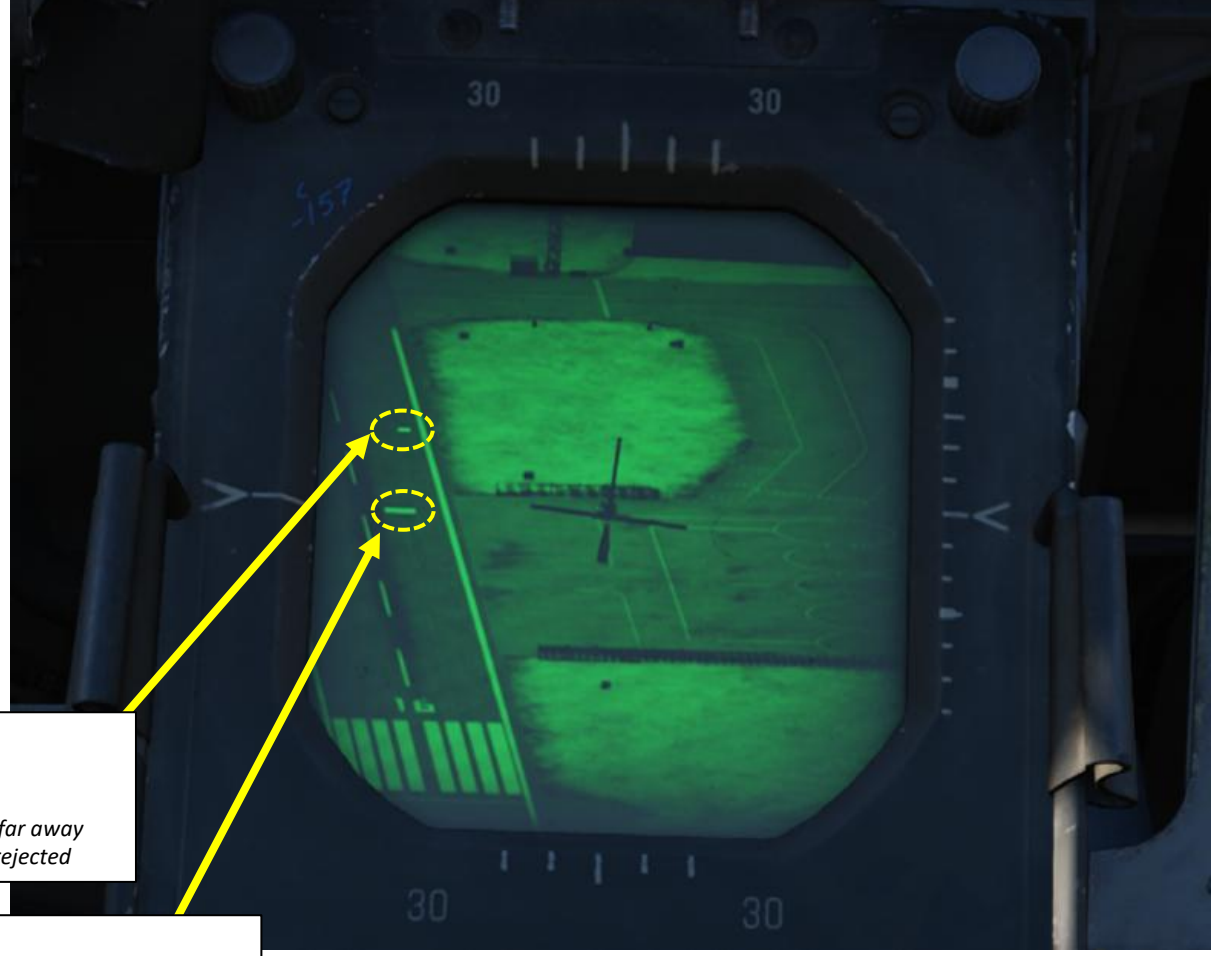
36. *[WSO]* Using the F10 map, find out the approximate elevation of the target. In our case, the target is at an elevation of 20 ft.
37. *[WSO]* Set the elevation of the target on the WRCS (Weapon Release Control Set) panel, which is 20 ft. We will round this value to 0 ft.
38. *[WSO]* The Pave Spike is a relatively primitive targeting pod compared to its modern counterparts like the LITENING or the LANTIRN. The slant range measured by the targeting pod's laser is compared to the slant range **computed based on INS (Inertial Navigation System) and WRCS data** (which is derived from the aircraft barometric altitude and the target altitude set on the WRCS panel).





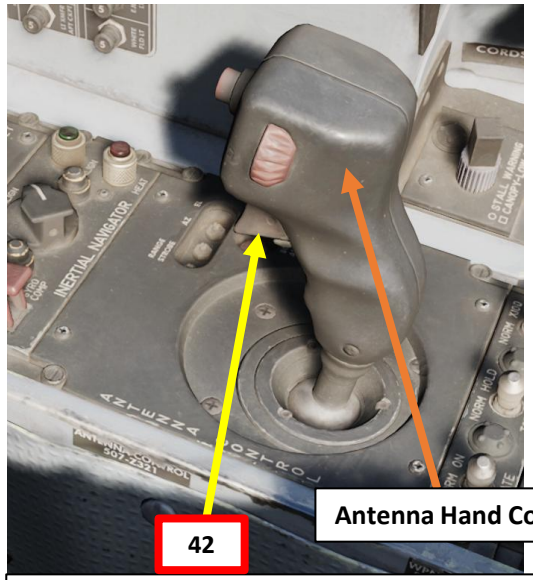
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.4 – Start-Up & Lasing Procedure

39. *[WSO]* As a general rule, the T0 cue indicates intention to fire the laser, while the TTG cue represents the outcome of the laser usage. If the slant range measured by the laser is not within +/- 20 % of the value computed from the INS & WRCS, it is rejected. This is indicated by TTG flashing slow.
40. *[WSO]* If the TTG Cue is flashing slowly (Pod is firing laser, but target range is rejected), you can force the system to use the laser-computed slant range to the target by pressing the Reject/Override Button.
    - Note: In practice, laser measured range is much more accurate than the slant range computed by the system. Hence, pilots developed a habit of always hitting the button whenever they fired the laser.
41. *[WSO]* As a rule of thumb, do not use the laser for longer than 15 minutes without allowing for cooling between uses. Limit continued slow and low-level flight while operating the pod to 30 minutes.
42. *[WSO]* To stop firing the laser, press the Hand Control Stick Trigger's second detent (Full-Action), then release trigger.



TTG (Time-to-Go) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is firing laser and target range is accepted*
- *Flashing Quickly: Pod is not firing laser or target is too far away*
- *Flashing Slowly: Pod is firing laser, but target range is rejected*

T0 (Release) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is commanded to fire laser (Hand Control Stick Trigger to FULL ACTION)*
- *Flashing Quickly: Pod is not commanded to fire laser*



Antenna Hand Control Stick

Action Switch (Two-Stage Trigger)
- *Half-Action and Release: Toggles between Acquisition Mode (12-Vis, 9-Vis, WRCS) and Tracking Mode*
- *Full-Action and Release: Toggles firing the laser*
- *If in Memory Mode or Acquisition Mode (12-Vis, 9-Vis, WRCS), Full-Action and Release will enter tracking mode and fire the laser.*



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.1 – 12-VIS Visual Acquisition Mode

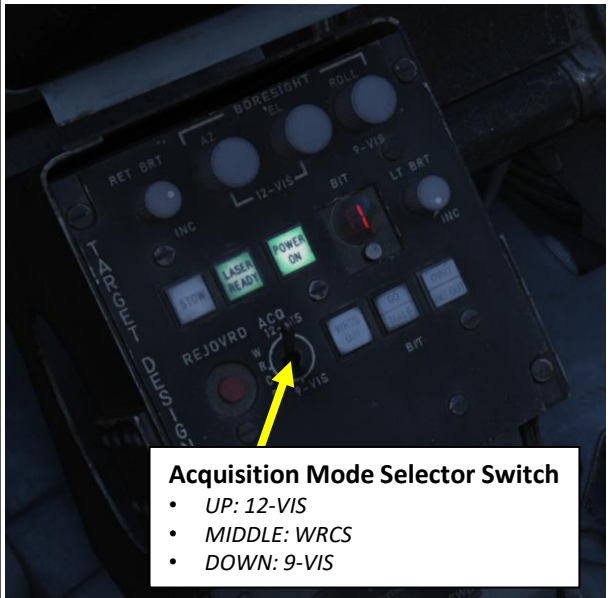
12-VIS is a visual acquisition mode which allows the crew visually acquire the general target area at the aircraft's **12 o'clock position** and put the targeting pod's line-of-sight in the vicinity.

12-VIS can be a great way to find targets of opportunity, as it allows the pilot to put a target directly on the nose. The position also corresponds to the caged HUD reticle. Additionally, if the inertial navigation system is integrated with the pod, 12-VIS is roll-stabilized.

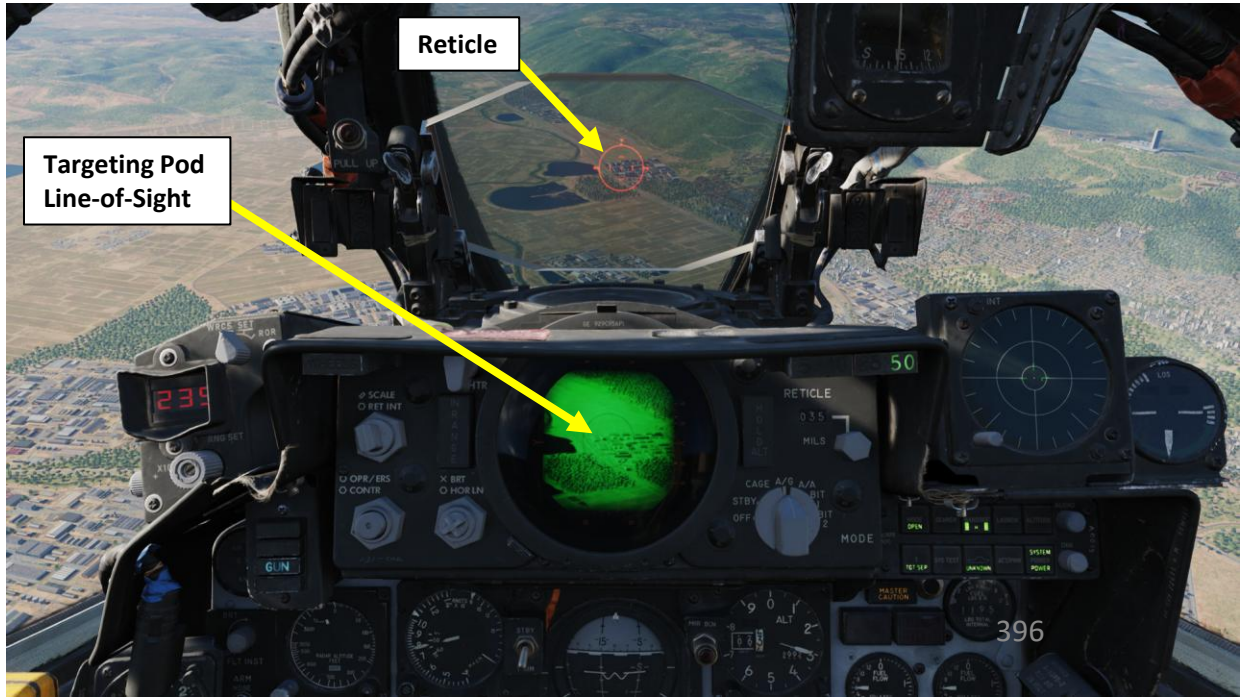
To use 12-VIS, set the **Acquisition Mode Selector Switch UP**.

The line-of-sight of the pod is set to the 12 o'clock (front) position:
- **0 degrees roll, -2 degrees elevation, looking slightly nose down**.









3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.2 – 9-VIS Visual Acquisition Mode

9-VIS is a visual acquisition mode which allows the crew visually acquire the general target area at the aircraft's **9 o'clock position** and put the targeting pod's line-of-sight in the vicinity.

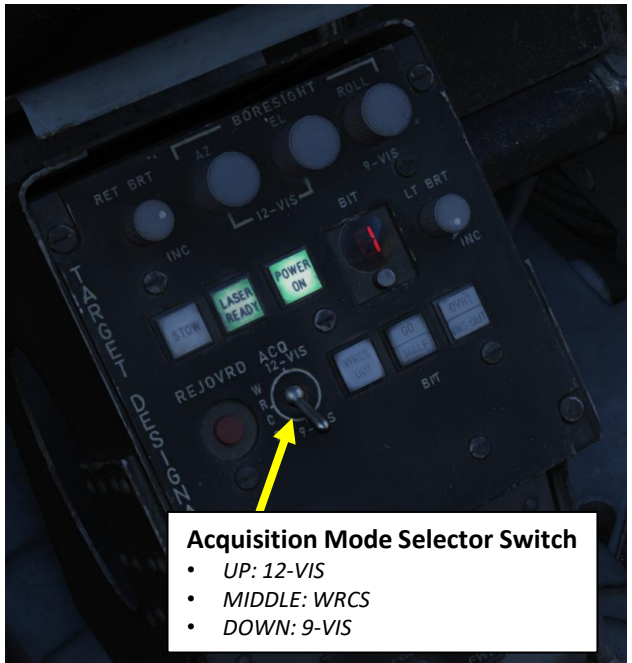
The use of 9-VIS is very limited. It is intended to aid in acquiring a target while observing an area in a turn. The target has to be put on the extension of the left wing. However, in practice it is very difficult to maintain a turn in such an attitude. Unless you are flying the correct altitude to maintain a constant bank pylon turn around the target, you cannot "freeze" the target in the pod line-of-sight.

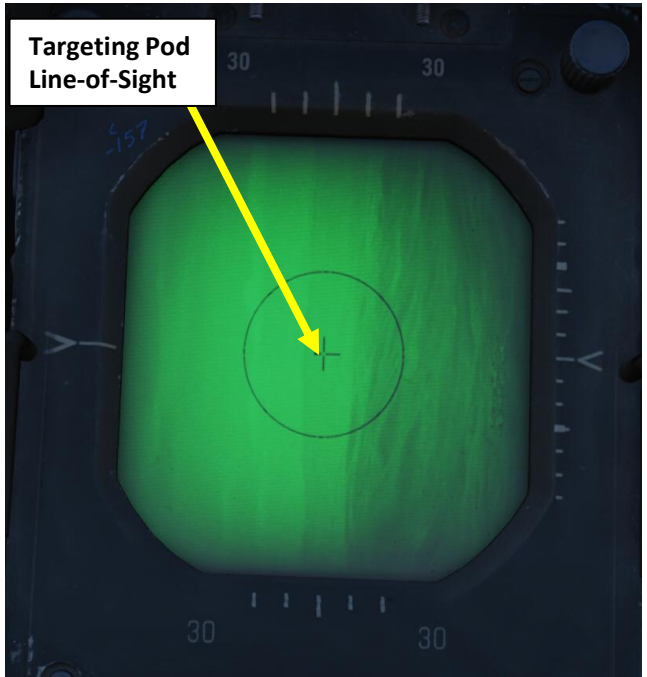
To use 9-VIS, set the **Acquisition Mode Selector Switch DOWN**.

The line-of-sight of the pod is set to the 9 o'clock (left) position:

- **-90 degrees roll clockwise, -90 degrees elevation (down), looking left.**









3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode

WRCS (Weapon Release Computer Set) is an acquisition mode that enables the crew to spot a target by using the radar or entering known coordinates and then slewing the pod to this destination. If no specific target has been inserted, the WRCS usually defaults to the aircraft position, resulting in the pod looking straight down.

Note: WRCS mode automatically falls back to the 12-VIS mode in case the WRCS integration is deactivated.

To use WRCS, set the **Acquisition Mode Selector Switch** to the **MIDDLE** position.

WRCS mode is mainly used with the following methods:

- **A – Cueing/Slaving the targeting pod to an offset from an IP (referred as "Initial Point", "Identification Point" or "Ingress Point")**
- **B – Cueing/Slaving the targeting pod to a target designation performed with the air-to-ground radar manually**
- **C – Cueing/Slaving the targeting pod to a target designation performed with the air-to-ground radar using known target coordinates**

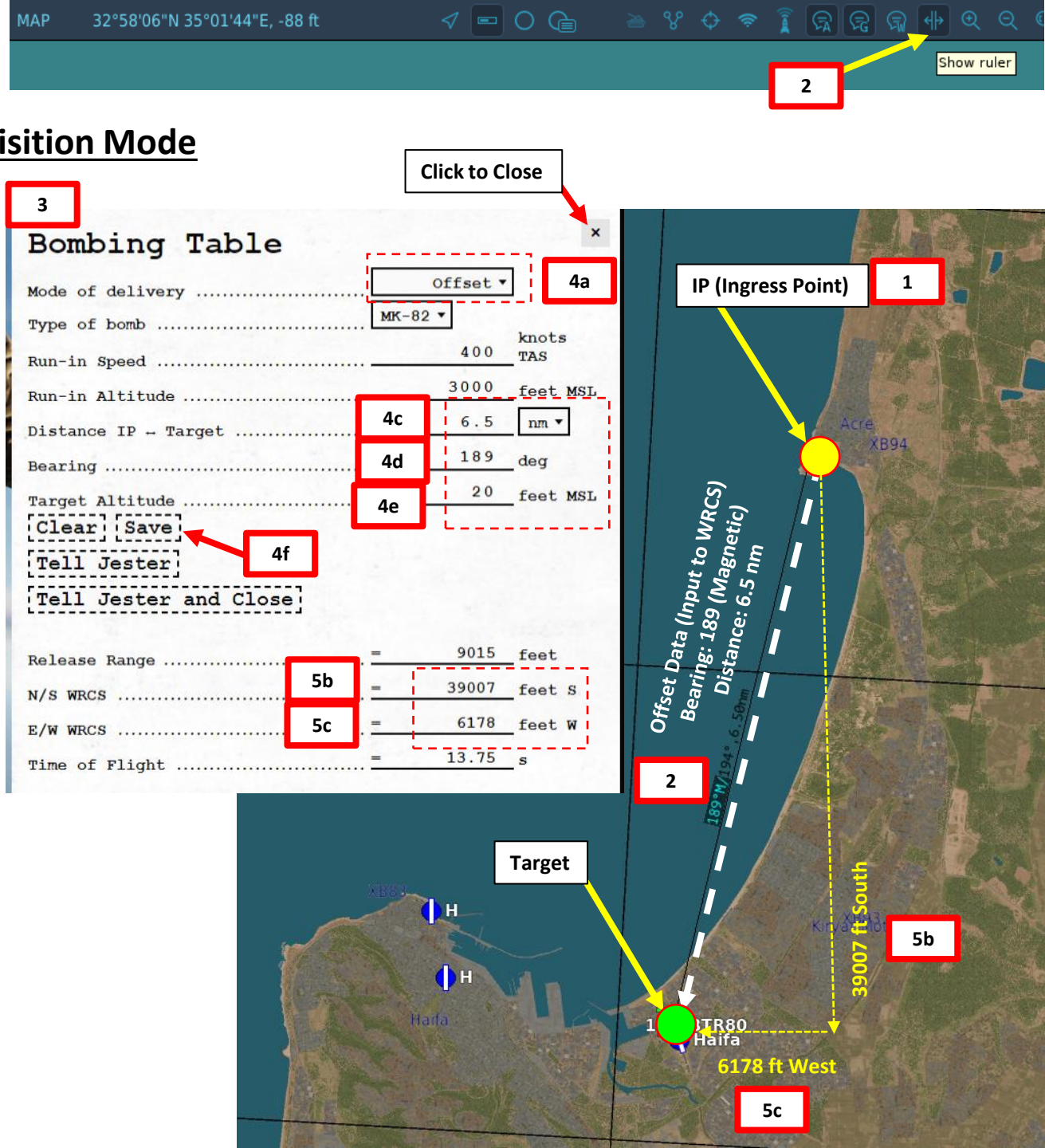


Acquisition Mode Selector Switch
- *UP: 12-VIS*
- *MIDDLE: WRCS*
- *DOWN: 9-VIS*

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
A – Cueing/Slaving TGP to IP (Ingress Point) Offset

This method requires the pilot to overfly a pre-determined IP (Ingress Point), which is set on something that is easily recognizable visually. The targeting pod is then given an offset from this IP which coincides with the position of the target.

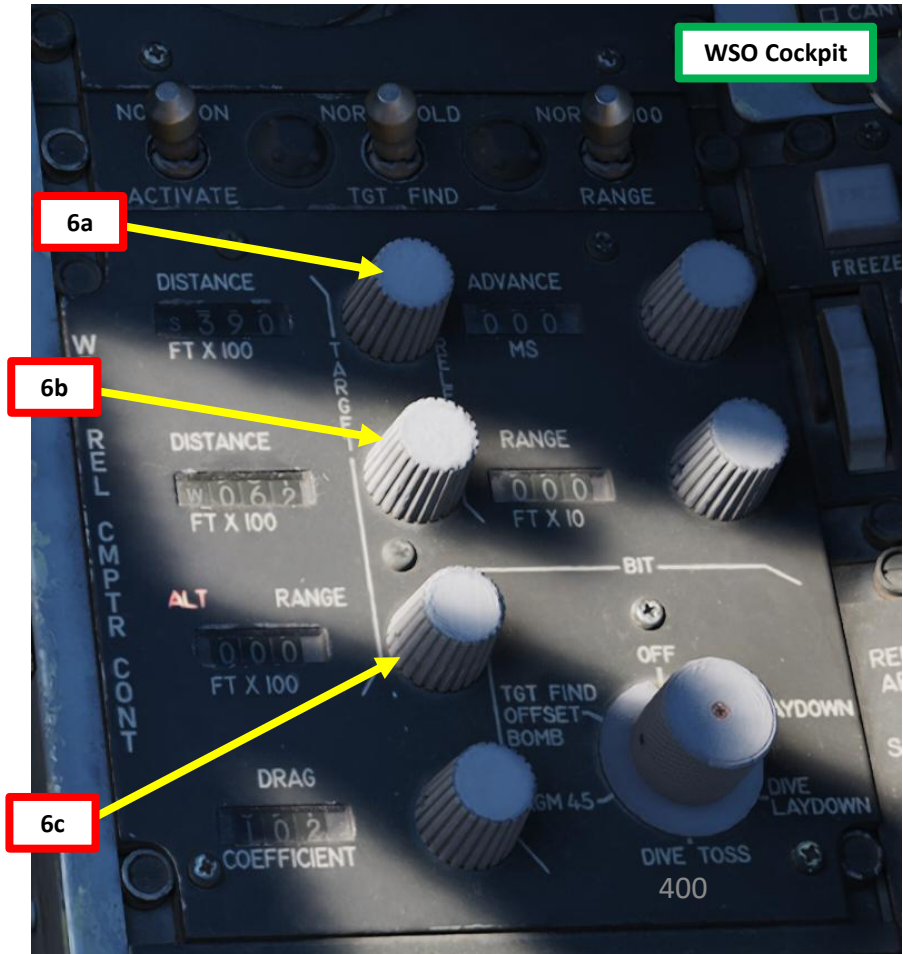
1. *[WSO]* Determine what the Ingress Point will be. In this example, the IP is set on the Acre Harbor.
2. *[WSO]* Use the "Show Ruler" function of the F10 map to determine the bearing and distance from the IP to the target. In this example, we get a **distance of 6.5 nm** and a **magnetic bearing of 189**.
3. *[WSO]* The WRCS system requires North/South and East/West offset distances in feet. To obtain those easily, select the « Bombing Table Utility » by pressing « RCTRL+B ».
4. *[WSO]* On Bombing Table Utility:
    a) Select OFFSET Mode of delivery
    b) Select desired Type of Bomb, Run-In Speed and Run-In Altitude – As desired.
    c) Set Distance from IP to Target: 6.5 nm
    d) Set Bearing from IP to Target: 189
    e) Set Target Altitude: 20 ft
    f) Click SAVE.
5. *[WSO]* On Bombing Table Utility, target offset data is automatically calculated:
    a) Release Range: 9015 ft
    b) North/South WRCS Offset: 39007 ft South
    c) East/West WRCS Offset: 6178 ft West
    d) Time of Flight: 13.75 sec



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
A – Cueing/Slaving TGP to IP (Ingress Point) Offset

6. *[WSO]* On WRCS (Weapon Release Computer Set) Panel, enter target offset data computed from the Bombing Table Utility:
   a) **North/South WRCS Offset: 39007 ft South (entered "390" x100 ft)**
   b) **East/West WRCS Offset: 6178 ft West (entered "61" x100 ft)**
   c) **Target Altitude: 0 ft (closest value to 20 ft)**
7. *[P]* Select Air-to-Ground Weapon Delivery Mode Knob – TGT FIND (Target Find)





Bombing Table

Mode of delivery	Offset	
Type of bomb	MK-82	
Run-in Speed	400	knots TAS
Run-in Altitude	3000	feet MSL
Distance IP – Target	6.5	nm
Bearing	189	deg
Target Altitude	20	feet MSL

Clear | Save

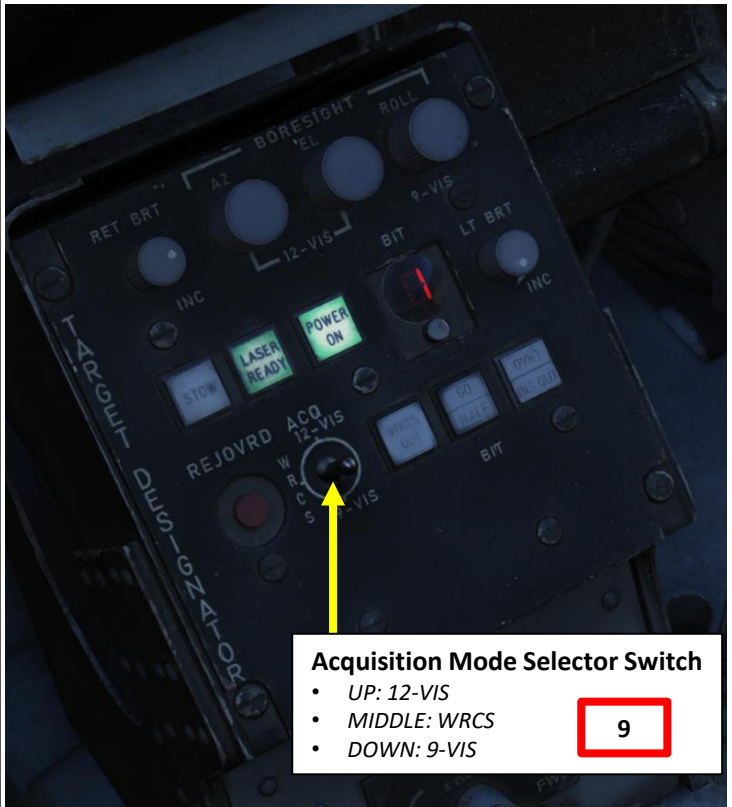
Tell Jester

Tell Jester and Close

Release Range	=	9015	feet
N/S WRCS	=	39007	feet S
E/W WRCS	=	6178	feet W
Time of Flight	=	13.75	s

3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
A – Cueing/Slaving TGP to IP (Ingress Point) Offset

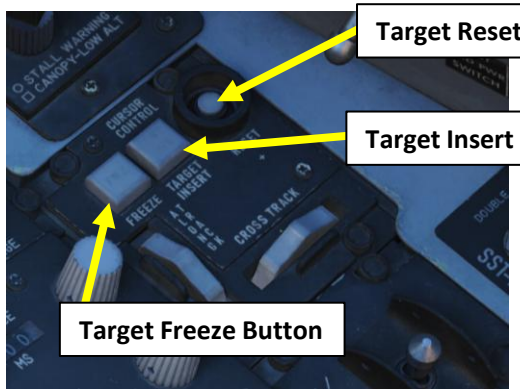
8. *[WSO]* Ensure Targeting Pod is Powered Up
    a) Set Target Designation Power On Button – ON
    b) Set Video Select Button – ASQ-153.
    c) Set DSCG (Digital Scan Converter Group) Mode Selector – TV.
9. *[WSO]* Set Acquisition Mode Selector Switch – WRCS (MIDDLE position)

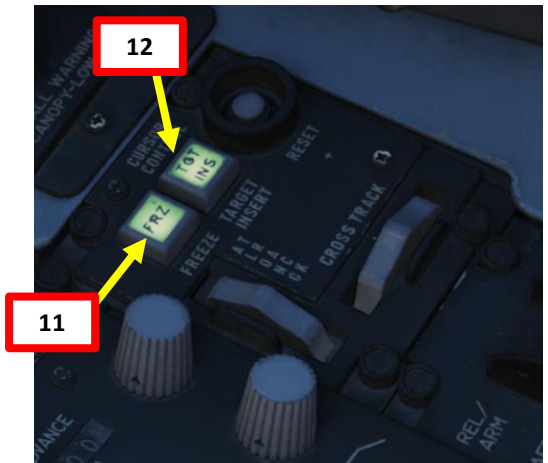


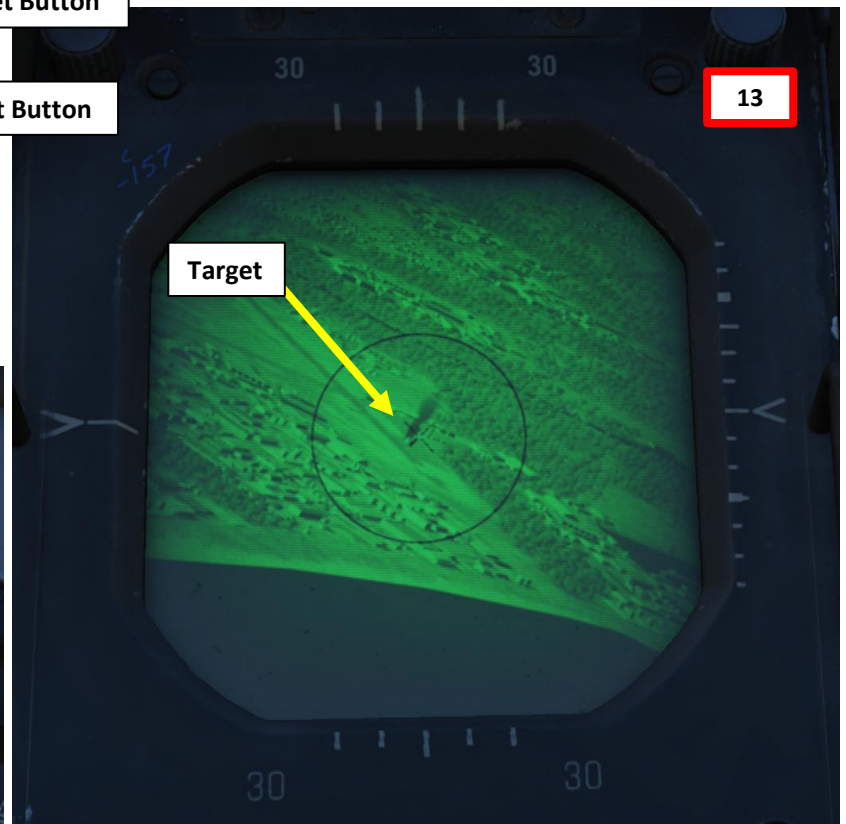


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
A – Cueing/Slaving TGP to IP (Ingress Point) Offset

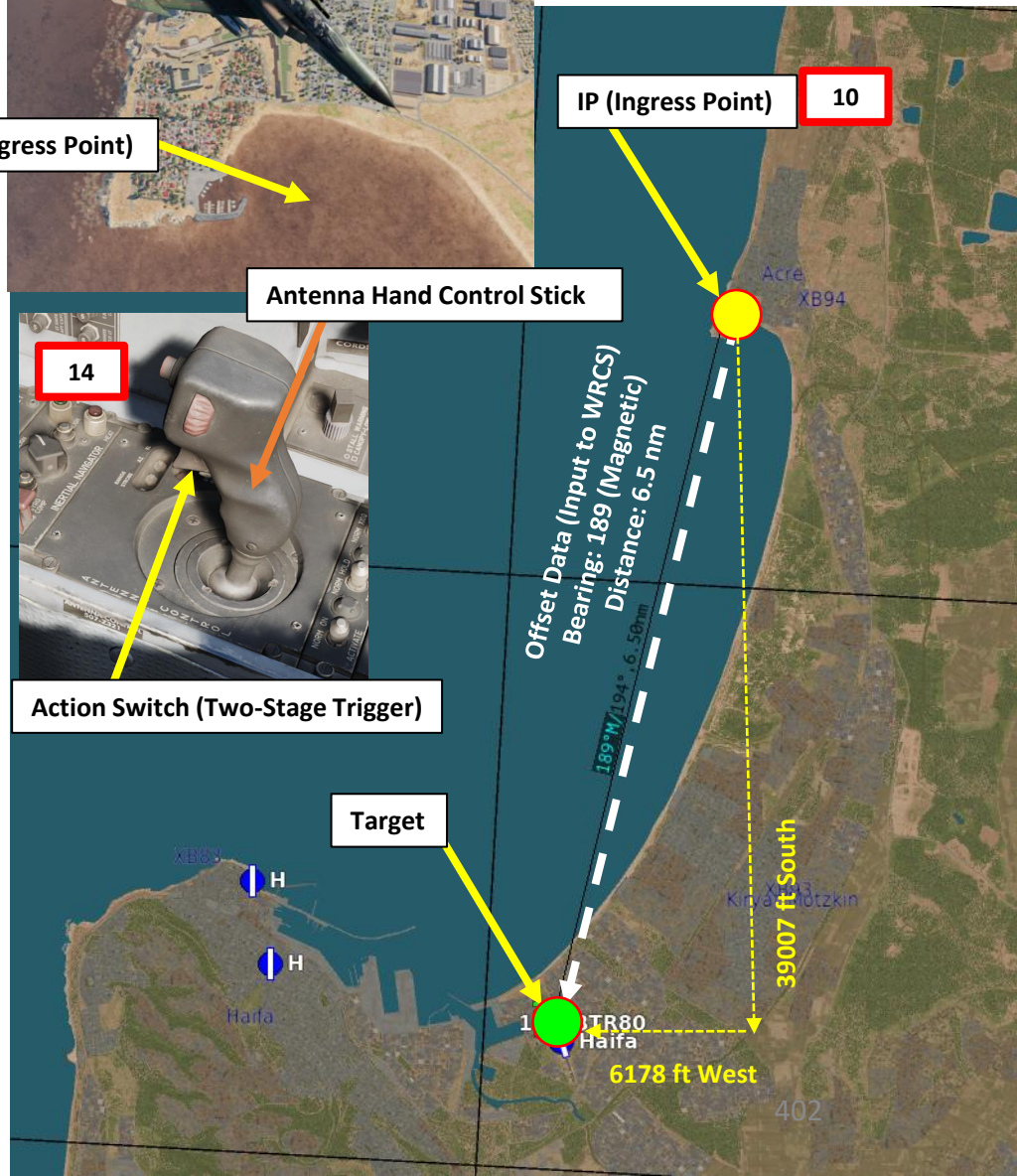
10. *[P]* Fly the aircraft over the IP (Ingress Point). When over the IP, let the WSO know that you are overflying the IP.
11. *[WSO]* Once overflying the IP, press the Target Freeze Button to memorize this position.
12. *[WSO]* Press the Target Insert Button.
13. *[WSO]* The targeting pod will then slew its line-of-sight on the approximate target area using the offset data from the IP we have fed the WRCS. Keep in mind that this will absolutely not be pin-point accurate.
14. *[WSO]* You can enter Track mode by pressing the trigger on the Antenna Hand Control to either Half or Full Action, then slew the pod as desired using the Antenna Hand Control stick.









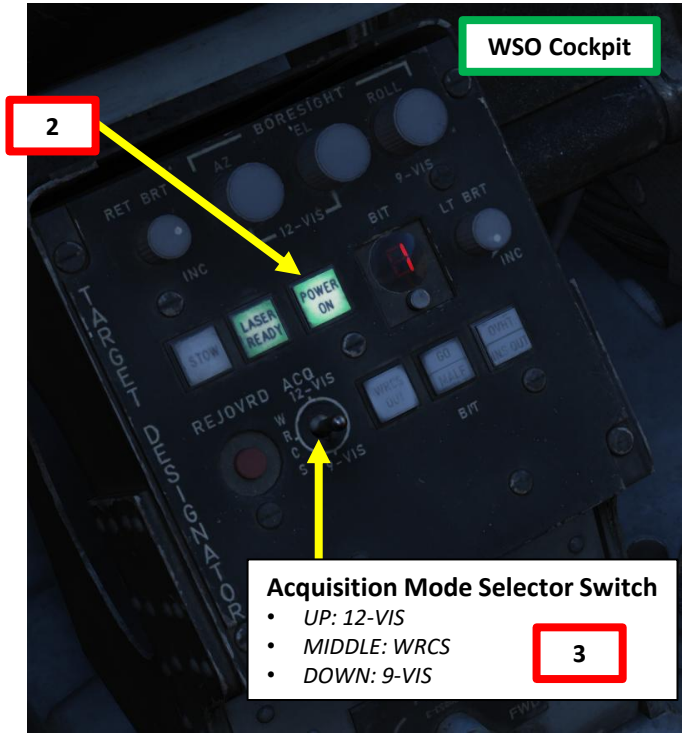


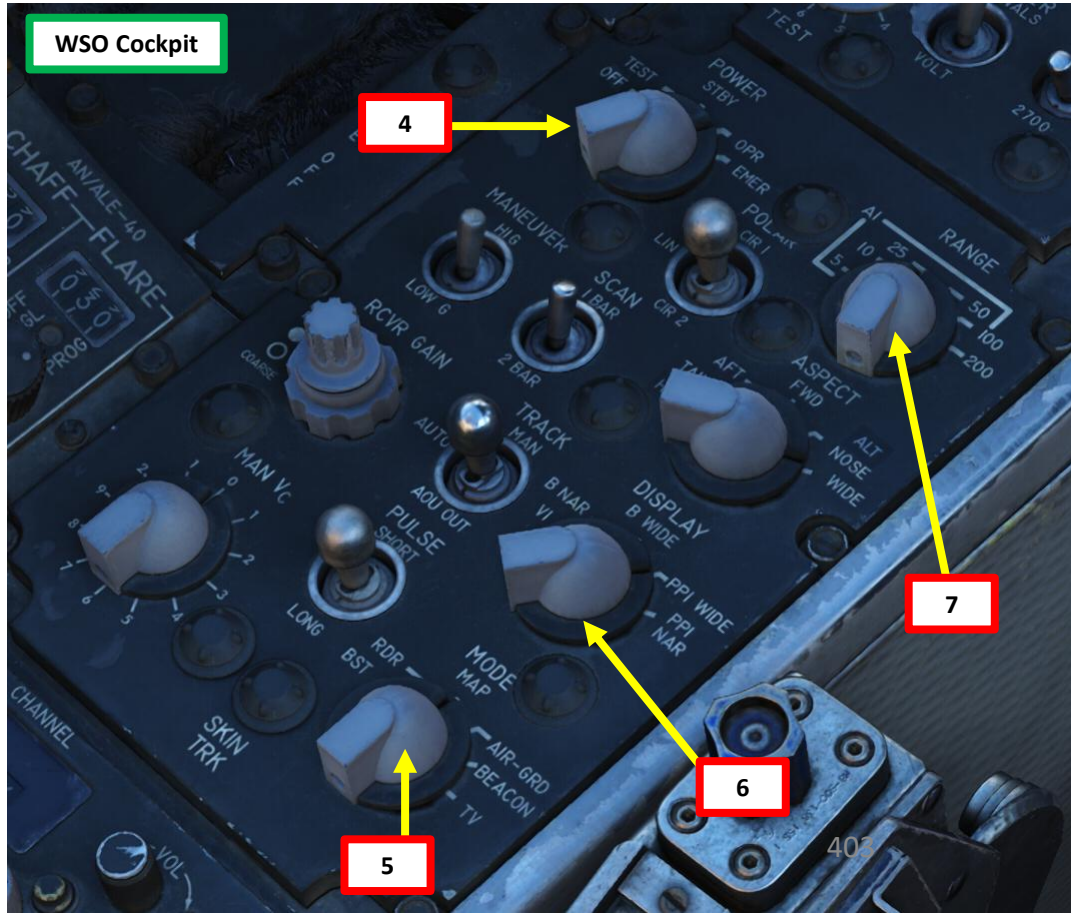
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
B – Cueing/Slaving TGP to Air-to-Ground Radar Designation

This method requires the WSO to designate a target using the air-to-ground radar to get a general idea of the area, then slave the targeting pod to this location.

1. *[P]* Select Air-to-Ground Weapon Delivery Mode Knob – TGT FIND (Target Find).
2. *[WSO]* Ensure Targeting Pod is Powered Up by setting Target Designation Power On Button – ON.
3. *[WSO]* Set Acquisition Mode Selector Switch – WRCS (MIDDLE position)
4. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
5. *[WSO]* Set Radar Operation Mode – MAP
6. *[WSO]* Set Display Selector – PPI NAR (Narrow) or PPI WIDE.
7. *[WSO]* Set Radar Range Selector – As desired.
    - Take note that **the 5 nm Distance Setting** is always displayed in B-Scope interpretation.

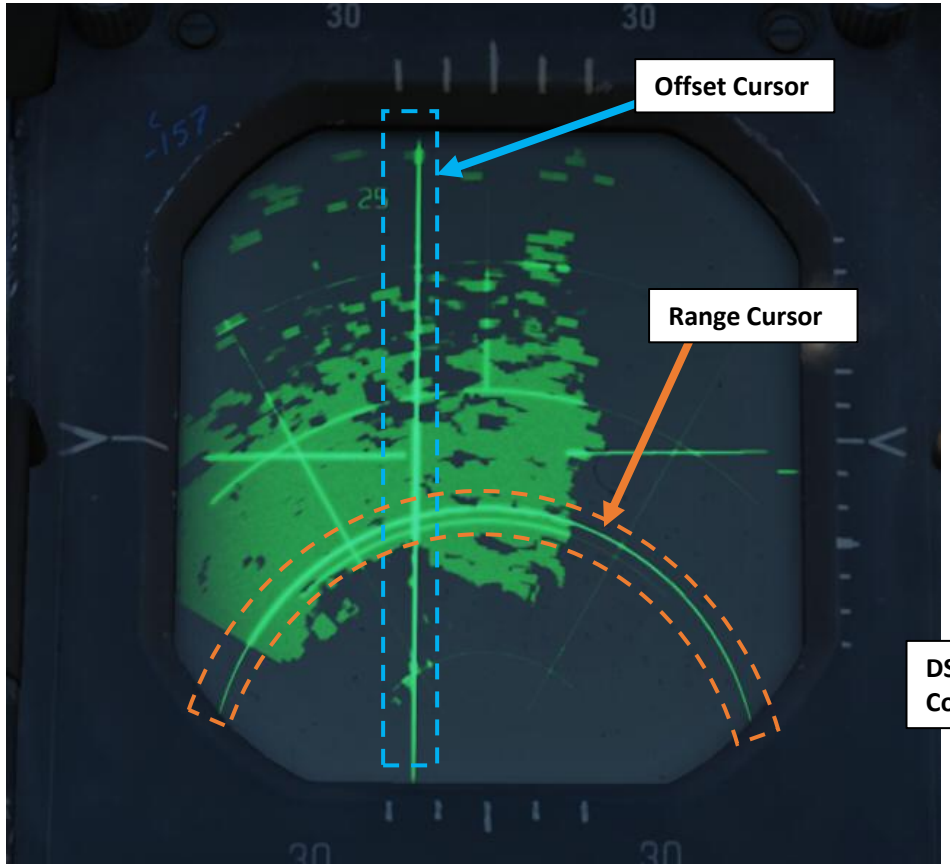


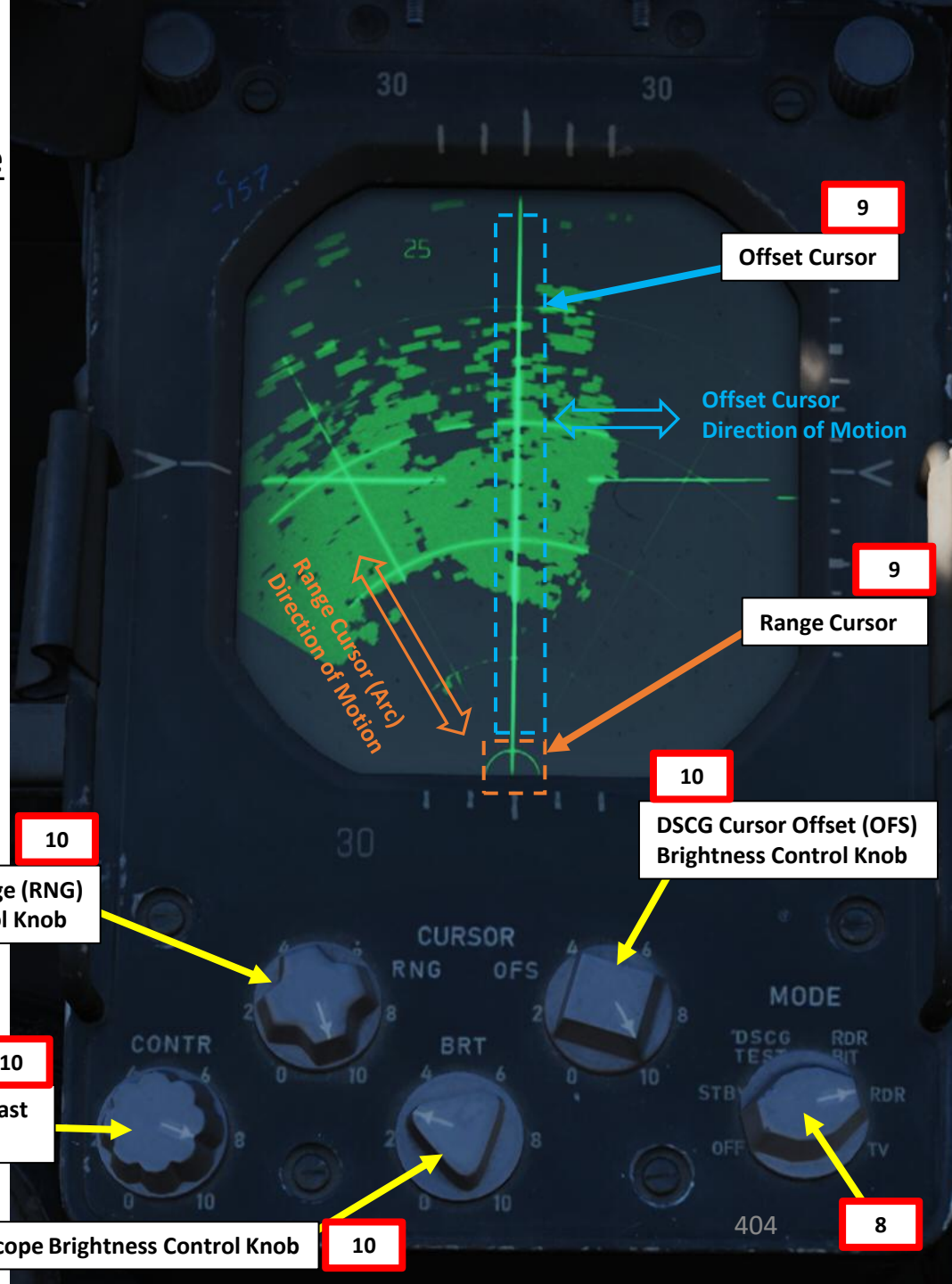




3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
B – Cueing/Slaving TGP to Air-to-Ground Radar Designation

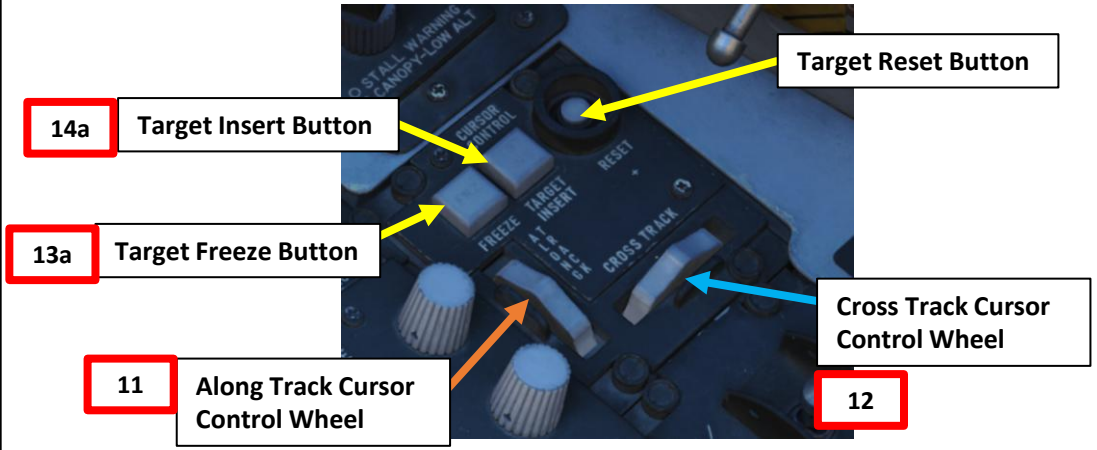
8. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
9. *[WSO]* There are two symbols that will interest us: the **Range Cursor** and the **Offset Cursor**. Both cursors can only be displayed in PPI modes.
    - The **Range Cursor** is an arc of constant range from the aircraft, which can be moved closer or away from the aircraft.
    - The **Offset Cursor** is an offset parallel to the drift of the aircraft, which can be offset left or right of the aircraft's current track.
10. *[WSO]* Adjust Cursor Range Brightness, Cursor Offset Brightness, Screen/Scope Contrast and Screen/Scope Brightness to ensure the range cursor and offset cursor are both visible.

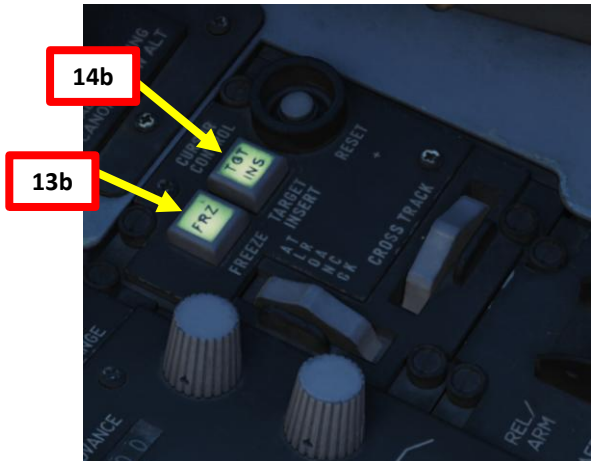


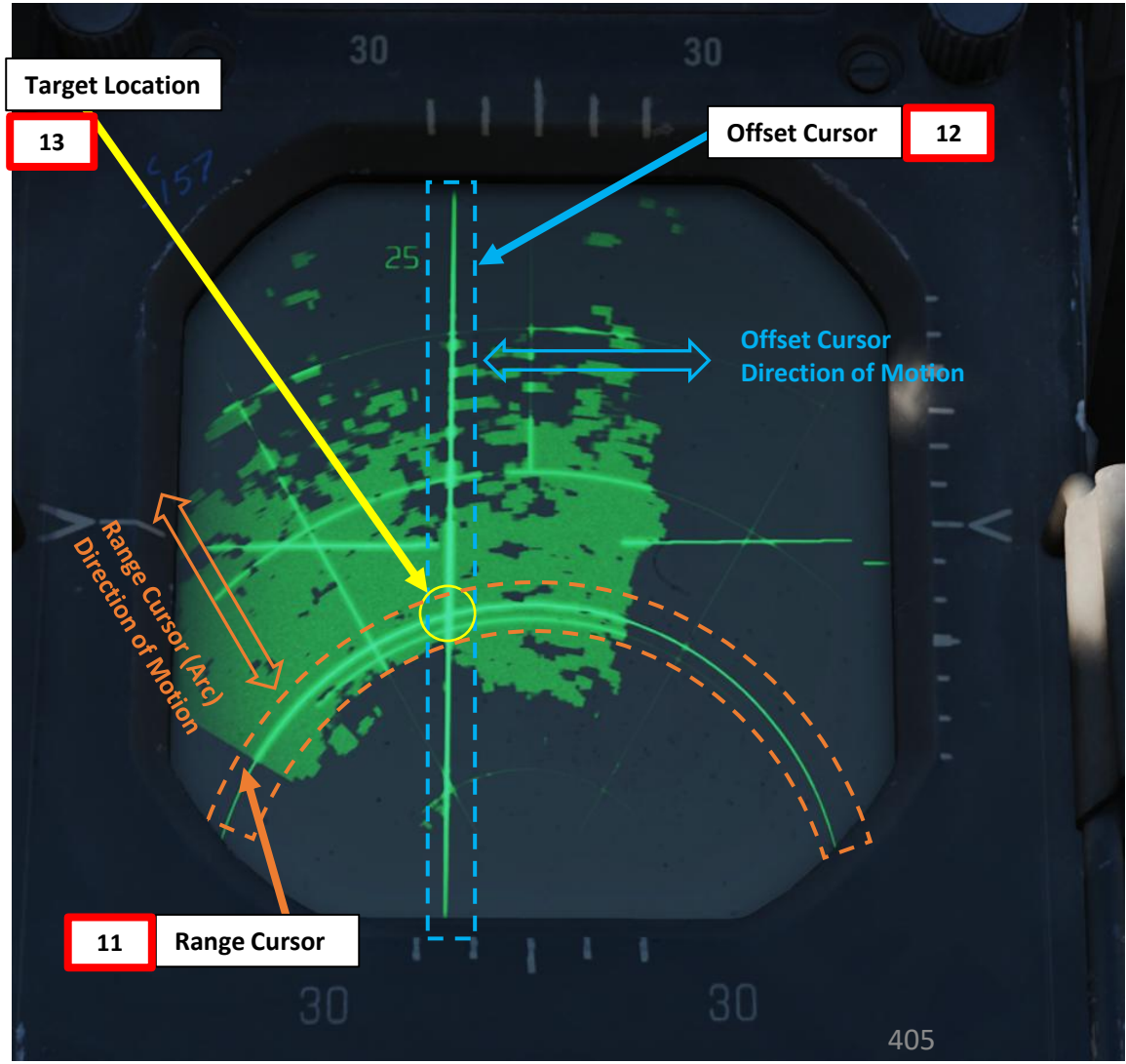


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
B – Cueing/Slaving TGP to Air-to-Ground Radar Designation

11. *[WSO]* The Along Track Control is used to increase and decrease the current setting for the range cursor.
12. *[WSO]* The Cross Track Control is used to move the offset cursor to the left and right of the aircraft's track.
13. *[WSO]* Once a target is at the meeting point between the range cursor and the offset cursor, press the Target Freeze Button to memorize this position.
14. *[WSO]* Press the Target Insert Button.
15. *[WSO]* The target is now designated.



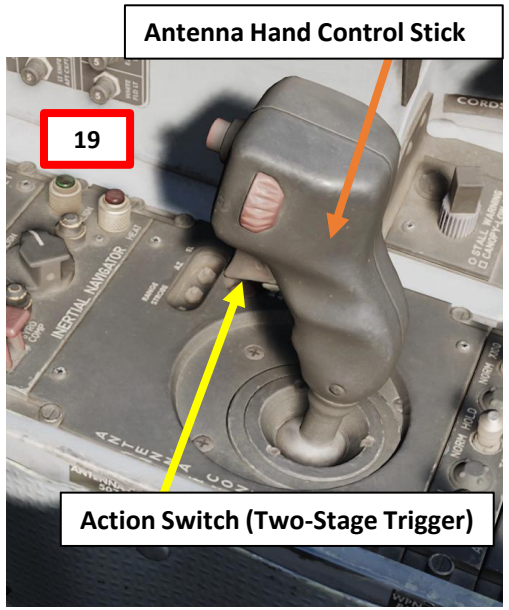




3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
B – Cueing/Slaving TGP to Air-to-Ground Radar Designation

16. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – TV.
17. *[WSO]* Set Video Select Button – ASQ-153.
18. *[WSO]* Upon pressing the Target Insert Button, the targeting pod will then slew its line-of-sight on the approximate target area using the target data designated by the air-to-ground radar. Keep in mind that this will absolutely not be pin-point accurate.
19. *[WSO]* You can enter Track mode by pressing the trigger on the Antenna Hand Control to either Half or Full Action, then slew the pod as desired using the Antenna Hand Control stick.







3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode C – Cueing/Slaving TGP to Target Coordinates

This method requires the WSO to find target coordinates and input them as TGT 1 (Target Turnpoint 1). You can then use the BDHI (Bearing Distance Heading Indicator) to find the relative location of the target, designate it using the air-to-ground radar to get a general idea of the area, then slave the targeting pod to this location.

1. *[WSO]* Find coordinate targets using the F10 map (deg, minutes format). In this example:
   - Coordinates: **North 32 deg 48 minutes** / **East 35 deg 02 minutes**
2. *[WSO]* Set Navigation Computer Mode Selector – TGT 1
3. *[WSO]* Set Target Latitude (**North 32 deg 48 minutes**)
4. *[WSO]* Set Target Longitude (**East 35 deg 02 minutes**)



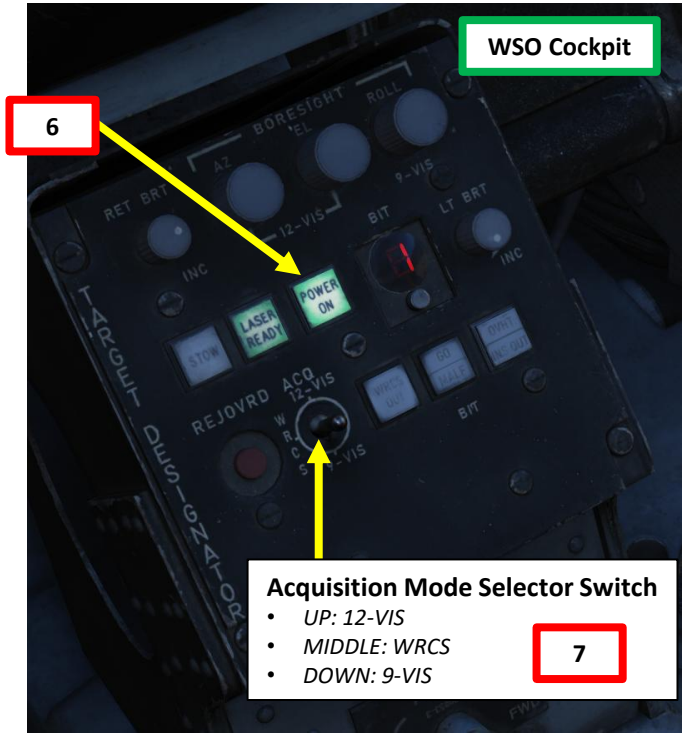


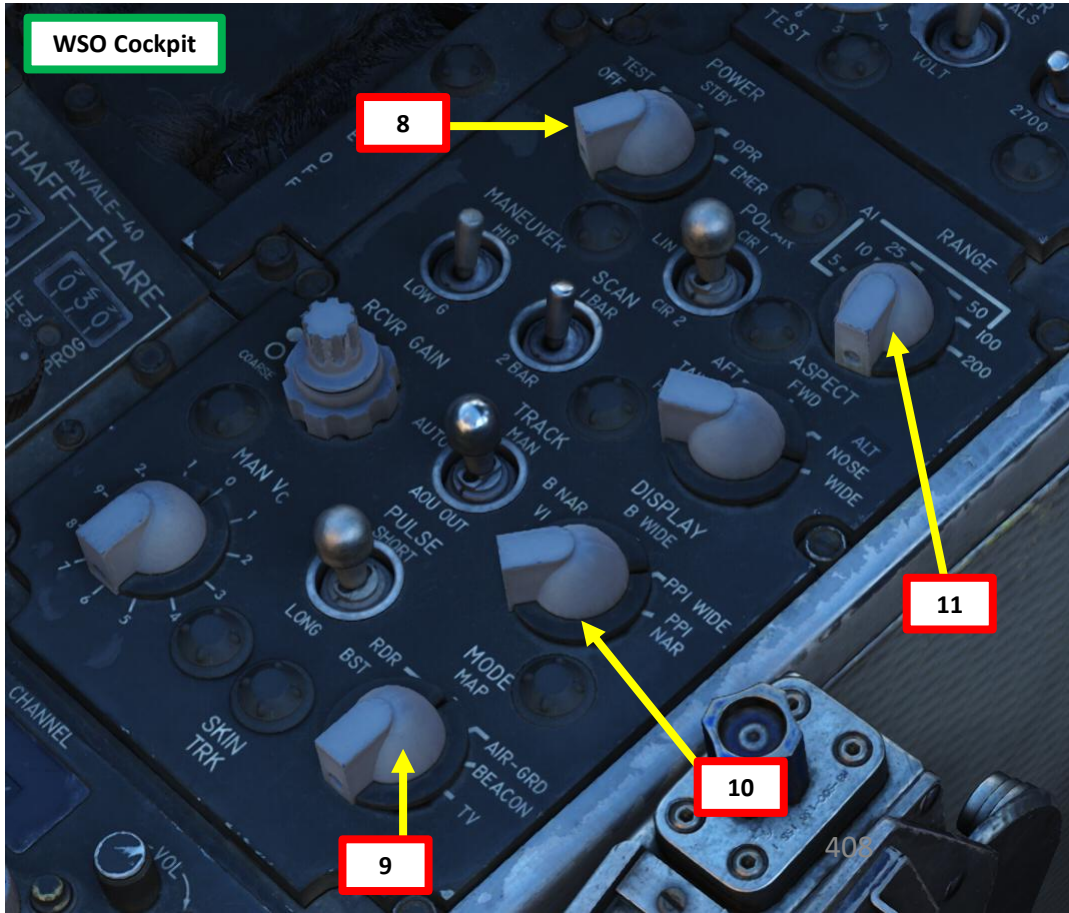


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
C – Cueing/Slaving TGP to Target Coordinates

5. *[P]* Select Air-to-Ground Weapon Delivery Mode Knob – TGT FIND (Target Find).
6. *[WSO]* Ensure Targeting Pod is Powered Up by setting Target Designation Power On Button – ON.
7. *[WSO]* Set Acquisition Mode Selector Switch – WRCS (MIDDLE position)
8. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
9. *[WSO]* Set Radar Operation Mode – MAP
10. *[WSO]* Set Display Selector – PPI NAR (Narrow) or PPI WIDE.
11. *[WSO]* Set Radar Range Selector – As desired.
    - Take note that **the 5 nm Distance Setting** is always displayed in B-Scope interpretation.

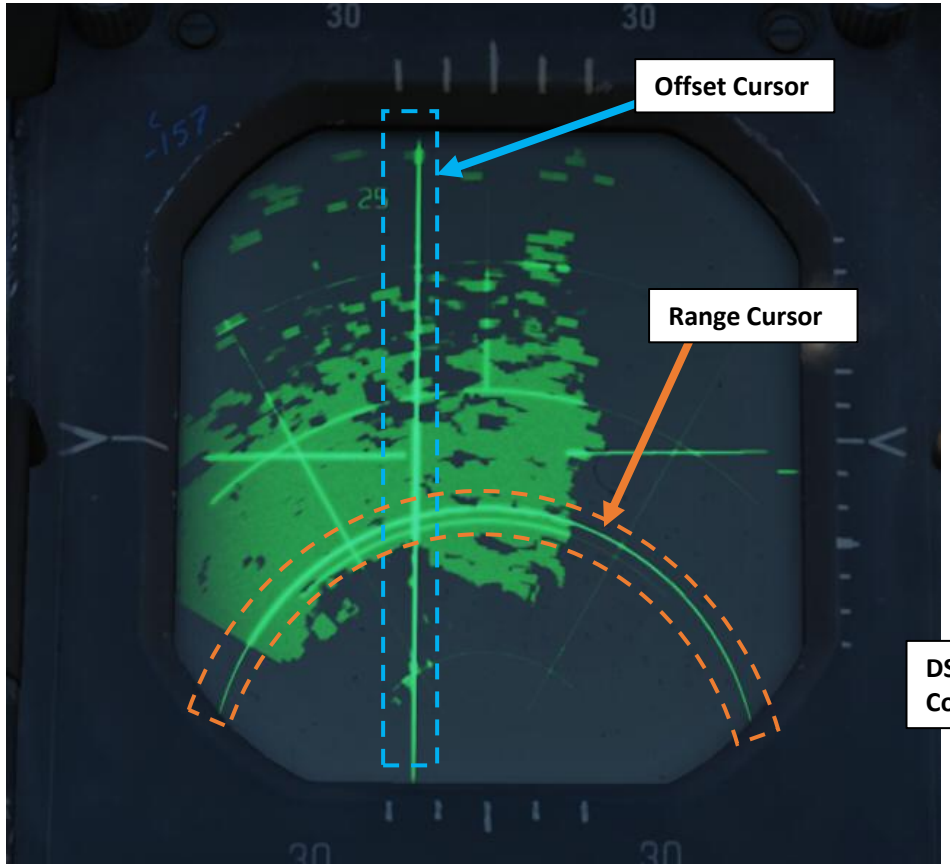


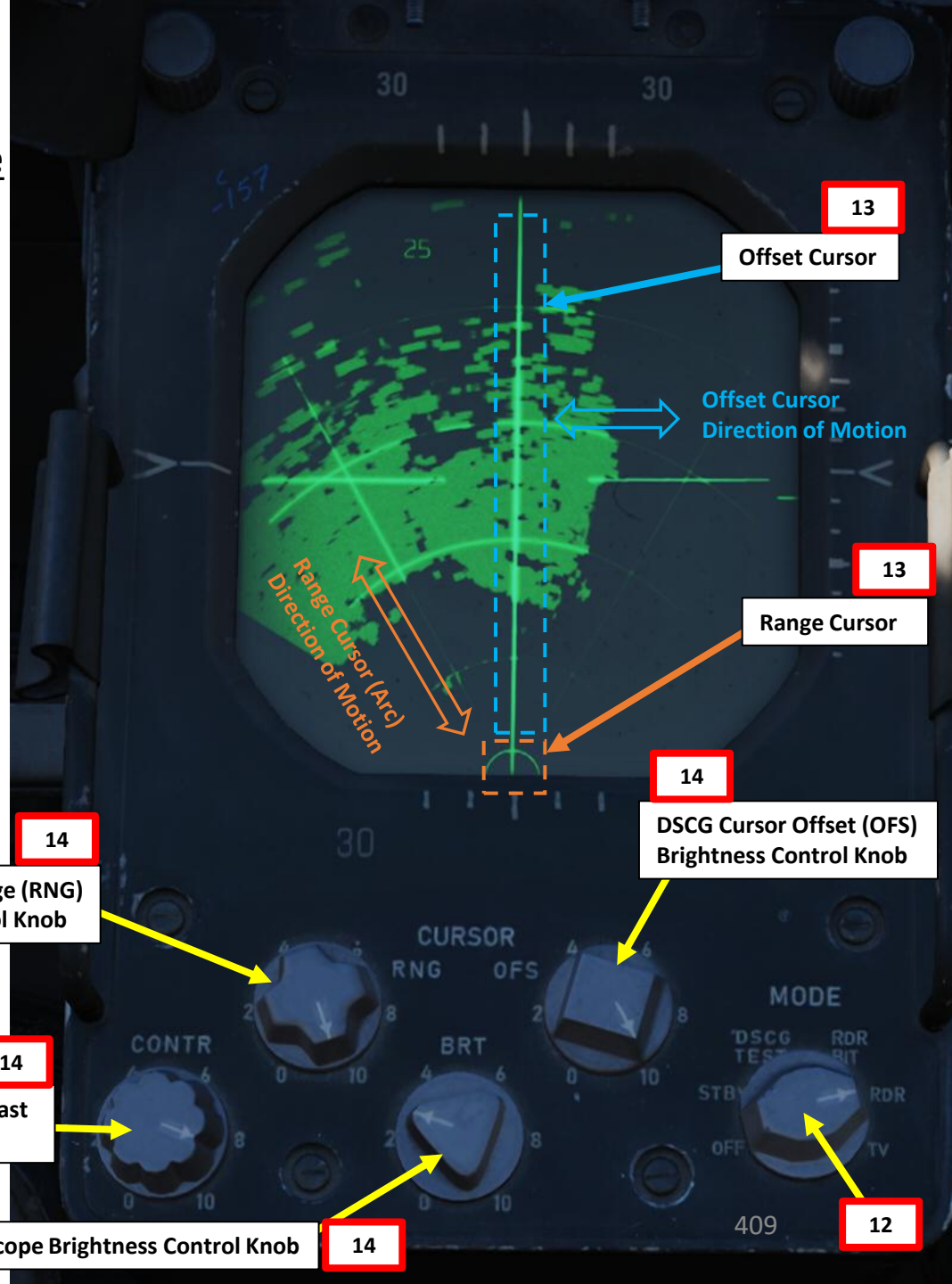




3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
C – Cueing/Slaving TGP to Target Coordinates

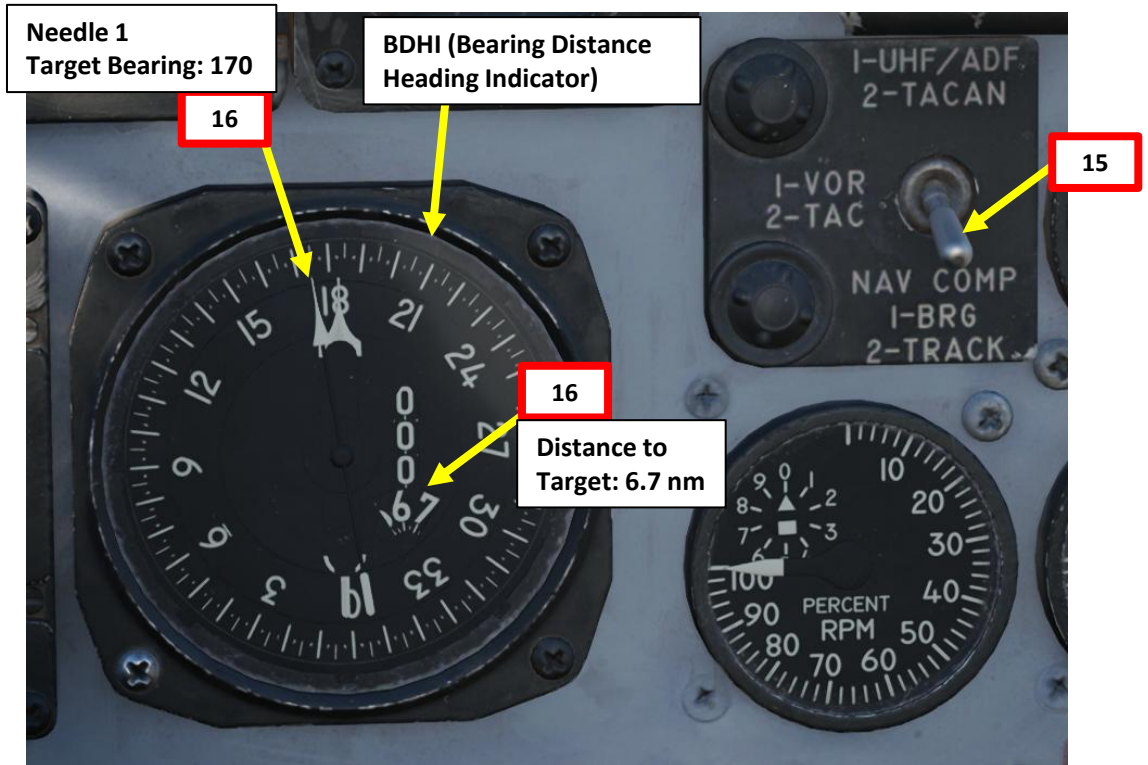
12. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
13. *[WSO]* There are two symbols that will interest us: the **Range Cursor** and the **Offset Cursor**. Both cursors can only be displayed in PPI modes.
    - The **Range Cursor** is an arc of constant range from the aircraft, which can be moved closer or away from the aircraft.
    - The **Offset Cursor** is an offset parallel to the drift of the aircraft, which can be offset left or right of the aircraft's current track.
14. *[WSO]* Adjust Cursor Range Brightness, Cursor Offset Brightness, Screen/Scope Contrast and Screen/Scope Brightness to ensure the range cursor and offset cursor are both visible.

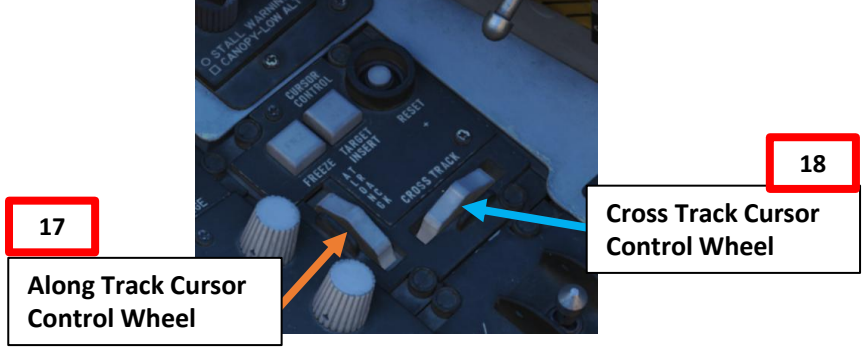


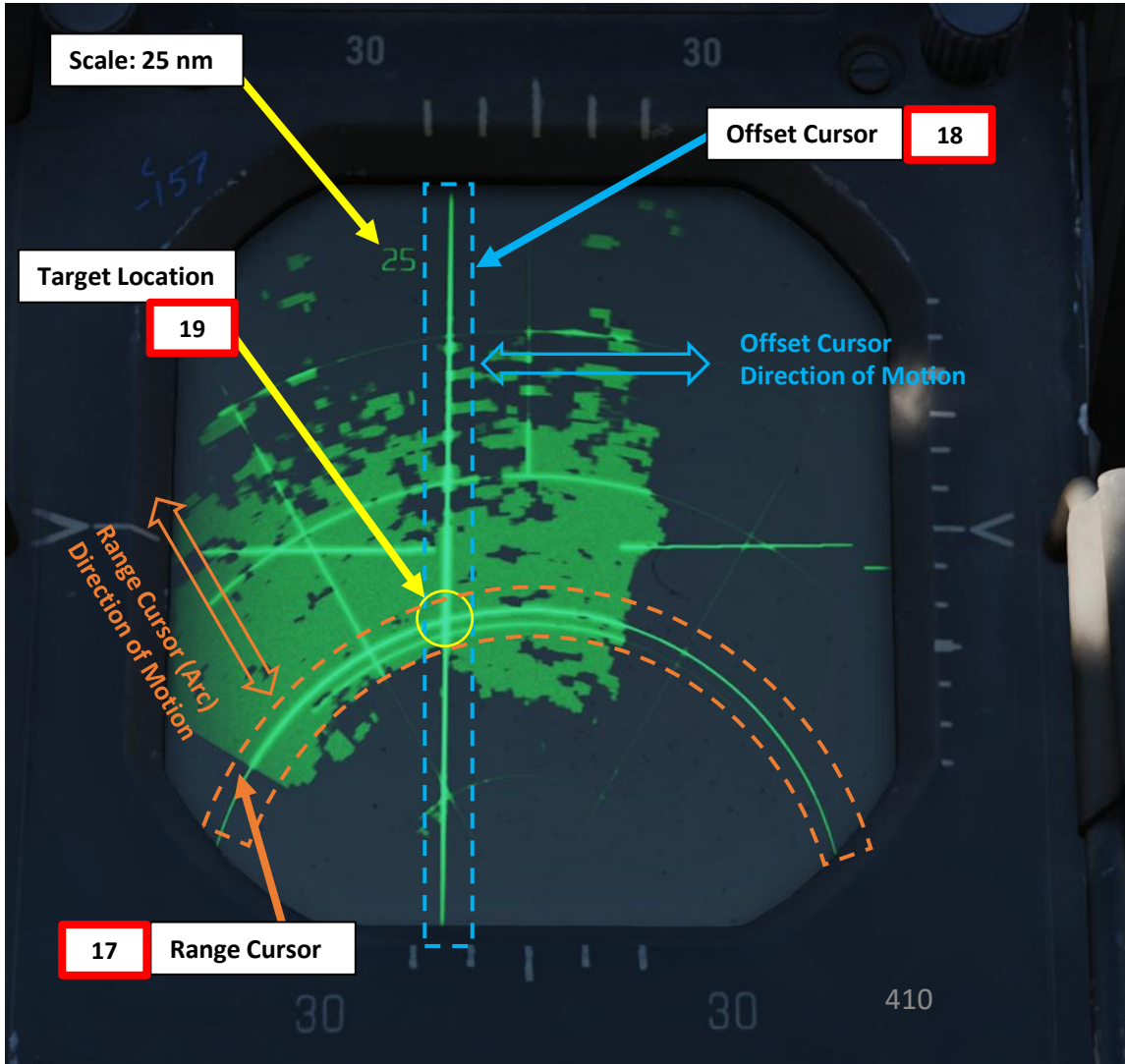


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
C – Cueing/Slaving TGP to Target Coordinates

15. *[WSO]* Set Navigation Input Selector Switch – DOWN position.
    - Needle 1: Navigation Computer Mode: Bearing
    - Needle 2: Navigation Computer Mode: Ground Track
16. *[WSO]* On BDHI (Bearing Distance Heading Indicator), determine the position of the target coordinates entered previously. Use Needle 1 for the target bearing and the Distance Indicator (nm).
17. *[WSO]* The Along Track Control is used to increase and decrease the current setting for the range cursor.
18. *[WSO]* The Cross Track Control is used to move the offset cursor to the left and right of the aircraft's track.
19. *[WSO]* Using the Along Track and Cross Track controls, align the Range Cursor and Offset cursor to match the bearing and distance information displayed on the BDHI, which should coincide with the approximate target location.

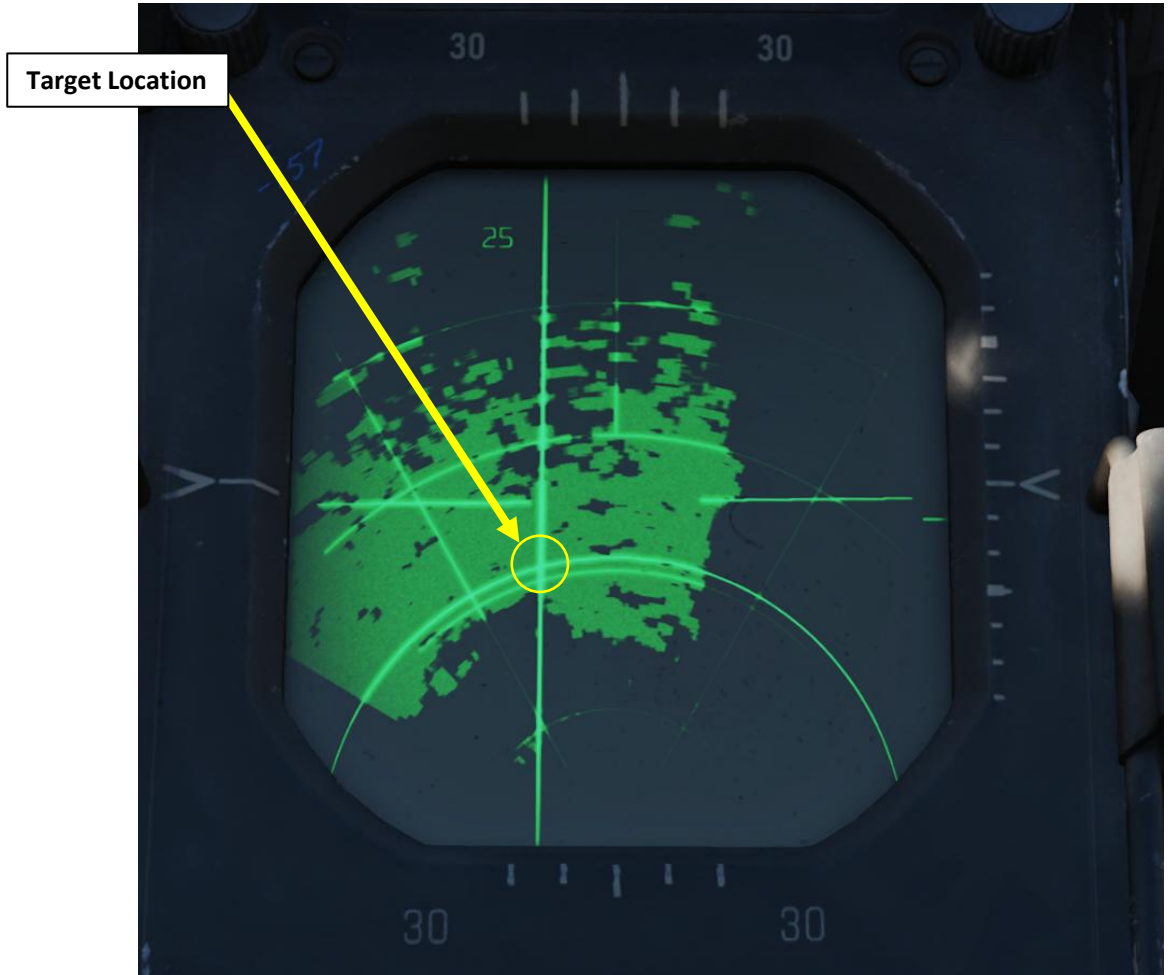


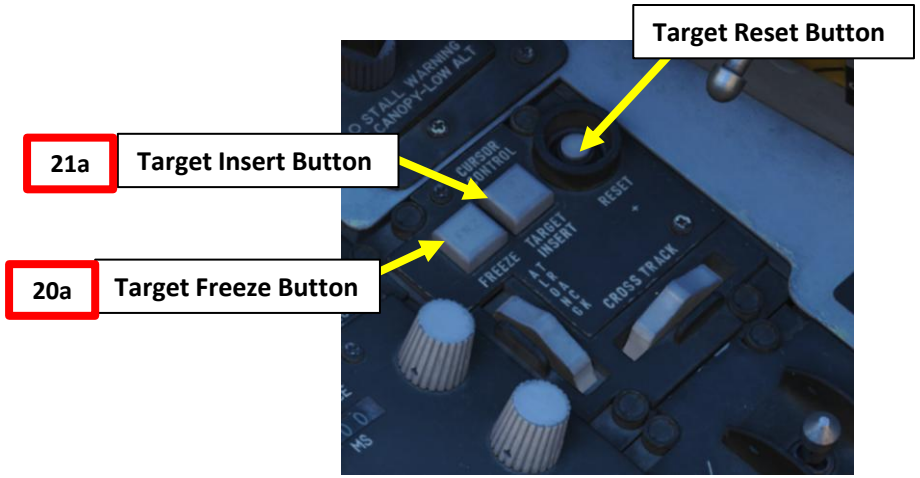


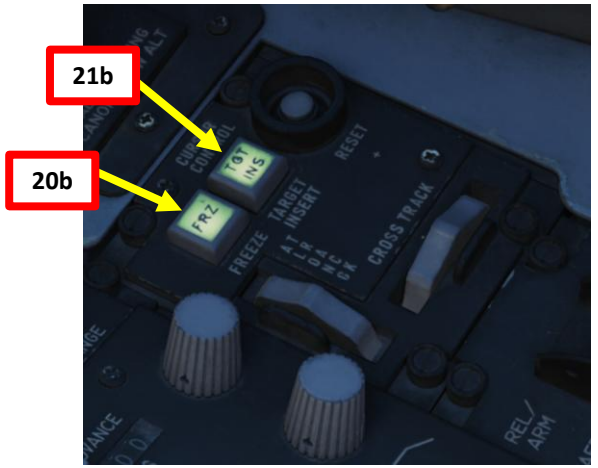


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
C – Cueing/Slaving TGP to Target Coordinates

20. *[WSO]* Once a target is at the meeting point between the range cursor and the offset cursor, press the Target Freeze Button to memorize this position.
21. *[WSO]* Press the Target Insert Button.
22. *[WSO]* The target is now designated.

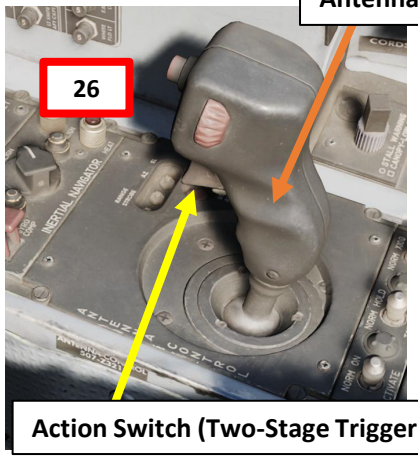




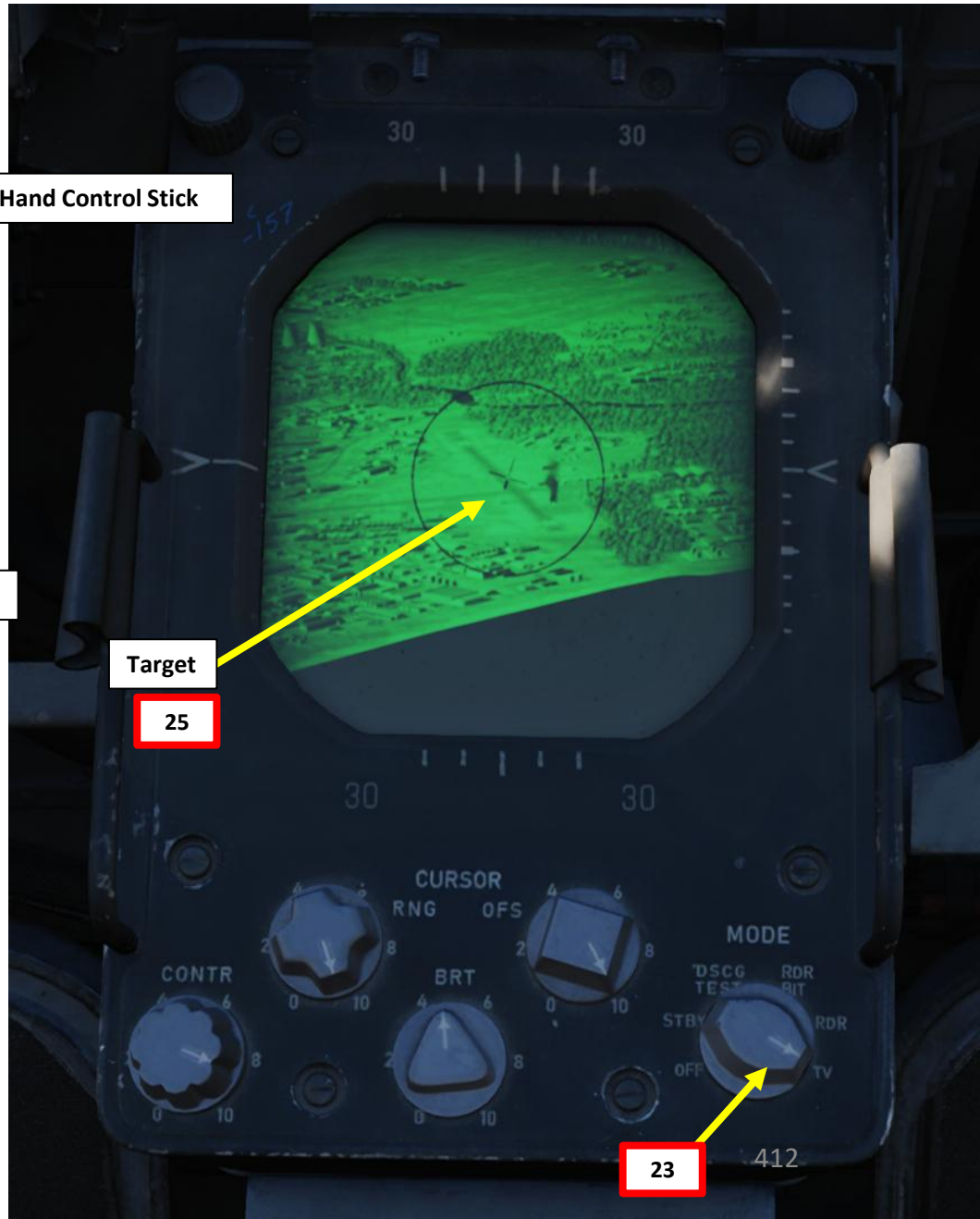


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.3 – WRCS (Weapon Release Computer Set) Acquisition Mode
C – Cueing/Slaving TGP to Target Coordinates

23. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – TV.
24. *[WSO]* Set Video Select Button – ASQ-153.
25. *[WSO]* Upon pressing the Target Insert Button, the targeting pod will then slew its line-of-sight on the approximate target area using the target data designated by the air-to-ground radar. Keep in mind that this will absolutely not be pin-point accurate.
26. *[WSO]* You can enter Track mode by pressing the trigger on the Antenna Hand Control to either Half or Full Action, then slew the pod as desired using the Antenna Hand Control stick.







3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.4 – Track Mode

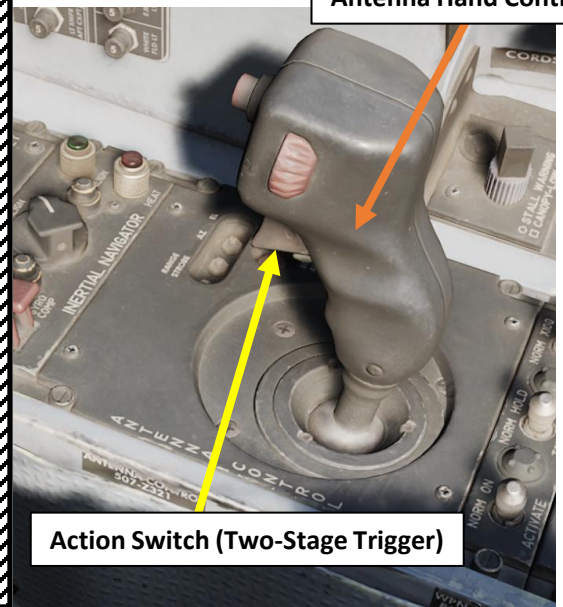
Once the target, or general target area, has been found using the acquisition modes, the WSO can enter Track mode by pressing the trigger on the Antenna Hand Control to either Half or Full Action.

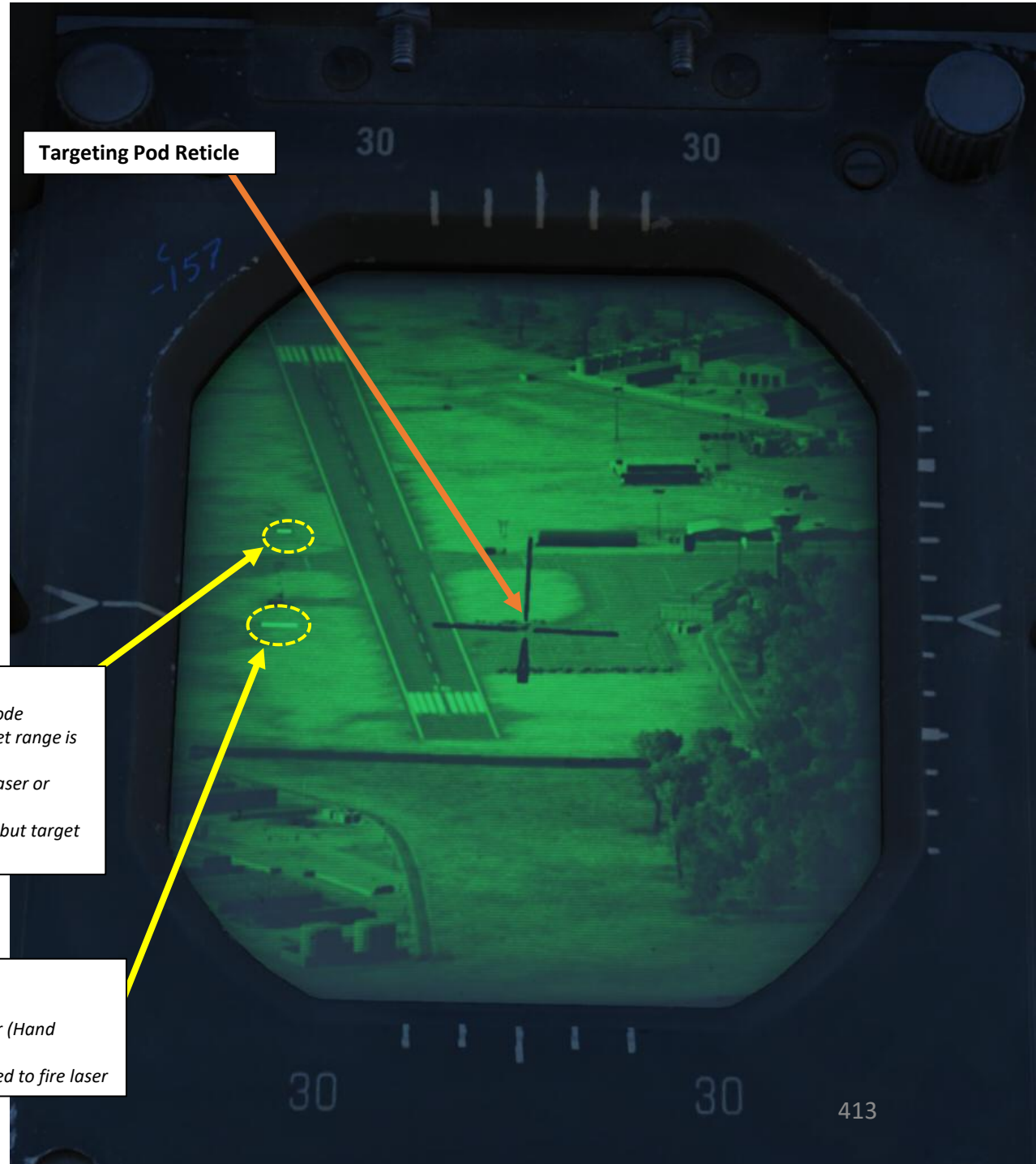
In this mode, the Antenna Stick can be moved to slew the pod line-of-sight. Operating the laser is only available in this mode, and can be activated by pressing the trigger on the Antenna Stick to Full Action.

Track mode is indicated by the T0 (Release) and TTG (Time-to-Go) cues becoming visible on the display. They also indicate the status during laser operation.

If the INS (Inertial Navigation System) is integrated with the pod, the image will automatically be space stabilized on the computed target position. Be aware that the stabilization is rudimentary and needs constant correction with the stick for the target to be kept centered.

The stabilization is mostly based on the measured slant range. Accurate slant range can be obtained by firing the laser. Alternatively, it is computed based on the aircraft barometric altitude and the target altitude, which can be set by the WSO on the WRCS (Weapon Release Computer Set) panel.





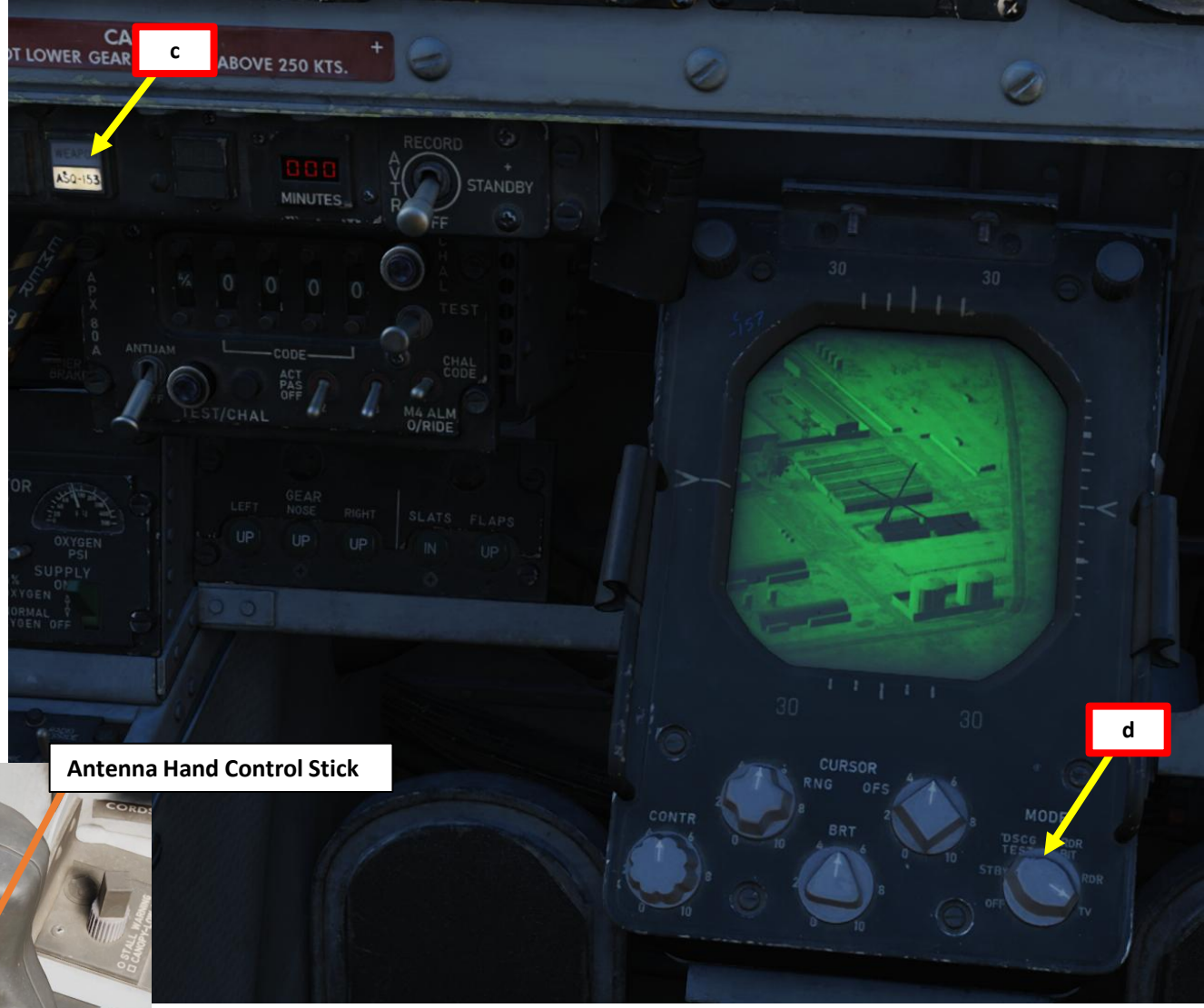
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.5 – Modes
3.5.5 – Memory Mode

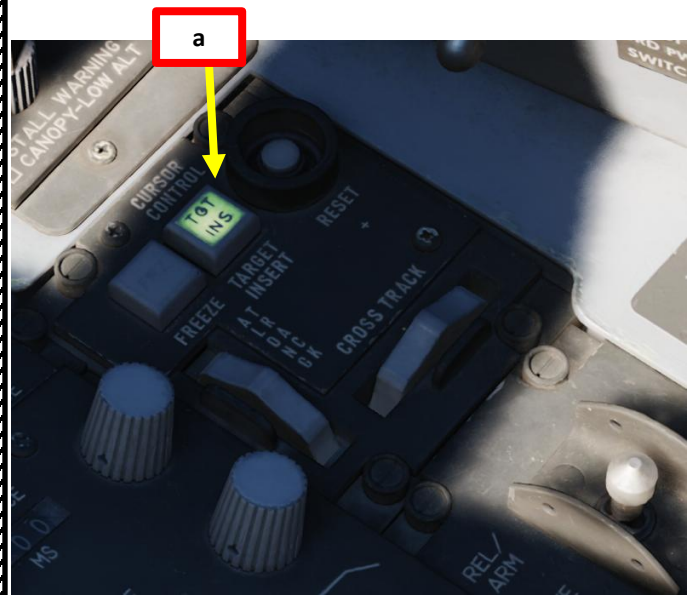
When a target is designated and a target-insert signal is sent, the system activates the Memory mode provided it is currently in Track mode and the WRCS (Weapon Release Computer Set) integration is active.

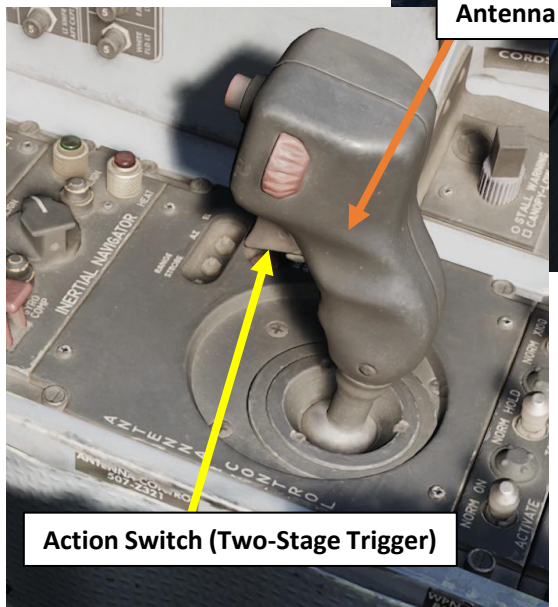
In Memory mode, the line-of-sight of the pod is slaved to the current WRCS target, even if it is outside of the pods gimbal limits and cannot be displayed currently. The mode acts very similar to the WRCS Acquisition mode. The memory mode has to be left explicitly again, by either pressing half or full action on the Antenna Stick.

Memory mode can be entered in any of the following ways:

a) When a target-insert signal is initiated by the WSO pressing the target-insert button.
b) When the pod is currently in Track mode and is maneuvered outside of its gimbal limits, it will automatically initiate a target-insert signal and send its current target position to the WRCS.
c) When the pod is de-selected by setting the Video Select Button from “ASQ-153” (Targeting Pod feed) to “Weapon” (Maverick missile feed).
d) When the pod is de-selected by setting the WSO DSCG (Digital Scan Converter Group) Mode Selector to any other position than “TV”.







3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.6 – Targeting Pod Limitations

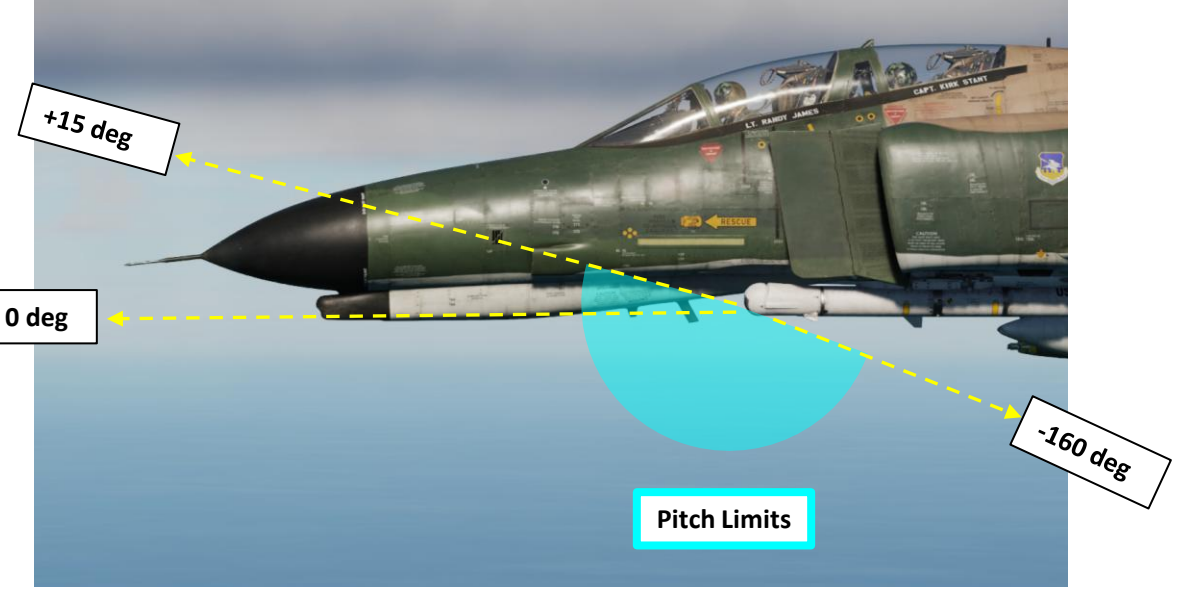
The limitations for the targeting pod gimbals are as follows:

- **Roll**: -160 to +110 deg
- **Pitch**: -160 to +15 deg
- **Yaw**: -15 to + 15 deg



Azimuth-Elevation / Line-of-Sight (LOS) Indicator

- *Main instrument for the pilot to assess the current attitude of the Pave Spike Targeting Pod in order to keep the line of sight within the operational limits.*
- *The needle shows the pods roll position from -160° (CW) to +110° (CCW).*
- *Three flags indicate the elevation: Green (-120° to -155°), Yellow (-155° to -160°) and Red (-160° or beyond).*



3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.7 – Smart-Track & Fast-Track Upgrades

Based on crew feedback, the Pave Spike targeting pod received two major upgrades, which are available as separate selectable weapon in DCS.

Smart-Track Upgrade

The Smart-Track upgrade aims at removing the requirement to press the Reject/Override button to force the laser measured slant range in situations in which the computed slant range was usually too inaccurate.

With the upgrade, the system will automatically accept the laser slant range whenever the pods elevation gimbal is above -7.5 deg (i.e. in shallow angles, for example during 12-VIS acquisition mode or low altitude attacks).

Fast-Track Upgrade

The Fast-Track upgrade overhauls the pod's gimbal motors, increasing the movement speed from 15 deg/sec to 60 deg/sec. At this speed, the targeting pod is capable of tracking a target during low altitude high speed flight, such as overflights at 1000 ft with 500 knots.



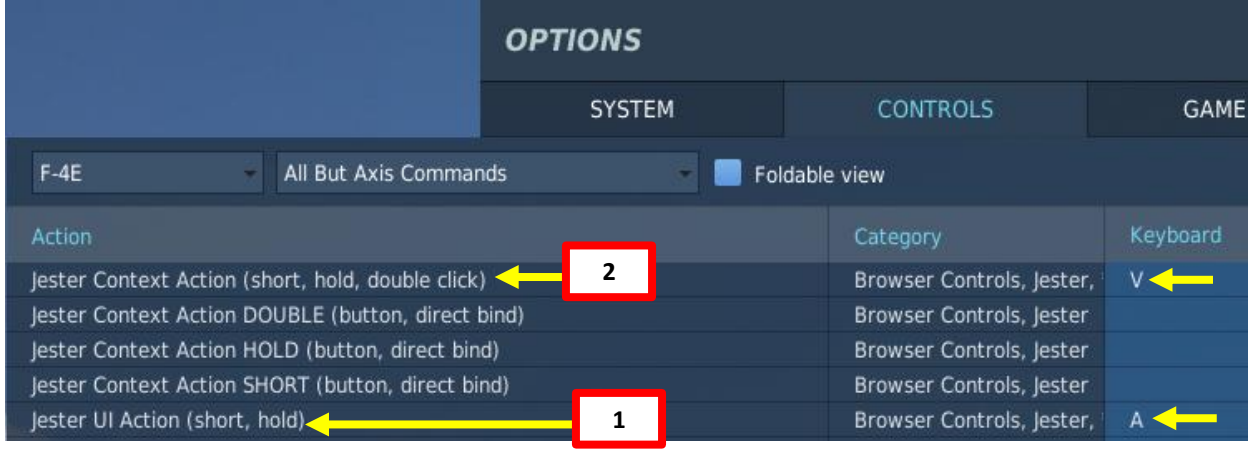
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.8 – Targeting Pod Operation with JESTER AI

When you are flying in the pilot position and the JESTER AI takes over WSO tasks, the targeting pod can be partially controlled.

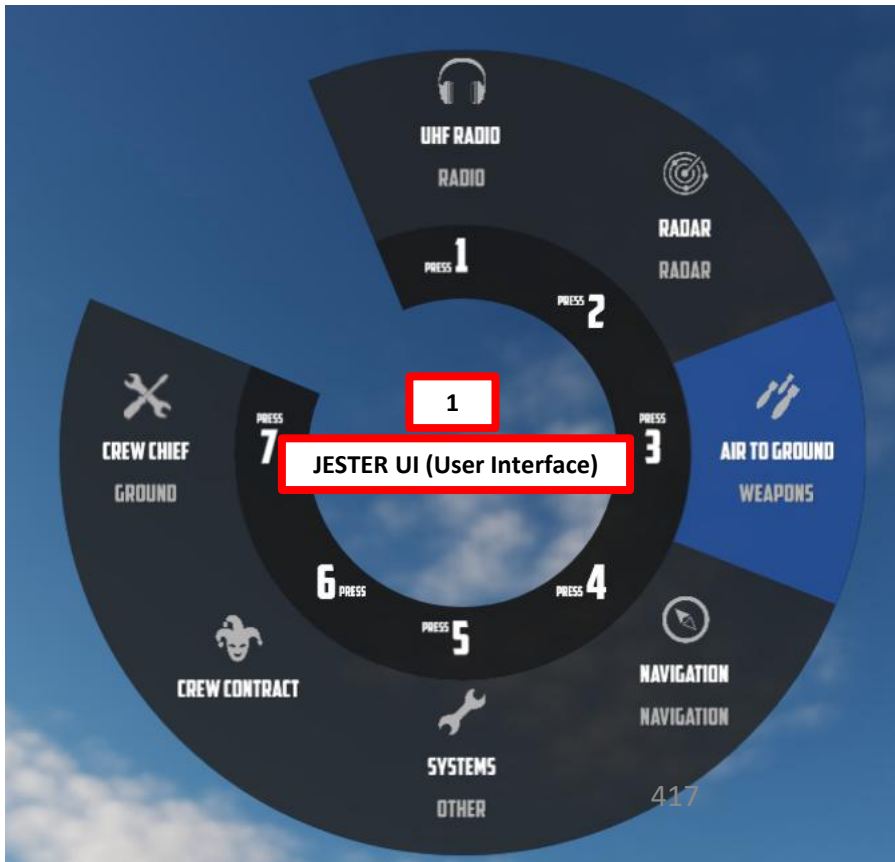
Keep in mind that this set of functionalities is currently very limited and will be expanded later by Heatblur Simulations.

There are two very important bindings you should set in the Controls tab in order to control JESTER.

1. To open JESTER AI wheel, short-press "**A**" (**JESTER UI Action binding**).
2. Make sure to map a binding for the **JESTER Context Action** (short, hold, double-click). In my case, I have it set to "**V** ". The JESTER Context Action does different things based in what context you are (d'uh!).





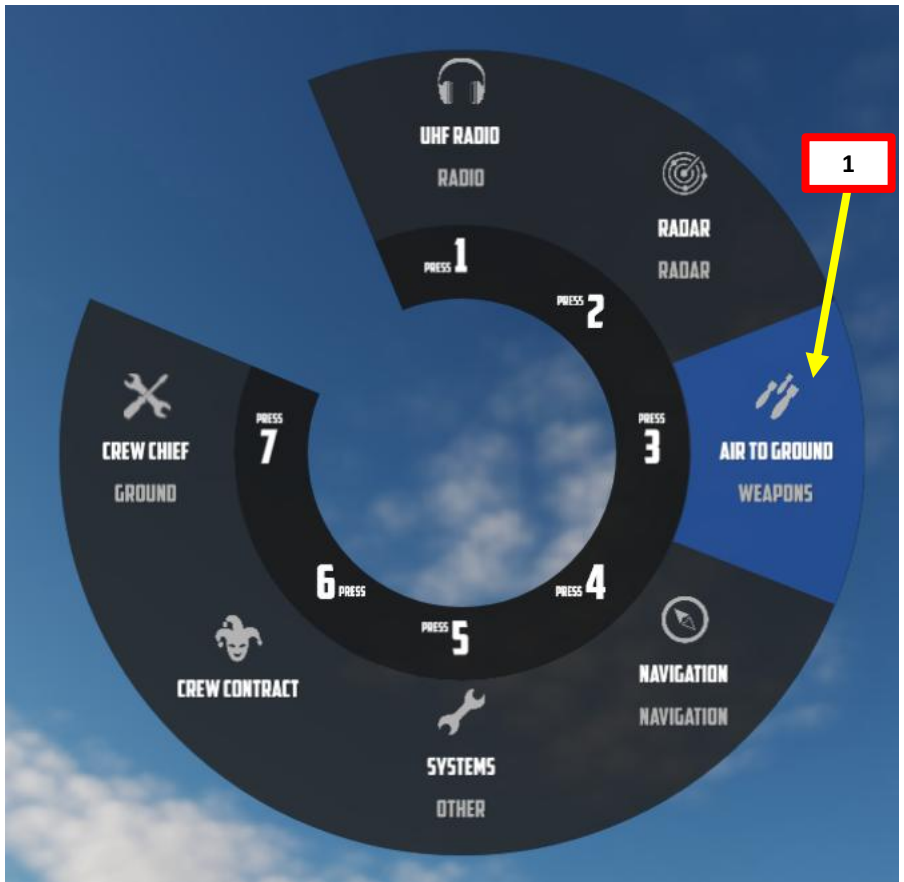


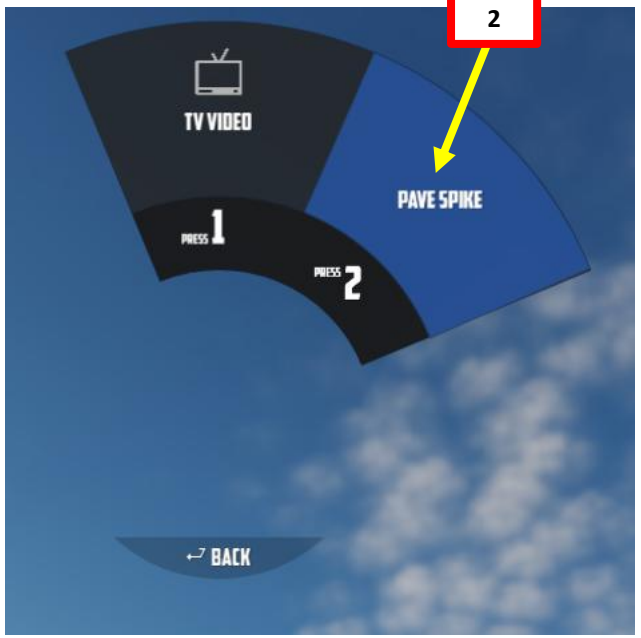
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.8 – Targeting Pod Operation with JESTER AI

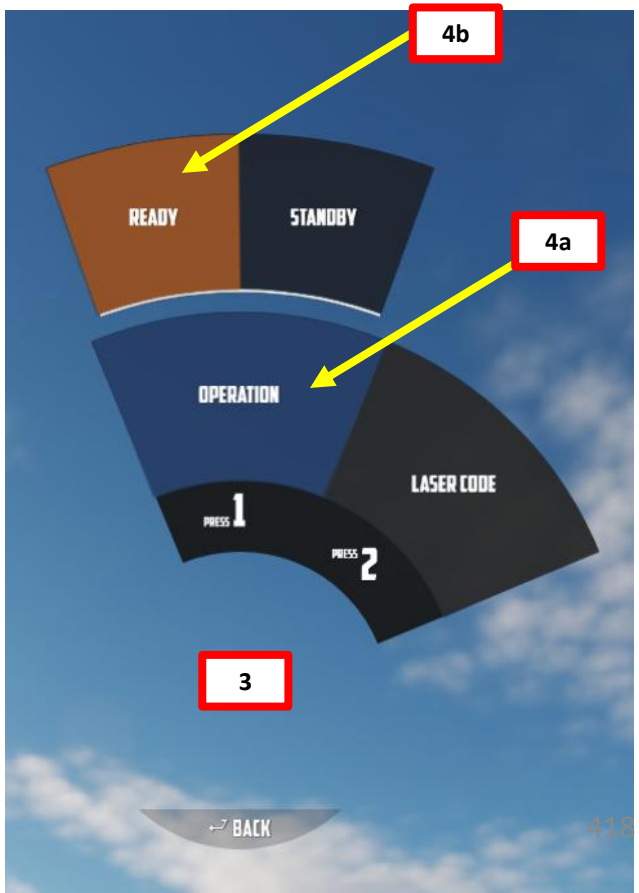
JESTER User Interface (UI) Functions

To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).

1. Select **AIR-TO-GROUND WEAPONS** menu.
2. Select **PAVE SPIKE** menu.
3. From the **PAVE SPIKE** menu, you will access all pod-related JESTER commands.
4. From the **OPERATION** menu, you can select the way JESTER operates the radar:
    - READY: Targeting pod is active.
    - STANDBY: Targeting pod is in Standby mode (inactive).





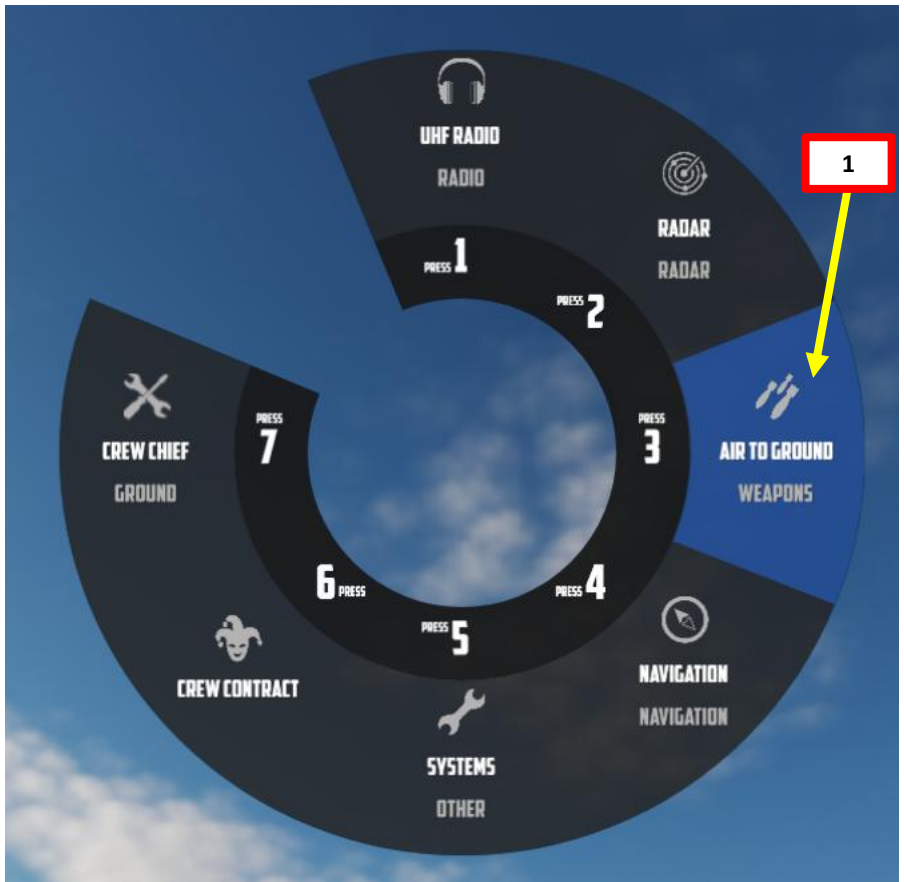


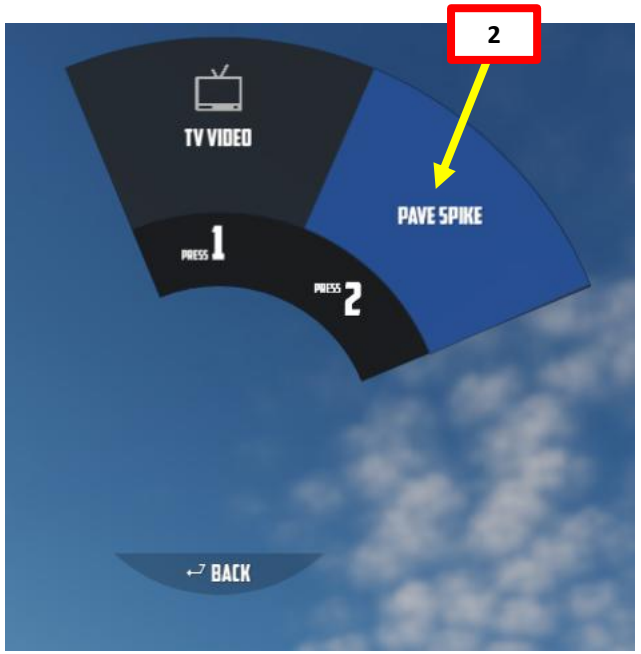
3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.8 – Targeting Pod Operation with JESTER AI

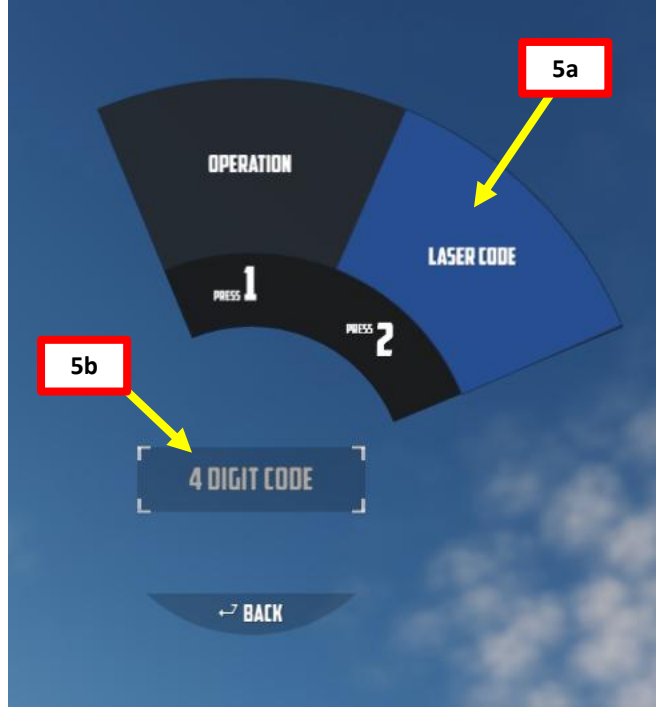
JESTER User Interface (UI) Functions

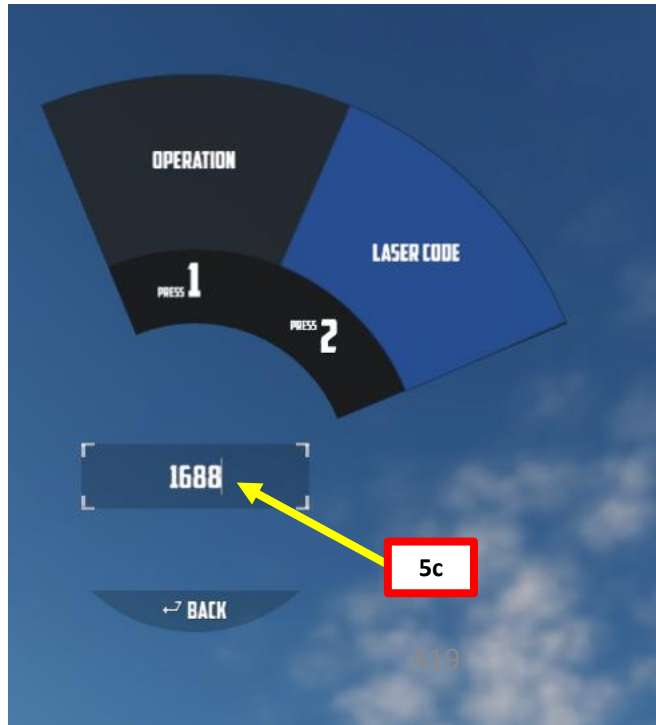
To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).

5. From the **LASER CODE** menu, you can type in the 4-digit laser code of the targeting pod designator.







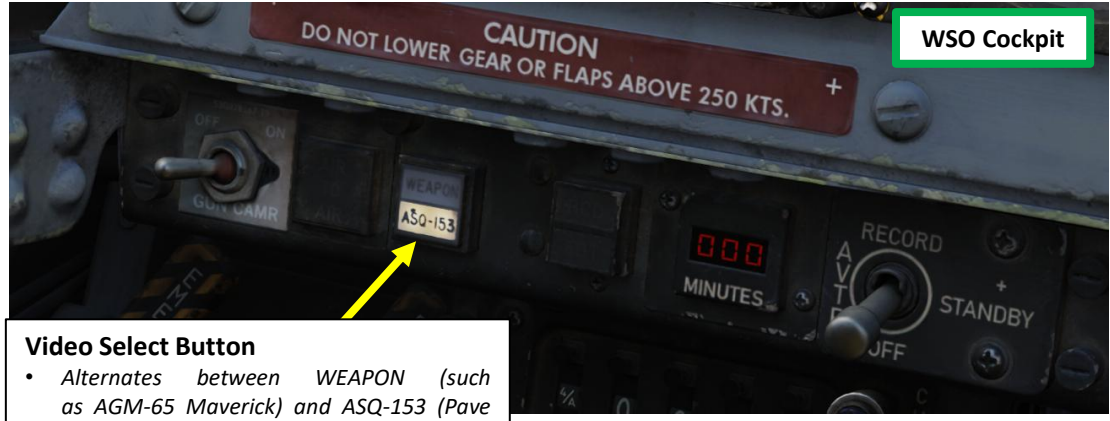


3 – AN/AVQ-23 PAVE SPIKE TARGETING POD (TGP)
3.8 – Targeting Pod Operation with JESTER AI

JESTER User Interface (UI) Functions

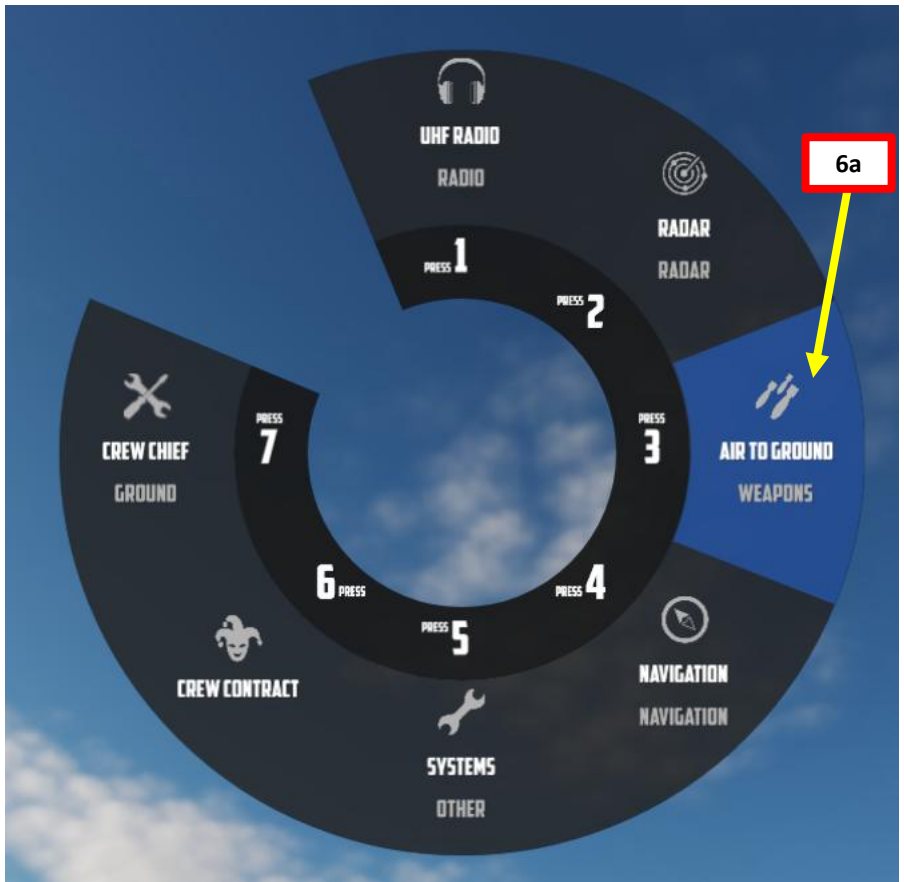
To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).

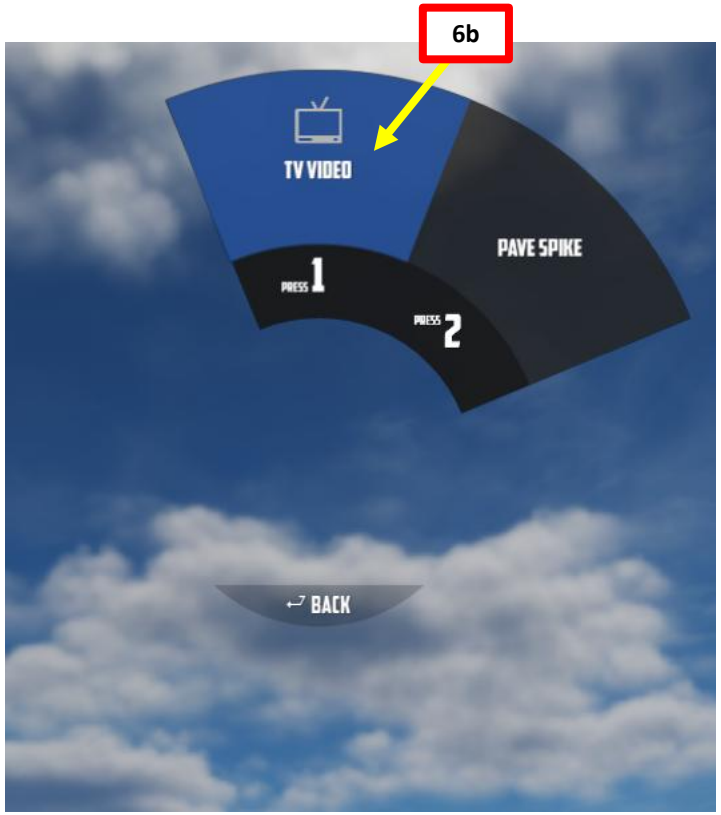
6. From the **TV VIDEO** menu, you can select which feed is shown on the DSCG (Digital Scan Converter Group) Scope, which is controlled with the Video Select Button.



Video Select Button

- *Alternates between WEAPON (such as AGM-65 Maverick) and ASQ-153 (Pave Spike targeting pod) television video on the radar scope display when in TV mode.*









SECTION STRUCTURE

- **1 – INTRODUCTION**
  - 1.1 – Introduction to Weapons
  - 1.2 – Armament Overview
  - 1.3 – My Weapons Control Setup
  - 1.4 – Weapon Interface
  - 1.5 – QFE & Altitude Accuracy for Air-to-Ground
  - 1.6 – Bomb Delivery Methods
  - 1.7 – Bombing Calculator Tool

- **2 – AIR-TO-GROUND WEAPONS**
  - 2.1 – Unguided Bombs
    - 2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode
    - 2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode
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  - 2.4 – Anti-Runway Bombs
    - 2.4.1 – BLU-107 Durandal: Direct Mode
  - 2.5 – Rockets
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  - 2.6 – Guns
    - 2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground
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    - 2.7.1 – AGM-12 Bullpup
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- **2 – AIR-TO-GROUND WEAPONS**
  - 2.9 – Anti-Radiation Missiles
    - 2.9.1 – AGM-45 Shrike
      - 2.9.1.1 – Introduction
      - 2.9.1.2 – AGM-45 Mode (WRCS)
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- **3 – AIR-TO-AIR WEAPONS**
  - 3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
    - 3.1.1 – Introduction
    - 3.1.2 – Employment without Radar
    - 3.1.3 – Employment with Radar
  - 3.2 – Infrared-Guided AIM-9 Sidewinder Missile
    - 3.2.1 – Introduction
    - 3.2.2 – Weapon Setup
    - 3.2.3 – Employment without Radar
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  - 3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
    - 3.3.1 – Introduction
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    - 3.3.3 – With Multicrew: Within Visual Range (WVR)
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    - 3.3.5 – With JESTER AI: Within Visual Range (WVR)
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- **4 – ORDNANCE JETTISON**
  - 4.1 – Selective Ordnance Jettison
  - 4.2 – Emergency Ordnance Jettison

1 – INTRODUCTION
1.1 – Introduction to Weapons

The F-4E carries a good variety of weapons and was considered a cornerstone of air forces around the globe. The Phantom's robust airframe allowed almost any kind of ordnance to be equipped, and its advanced avionics (for the time) like its radar and targeting pod allowed an impressive flexibility in terms of what kind of missions it could perform. The F-4 bridged the gap between traditional air-to-ground attackers of the 1950's and modern multirole aircraft like the Teen Series of fighter jets (F/A-18, F-15, etc.). By today's standards, most of the interface might appear clunky to the untrained eye, but it is important to consider that back in the 1960's… this was top-of-the-line equipment built for a conventional war with the USSR.



1 – INTRODUCTION
1.2 – Armament Overview

BOMBS

WEAPON	TYPE	WEAPON	TYPE
MK-81	250 lbs low-drag unguided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***	***BDU-33***	25 lbs inert low-drag training bomb
MK-82	500 lbs low-drag unguided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***	***BDU-50HD***	500 lbs inert high-drag training bomb
MK-82SE Snake Eye	500 lbs unguided low-drag retarded bomb ***Fuze Setting:*** • ***N/T (Nose & Tail): High Drag*** • ***NOSE: Low Drag*** • ***TAIL: High Drag***	***BDU-50LD***	500 lbs inert low-drag training bomb
MK-82AIR	500 lbs high-drag unguided bomb ***Fuze Setting:*** • ***N/T (Nose & Tail): High Drag*** • ***NOSE: Low Drag*** • ***TAIL: High Drag***	***BDU-45 LG***	500 lbs inert laser-guided training bomb
MK-84	2000 lbs low-drag unguided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***	***GBU-10/12 Paveway II***	2000/500 lbs laser-guided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***
SAMP-250	250 kg (550 lbs) low drag unguided bomb by the *Société des Ateliers Mécanique de Port-sur-Sambre* (SAMP) in France. Used by the german F-4EF. ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***	***GBU-24 Paveway III***	2000 lbs laser-guided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***
M117	750 lbs low-drag unguided bomb ***Fuze Setting:*** • ***Either Nose, Tail, or N/T (Nose/Tail) for redundancy.***	***BLU-107 Durandal***	440 lbs Anti-Runway penetration bomb. • The initial phase of flight is retarded by a parachute. Once the bomb reaches a 40° angle, the parachute is discarded and a rocket booster initializes, driving the bomb into the runway surface. The primary charge then explodes, sending the smaller, secondary charge with delayed fuse even deeper.

1 – INTRODUCTION
1.2 – Armament Overview

CLUSTER MUNITIONS

WEAPON	TYPE	WEAPON	TYPE
MK-20 Rockeyes	490 lbs unguided cluster munitions (247 x HEAT bomblets)	***CBU-1A/A***	Unguided cluster munitions (19 dispenser tubes, 513 BLU-4B High Explosive bomblets)
CBU-87	950 lbs unguided all-purpose Combined Effects Munitions (CEM) (220 x bomblets). ***Fuze Setting:*** • ***N/T (Nose & Tail): Bomblets dispense using altitude proximity fuze setting*** • ***NOSE: Bomblets dispense after a preset timer (selectable on ground between 1.39 and 4.25 seconds)*** • ***TAIL: Dud (Disarmed)***	***CBU-2/A***	Unguided cluster munitions (19 dispenser tubes, 361 BLU-3 High Explosive bomblets)
CBU-52B	760 lbs unguided cluster munitions (220 x High Explosive / Fragmentation) Cluster Bomblets	***CBU-2B/A***	Unguided cluster munitions (22 dispenser tubes, 418 BLU-3B High Explosive bomblets)
BL-755	580 lbs unguided cluster munitions (147 x HEAT bomblets). Used extensively during the Falklands War by the Royal Air Force. It was also used by the German Air Force, including the F-4F.		

EXTERNAL FUEL & MISCELLANEOUS ORDNANCE

ORDNANCE	TYPE	ORDNANCE	TYPE
SUU-25 x 8 LUU-2	Target Marker Flares	***Sargent Fletcher External Fuel Tank***	External fuel drop tanks (370 gal for wing tanks, 600 gal for centerline tank)
ALQ-131	Electronic Countermeasures (ECM) pod	***AN/AVQ-23***	Pave Spike targeting pod
AN/ASQ-T50	Referred as the Tactical Combat Training System (TCTS), this pod records tactical data during training flights. This pod serves no function in DCS.	***AN/ALE-40***	Countermeasure dispenser system (chaff & flares).

1 – INTRODUCTION
1.2 – Armament Overview

AIR-TO-AIR MISSILES

WEAPON	TYPE
AIM-9 Sidewinder • *Variants: AIM-9B, J, JULI, L, M, P, P3, P5*	Infrared guided air-to-air missile.
AIM-7F/M/MH Sparrow • *Variants: AIM-7E, E-2, F, M*	Semi-active radar-guided air-to-air missile.

GUN & GUNPODS

WEAPON	TYPE
M61A1 Vulcan	Six-barrel 20 mm Gatling-type rotary cannon (639 rounds).
SUU-23 Gun Pod	20 mm gun pod (1200 rounds capacity, firing rate at 6000 rounds/minute)

ROCKETS

WEAPON	TYPE
Hydra 70 (LAU-3 Pod)	19 x 70 mm (2.75 in) unguided FFAR (Folding-Fin Aerial Rockets)
Hydra 70 (LAU-68 Pod)	7 x 70 mm (2.75 in) unguided FFAR (Folding-Fin Aerial Rockets)

AIR-TO-GROUND MISSILES

WEAPON	TYPE
AGM-12 Bullpup	Air-to-Ground missile guided manually via a small joystick in the aircraft cockpit.
AGM-65 Maverick	Air-to-Ground missile guided by infrared imaging system and used at night and during bad weather.
AGM-45 Shrike	Anti-radiation missile derived from the AIM-7 Sparrow for the suppression of enemy air defense (SEAD) role, mainly engagement of enemy SAM (Surface-to-Air-Missile) radars.

ELECTRO-OPTICAL/TV GUIDED BOMBS

WEAPON	TYPE
GBU-8 HOBOS (Homing Bomb System)	2000 lbs electro-optical TV-guided glide bomb. This precision-guided munition is equipped with a television camera in its nose.
AGM-62 Walleye I	1000 lbs electro-optical TV-guided glide bomb. This precision-guided munition is equipped with a television camera in its nose.
AGM-62 Walleye II ER	2000 lbs electro-optical TV-guided glide bomb. This precision-guided munition is equipped with a television camera in its nose. “ER” stands for “extended range”.

1 – INTRODUCTION
1.2 – Armament Overview

The following diagram gives an overview of all stores that can be loaded on the stations.

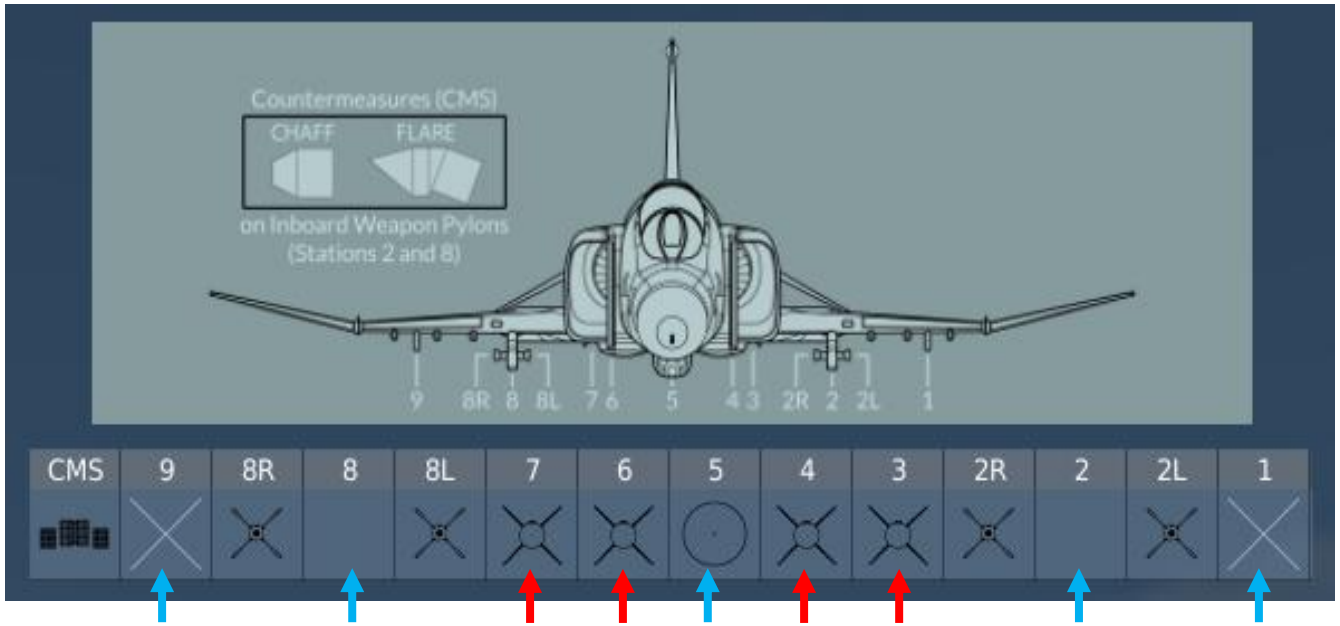
In general, **stations 3, 4, 6 and 7** can be used to load Air-To-Air Missiles, or also Jammer and Targeting pods.

Air-To-Ground Ordnance is mostly carried on **pylons 1, 2, 5, 8 and 9**.

Pylons 2 and 8 are special, since they can be equipped with the Special-Weapons-Adapter (SWA) and have additional attach-points on their sides (labelled 2L, 2R, 8L, 8R) for loading AIM-9 Sidewinder missiles without occupying the entire pylon.

AN/ALE-40 Countermeasure Dispensers can be attached to the aft section of Pylon 2 and 8, allowing the aircraft to carry a mix between 120 chaff and 30 flares in total.

Note: AIM-9 Sidewinder can be loaded onto pylon 2 and 8 additionally to other ordnance. Hence, it is still possible to equip for example a Maverick on the same pylon.



Store / Station	9	8	7	6	5	4	3	2	1	Total
AIM-7			1	1		1	1			4
AIM-9		(2)						(2)		4
AGM-12	1	1						1	1	4
AGM-45	1	1						1	1	4
AGM-62	1							1		2
AGM-65		3						3		6
MK-81	6	3			6			3	6	24
MK-82	6	3			6			3	6	24
Mk-83	2	3			3			3	2	13
Mk-84	1	1			1			1	1	5
M117	3	3			5			3	3	17
SAMP-250	3	3			3			3	3	15
Mk-20		3			6			3		12
CBU-1/A	2				1				2	5
CBU-2/A	2				1				2	5
CBU-52	3	2						2	3	10
CBU-87	3	2			4			2	3	14
BL-755	2	3			3			3	2	13
GBU-10	1	1						1	1	4
GBU-12	1	2						2	1	6
GBU-24	1	1						1	1	4
BDU-33	6	3			6			3	6	24
BDU-45	1	2						2	1	6
BDU-50	6	3			6			3	6	24
BLU-107		3			6			3		12
GBU-8	1	1						1	1	4
FFAR (×19)	3	3			3			3	3	285
SUU-23	1				1				1	3
SUU-25 (x8)	2				2				2	48
ALQ-131		1				1		1		3
AN/AVQ-23						1				1
AN/ASQ-T50		(2)						(2)		4
AN/ALE-40		(1)						(1)		2
Fuel Tank	1				1				1	3

1 – INTRODUCTION
1.3 – My Weapons Control Setup

PILOT
CONTROL SETUP

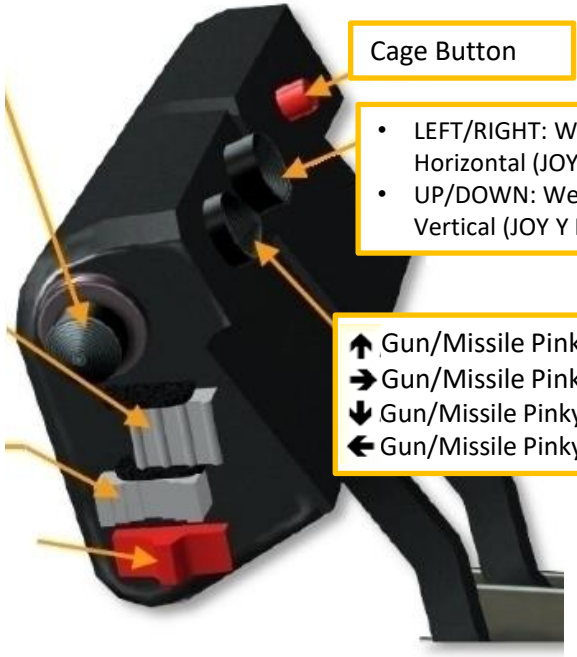


Bomb Release Button
(RALT+Space)

First Detent: Trigger Half-Action (2-stage trigger)
Second Detent: Trigger Full-Action (2-stage trigger) (Space)

↑ ↓ ← P Air Refuel (AAR) Release Button – PRESS

Nose Gear Steering / Auto Acquisition Button



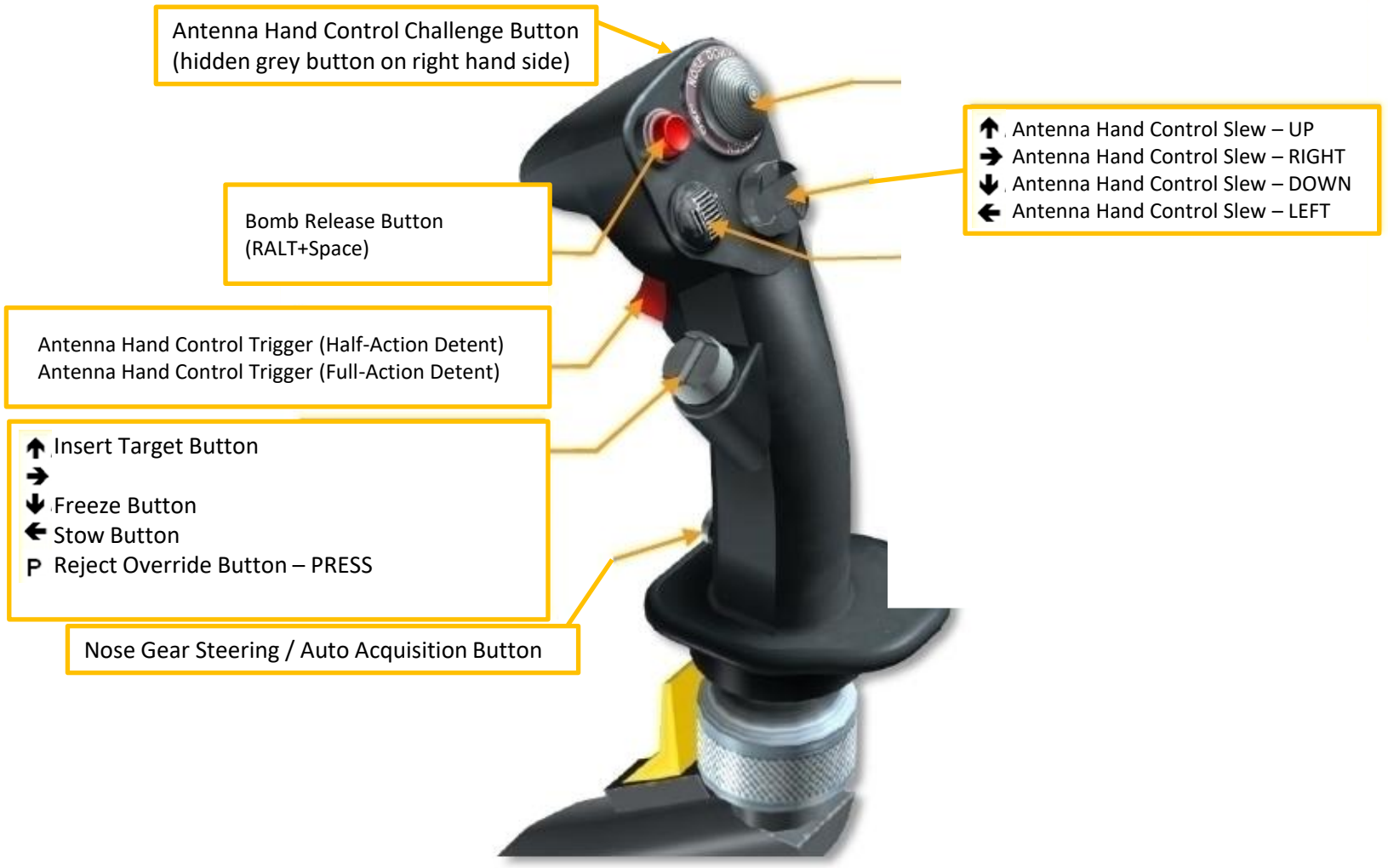
Cage Button

- LEFT/RIGHT: Weapon Slew (Forward Hand Control) Axis Horizontal (JOY X)
- UP/DOWN: Weapon Slew (Forward Hand Control) Axis Vertical (JOY Y Inverted)

↑ Gun/Missile Pinky Switch – REJECT (UP)
→ Gun/Missile Pinky Switch – RADAR (FWD)
↓ Gun/Missile Pinky Switch – HEAT MISSILES (CENTER)
← Gun/Missile Pinky Switch – GUN (AFT)

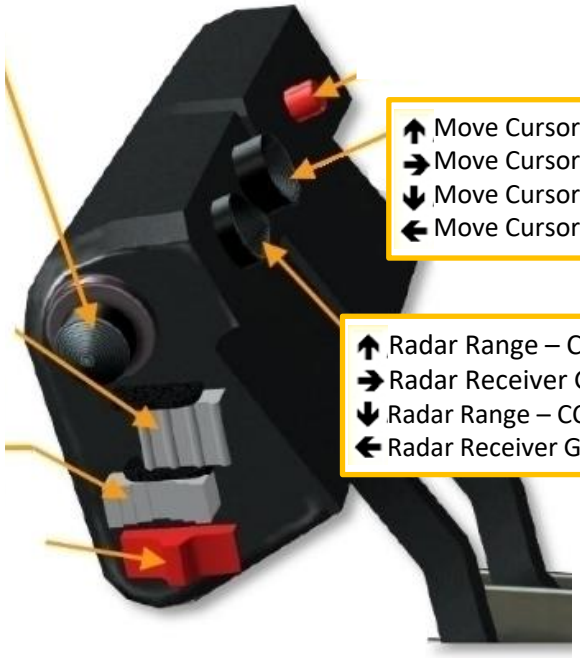
1 – INTRODUCTION
1.3 – My Weapons Control Setup

WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



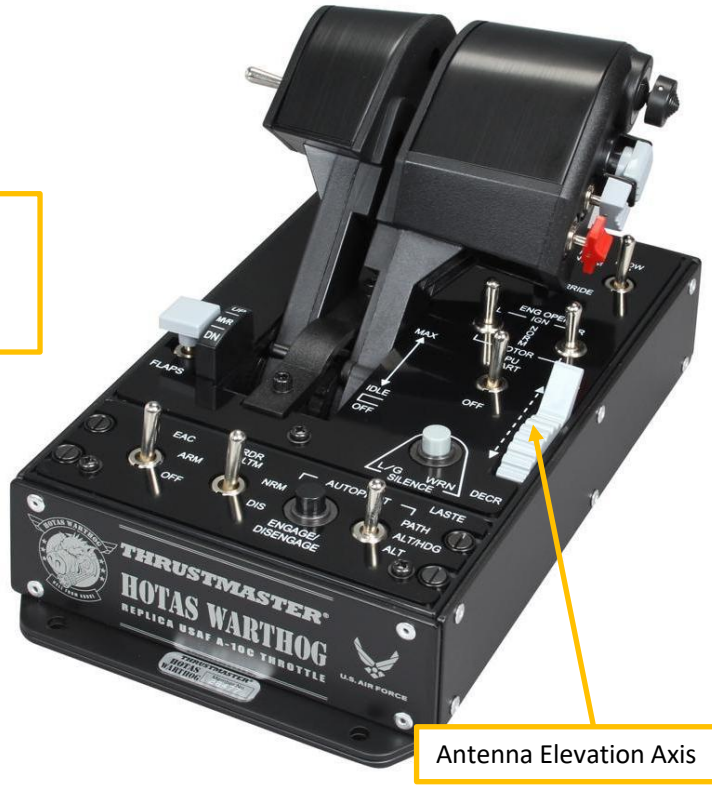
1 – INTRODUCTION
1.3 – My Weapons Control Setup

WSO (WEAPON SYSTEMS OFFICER) CONTROL SETUP



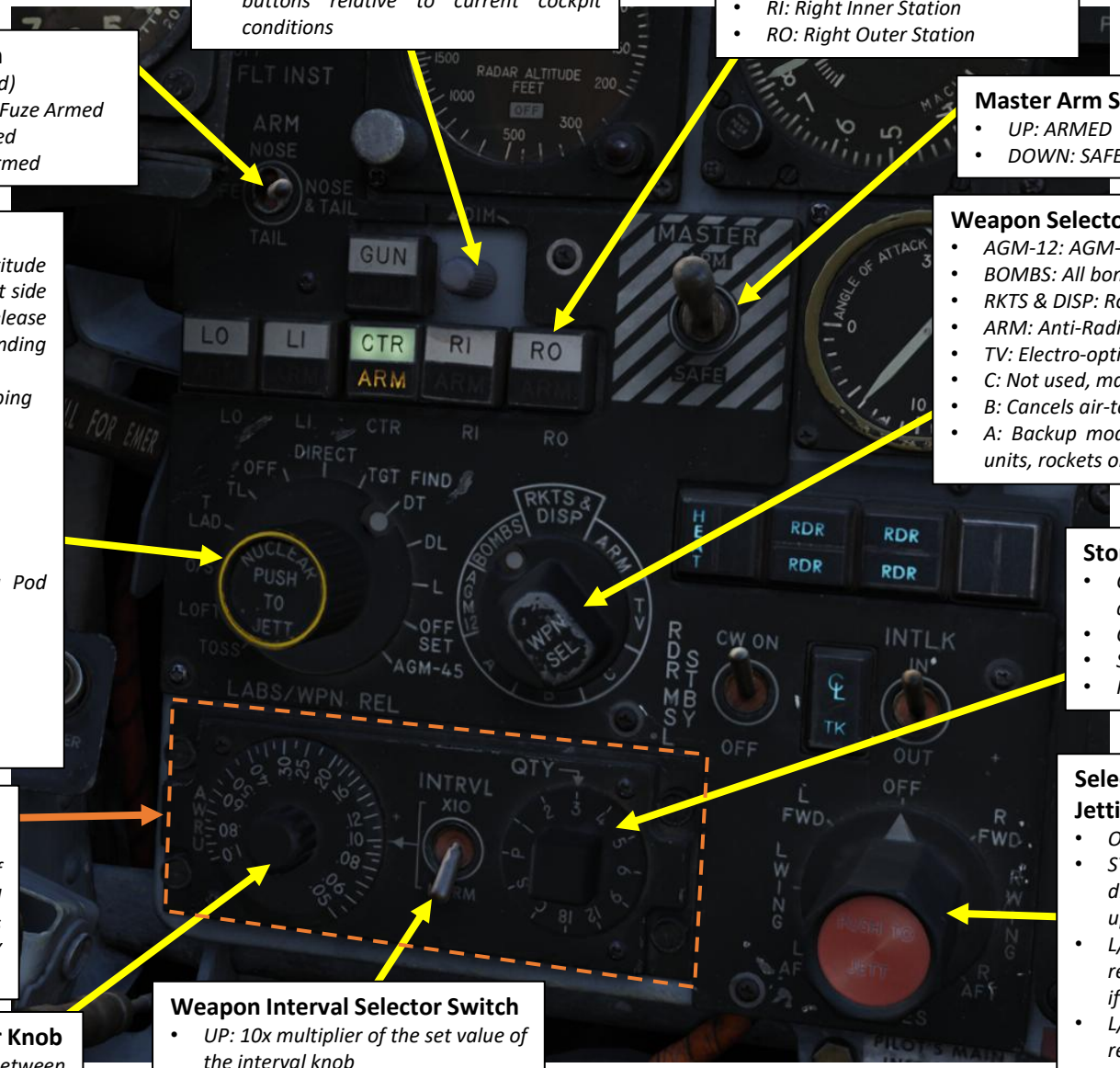
↑ Move Cursor (Along Track) (JOY_Y) – Inverted
→ Move Cursor (Cross Track) (JOY_X)
↓ Move Cursor (Along Track) (JOY_Y) – Inverted
← Move Cursor (Cross Track) (JOY_X)

↑ Radar Range – CW (Clockwise)
→ Radar Receiver Gain (Coarse) – Increase
↓ Radar Range – CCW (Counter-Clockwise)
← Radar Receiver Gain (Coarse) – Decrease



Antenna Elevation Axis

1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)



Station Select Buttons
- *GUN: Nose Gun/Cannon*
- *LO: Left Outer Station*
- *LI: Left Inner Station*
- *CTR: Center Station*
- *RI: Right Inner Station*
- *RO: Right Outer Station*

Station Select Button Dimming Knob
- *Controls lighting of the station select buttons relative to current cockpit conditions*

Fuze Arming Switch
- *LEFT: OFF (Disarmed)*
- *RIGHT: Nose & Tail Fuze Armed*
- *UP: Nose Fuze Armed*
- *DOWN: Tail Fuze Armed*

Master Arm Switch
- *UP: ARMED*
- *DOWN: SAFE*

Air-to-Ground Weapon Delivery Mode Knob

Split into two halves, the left side of the dial references ARBCS (Attitude Reference and Bombing Computer Set) delivery modes, while the right side provides automated release functions using the WRCS (Weapon Release Computer Set) with possible tie-in to the navigation computer, depending on mode.
- *INST O/S (labelled "TOSS"): Instantaneous Over the Shoulder Bombing*
- *LOFT: Loft Bombing*
- *O/S: (Timed) Over the Shoulder Bombing*
- *T LAD: Timed LADD (Low Angle Drogue Delivery) Bombing*
- *TL: Timed Level Bombing*
- *OFF: OFF (Air-to-Air)*
- *DIRECT: Manual Direct Bombing*
- *TGT FIND: Target Find (Nav Mode and Pave Spike Targeting Pod bombing only)*
- *DT: Dive Toss Bombing*
- *DL: Dive Laydown Bombing*
- *L: Laydown Bombing*
- *OFF SET: Offset Bombing*
- *AGM-45: Used for AGM-45 Shrike missile*

Weapon Selector Knob
- *AGM-12: AGM-12 Bullpup Missile*
- *BOMBS: All bomb types, including cluster bomb units*
- *RKTS & DISP: Rockets and dispensers*
- *ARM: Anti-Radiation Missile (AGM-45 Shrike)*
- *TV: Electro-optical weapons (AGM-65 Maverick)*
- *C: Not used, may be used as an OFF position.*
- *B: Cancels air-to-air missile CAGE requirement.*
- *A: Backup mode that simultaneously releases cluster bomb units, rockets or dispensers. Bombs do not release.*

Store Quantity Knob
- *Controls how many stores are released per impulse*
- *C: Single Continuous*
- *S: Salvo*
- *P: Pairs Manual Mode*

AWRU (Aircraft Weapons Release Unit) Control Panel
- *Provides timed interval release scheduling of single or multiple bombs or rockets and dispensed munitions based on the selections made between the interval knob, the QTY (quantity) knob and the INTRVL switch.*

Weapon Release Interval Selector Knob
- *Provides release pulse sequences between 0.05 second and 1 second*

Weapon Interval Selector Switch
- *UP: 10x multiplier of the set value of the interval knob*
- *DOWN: Normal, the interval knob value is the trigger timer.*

Selective Jettison Control Knob / Push to Jettison Button
- *OFF: Safety position.*
- *STORES: Releases all weapon racks, rounds or drop tanks selected on the station buttons upon PUSH TO JETT.*
- *L/R FWD: Jettisons AIM-7 missile from respective position on PUSH TO JETT. Inhibited if CL TK is ON.*
- *L/R AFT: Jettisons AIM-7 missile from respective position on PUSH TO JETT.*
- *L/R WING: In conjunction with TV or ARM, jettisons single AGM-65 Maverick or AGM-45 Shrike from wing on PUSH TO JETT.*

1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)



External Stores Emergency Release Button



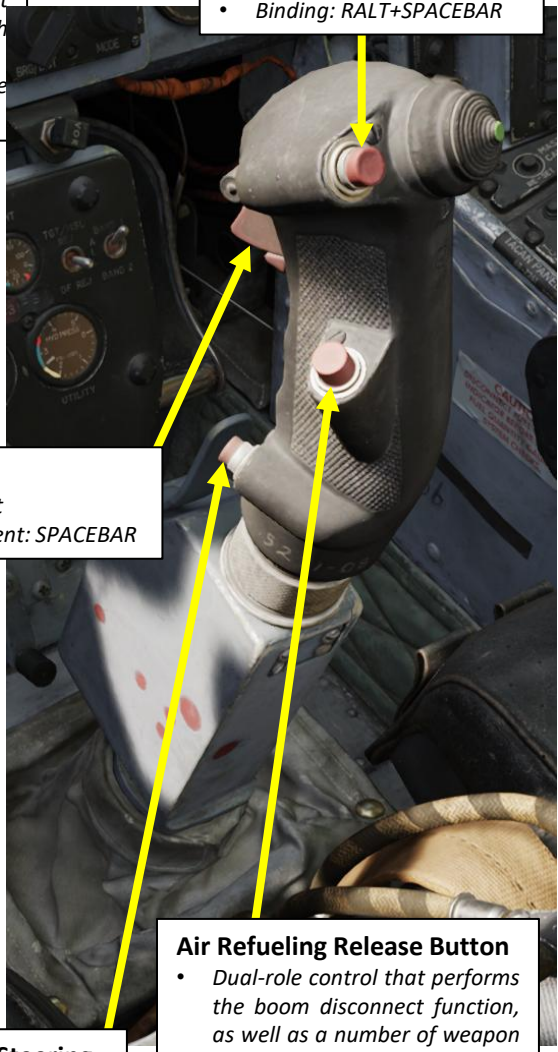
Missile HEAT Status Lights
- *HEAT lights illuminate one at a time, rather than all up upon circuit configuration. The light of the currently selected station will illuminate beginning at the raising of the gear handle, and remain in that position until the weapon is either cycled using the throttle's Gun/Missile Switch reject option, or is launched. The HEAT light arrangement corresponds with the launch sequence of the AIM-9 Sidewinder.*
- *The left pair of lights represent station 2 Left and 2 Right respectively, while the right pair is linked to stations 8 Left and 8 Right.*

Missile RDR Status Lights
- *RDR lights illuminate once AIM-7 Sparrow missiles are properly tuned with the fire control system; any station that does not carry a Sparrow, does not correctly sync up during tuning, or is launched, will turn off.*
- *The left pair of lights indicates stations 4 and 3 from top to bottom, while the right pair links to stations 6 and 7 respectively.*

Interlock Switch
- *UP: IN, fire control system launch parameter interlocks are engaged. Range limits, ASE (Allowable Steering Error) limits, or radar not in visual intercept inhibits missile launch.*
- *DOWN: OUT, fire control system launch parameter interlocks override. AIM-7 will fire when trigger is pulled even when no launch condition is met.*

Centerline External Fuel Tank (CL TK) Aboard Light
- *Illuminates when a stores condition exists that precludes ejection or launch of an AIM-7 missile installed in one of the two forward positions. To use the Sparrows on these stations the centerline store must be first jettisoned.*

Radar Missile Power Switch
- *UP: CW ON, provides power to the klystron continuous wave (CW) emitter responsible for AIM-7 guidance signals*
- *DOWN: OFF*



Bomb Release Button
- *Binding: RALT+SPACEBAR*

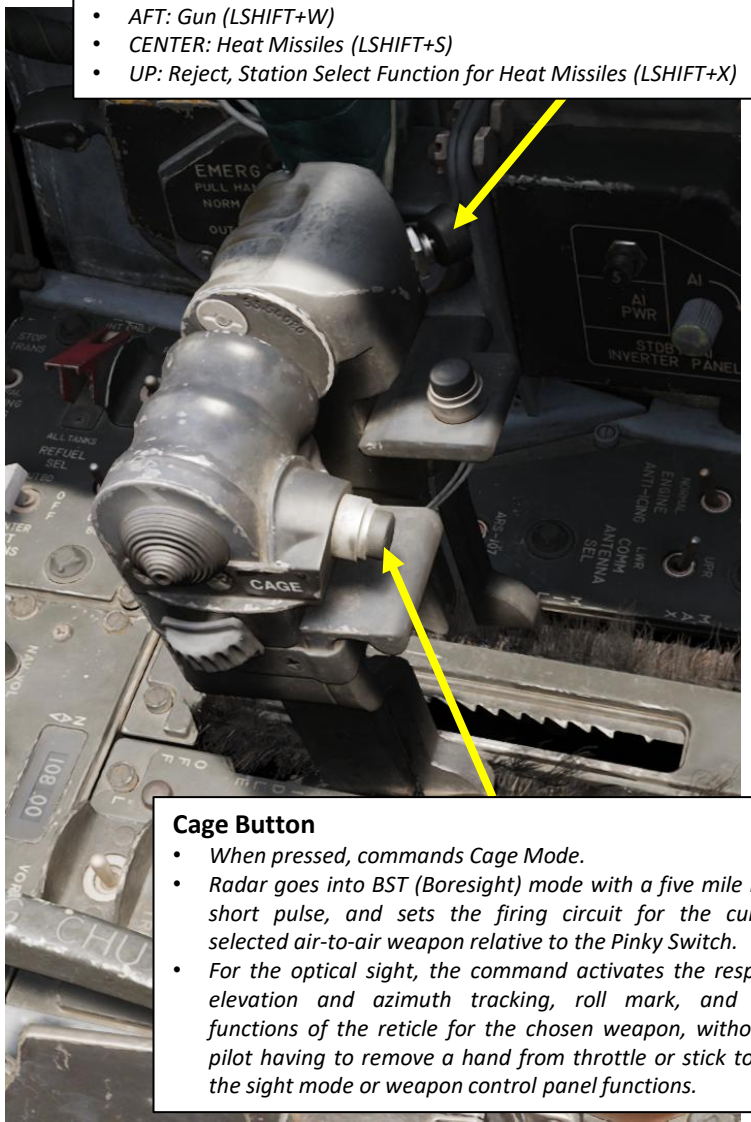
Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

Air Refueling Release Button
- *Dual-role control that performs the boom disconnect function, as well as a number of weapon selection functions*
- *Binding: S*

Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*

1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)

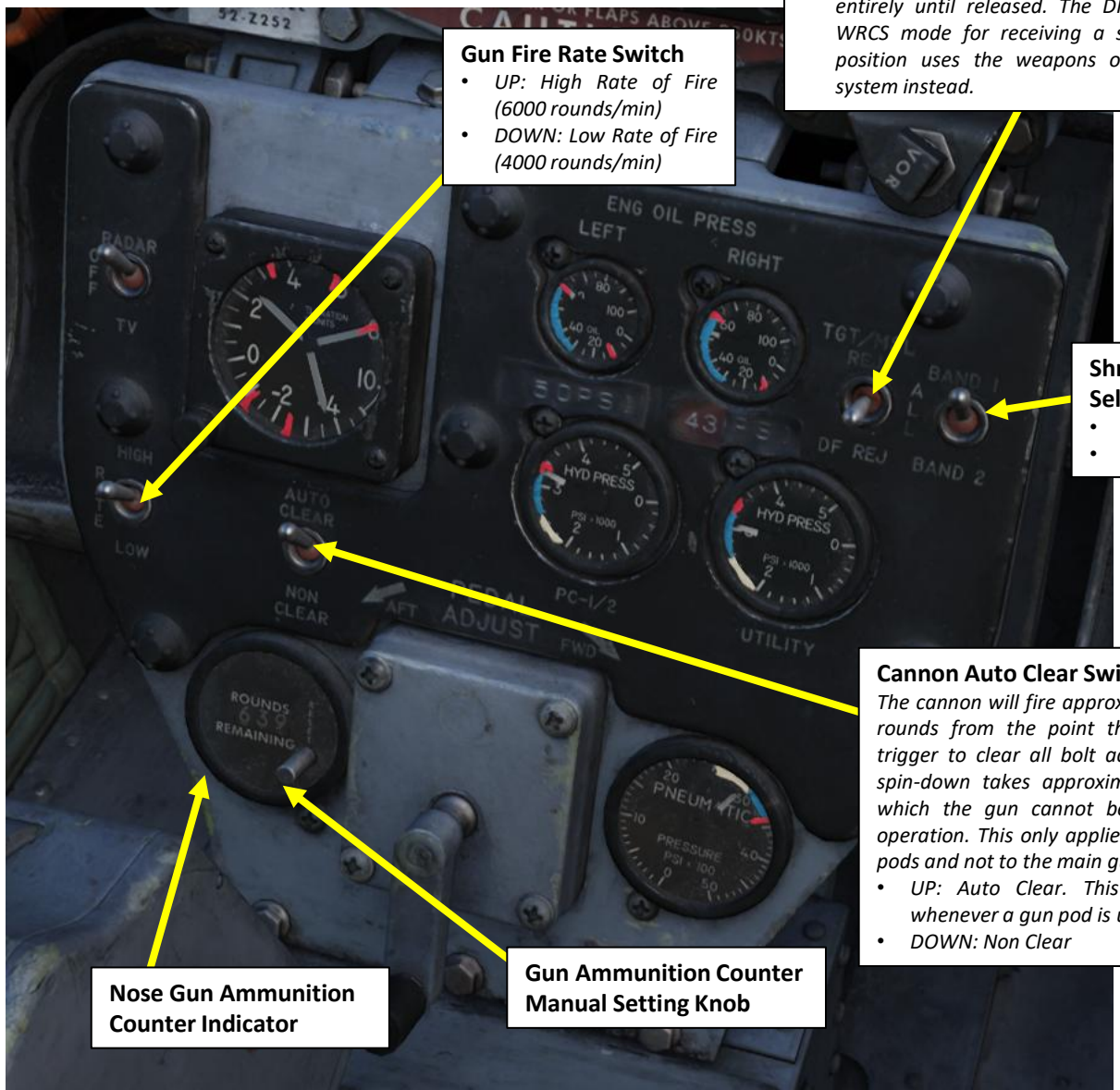
Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



Cage Button
- *When pressed, commands Cage Mode.*
- *Radar goes into BST (Boresight) mode with a five mile range, short pulse, and sets the firing circuit for the currently selected air-to-air weapon relative to the Pinky Switch.*
- *For the optical sight, the command activates the respective elevation and azimuth tracking, roll mark, and range functions of the reticle for the chosen weapon, without the pilot having to remove a hand from throttle or stick to swap the sight mode or weapon control panel functions.*

TGT/MSL REJ (Target/Missile Reject) Switch
- *For Mavericks, the spring-loaded TGT/MSL REJ position cycles through the available Mavericks currently selected and armed. If six Mavericks are equipped the station with the uncaged and active Maverick is cycled. To cycle the other station simply de-arm the active station, and select the other. The DF REJ position has no function.*
- *For Shrikes, TGT/MSL REJ turns off the weapon seeker entirely until released. The DF REJ position selects the WRCS mode for receiving a solution, while the center position uses the weapons own, less accurate seeker system instead.*

Gun Fire Rate Switch
- *UP: High Rate of Fire (6000 rounds/min)*
- *DOWN: Low Rate of Fire (4000 rounds/min)*



Shrike Missile Band Selector Switch
- *UP: Band 1*
- *DOWN: Band 2*

Cannon Auto Clear Switch
The cannon will fire approximately between 5 and 11 rounds from the point the pilot has released the trigger to clear all bolt actions in the cannon. This spin-down takes approximately one second during which the gun cannot be fired again during this operation. This only applies to externally carried gun pods and not to the main gun.
- *UP: Auto Clear. This option should be used whenever a gun pod is used.*
- *DOWN: Non Clear*

Nose Gun Ammunition Counter Indicator

Gun Ammunition Counter Manual Setting Knob

1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)

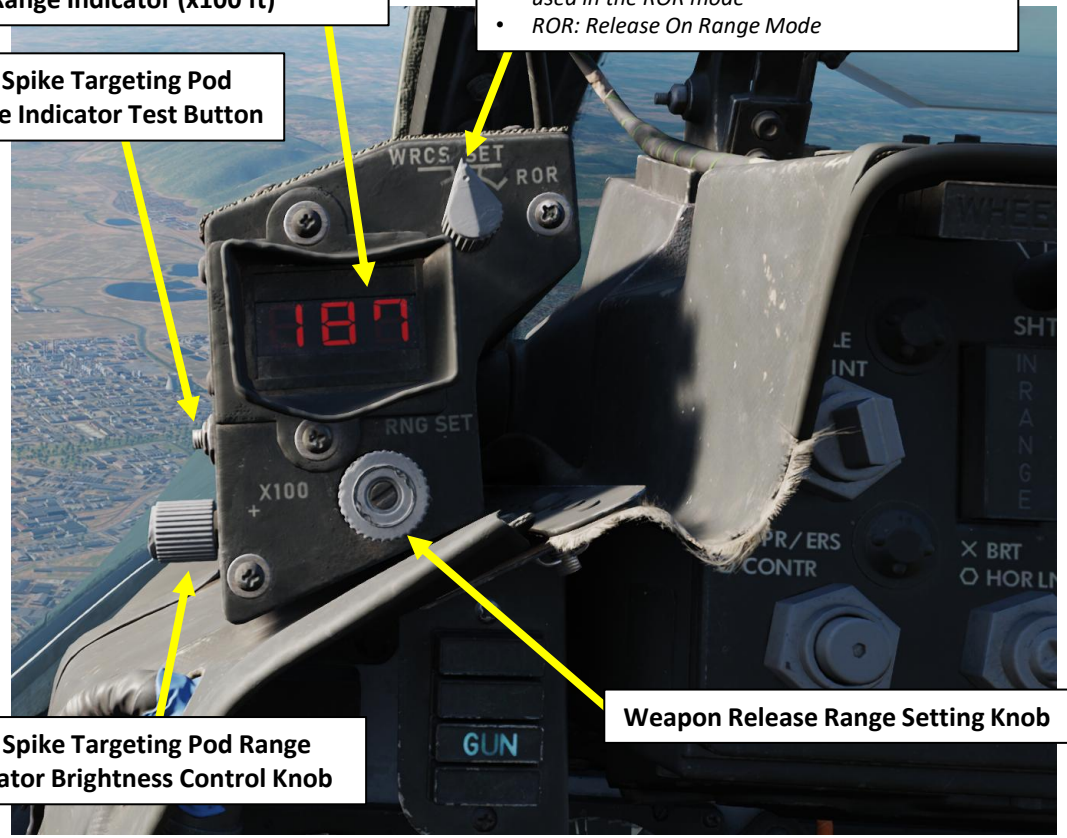
Target Contrast Switch
- *FWD: WHT/BLK (White/Black), programs the Maverick missile seeker to track a light target on a dark background.*
- *MIDDLE: AUTO, Programs the missile to use its automatic tracking mode.*
- *AFT: BLK/WHT (Black/White), programs the Maverick missile seeker to track a dark target on a light background.*

Forward Hand Control
- *Joystick enabling the Pilot to control and steer guided Weapons such as Maverick or Bullpup missiles.*

Weapon Release Mode Selector
- *WRCS: Weapon Release Computer Set, also known as Automatic Delivery*
- *SET: Display shows the desired release range used in the ROR mode*
- *ROR: Release On Range Mode*

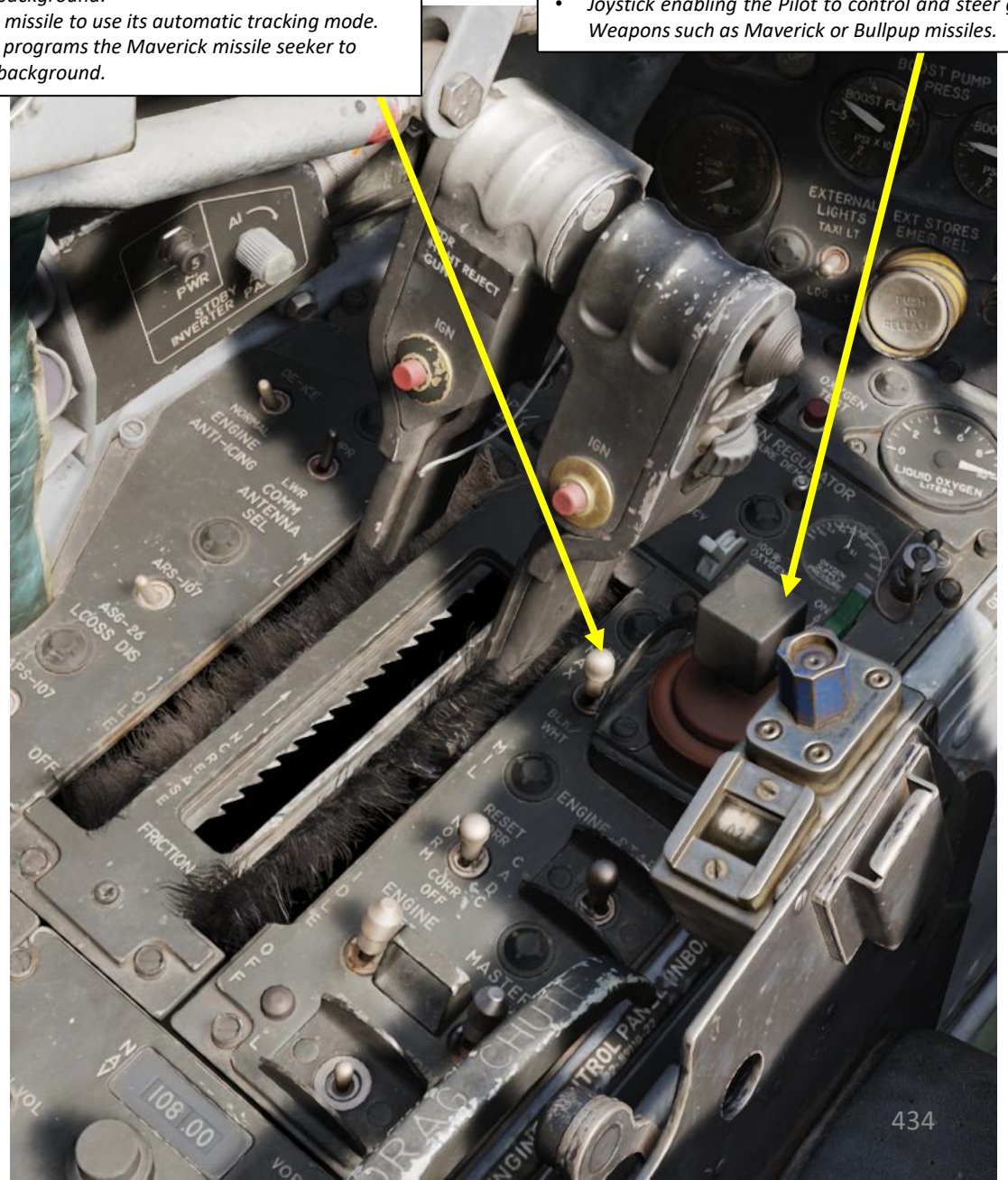
Pave Spike Targeting Pod Slant Range Indicator (x100 ft)

Pave Spike Targeting Pod Range Indicator Test Button

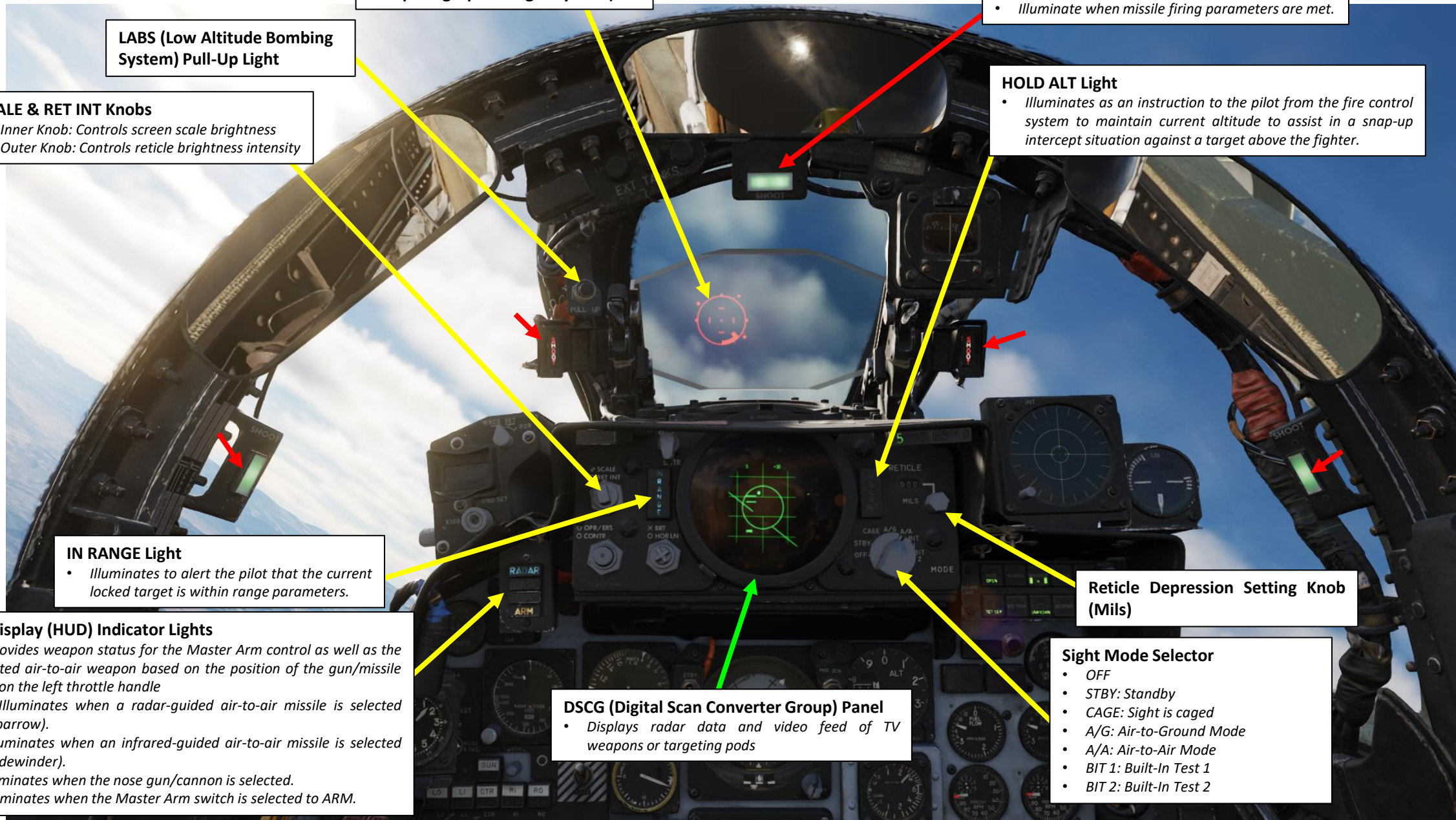


Weapon Release Range Setting Knob

Pave Spike Targeting Pod Range Indicator Brightness Control Knob



1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)



Optical Sight (LCOSS, Lead Computing Optical Sight System)

LABS (Low Altitude Bombing System) Pull-Up Light

SCALE & RET INT Knobs
- *Inner Knob: Controls screen scale brightness*
- *Outer Knob: Controls reticle brightness intensity*

SHOOT Lights
- *Illuminate when missile firing parameters are met.*

HOLD ALT Light
- *Illuminates as an instruction to the pilot from the fire control system to maintain current altitude to assist in a snap-up intercept situation against a target above the fighter.*

IN RANGE Light
- *Illuminates to alert the pilot that the current locked target is within range parameters.*

Head-Up Display (HUD) Indicator Lights

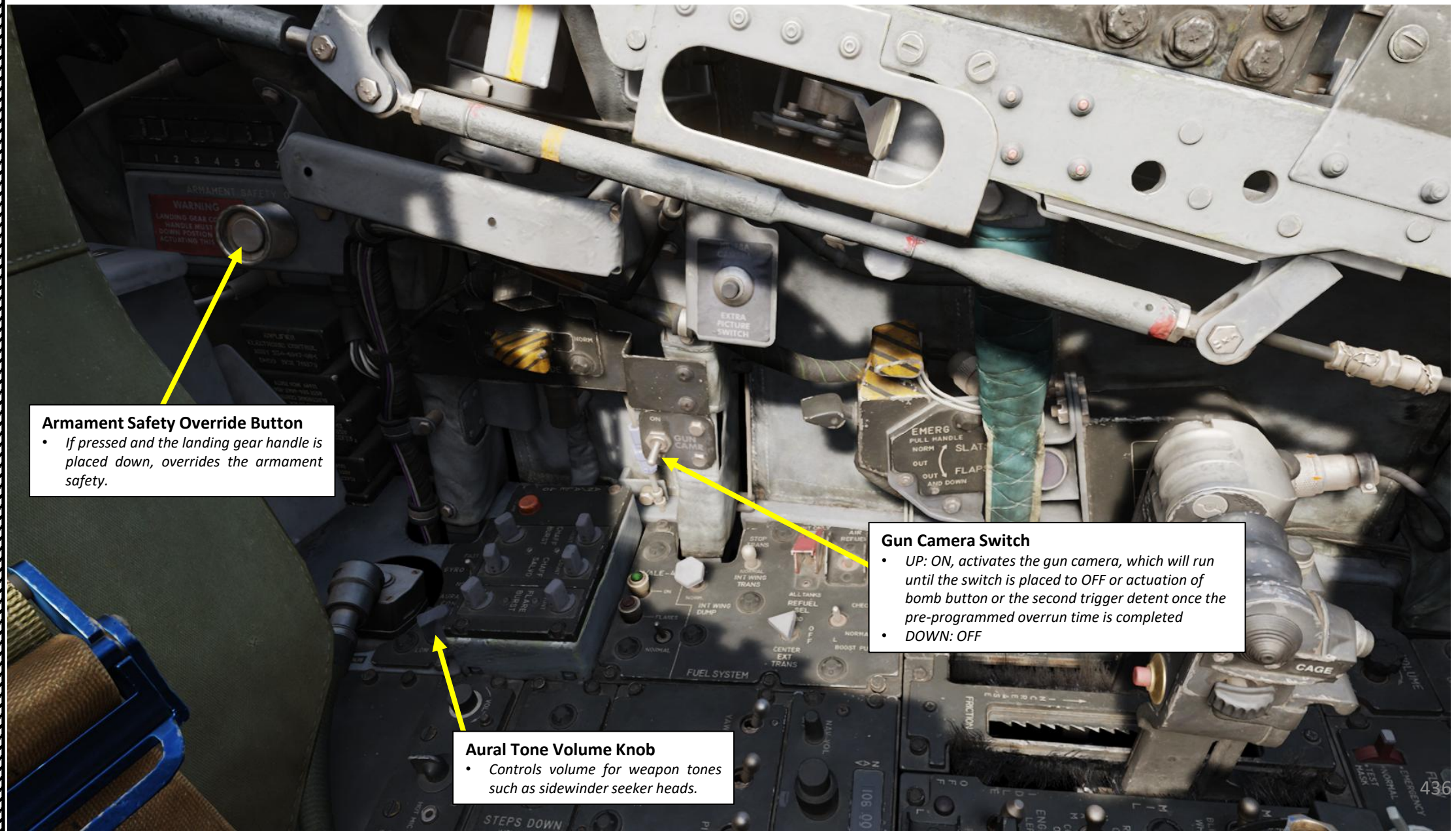
This panel provides weapon status for the Master Arm control as well as the current selected air-to-air weapon based on the position of the gun/missile pinky switch on the left throttle handle
- ***RADAR**: Illuminates when a radar-guided air-to-air missile is selected (AIM-7 Sparrow).*
- ***HEAT**: Illuminates when an infrared-guided air-to-air missile is selected (AIM-9 Sidewinder).*
- ***GUN**: Illuminates when the nose gun/cannon is selected.*
- ***ARM**: Illuminates when the Master Arm switch is selected to ARM.*

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*

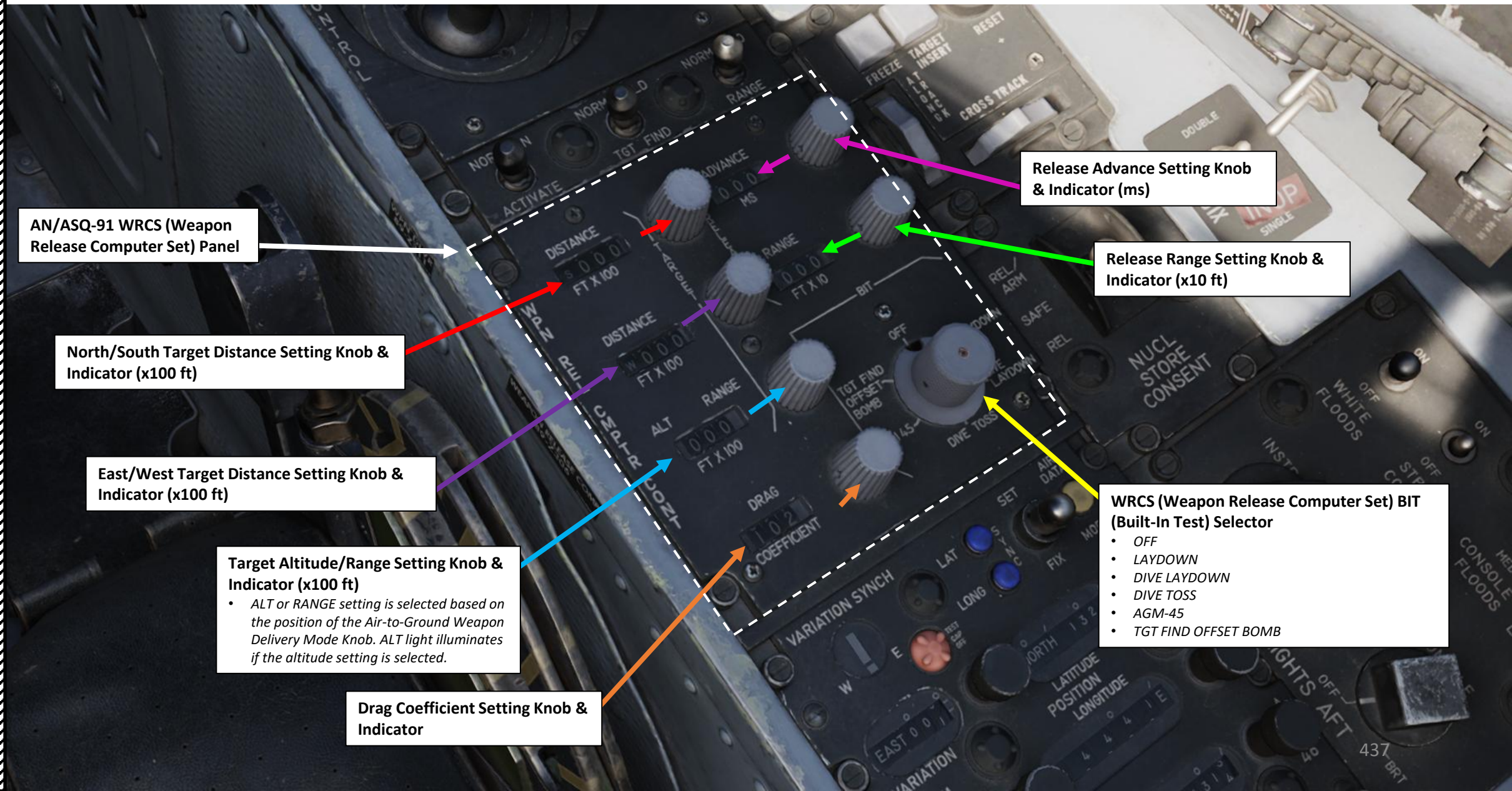
Reticle Depression Setting Knob (Mils)

Sight Mode Selector
- *OFF*
- *STBY: Standby*
- *CAGE: Sight is caged*
- *A/G: Air-to-Ground Mode*
- *A/A: Air-to-Air Mode*
- *BIT 1: Built-In Test 1*
- *BIT 2: Built-In Test 2*

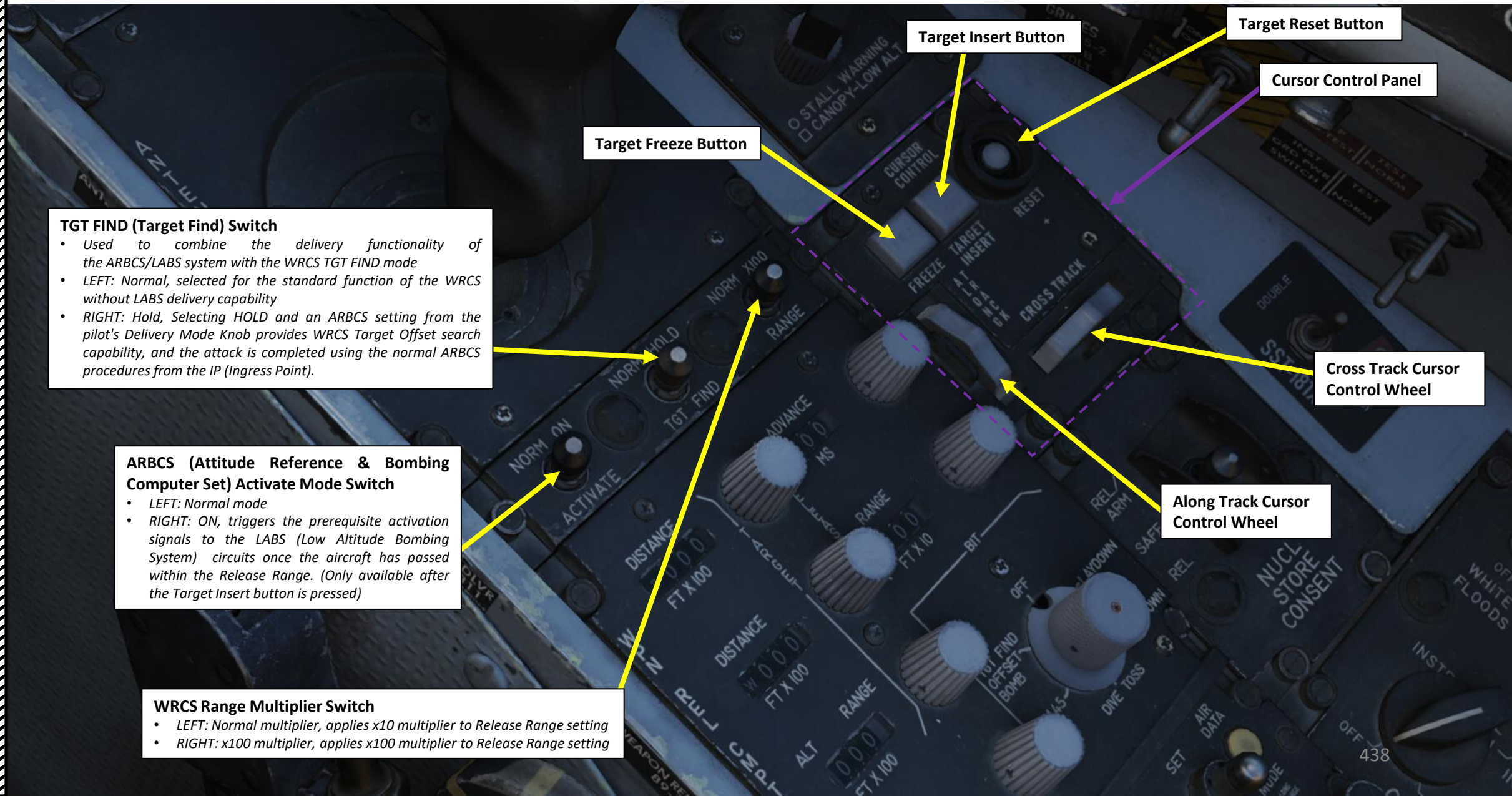
1 – INTRODUCTION
1.4 – Weapon Interface (Pilot)



1 – INTRODUCTION
1.4 – Weapon Interface (WSO)



1 – INTRODUCTION
1.4 – Weapon Interface (WSO)



TGT FIND (Target Find) Switch
- *Used to combine the delivery functionality of the ARBCS/LABS system with the WRCS TGT FIND mode*
- *LEFT: Normal, selected for the standard function of the WRCS without LABS delivery capability*
- *RIGHT: Hold, Selecting HOLD and an ARBCS setting from the pilot's Delivery Mode Knob provides WRCS Target Offset search capability, and the attack is completed using the normal ARBCS procedures from the IP (Ingress Point).*

ARBCS (Attitude Reference & Bombing Computer Set) Activate Mode Switch
- *LEFT: Normal mode*
- *RIGHT: ON, triggers the prerequisite activation signals to the LABS (Low Altitude Bombing System) circuits once the aircraft has passed within the Release Range. (Only available after the Target Insert button is pressed)*

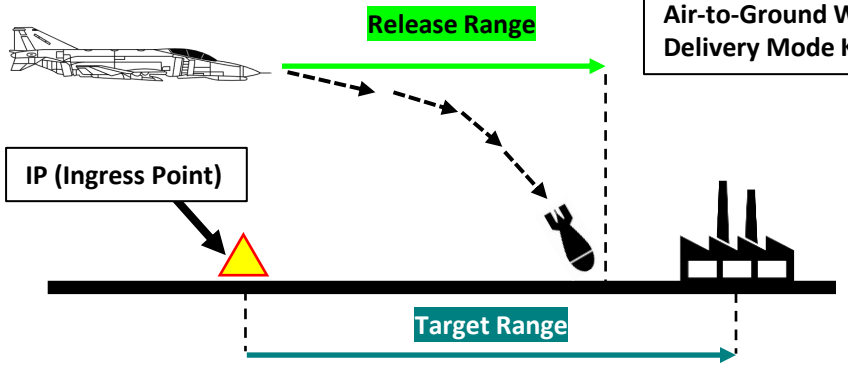
WRCS Range Multiplier Switch
- *LEFT: Normal multiplier, applies x10 multiplier to Release Range setting*
- *RIGHT: x100 multiplier, applies x100 multiplier to Release Range setting*

1 – INTRODUCTION
1.4 – Weapon Interface (WSO)

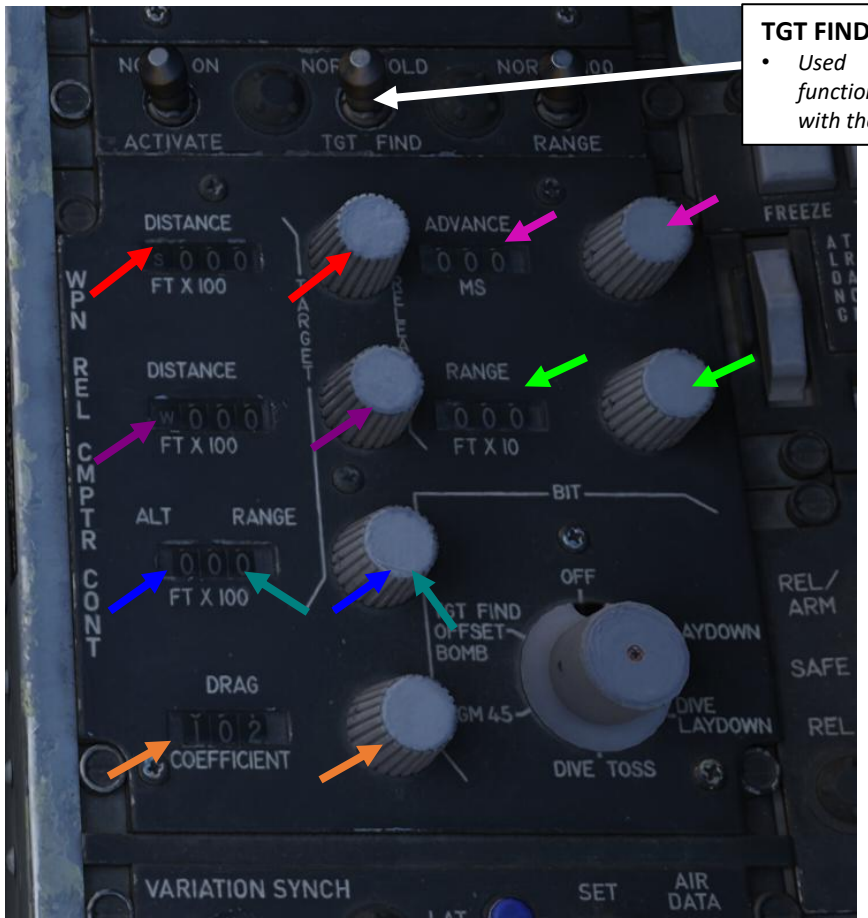
The WRCS (Weapon Release Computer Set) panel has several parameters, but not all of them are applicable to every delivery mode.

Target Range Input Controls are used for the TGT FIND (Target Find) and Offset modes and represent the distance between the Ingress Point (IP) and the target.

Release Range Input controls are used for the laydown, dive laydown and offset bombing modes and represent a manually set bomb range.



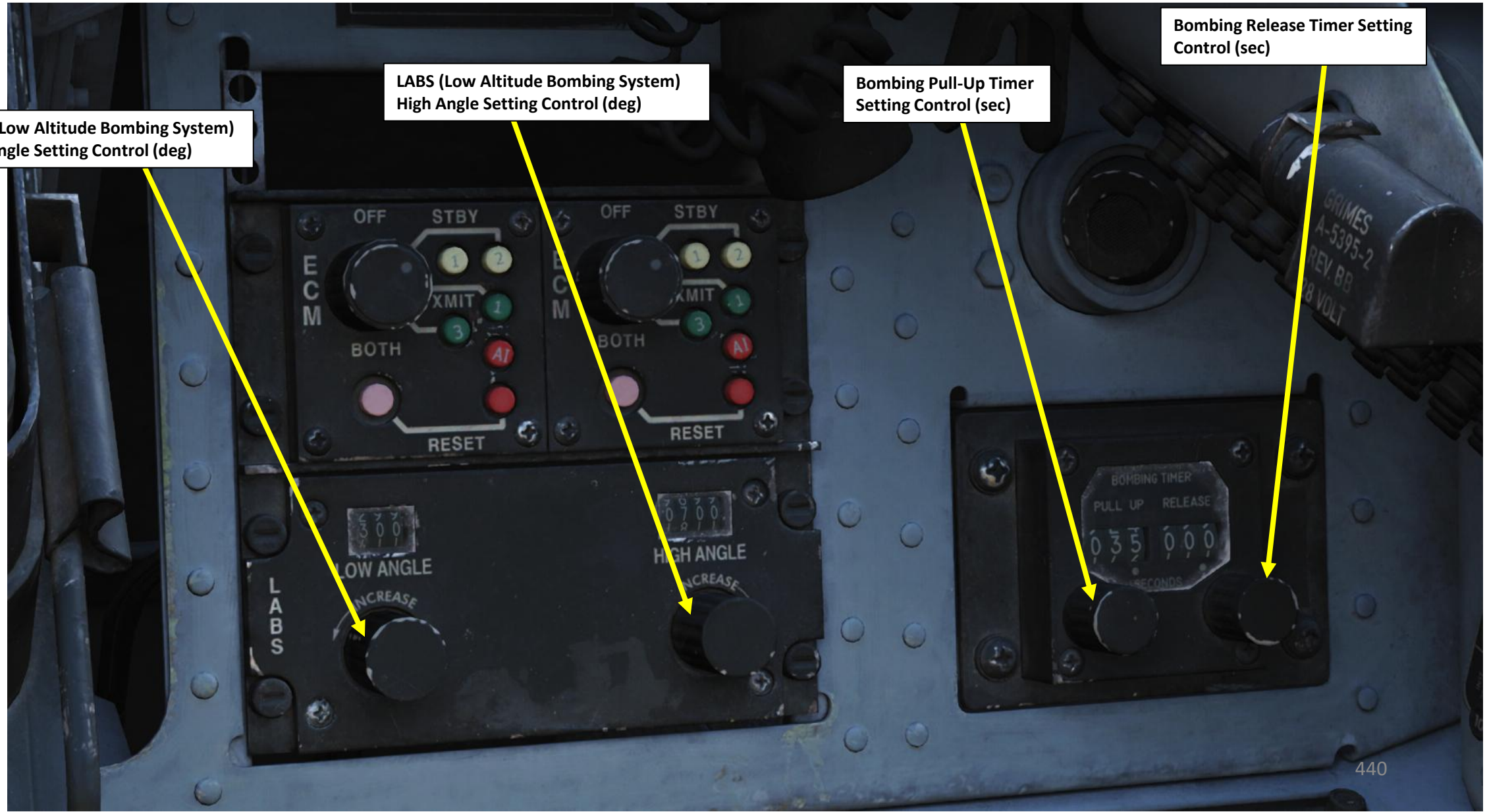




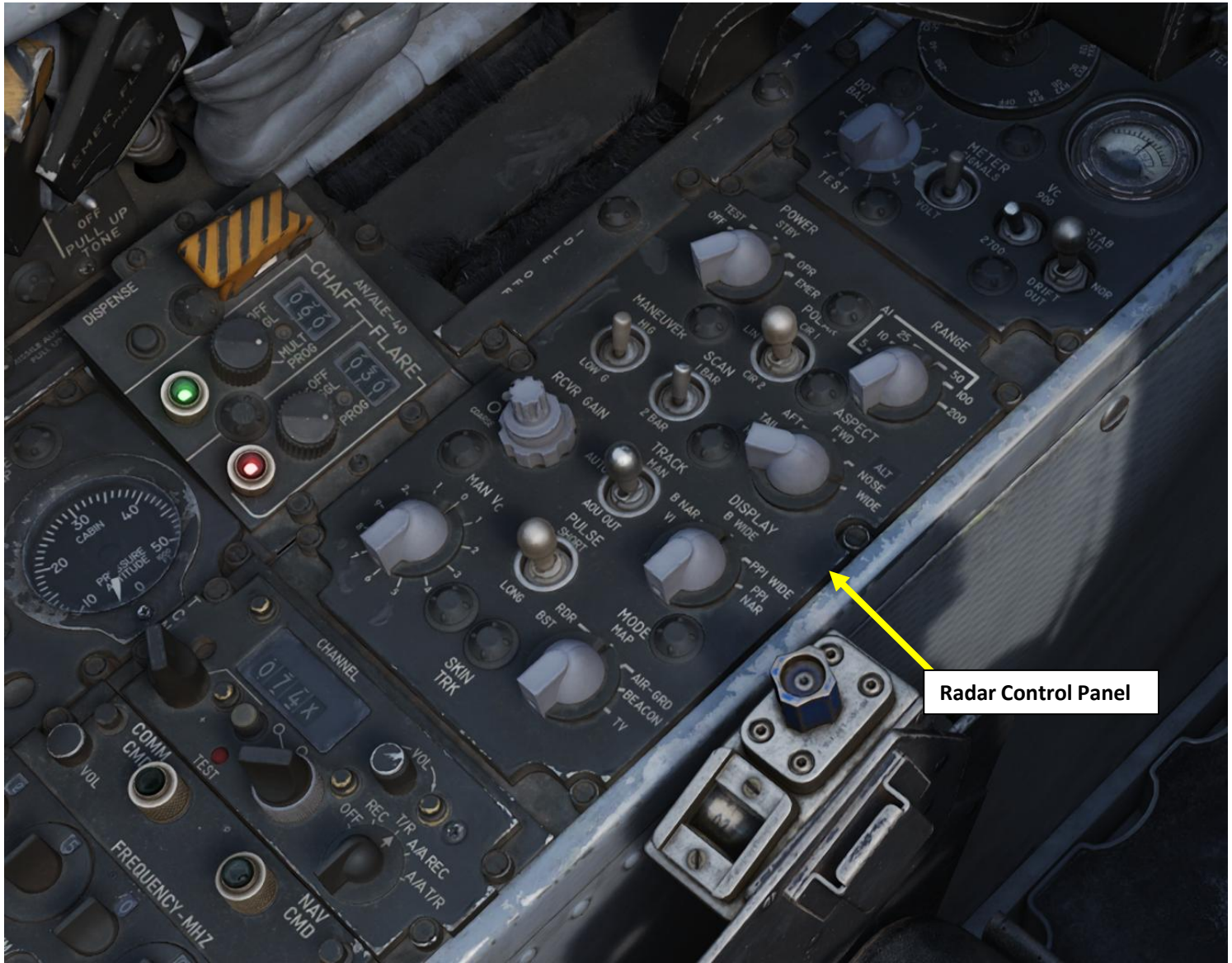
WRCS Manual Inputs Required vs Delivery Mode Table

Delivery Mode	Target				Drag Coefficient	Release	
	N/S DIST (ft x 100)	E/W DIST (ft x 100)	ALT (ft x 100)	RANGE (ft x 100)		Advance (ms)	Range (ft x10)
Dive Toss					Required	Required	
Dive Laydown						Required	Required
Laydown				Required		Required	Required
Offset Bomb	Required	Required	Required			Required	Required
TGT FIND	Required	Required	Required				
AGM-45			Required			Required	
TGT FIND/LABS (Low Altitude Bombing)	Required	Required	Required			Required	Required

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1.4 – Weapon Interface (WSO)

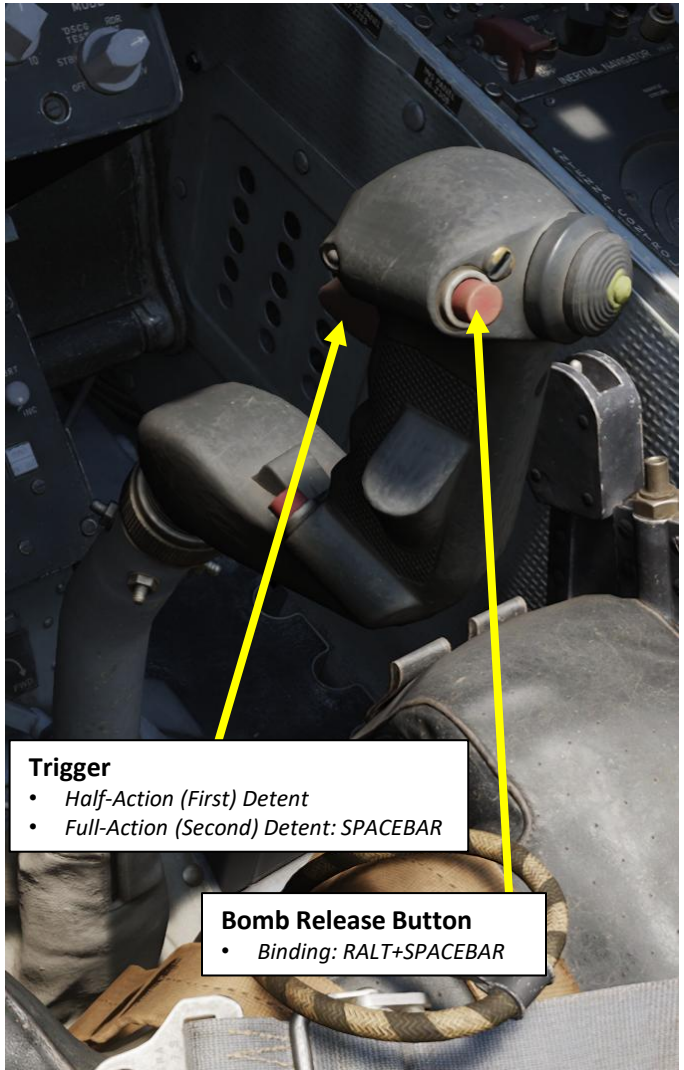


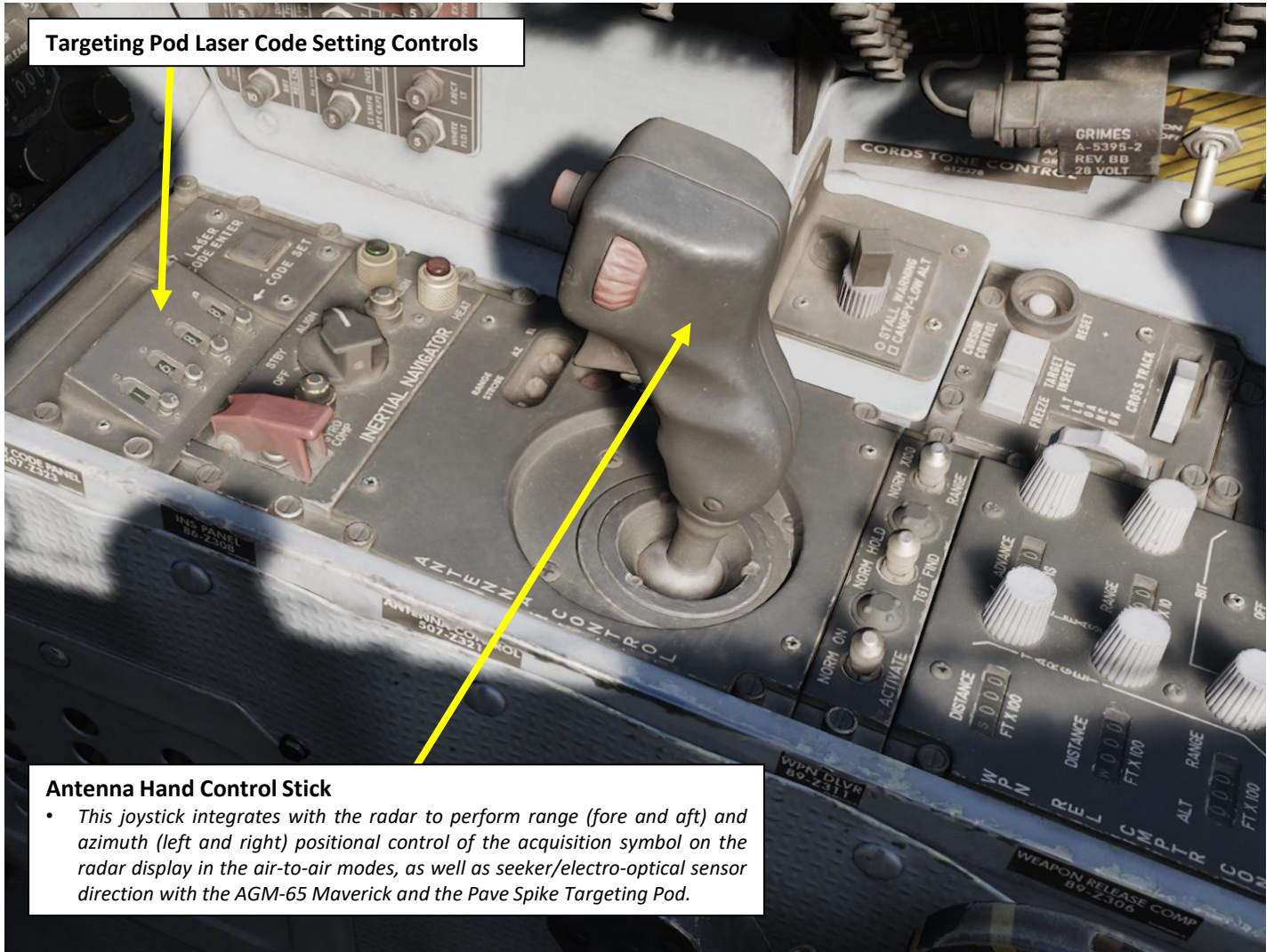
1 – INTRODUCTION
1.4 – Weapon Interface (WSO)



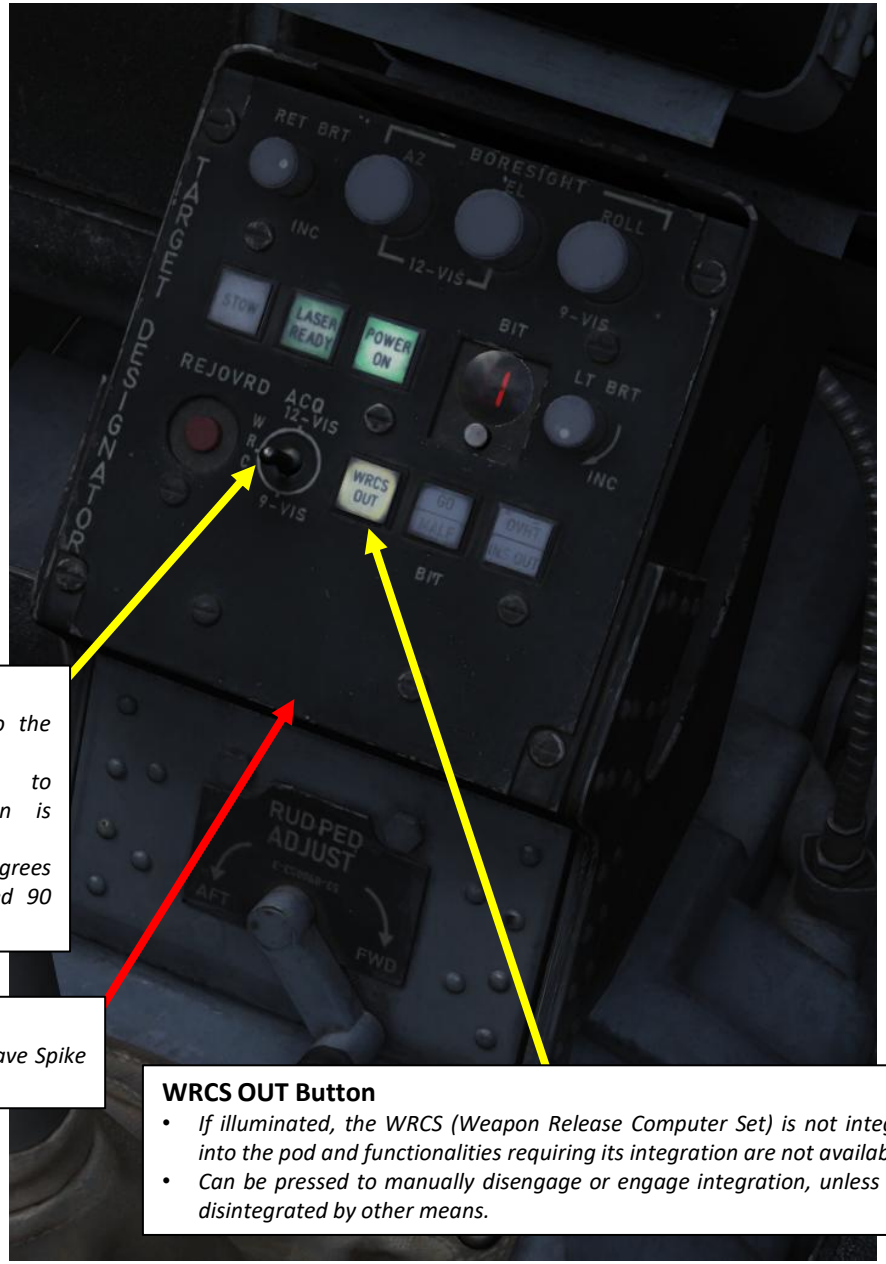


1 – INTRODUCTION
1.4 – Weapon Interface (WSO)





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1.4 – Weapon Interface (WSO)



Acquisition Mode Selector Switch
- *UP: 12-VIS, slaves pod line-of-sight parallel to the optical sight pipper.*
- *MIDDLE: WRCS, slaves pod line-of-sight to the WRCS cursor unless WRCS integration is deactivated; reverts to 12-VIS otherwise.*
- *DOWN: 9-VIS, slaves pod line-of-sight to 90 degrees below FRL (Fuselage Reference Line) and rolled 90 degrees left.*

Target Designator Control Set
- *Main panel to interact with the Pave Spike Targeting Pod.*

WRCS OUT Button
- *If illuminated, the WRCS (Weapon Release Computer Set) is not integrated into the pod and functionalities requiring its integration are not available.*
- *Can be pressed to manually disengage or engage integration, unless it was disintegrated by other means.*

DSCG (Digital Scan Converter Group) Panel
- *Displays radar data and video feed of TV weapons or targeting pods*



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1.4 – Weapon Interface (WSO)



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1.5 – QFE & Altitude Accuracy for Air-to-Ground

Introduction to QFE and QNH

Unlike modern planes, the F-4E does not have terrain elevation data available. Therefore, weapon release cues rely on either radar ranging or triangulation ranging, which requires altitude data (based on barometric pressure readings derived from the pitot tube).

An **Altimeter setting** is the value of the atmospheric pressure used to adjust the scale of a pressure altimeter so that it indicates the height of an aircraft above a known reference surface. This reference can be the mean sea level pressure, or the barometric pressure at the nearby surface airport or the pressure level of 29.92 inches of Hg (Mercury) or 1,013.25 hectopascals, which gives the standard flight levels.

QNH is the **"sea-level pressure".** It's used to cause the altimeter to register height above sea level. When sitting on the ground at an airport, dialing QNH into the altimeter will cause it to display the airport's altitude above sea level.

- Note: A barometric altitude with a QNH altimeter setting is sometimes referred to as "Nautical Height".

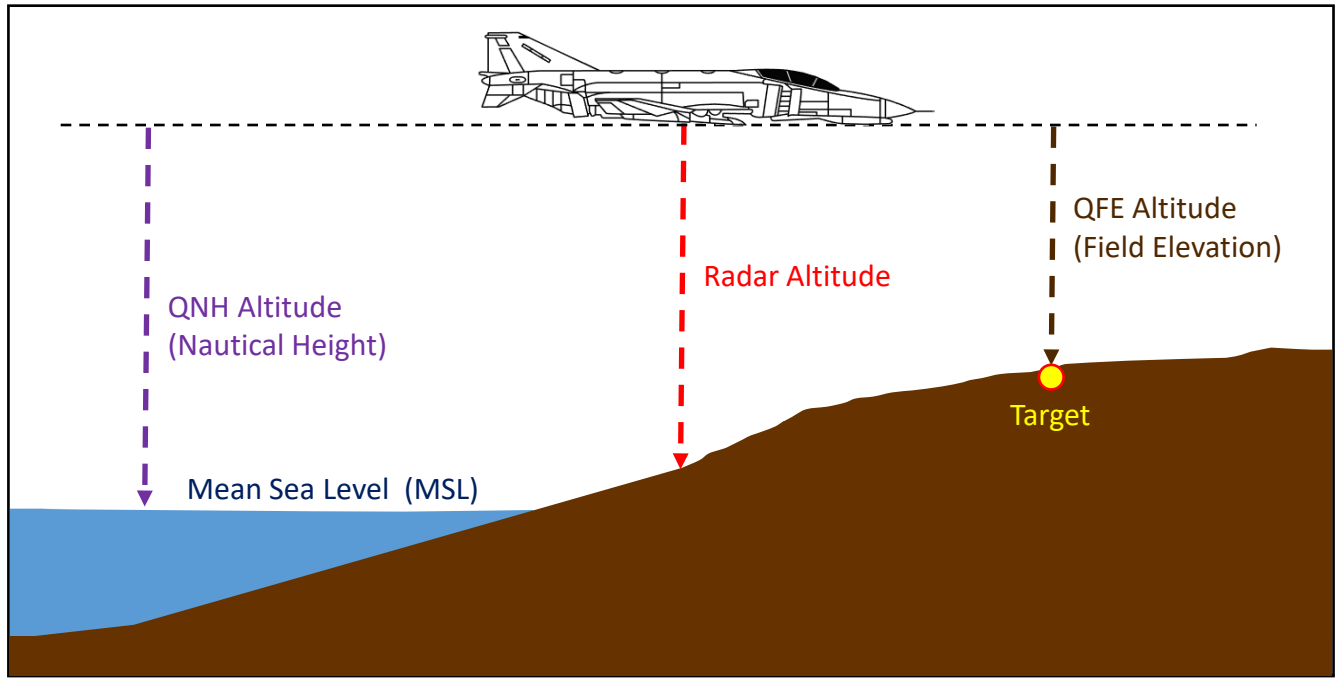
QFE is the **"air pressure at the current ground level".** It's used to cause the altimeter to register height above the ground (for a certain area). When sitting on the ground at an airport, dialing QFE into the altimeter will cause it to display zero feet.

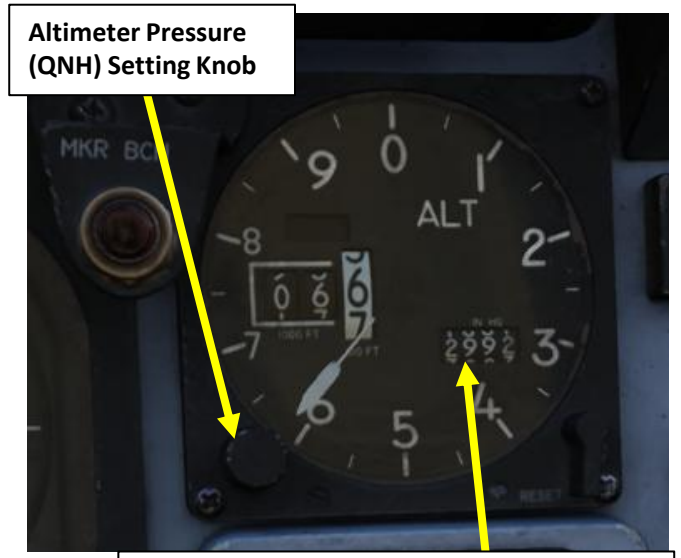
- Note: A barometric altitude with a QFE altimeter setting is sometimes referred to as "Field Elevation".

Western countries largely standard on using QNH during takeoff and landing. It allows you to accurately know your height above sea level, but you must know the height of the local terrain to know if you are at risk of impacting terrain.

Eastern countries have sometimes standardized on using QFE, which allows you to know your height above the airport by just reading the altimeter.

In practice, **USAF pilots would always set the barometric pressure to the forecast QNH for the target area.** QFE was not used since this measurement could come from radar altimeters. This was a briefing item during the flight brief, obtained from the Met office. Air-to-ground weapon delivery would be based on this barometric altimeter setting.





Altimeter Barometric Pressure (QNH) Setting (in Hg)
Ex: 29.92 in Hg = 1013.25 Hpa

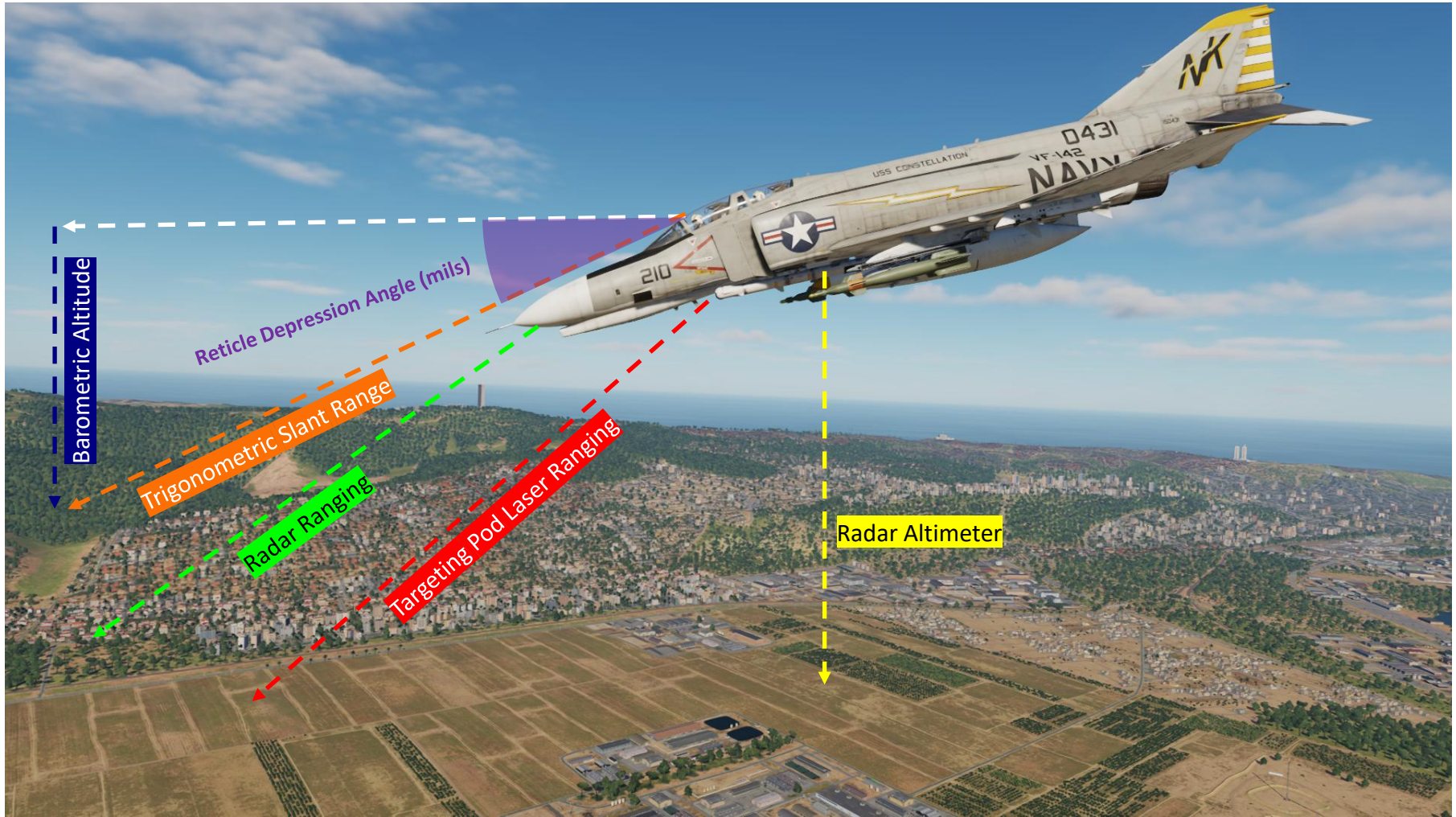


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1.5 – QFE & Altitude Accuracy for Air-to-Ground

Range Computation

The range to a target can be computed in a number of ways, but it is important to know that you will sometimes not have access to all these methods due to battle damage, difficult terrain, operational considerations or even equipment restrictions.

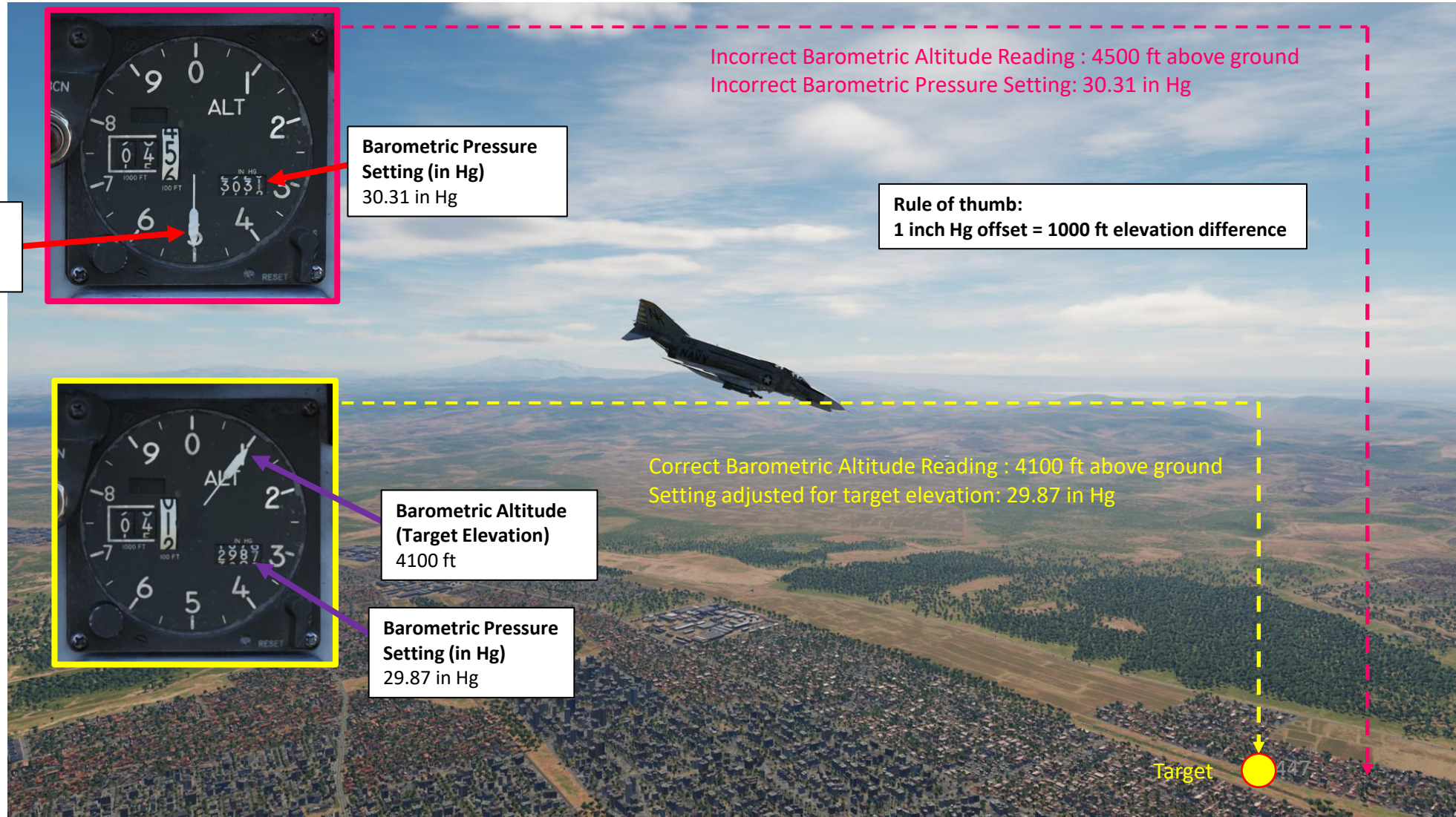
- The most basic method is a trigonometric method which basically estimates slant range to a target from the reticle depression angle and the barometric or radar altimeter (RADALT).
- The radar in air-to-ground mode can also compute a range based on radar returns.
- The targeting pod has laser ranging capabilities as well.



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1.5 – QFE & Altitude Accuracy for Air-to-Ground

QFE/QNH Problems

In case you are performing direct dive bombing with altitude, speed and dive angle data only you can use your altimeter either with either QNH (giving you altitude above mean sea level) or QFE (giving you elevation above ground). Having a QFE/QNH set incorrectly means that the barometric altitude read on your altimeter may not give you the "real" desired altitude. This can throw off your aim when following attack profiles. In the example below, both altimeter readings are taken at the same time, but for different QFE/QNH settings for illustrative purposes.



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1.5 – QFE & Altitude Accuracy for Air-to-Ground

QNH to QFE Conversion

While in real life QNH was typically used for bombing, here is a method to use QFE instead in case you want to have the altimeter display elevation above ground level (QFE) instead of altitude above mean sea level (QNH). This method requires a bit of math and the location of the target. We will calculate the QFE value with the QNH value from the starting airfield (assuming it is not too far and that the weather does not change too much).

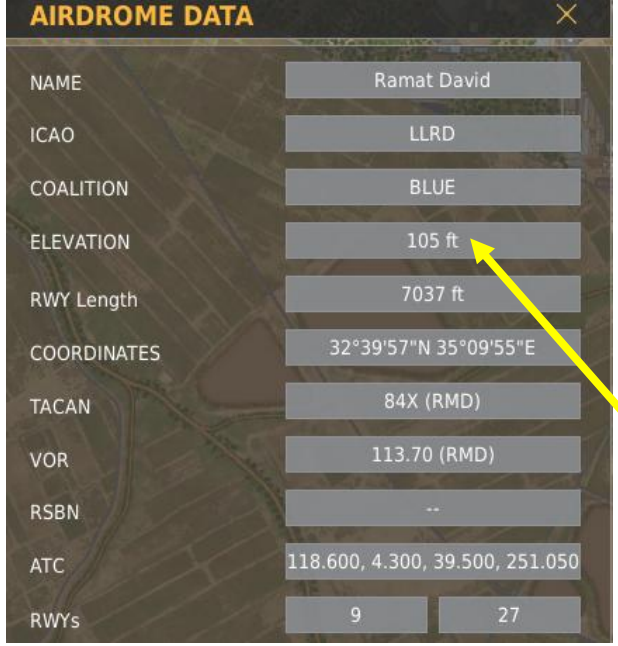
1. When you are on your takeoff airfield, find the airfield elevation, which is available in the F10 map.
2. In our case, we takeoff from Ramat David, which has an elevation of 105 ft.
3. When on ground, adjust the Altimeter Pressure Setting knob to match the altitude indicated by the altimeter with the airfield elevation (105 ft). In our case, we get an elevation of 105 ft by setting the altimeter setting knob to 29.87 in Hg.
4. Therefore, from the airfield elevation, we calculated that the airfield **QNH** (barometric pressure at sea level) is **29.87 in Hg**.
5. In the F10 map, hover the mouse over the target and write down the **target elevation** (772 ft in our case).
6. $$QFE = QNH - \frac{(Target\ Elevation\ in\ ft)}{1000 \frac{ft}{inch\ Hg}}$$
$$QFE = 29.87\ in\ Hg - \frac{(772\ ft)}{1000\ \frac{ft}{inch\ Hg}} = 29.10\ inches\ Hg$$
7. Therefore, the **QFE expected at a target** of an elevation of 772 ft is approx. **29.10 in Hg**.

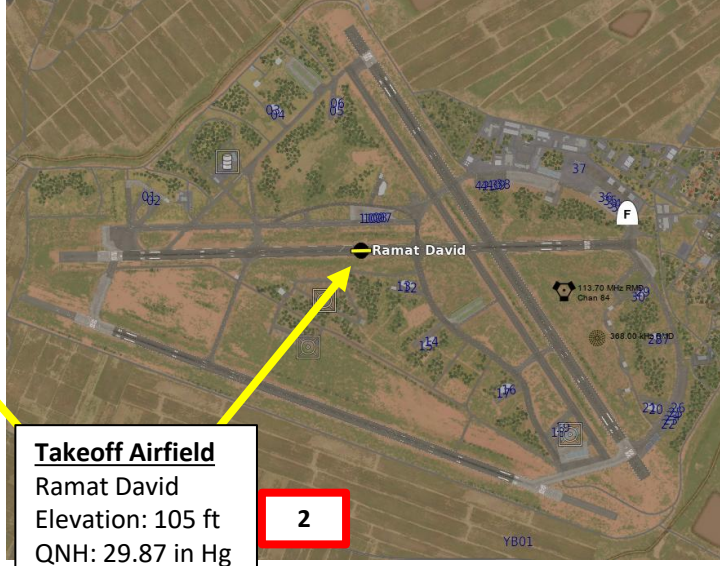


3

Barometric Pressure Setting (in Hg)
29.87 in Hg

Barometric Pressure Setting Control Knob





Takeoff Airfield
Ramat David
Elevation: 105 ft
QNH: 29.87 in Hg

2

MAP 32°45'49"N 35°23'38"E, 772 ft



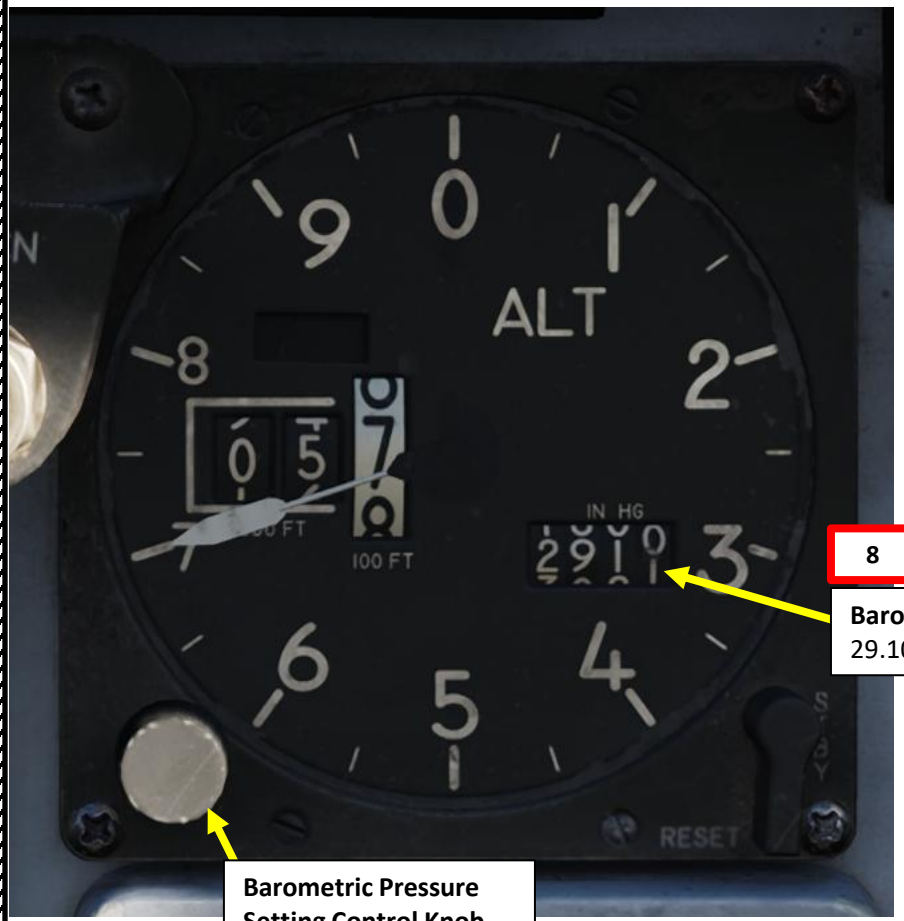
Target
Elevation: 772 ft
QNH: 29.87 in Hg
QFE: 29.10 in Hg (used for elevation above ground)

5

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1.5 – QFE & Altitude Accuracy for Air-to-Ground

QNH to QFE Conversion

8. Adjust the Altimeter Pressure Setting knob to 29.10 in Hg. During your bombing run, the altitude displayed will now be the elevation above ground (QFE) instead of the altitude above mean sea level (QNH). Keep in mind that using QFE or QNH is up to your personal preference. I personally prefer sticking to QNH and adding terrain elevation to the altitude required for my attack profile.





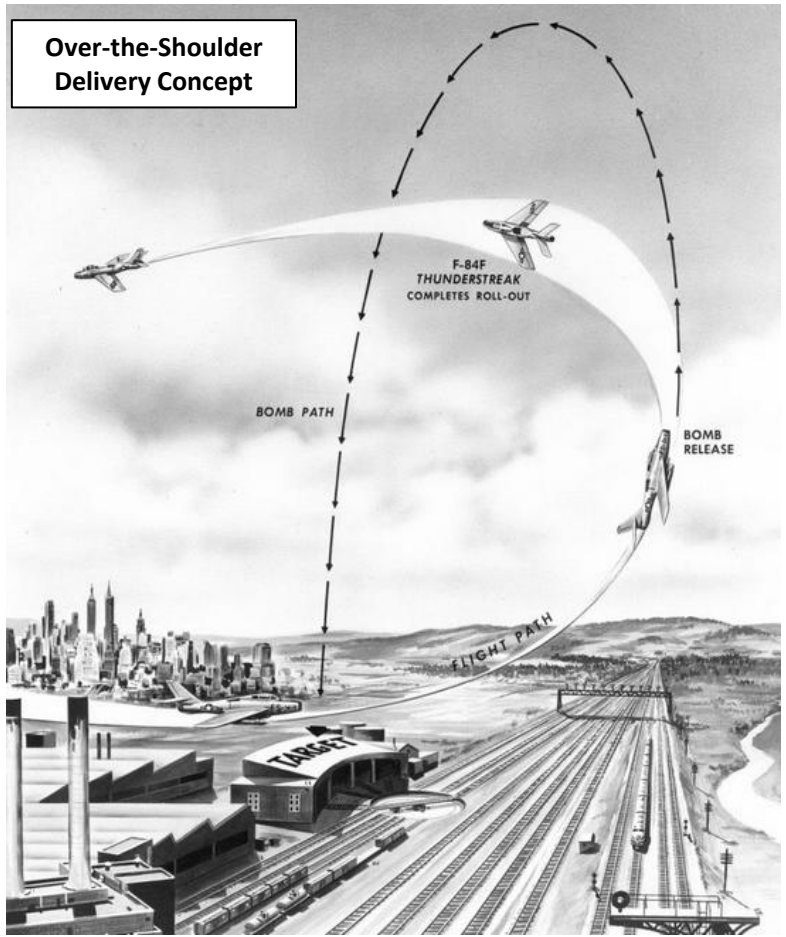
1 – INTRODUCTION
1.6 – Bomb Delivery Methods

The F-4E can employ bombs using many different delivery methods. These modes are selected with the Air-to-Ground Weapon Delivery Mode knob.

Delivery modes primarily use one of these two systems:

- **WRCS** (Weapon Release Computer Set) system, which is used for conventional bombs ; or
- **ARBCS** (Attitude Reference and Bombing Computer Set) system, also referred as **LABS** (Low Altitude Bombing System), which is used for low-level nuclear weapon strike.

In most cases, DT (Dive Toss) Mode or Direct Mode can be used to solve most of your problems. The employment of nuclear weapons is not simulated in DCS World, which means that most ARBCS/LABS modes are not of much use to us.





Air-to-Ground Weapon Delivery Mode Knob

*Split into two halves, the left side of the dial references **ARBCS** (Attitude Reference and Bombing Computer Set) delivery modes, while the right side provides automated release functions using the **WRCS** (Weapon Release Computer Set) with possible tie-in to the navigation computer, depending on mode.*

- ***INST O/S** (labelled "TOSS"): Instantaneous Over the Shoulder Bombing – **ARBCS System***
- ***LOFT**: Loft Bombing – **ARBCS System***
- ***O/S**: (Timed) Over the Shoulder Bombing – **ARBCS System***
- ***T LAD**: Timed LADD (Low Angle Drogue Delivery) Bombing – **ARBCS System***
- ***TL**: Timed Level Bombing – **ARBCS System***
- *OFF: OFF (Air-to-Air)*
- *DIRECT: Manual Direct Bombing*
- ***TGT FIND**: Target Find (Nav Mode and Pave Spike Targeting Pod bombing only) – **WRCS System***
- ***DT**: Dive Toss Bombing – **WRCS System***
- ***DL**: Dive Laydown Bombing – **WRCS System***
- ***L**: Laydown Bombing – **WRCS System***
- ***OFF SET**: Offset Bombing – **WRCS System***
- ***AGM-45**: Used for AGM-45 Shrike missile – **WRCS System***

1 – INTRODUCTION
1.6 – Bomb Delivery Methods

Terminology Reminder:
- *ARBCS: Attitude Reference & Bombing Computer Set*
- *AWRU: Aircraft Weapons Release Unit*
- *INS: Inertial Navigation System*
- *LABS: Low Altitude Bombing System*
- *WRCS: Weapon Release Computer Set*

Delivery Method (Mode)	Category	Description
DT **(Dive Toss)**	Accurate	• Used for targets of opportunity, requires a direct line of sight and computing the right drag coefficient value for the WRCS. • The pilot flies a dive attack on the target while the WSO obtains accurate target range information using the radar. Once the target is designated, the pilot simple holds down the Bomb Button and begins to gently pull out of the dive. • Weapons automatically release at the right moment during the maneuver.
TGT FIND **(Target Find)**	Accurate	• Used for targets of opportunity, requires a direct line of sight and computing the right drag coefficient value for the WRCS. • Target Find will signal the WRCS to use the target defined by the targeting pod's line-of-sight for a Dive Toss delivery, instead of defining the target by radar lock. • Weapons automatically release at the right moment when the parameters for the ballistic solution are met.
OFFSET	Offset Delivery	• Used when target is not directly visible, Offset bombing provides a blind bombing capability, with high and low level bombing profiles, using the full integration of the WRCS, INS, and radar in combination. • The crew chooses a known reference point (IP, Initial Point) and obtains target position by a means of an offset to that reference point. After setting up the aircraft with the corresponding values, the attack is then flown by designating the reference point instead of the actual target. • Weapons automatically release at the right moment based on the offset values.
TL **(Timed Level Bombing)**	Level Release	• Used for attacks from high altitude that do not require to be accurate, dropping bombs safely from above cloud cover. • An IP (Initial Point) is chosen relative to the bomb range distance, and a Release timer value is then calculated using the distance between the point of release and the IP based on the chosen airspeed. • Once the Bomb Button is pressed and hold down, a release timer counts down. As soon as it reaches zero, weapons are deployed.
DL **(Dive Laydown Bombing)**	Laydown	• Used at low level for releasing weapons (high drag bombs or cluster munitions) from a wings level attitude by designating the target with the radar. • The pilot flies a dive attack similar to the Dive Toss mode, while the WSO obtains accurate range information to the target by obtaining a radar lock. • After target designation, the pilot levels out at the planned altitude and weapons release automatically at the set range to the target.
L **(Laydown Bombing)**	Laydown	• Used at low level for releasing weapons (high drag bombs or cluster munitions) from a wings level attitude by designating the target visually either by using the pipper set to a certain sight depression or the radar. • Target is designated by means of a distance to a point prior to the target (IP, Initial Point). Once over that point, the Bomb Button is held down and weapons automatically release after passing the setup release range. • As a visual aid, the sight should be depressed in a way that it will be exactly over the target when at the IP. That way, as soon as the pipper is over the target, the Bomb Button can be held down and weapons will impact.

1 – INTRODUCTION
1.6 – Bomb Delivery Methods

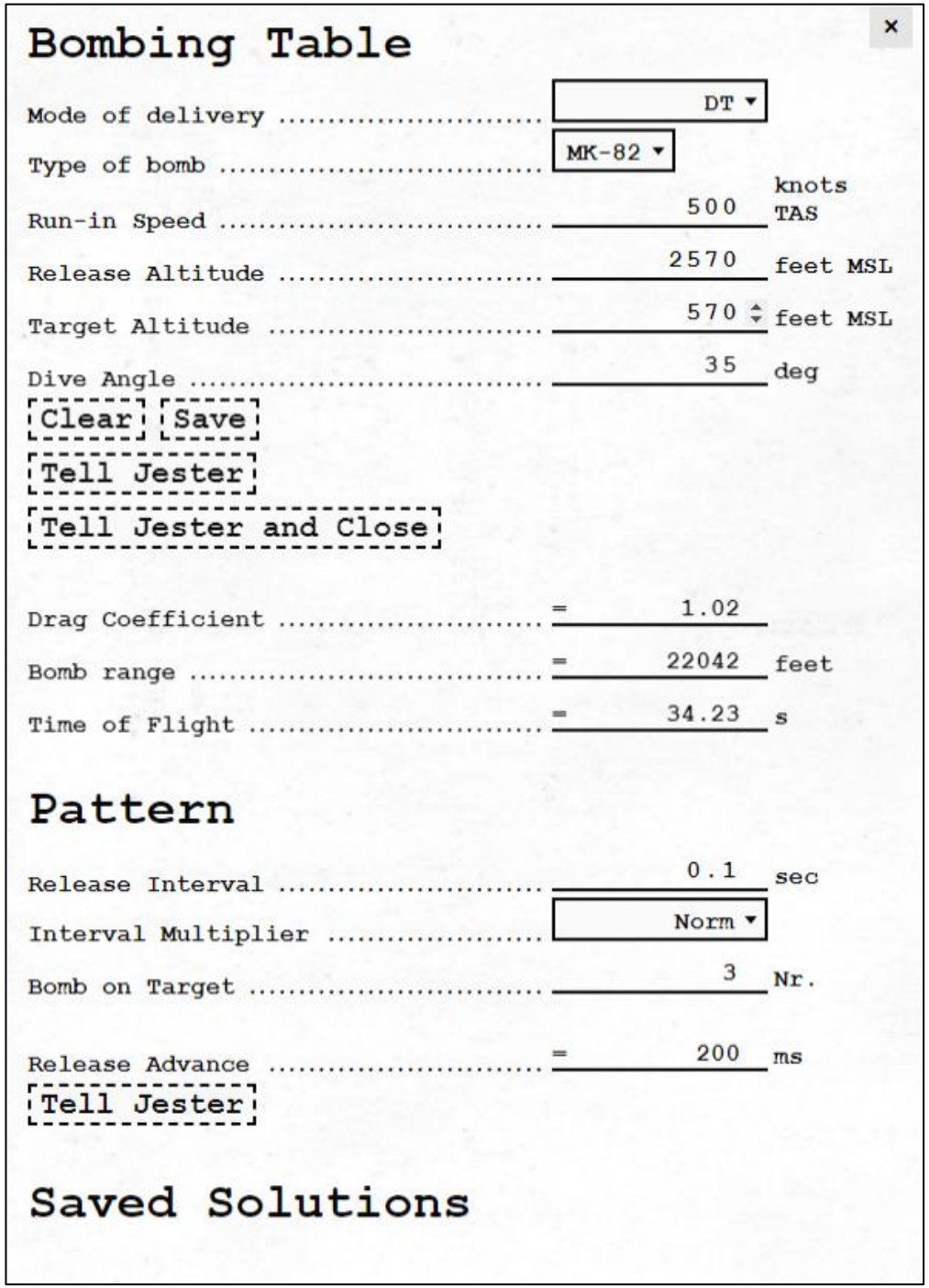
Terminology Reminder:
- *ARBCS: Attitude Reference & Bombing Computer Set*
- *AWRU: Aircraft Weapons Release Unit*
- *INS: Inertial Navigation System*
- *LABS: Low Altitude Bombing System*
- *WRCS: Weapon Release Computer Set*

Delivery Method (Mode)	Category	Description
LOFT (Loft Bombing)	Lofting (release angle below 90 deg)	• Designed to be used with nuclear weapons, but can also be used effectively with conventional bombs when employing a high amount of ammunition while attacking a larger area target. • Planning for a loft attack requires a known target location, so that distances for the IP (Initial Point) and respective bomb ranges can be calculated. Ballistics tables are used to determine delivery pattern and pull-up-to-target range. With this information, the number of bombs can be decided, which determines the spread, and knowing the pull-up to target range - the pull-up point distance to the IP can be chosen. • Upon entry to the target area, the pilot flies the intended course to the IP, and once over, presses and holds the bomb release button to initiate the run. Flying direct or crabbed to the pull-up point, the pilot maintains the bomb release button in the down position, and holds it until the desired munitions have released. The ARBCS programs for a 4 G pull-up schedule, and will automatically release the selected munitions once the bombing run is initiated, timer runout has occurred, and pre-set LOW pitch (gyro) angle is achieved.
T LADD (Timed Low Angle Drogue Delivery)	Lofting (release angle below 90 deg)	• T LADD is a variation of LOFT to maximize the time to impact by lofting a bomb with drogue at maximum distance to the target. • The mode performs a low altitude ingress, transitioning through a 3.5 G pull-up into a 45 degree climb profile that allows for a lofted release of a weapon at the top of the climb, allowing an escape attempt as the munition's deployed drogue slows the decent to the target.
O/S (Timed Over-the-Shoulder Bombing)	Tossing (release angle above 90 deg)	• Similar to LOFT, O/S is used to deploy weapons based on a pull-up timer that represents the distance from IP (Initial Point) to target. • The mode revolves around computing and setting a pull-up timer based on the desired release parameters, such as altitude, speed and toss angle. • Setup of the LABS requires time (calculated using the known distance from the set IP to the target flyover point and the intended airspeed) and calculated release angle for the resulting airspeed and munition, which is entered into the High Angle setting; this value must be in excess of 90 degrees, and the Low Angle and secondary timer settings can be left at any value. • The pilot flies to the reference point, holds the bomb button and starts initiating the 4 G pull-up maneuver the moment the aircraft gives the pull-up cue. Weapons automatically release during the pull-up maneuver when reaching the setup toss angle (beyond 90 deg), effectively tossing the weapon over the shoulder, in contrast to lofting it ahead.
INST O/S (Instantaneous Over-the-Shoulder Bombing)	Tossing (release angle above 90 deg)	• Derived from the Timed O/S mode, Instantaneous Over the Shoulder bombing provides the same combined attack/escape profile as the former against targets of opportunity. • In this mode, setting up an IP (Initial Point) and a timer are not needed. Instead, the target is designated by pressing the Bomb Button once over the target and executing the 4 G pull-up maneuver shortly after.
DIRECT	Manual	• Direct visual bombing, with both dive and level bombing release passes possible. Both the ARBCS and WRCS are excluded from this release mode. • The pilot flies a bombing profile as found for the intended munition in the bombing tables, setting the sight depression to match, and hand flying the aircraft to place the pipper directly onto the target in accordance with the desired type of attack. • Once pipper on target is achieved, the bomb release button is pressed, and the selected number of munitions with the given program settings will be released.

1 – INTRODUCTION
1.7 – Bombing Calculator Tool

The bombing calculator provides the pilot and WSO with an easy way to calculate the needed values for the different bombing modes. You can use it to calculate every value (except for drag coefficient) that you need to drop precise ordnance on your target. It is opened or closed with the **binding "RCTRL+B"**.

This tool is incredibly useful since it allows you to compute all the parameters you need to set in the aircraft without having to go through the excruciating process of going through attack profile tables.



1 – INTRODUCTION
1.7 – Bombing Calculator Tool

Here is a list of input parameters typically required by the bombing calculator. These inputs vary depending on the mode of delivery and bomb type.

Bombing Table Input Parameters

Mode of Delivery
The first thing that should be selected is the Mode of delivery, which will depend on your attack run/profile.

Type of bomb
With the Type of bomb selection, you can choose which ordinance you want to drop. Always choose the correct ordnance to get correct results.

Run-in Speed
Sets the speed at which you want to fly from the ingress point to bomb release. The speed is the true air speed and can be set in increments of 5 knots per click.

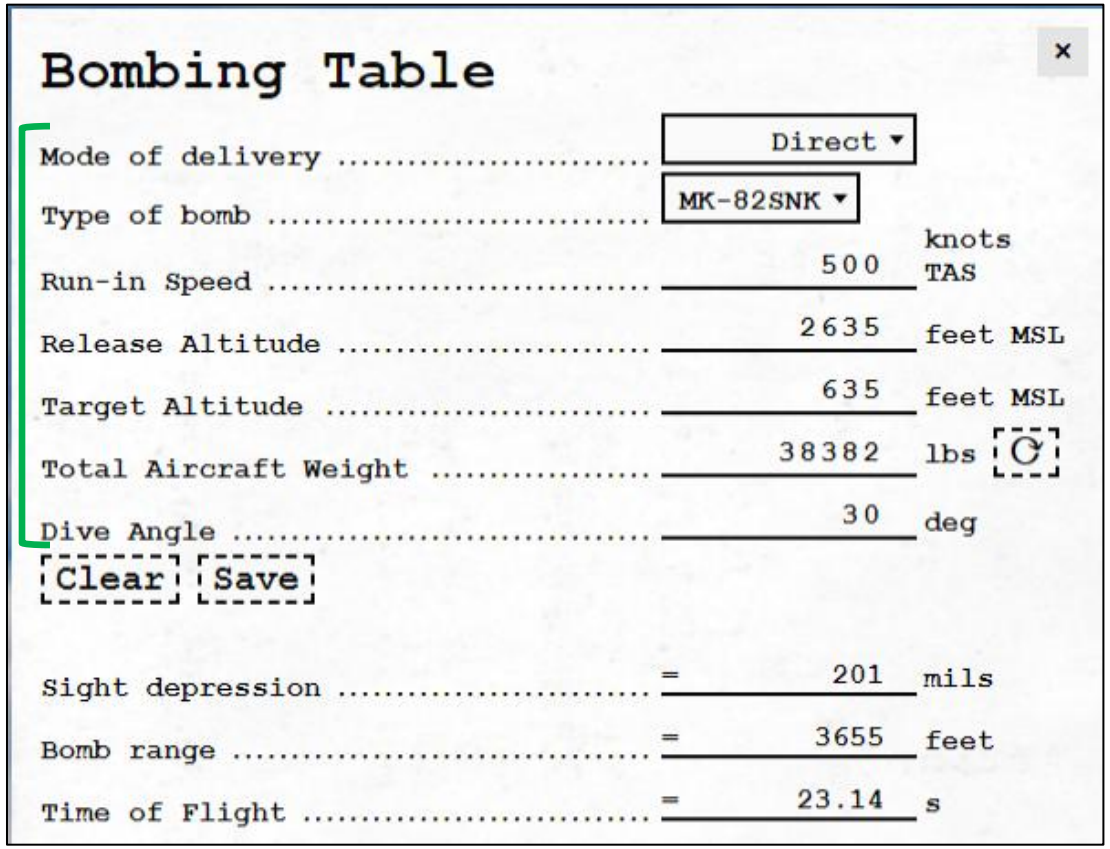
Run-in Altitude
Sets the altitude at which you want to start your bombing run. The run-in altitude must be held from the identification point till bomb release. You can set it in increments of 100 ft per click.

Distance IP <-> Target
Sets the distance between the identification/ingress point and the target point. You can select from either setting it in nautical miles with a 0.1 nautical miles increment or switch the unit to feet with the drop-down on the right. The increment in feet is in 100ft per click. Unit conversion also converts your actual input.

Target altitude
Sets the target altitude in feet above msl. You can set it in increments of 10ft per click.

Dive Angle
Sets the desired dive angle for the attack run. Can be set in 1° increments per click. Needs to be set in Direct and Dive Toss mode.

Loft angle
Sets the desired lofting angle for the attack run. Can be set it in 1° increments per click. Only used for LABS modes.



Available Delivery Modes:
- Direct
- Dive Toss (DT)
- TGT Find
- Dive Laydown (DL)
- Laydown (L)
- Offset
- Loft
- Over-the-shoulder (O/S)
- Over-the-shoulder instantaneous (O/S INST)

Available Bomb Types
- MK-81
- MK-82
- MK-83
- MK-84
- M117
- CBU-87
- MK-82 AIR
- MK-82 Snakeye (SNK)
- BLU-107

1 – INTRODUCTION
1.7 – Bombing Calculator Tool

Here is a list of output parameters typically computed by the bombing calculator. These outputs vary depending on the mode of delivery and bomb type.

Bombing Table Output Parameters

Pull-Up Timer
Gives you the calculated pull-up timer in seconds that the WSO can put in the ARBCS computer.

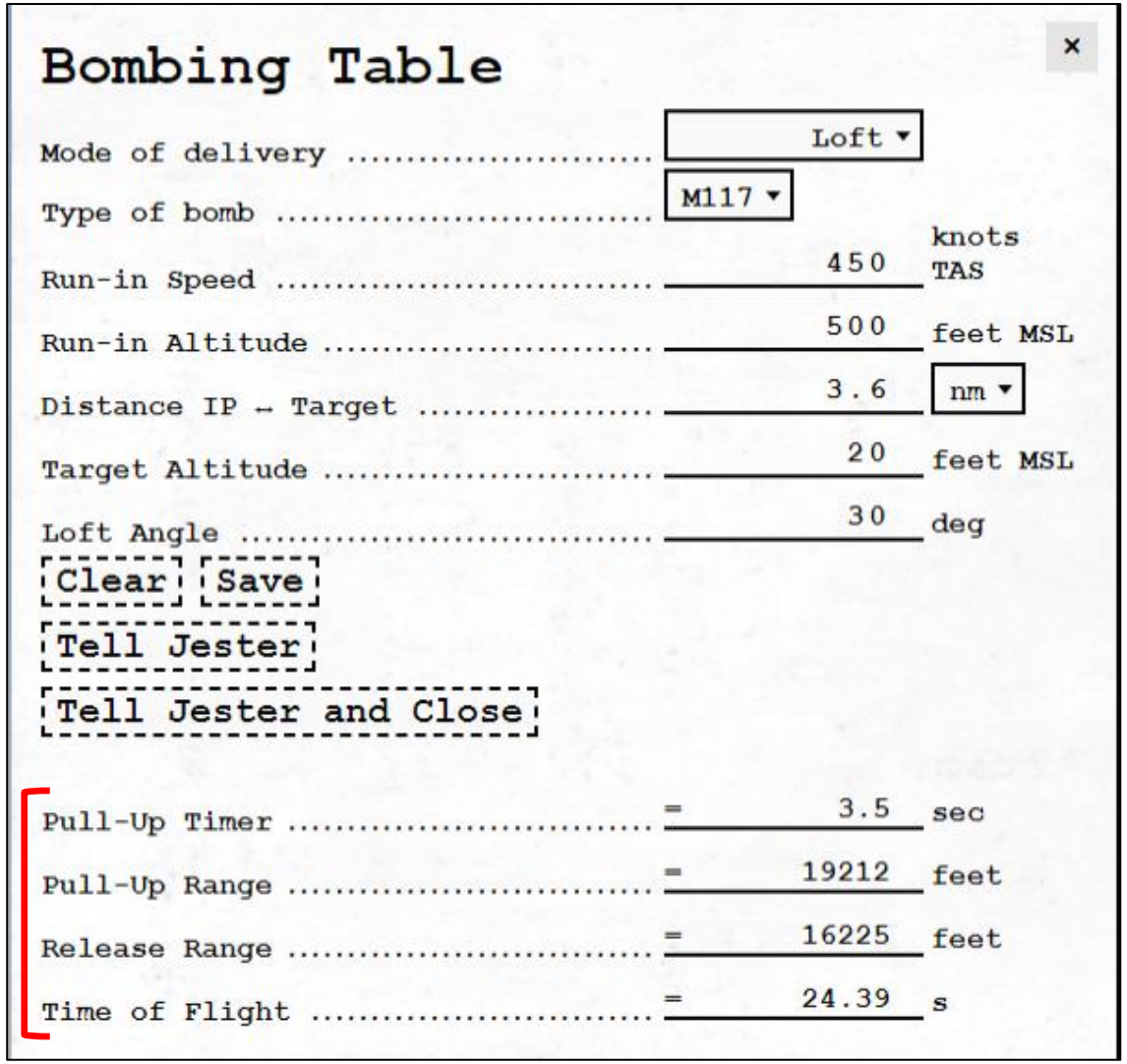
Release Range
Gives you the calculated bombing range in feet that the WSO can put in the WRCS panel.

Sight Depression
Gives you the calculated manual sight depression in mils. This can be put into the sight depression knob in order to align the reticle with the target for a manual MIL bombing solution.

Drag Coefficient
Gives you the Drag Coefficient that the WSO then can set in the WRCS panel. This is only applicable to DT (Dive Toss) mode.

N/S WRCS and E/W WRCS
Gives you the calculated offset distance values that the WSO then can set in the WRCS panel.

Terminology Reminder:
- *ARBCS: Attitude Reference & Bombing Computer Set*
- *AWRU: Aircraft Weapons Release Unit*
- *INS: Inertial Navigation System*
- *LABS: Low Altitude Bombing System*
- *WRCS: Weapon Release Computer Set*



1 – INTRODUCTION
1.7 – Bombing Calculator Tool

Here is a list of input and output parameters typically required to calculate bombing pattern parameters. Operative in all WRCS and WRCS/LABS integrated motes, the Release Advance Control works in conjunction with the AWRU to advance the release signal in milliseconds. Whereas the AWRU Intervalometer setting triggers the release pulse sequence from the moment the bomb release button is pressed, when the Release Advance Control is applied in a WRCS driven delivery, the specific bomb location in a multiple ripple sequence can be calculated in advance, allowing the most effective spread possible across a given target.

Pattern Input ***Parameters***

Release Interval
Sets the release interval that the pilot sets. You can set it in 0.01 increments per click.

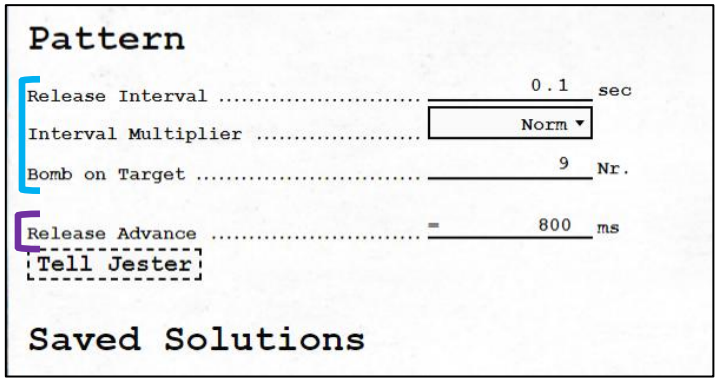
Interval Multiplier
Sets the interval multiplier that the pilot sets. You can select "Norm" or "x10" in the drop-down.

Bomb on Target
Lets you select the number of the bomb in the pattern that you want to hit the target. Every bomb before the selected bomb will hit in front of the target. The rest of the bombs will hit behind the target.

Pattern Output ***Parameters***

Release Advance
Gives you the calculated release advance that the WSO can put in the WRCS.

Terminology Reminder:
- *ARBCS: Attitude Reference & Bombing Computer Set*
- *AWRU: Aircraft Weapons Release Unit*
- *INS: Inertial Navigation System*
- *LABS: Low Altitude Bombing System*
- *WRCS: Weapon Release Computer Set*



As an example, an AWRU single-ripple quantity release of 4 is selected with an interval of 120 milliseconds. To place the third bomb in the ripple on target, the following equation is used:

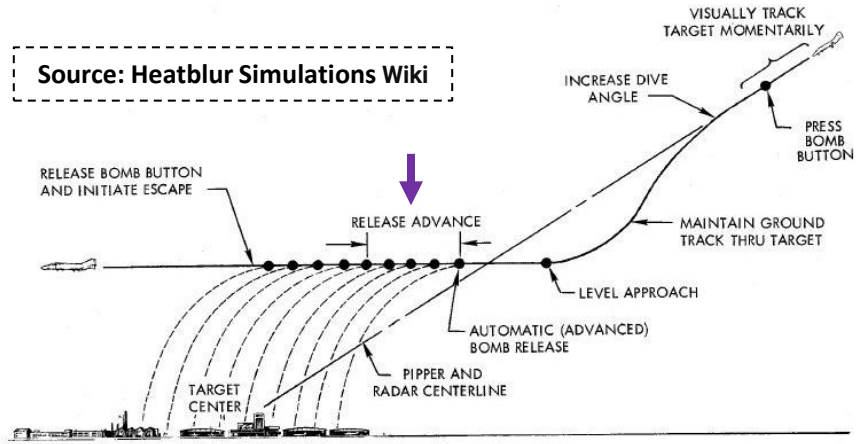
$$RA = I_R \cdot (N_{Tgt} - 1)$$

RA = **Release Advance Setting**, milliseconds
I_R = AWRU Release Intervalometer setting, milliseconds
N_{Tgt} = Impact Sequence number of bomb desired on target

$$RA = 120 \cdot (3 - 1)$$

Thus, for this release, we would set the value of RA to 240 msec. This would produce a spread of two bombs ahead of target, one on the calculated target point, and one behind.

Source: Heatblur Simulations Wiki



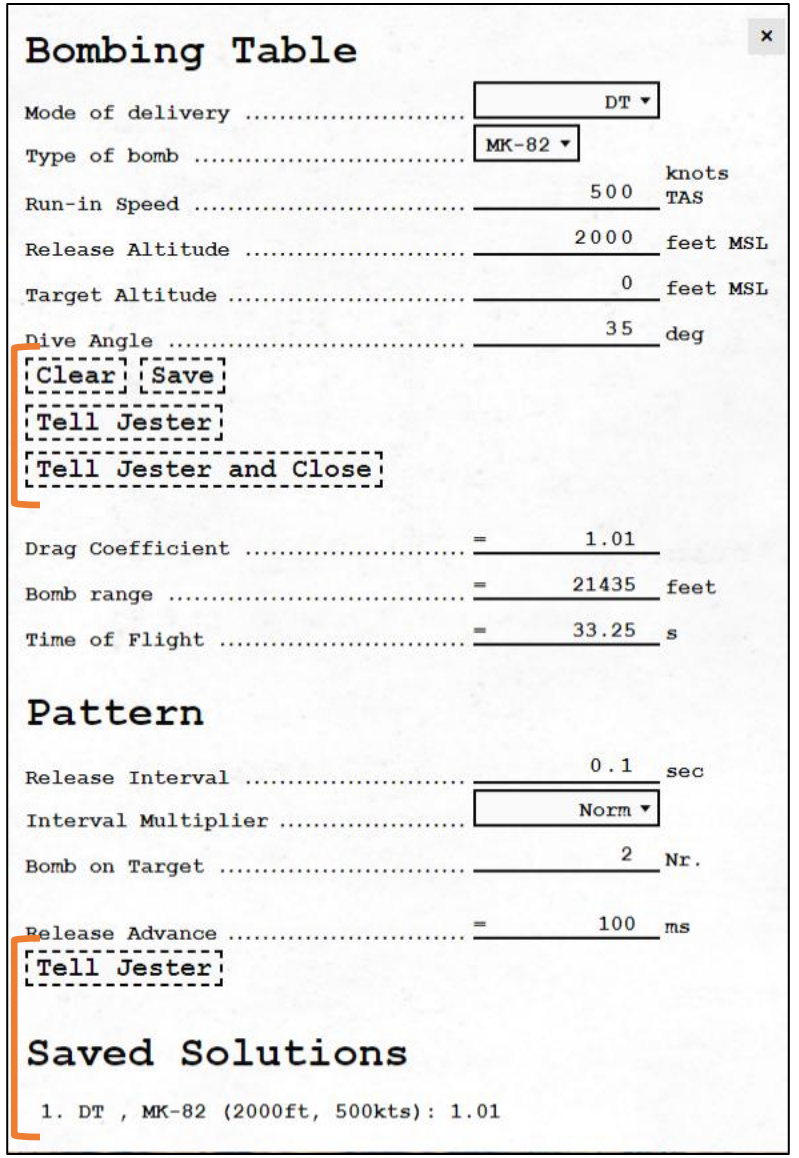
1 – INTRODUCTION
1.7 – Bombing Calculator Tool

Other Controls

Clear
Resets all inputs to standard values.

Save
Saves the actual solution under the Bombing Solutions tab at the end of the page.

Tell Jester and Tell Jester and close
With this button, the values calculated by the bombing calculator can be transferred to the JESTER AI crew. He will either confirm the input or tell you "can't do" when the input is not correct.



1 – INTRODUCTION
1.7 – Bombing Calculator Tool

There is often confusion over what airspeed definition is to be used for weapon deliveries. Do you use True Airspeed (TAS) or Indicated Airspeed (IAS)?

- **Dive bombing deliveries** are all performed based on **indicated airspeed (IAS) at release**, not true airspeed. Release IAS is usually planned on 450 or 500 kts for MK-82s, no less or no more, due to threat and weapon carriage limits.
- **Level and loft bombing deliveries** are performed based on **true airspeed (TAS)**, between 500 and 550 kts being the usual numbers for Mk-82s.

The Bombing Calculator Tool developed by Heatblur Simulations only uses **true airspeeds**, which means that delivery modes like Dive Toss (DT) or Direct (Manual) need to be entered in the calculator as True Airspeed despite the profile being based on Indicated Airspeed.

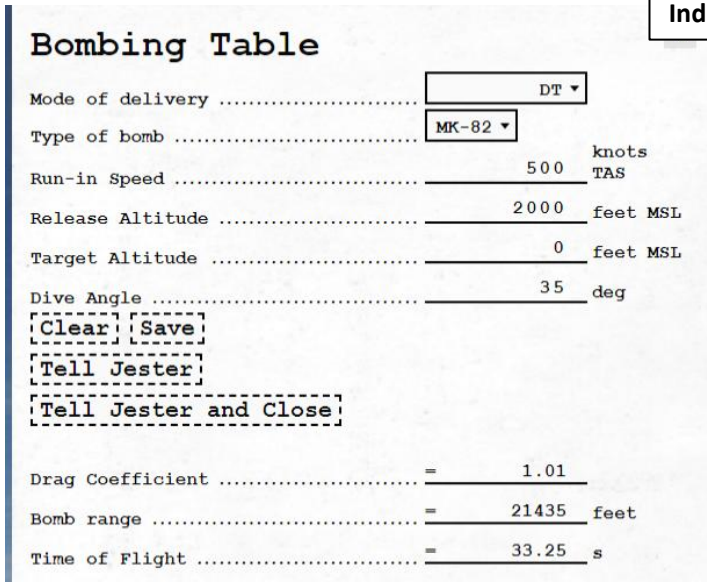
Some of you may wonder… but how can we convert Indicated Airspeed to True Airspeed? There are many online tools that can do that for you… or you can make your life easier.

- The general rule of thumb is that true airspeed is roughly an additional **2%** higher than indicated airspeed for each 1000 feet above sea level.
- Example: **450 KIAS at 3000 ft MSL altitude = 450 + (0.02 x 3 x 450) = 477 KTAS**

You can also be lazy like me and simply add 50 knots to Indicated/Calibrated Airspeed and you should be close enough (**450 KIAS** + 50 kts ≈ **500 KTAS**).

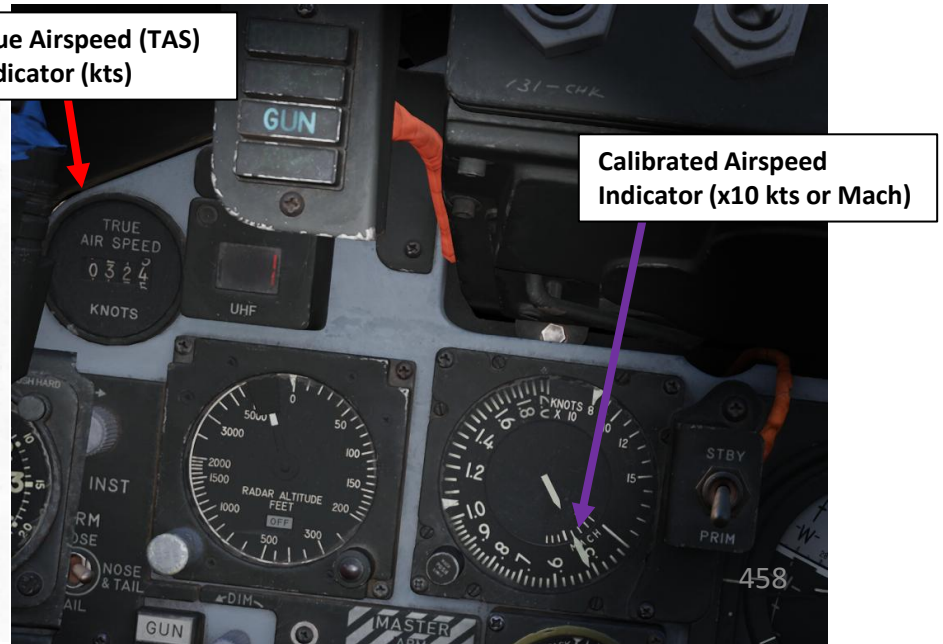
Why is IAS used for dive bombing and TAS for level or loft bombing, one might ask? Here are a few reasons.

1. Before the F-4, most jets didn't actually have a TAS indicator in the cockpit.
2. It's a lot easier to read a big airspeed indicator (IAS) that is rapidly changing than a small digital gauge (TAS) that is spinning rapidly. For any delivery that involves changing airspeeds (like dive bombing), TAS is converted to IAS for the actual delivery numbers.
3. Level bombing has a better stabilized approach where TAS can be used.



Airspeed Definitions (« ICE T »)

- **Indicated Airspeed (IAS):** This is the airspeed indicated on your airspeed indicator. This is the airspeed measured from the raw dynamic pressure of the outside air entering a pitot tube.
- **Calibrated Airspeed (CAS):** This is the Indicated Airspeed corrected for position installation (instrument calibration) errors. This relationship is typically provided by the aircraft manufacturer, but we can assume it to be roughly equal to indicated airspeed within a simulated environment.
- **Equivalent Airspeed (EAS):** This is the Calibrated Airspeed corrected for air compressibility. In other words, it is defined as the speed at sea level, under ISA (International Standard Atmosphere) conditions, that would produce the same incompressible dynamic pressure that is produced at the true airspeed and the altitude at which the vehicle is flying.
- **True Airspeed (TAS):** This is the Equivalent Airspeed corrected for temperature and pressure altitude. Think of this as speed of the aircraft relative to the airmass (air density, which changes with altitude) in which it is flying. At sea level in ISA conditions (ambient temperature 15 deg C, barometric pressure 29.92 in Hg), and at slow speeds where air compressibility is negligible, IAS corresponds to TAS.
- **Ground Speed (GS):** This is the horizontal speed of an aircraft relative to the Earth's surface. This is what the navigator uses to determine arrival times to the waypoints of a flight plan. The way to approximate your ground speed is to have the aircraft fly level, obtain the True Airspeed and then perform the vector sum of the aircraft's true airspeed and the current wind speed and direction; a headwind subtracts from the ground speed, while a tailwind adds to it. Winds at other angles to the heading will have components of either headwind or tailwind as well as a crosswind component.



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
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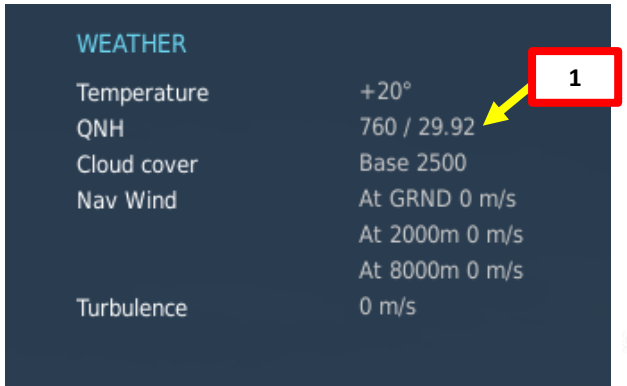
A – Determine Attack Profile

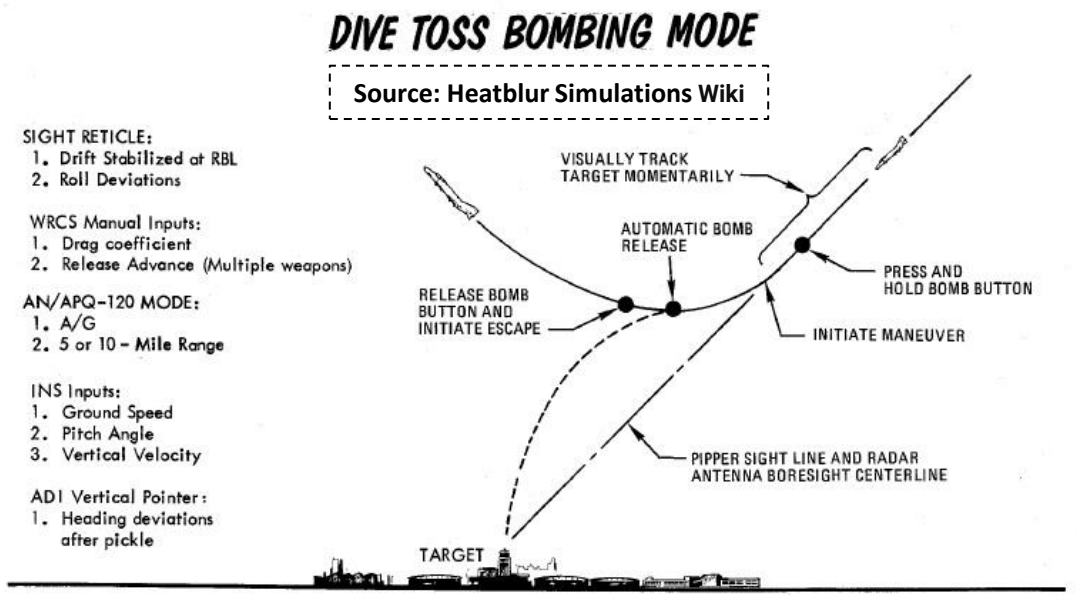
Dive Toss Mode is considered to be the most flexible and accurate bombing mode of the F-4E. This should be your go-to method when employing unguided bombs for targets of opportunity.

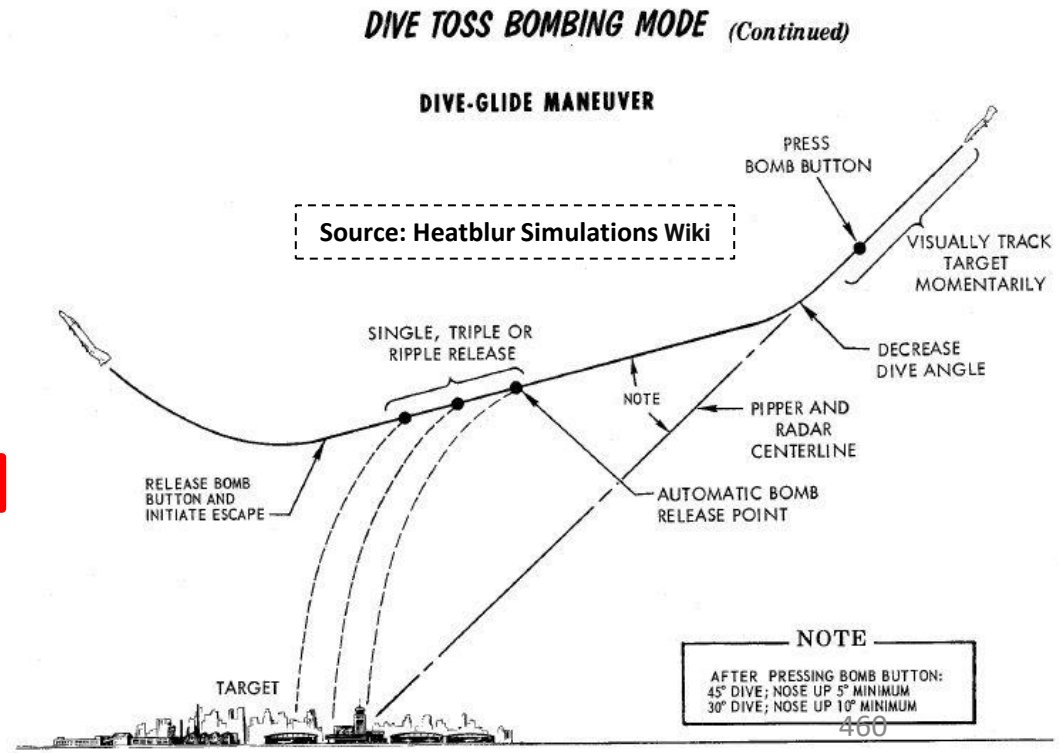
In this tutorial, we want to drop three Mk-82 bombs (ripple release) at an interval of 0.1 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.







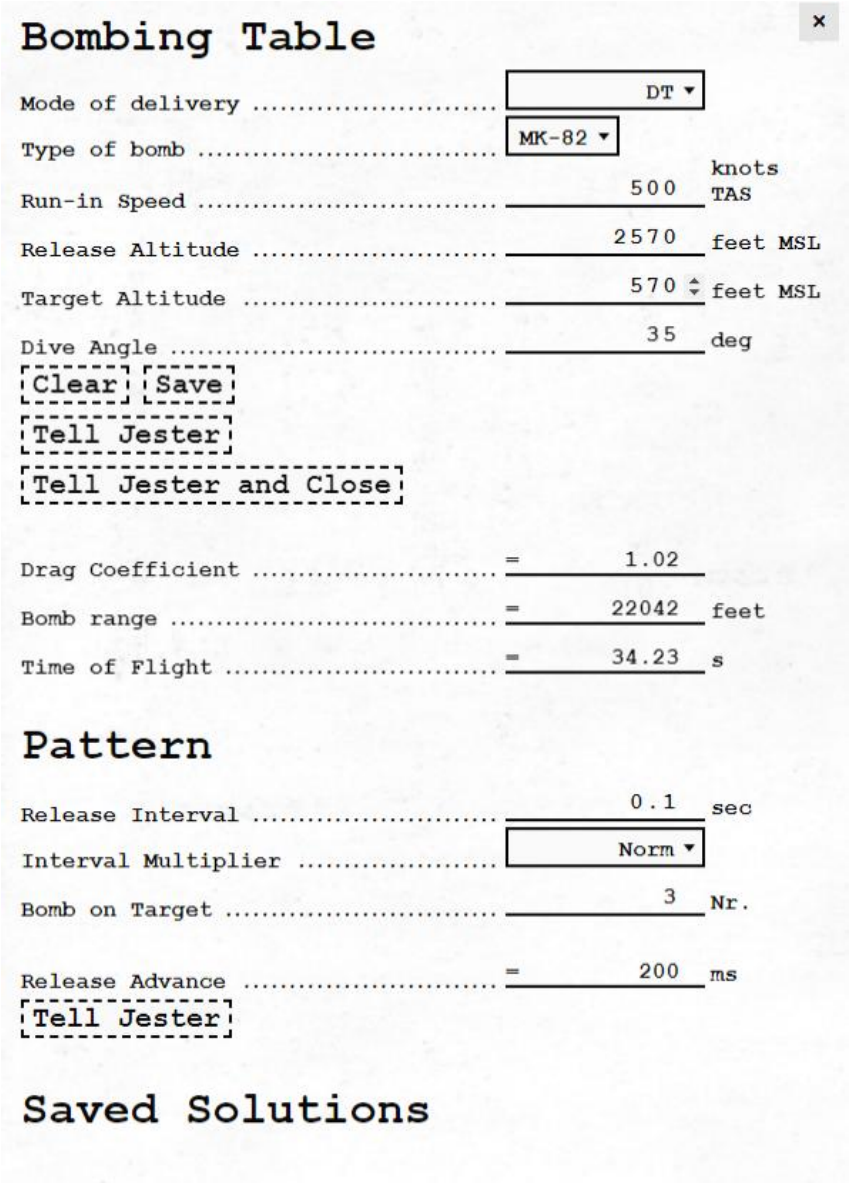


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

A – Determine Attack Profile

2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
   a) Select DT Mode of delivery
   b) Select MK-82 Type of Bomb
   c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
   d) Select Target Altitude: 570 ft MSL (Mean Sea Level) – Obtained from F10 map
   e) Select Release Altitude: 2570 ft (MSL, Mean Sea Level)
      - Release Altitude (MSL) = Target Altitude (MSL) + Release Altitude (AGL, Above Ground Level)
        2570 ft MSL = 570 ft MSL + 2000 ft AGL
   f) Select desired Dive Angle: 35 deg
   g) Click SAVE.
   h) Drag Coefficient is calculated automatically: 1.02
   i) If using the JESTER AI as the WSO, click TELL JESTER to set the drag coefficient in the rear cockpit.
   j) If applicable (ripple bombing), select Bomb Number of Pattern on Target: As desired, 3rd Bomb (of a total pattern of 3 bombs being dropped)
   k) If applicable (ripple bombing), select Release Interval: 0.1 sec
   l) If applicable (ripple bombing), select Interval Multiplier: NORM.
   m) Release Advance is calculated automatically: 200 ms.
   Note: See Release Advance Setting & Bombing Pattern explanation here.
   n) If using the JESTER AI as the WSO, click TELL JESTER to set the Release Advance in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».



MK-82 Low-Drag Bomb *DT (Dive Toss) Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 35 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2570 ft	Bomb # of Pattern on Target: 3
Target Elevation: 570 ft MSL	

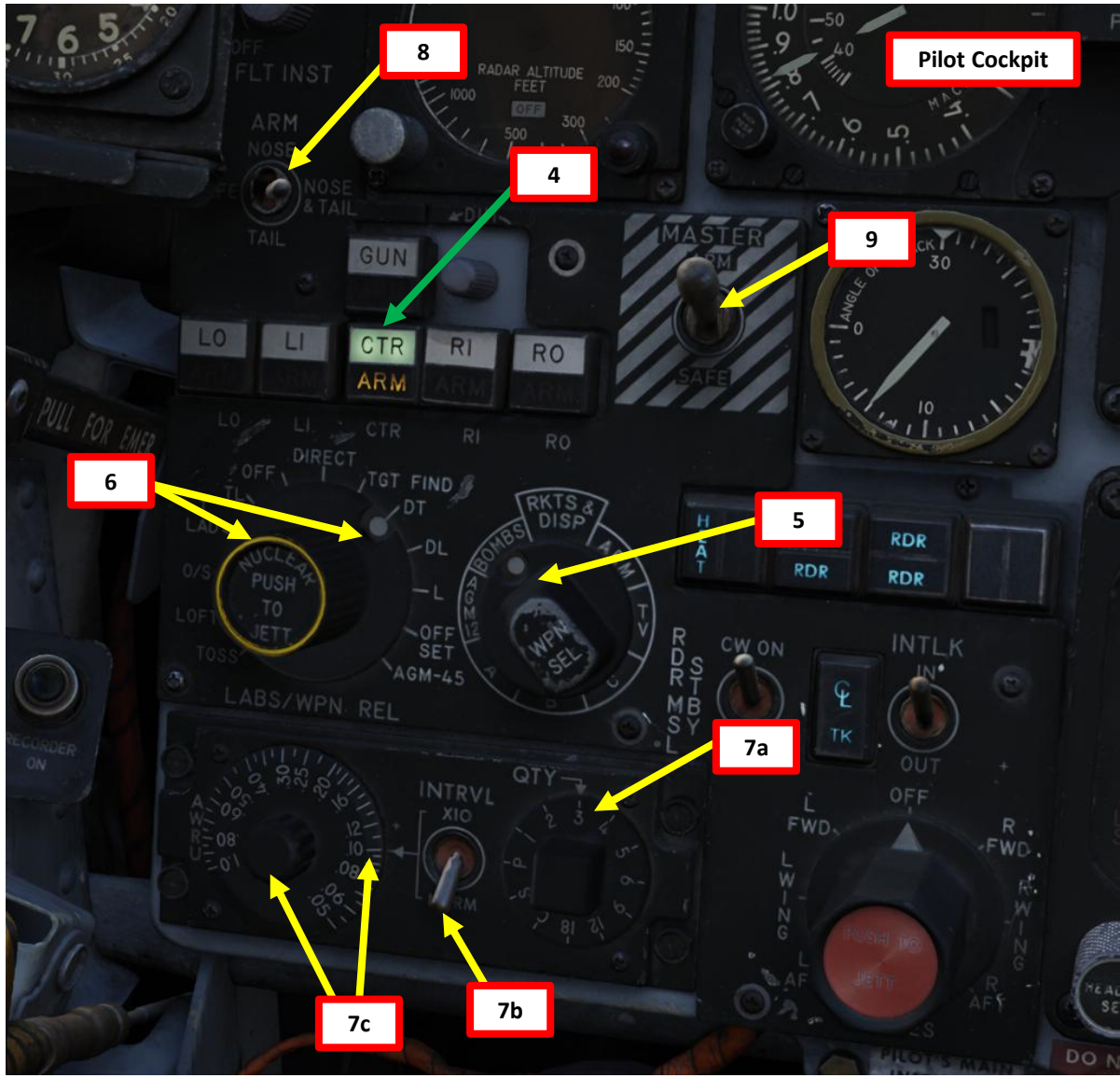
MK-82 Low-Drag Bomb *DT (Dive Toss) Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Drag Coefficient: 1.02	Release Advance: 200 ms

2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

B – Weapon Setup

4. *[P]* Select desired Station Select Button. We will use CTR (Center).
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
5. *[P]* Set Weapon Selector Knob – BOMBS
6. *[P]* Set Air-to-Ground Weapon Delivery Mode – DT (Dive Toss)
7. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop a total of 3 bombs)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
8. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
9. *[P]* Set Master Arm Switch – ARMED (UP)

MK-82 Low-Drag Bomb *DT (Dive Toss) Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 35 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2570 ft	Bomb # of Pattern on Target: 3
Target Elevation: 570 ft MSL	

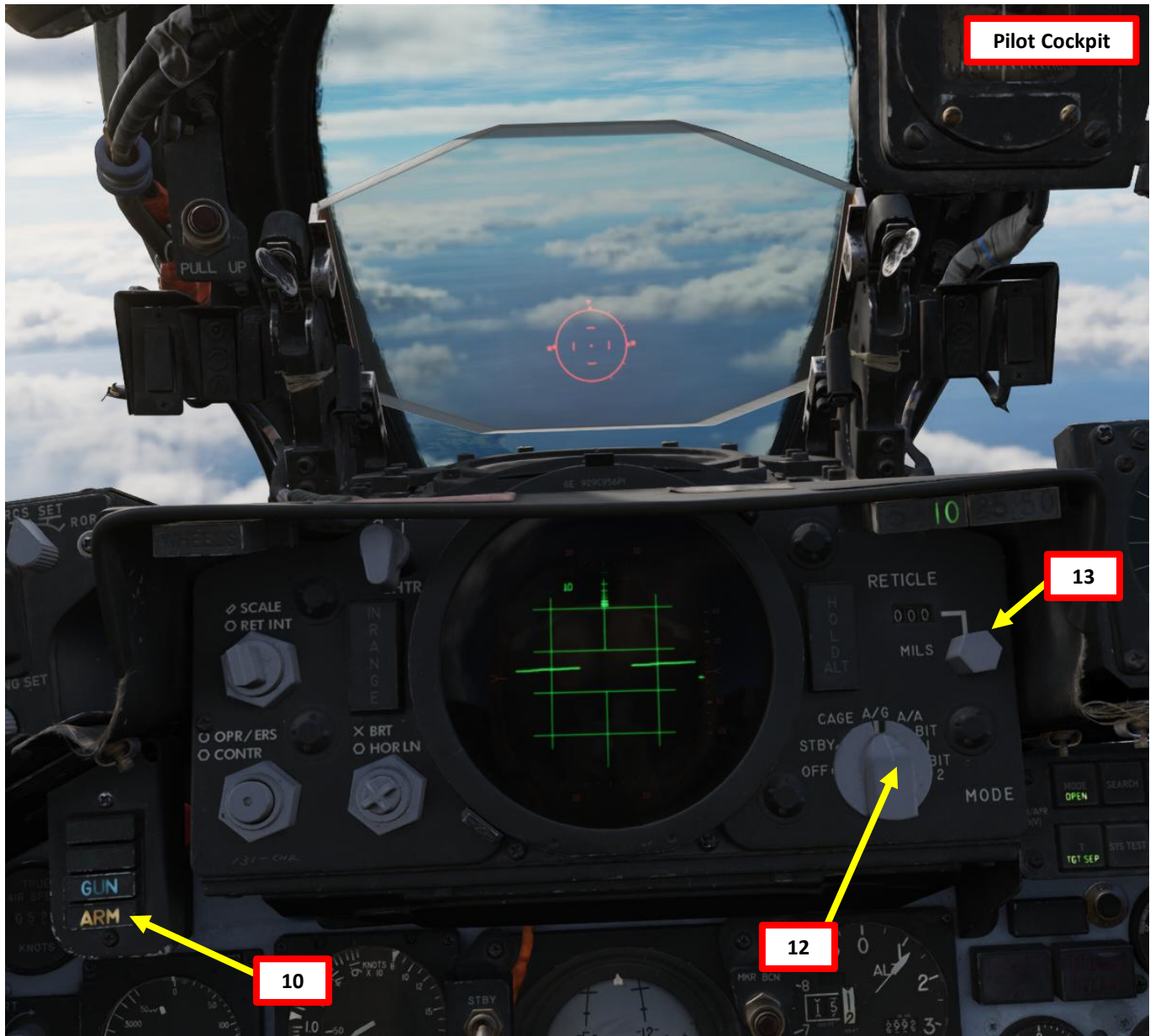


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

B – Weapon Setup

10. *[P]* Confirm ARM light is illuminated
11. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).
12. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
13. *[P]* In Dive Toss Mode, the reticle automatically cages in elevation along the RBL (Radar Boresight Line). You can leave the Reticle Depression Setting Knob to 0 Mils.
    - *Note: A good practice would be to set the reticle depression required for the Direct Mode profile you would use as a backup in case you cannot perform a Dive Toss delivery. This depression setting would only be applied when switching the Air-to-Ground Weapon Delivery Mode Selector from Dive Toss to Direct.*





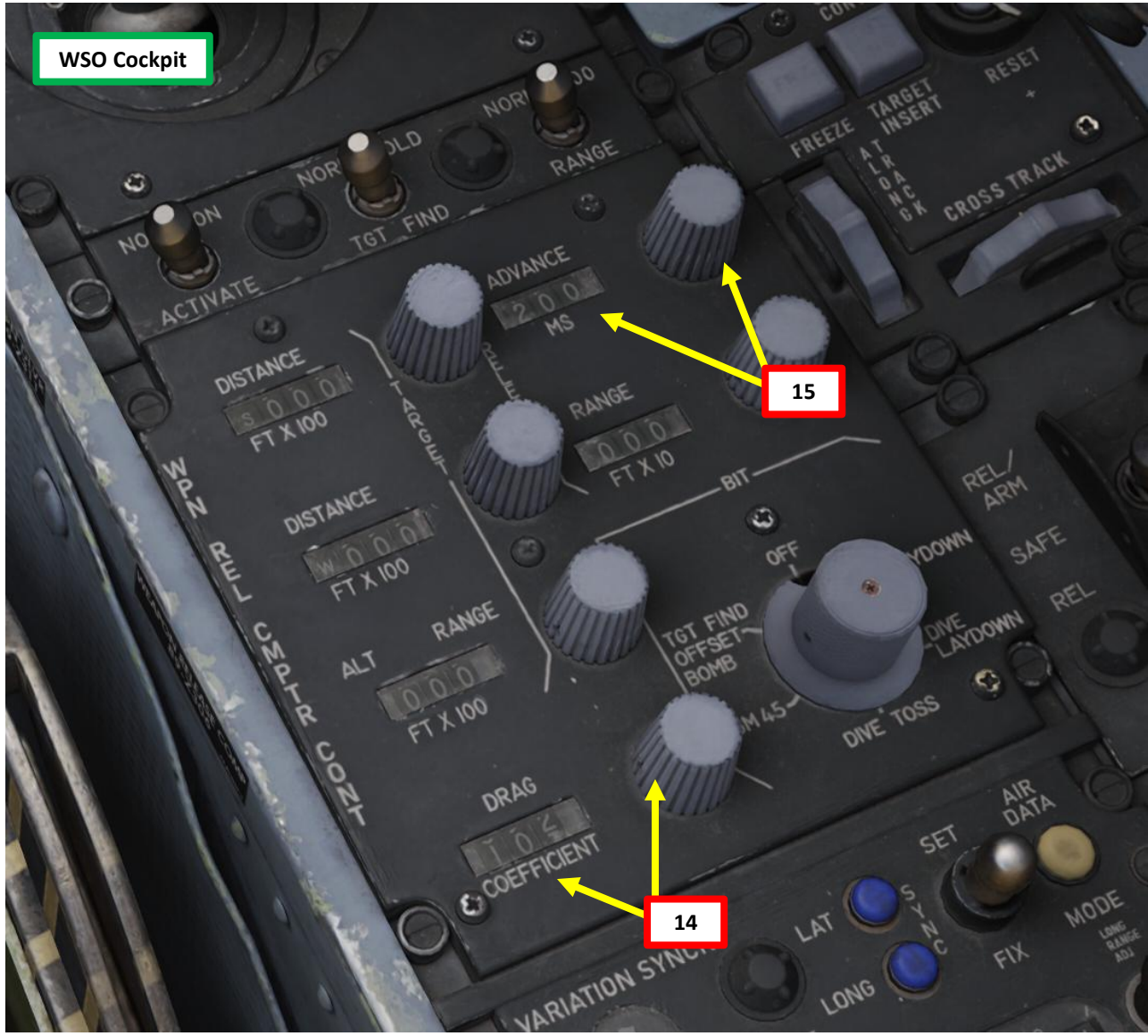
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

B – Weapon Setup

Note: These steps can be performed by JESTER.

14. *[WSO]* Set Drag Coefficient: 1.02 (value computed from Bombing Table).
15. *[WSO]* Set Release Advance Setting: 200 ms (value computed from Bombing Table).

MK-82 Low-Drag Bomb *DT (Dive Toss) Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Drag Coefficient: 1.02	Release Advance: 200 ms

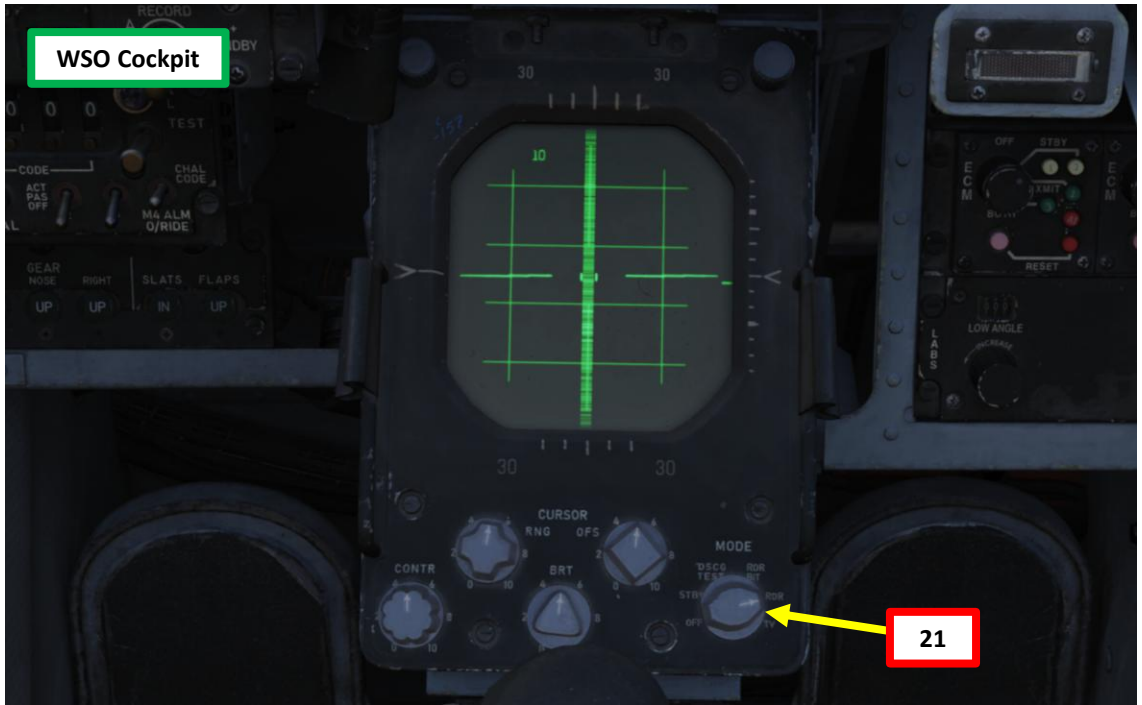


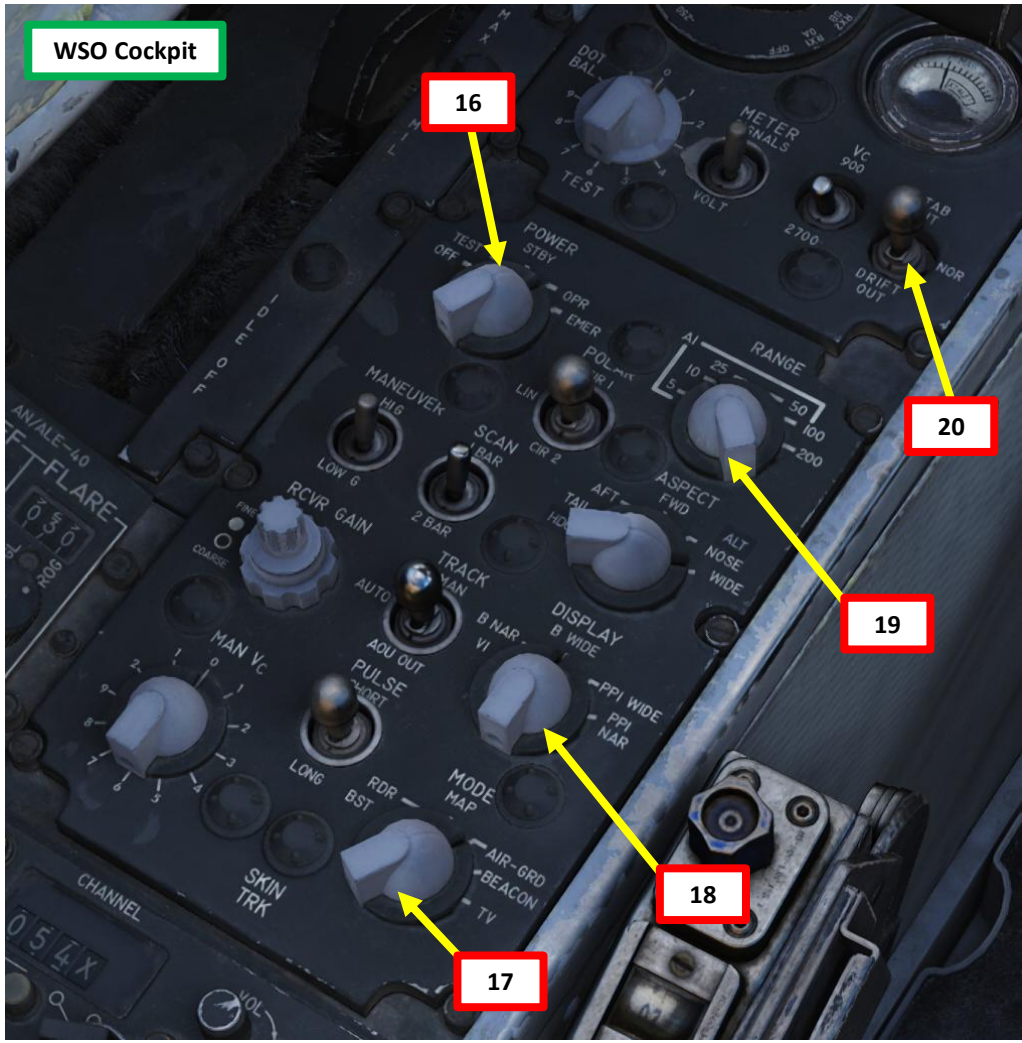
2 – AIR-TO-GROUND WEAPONS
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B – Weapon Setup

Note: These steps can be performed by JESTER.

16. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
17. *[WSO]* Set Radar Operation Mode – AIR-GRD (Air-to-Ground).
    - In this mode, the radar antenna is fixed to the radar boresight while also being stabilized in drift. AIR-GRD mode disables Angle Track operation and only uses Range Track. Once locked on the main lobe clutter (ground radar echo), it will be tracked in range.
18. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE.
19. *[WSO]* Set Radar Range Selector – 5 nm or 10 nm settings only. In this example, we will select 10 nm.
20. *[WSO]* Set Stab (Antenna Stabilization Mode) Switch – NORMAL (MIDDLE)
    - In case of an INS (Inertial Navigation System) failure, you can remove the drift correction by setting the Stab Switch to DRIFT OUT (AFT).
21. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).

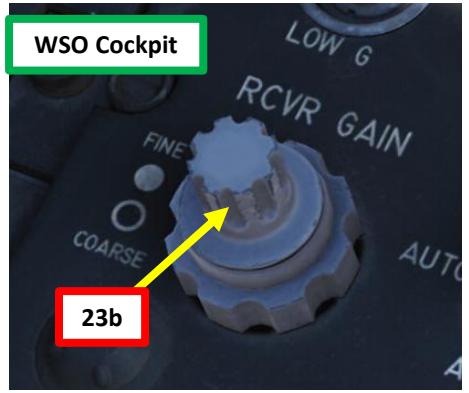




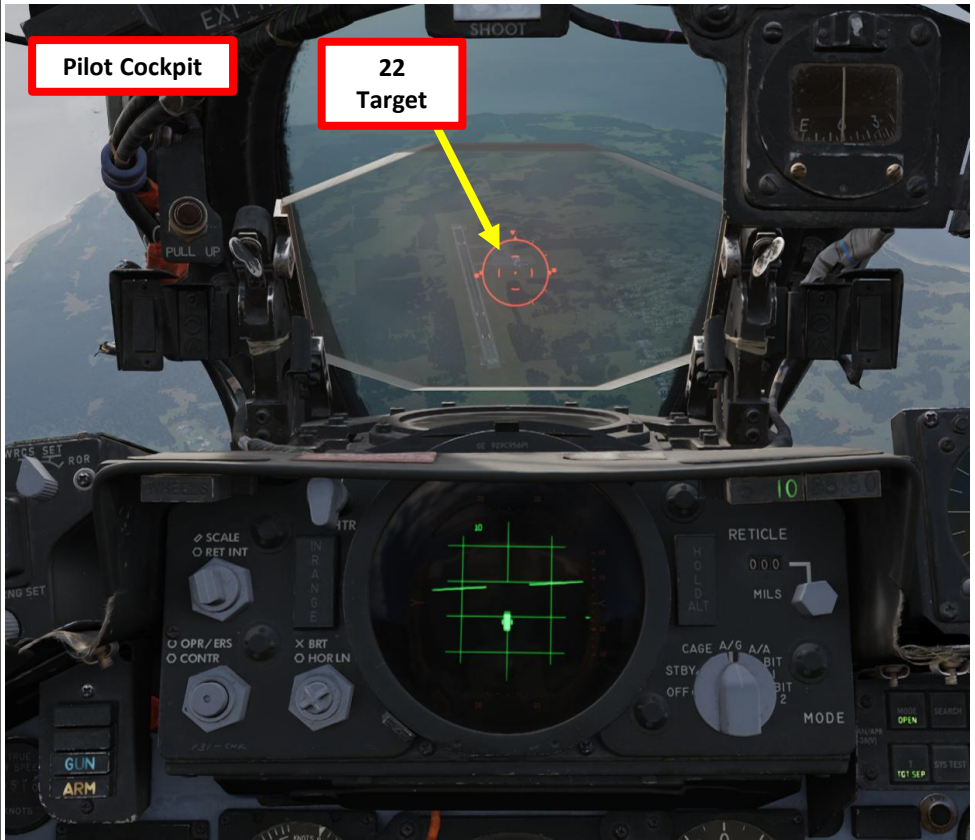
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

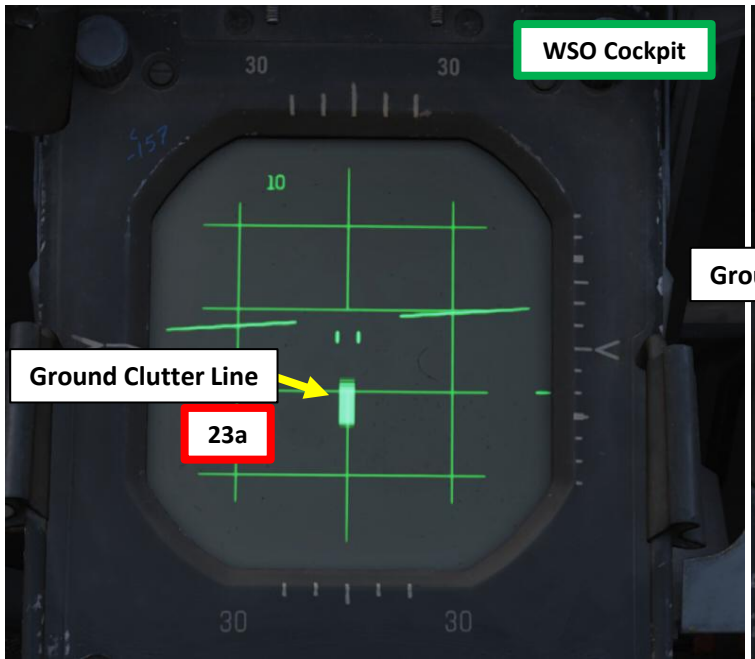
C – Perform Attack

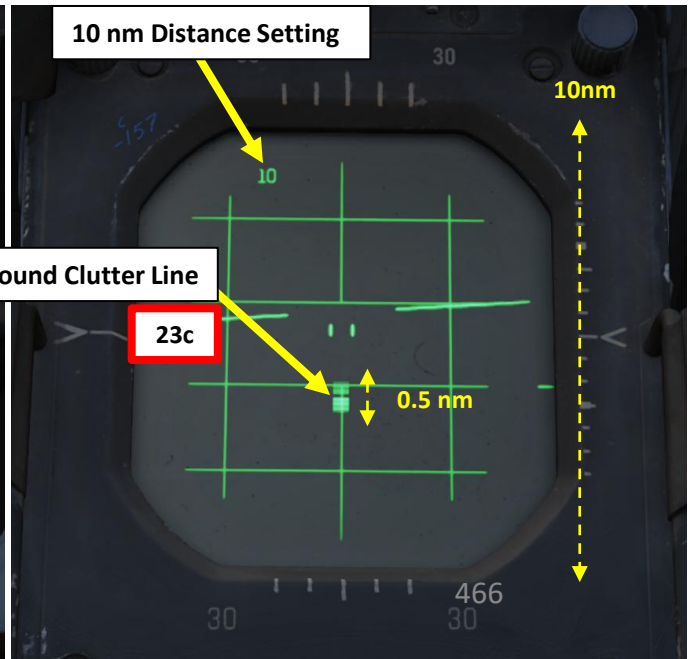
22. *[P]* Once the target has been identified, throttle down, perform a 35 deg dive towards the target and maintain an airspeed of 450 kts indicated.
23. *[WSO]* As the aircraft is diving, adjust receiver gain to reduce radar clutter signal to 0.5 nm. This is done to prevent erroneous track of sidelobes which would result in incorrect ranging information.
    - In this example, we have a distance setting of 10 nm, therefore the ground clutter "line" should be as shown.



MK-82 Low-Drag Bomb *DT (Dive Toss) Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 35 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2570 ft	Bomb # of Pattern on Target: 3
Target Elevation: 570 ft MSL	



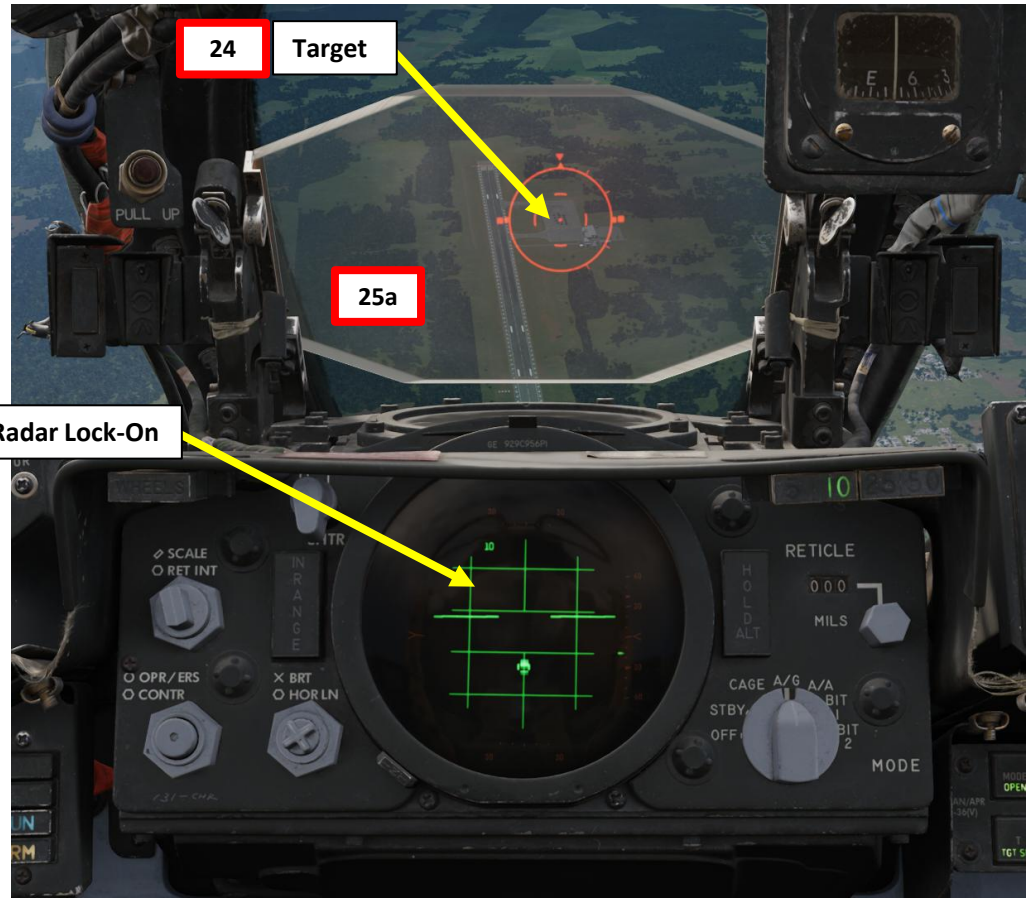


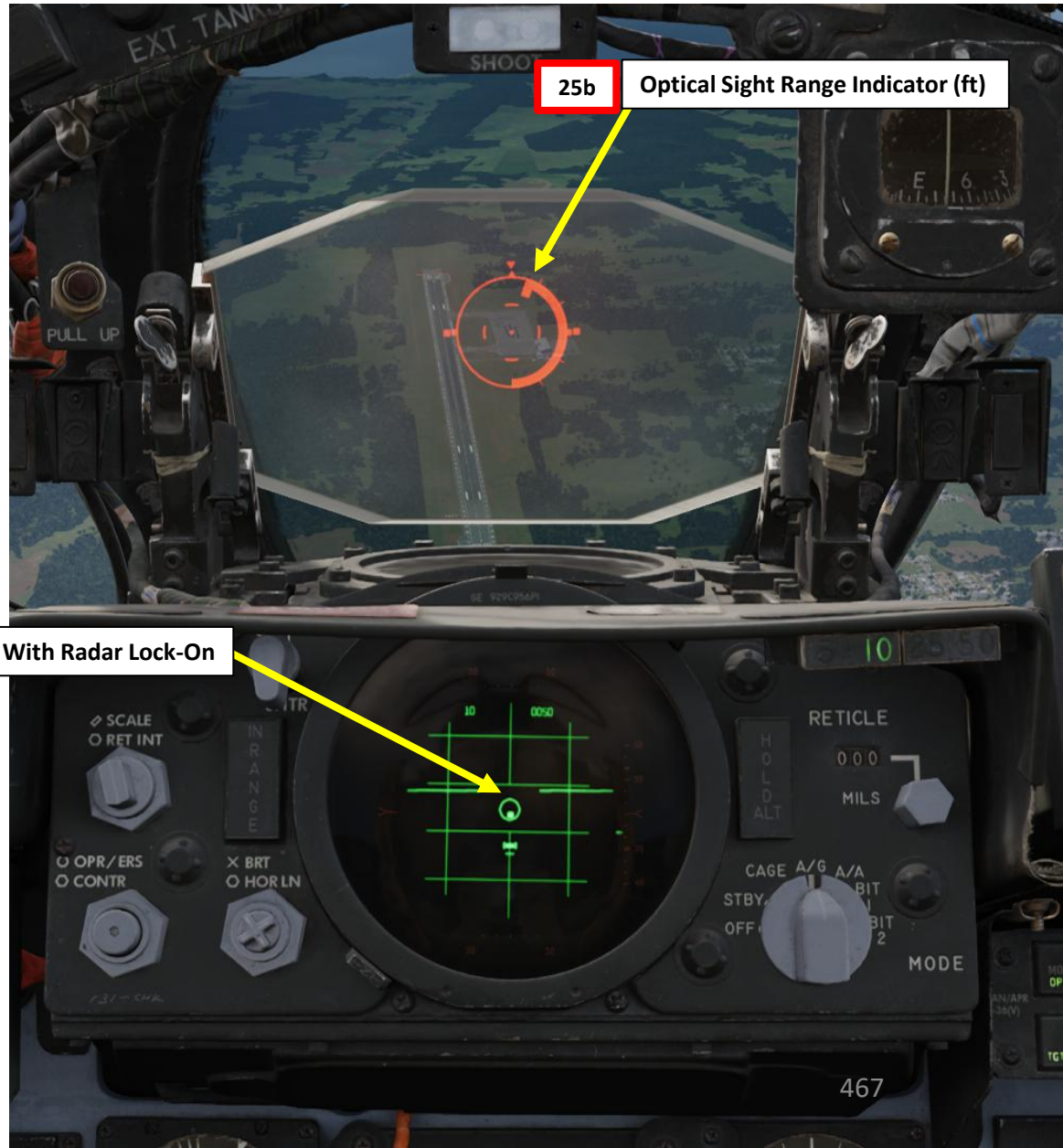


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

C – Perform Attack

24. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (450 kts indicated, 35 deg dive).
25. *[P]* When aircraft is stabilized and reticle is roughly on target, command JESTER to perform a radar lock on the target by using the JESTER Context Action binding ("V").
    - Once radar lock-on is acquired, the WSO should call out "Captured". Target range information should now be provided by the radar on the radar scope and on the optical sight as well.
    - Note: The radar lock-on process **in multicrew** is explained in more detail in the next page.





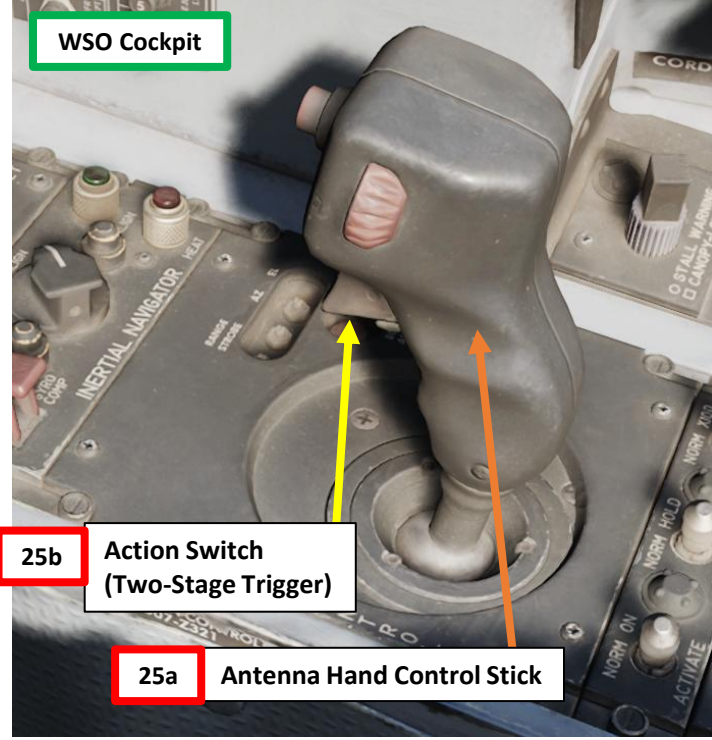
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

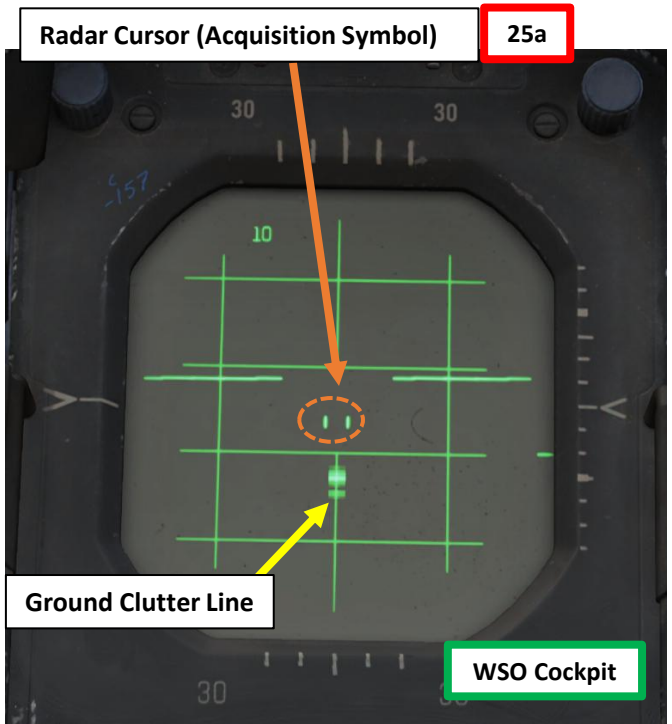
C – Perform Attack

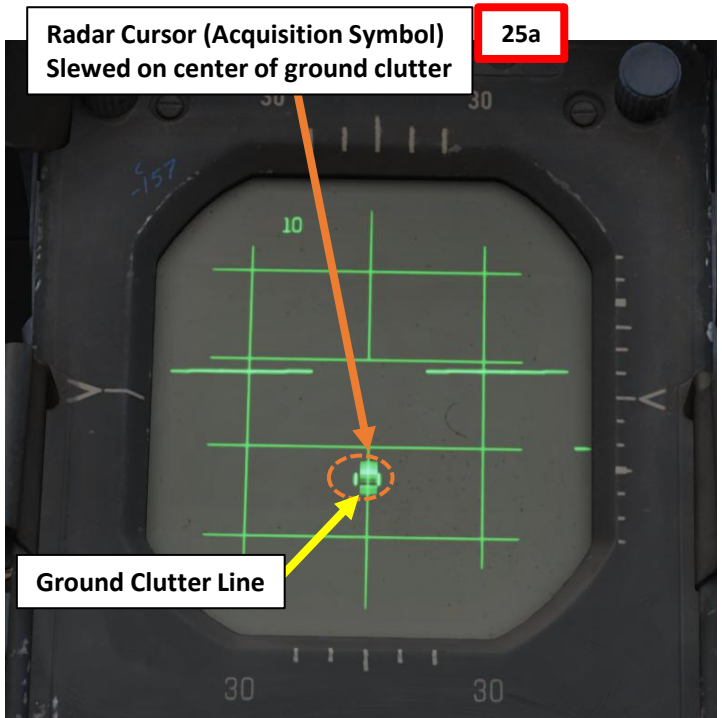
25. *[WSO]* To acquire radar lock-on on the target:
    a. Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the center of the ground clutter signal.
    b. Once the radar cursor is slewed over the ground clutter, press the Hand Control Stick Trigger's second detent (Full-Action). Release once the ASE (Allowable Steering Error) Circle becomes visible.
    c. Confirm radar lock-on, then call out to the pilot "Captured".
    d. Target range information should now be provided by the radar on the radar scope and on the optical sight as well.

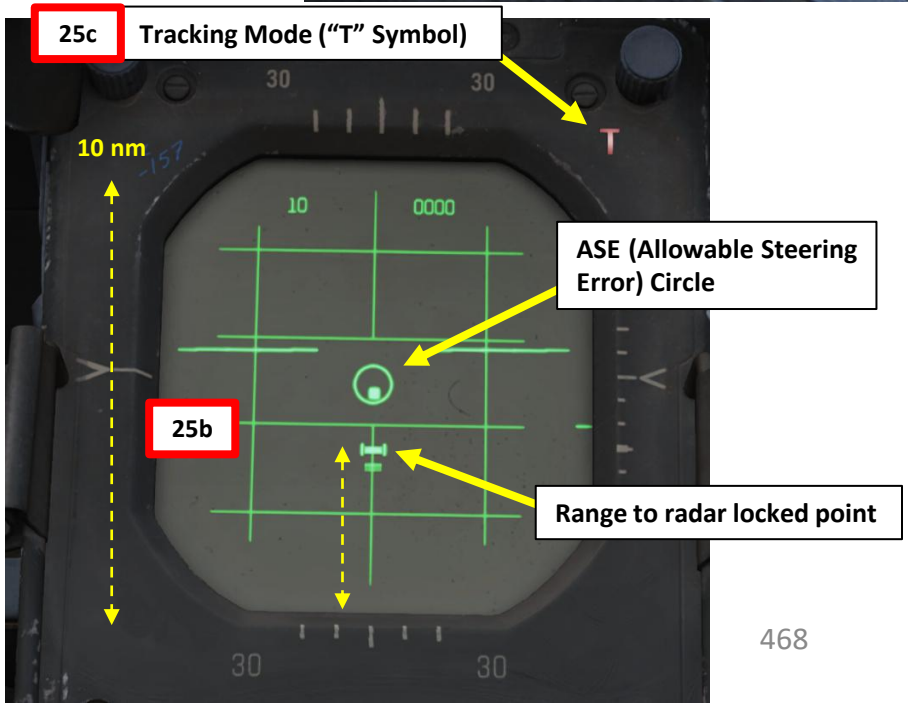
Note: Sometimes, false tracking can occur, which is indicated by a rapid decrease in slant range displayed on either the pilot's optical sight or the radar display. To correct this condition the following actions can be taken:
- Press Action Switch to half action, then release. Then, begin acquisition process again.









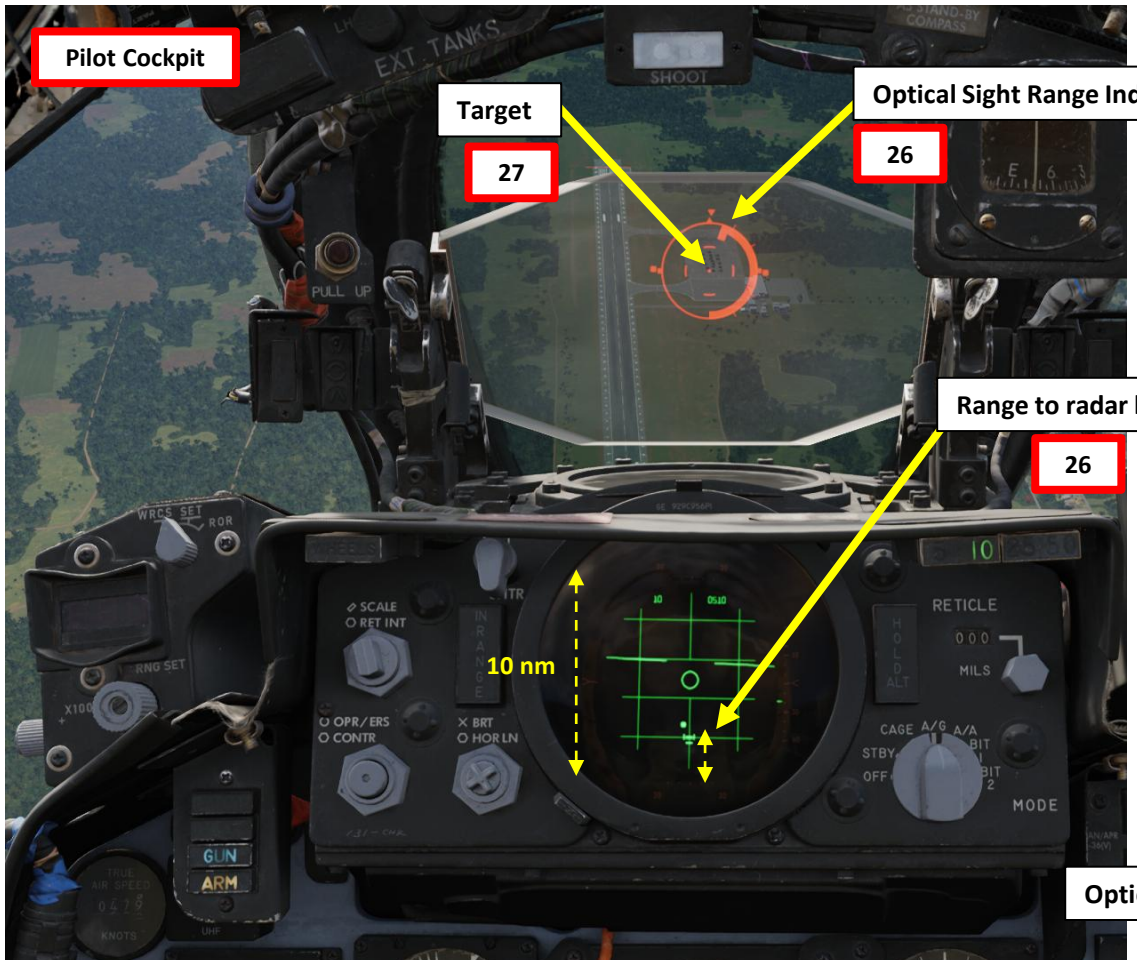


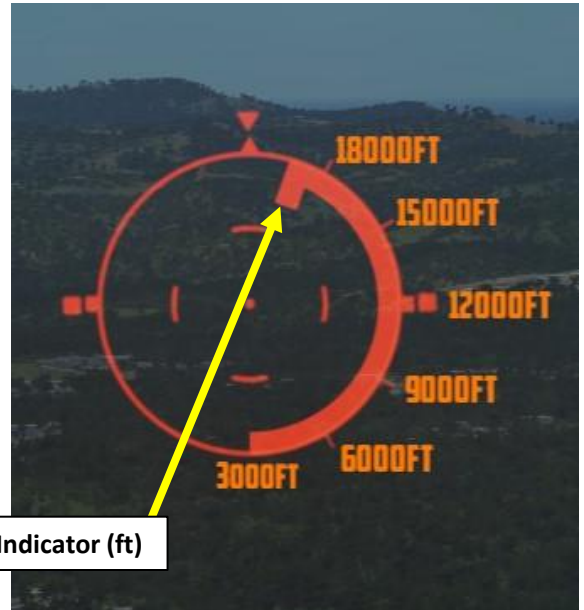
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

C – Perform Attack

26. *[P]* Once radar lock-on is achieved, target range information is provided by the radar on the radar scope and on the optical sight as well.
27. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
28. *[P]* Once the reticle is stabilized on target, press and hold the Bomb Release Button (RALT+SPACEBAR) to insert radar range to the WRCS (Weapon Release Computer Set), and then begin the pullout maneuver, maintaining wings level.







28 **Bomb Release Button**
- *Binding: RALT+SPACEBAR*



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

C – Perform Attack

29. *[P]* An audio tone indicates that the WRCS (Weapon Release Computer Set) has accepted the range from the radar when the bomb release button is pressed. This tone stays on until the bombs release automatically or the bomb release button is released.
30. *[P]* After the bomb release button is pressed, radar ground lock is no longer required. The pullout maneuver must maintain as constant a rate of turn as possible for maximum precision.
31. *[P]* At the point where the bomb computed trajectory will intersect the target, the WRCS (Weapon Release Computer Set) provides the release signal, dropping ordnance based on the settings chosen for number and interval.







2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.1 – MK-82 (Low Drag): Dive Toss (DT) Mode

D – Additional Tips

Dive Toss is a great delivery mode, but you might not always be able to use it (battle damage, failed radar, failed WRCS, failed INS, etc.). It is good practice to always plan to have a backup delivery method available like Direct Mode.

1. Once you have planned your Dive Toss delivery (dive angle, release altitude, release airspeed), plan for a Direct delivery 5 degrees shallower. For a dive toss diving angle of 35 deg, plan for a Direct delivery of 30 deg. From the Bombing Table Utility (MK-82 in Direct Mode), we obtain a required sight depression angle of 69 mils.
2. Set Reticle Depression Setting Knob to 69 Mils, as required by Direct Mode profile calculated previously.
3. If following a Dive Toss (DT) attack profile (35 deg dive, pipper on target) and you want to switch from DT to DIRECT, set Air-to-Ground Weapon Delivery Mode Selector from Dive Toss to Direct.
4. Pull up about 5 degrees, put the reticle/pipper on the target and fly the delivery as per the profile parameters (450 kts indicated, 30 deg dive, 2570 ft release altitude).

Dive Toss Profile

Bombing Table

Mode of delivery	DT	
Type of bomb	MK-82	
Run-in Speed	500	knots TAS
Release Altitude	2570	feet MSL
Target Altitude	570	feet MSL
Dive Angle	35	deg

Clear | Save | Tell Jester | Tell Jester and Close

Drag Coefficient	= 1.02	
Bomb range	= 22042	feet
Time of Flight	= 34.23	s

Pattern

Release Interval	0.1	sec
Interval Multiplier	Norm	
Bomb on Target	3	Nr.
Release Advance	= 200	ms

Tell Jester

Saved Solutions

Direct Profile

Bombing Table

Mode of delivery	Direct	
Type of bomb	MK-82	
Run-in Speed	500	knots TAS
Release Altitude	2570	feet MSL
Target Altitude	570	feet MSL
Total Aircraft Weight	36169	lbs C
Dive Angle	30	deg

Clear | Save

Sight depression	= 69	mils
Bomb range	= 20513	feet
Time of Flight	= 29.96	s

Pattern

Release Interval	0.1	sec
Interval Multiplier	Norm	
Bomb on Target	3	Nr.
Release Advance	= 200	ms

Tell Jester

Saved Solutions

2





2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

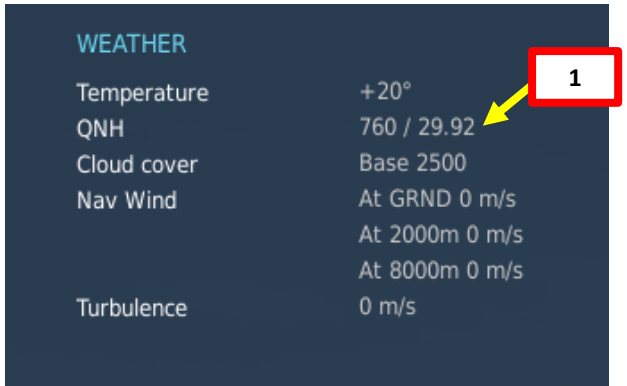
A – Determine Attack Profile

Direct Mode is considered to be the most basic/classic bombing mode of the F-4E; following a simple attack profile should be enough to successfully engage targets of opportunity. Both the ARBCS (Attitude Reference & Bombing Computer Set) and WRCS (Weapon Release Computer Set) are excluded from this release mode, and the pilot flies the profile as found for the intended munition in the bombing tables, setting the sight depression to match, and hand flying the aircraft to place the reticle/pipper directly onto the target in accordance with the desired type of attack.

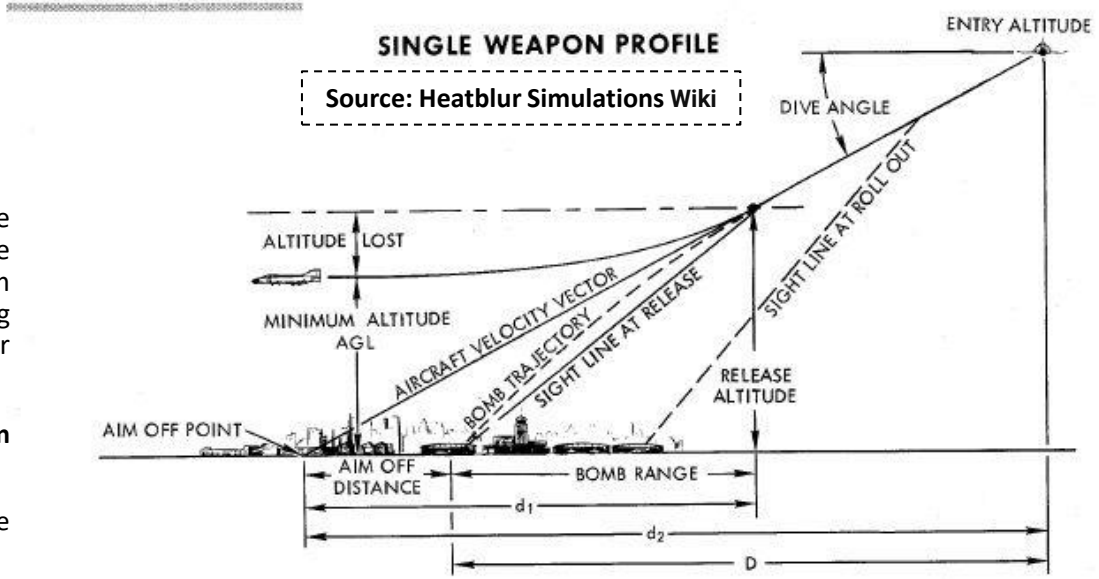
In this tutorial, we want to drop nine Mk-82 Snake Eye bombs (ripple release) in a high-drag configuration at an interval of 0.1 sec.

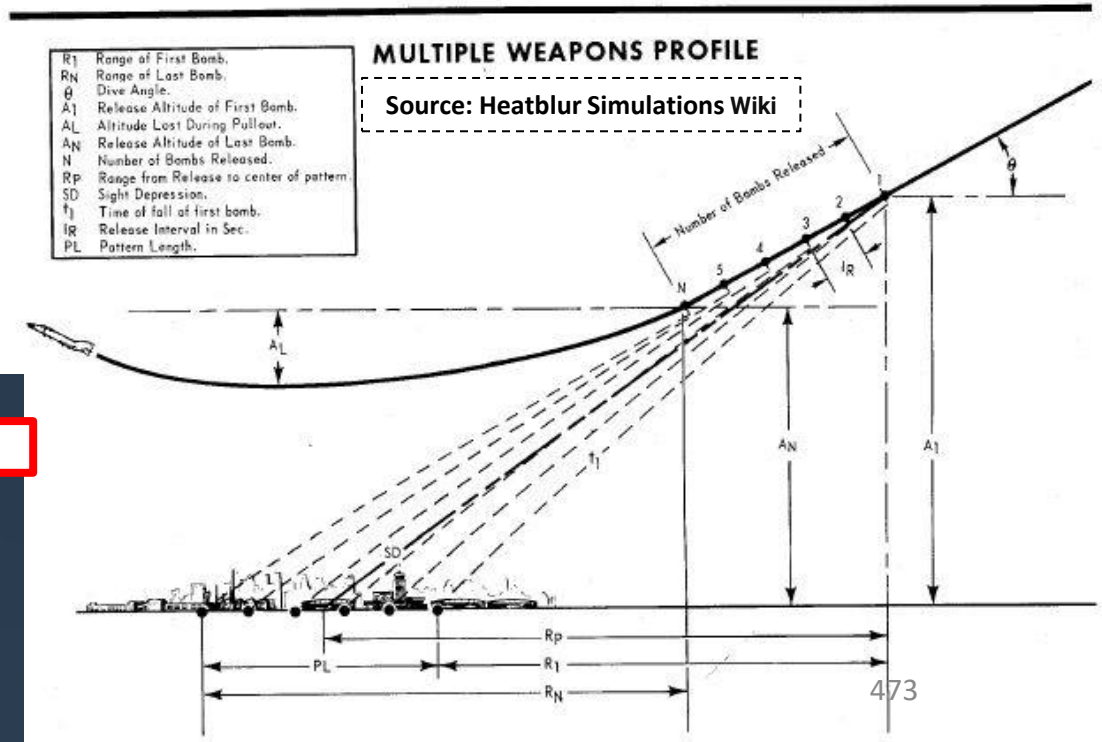
1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.





DIVE DELIVERY





2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

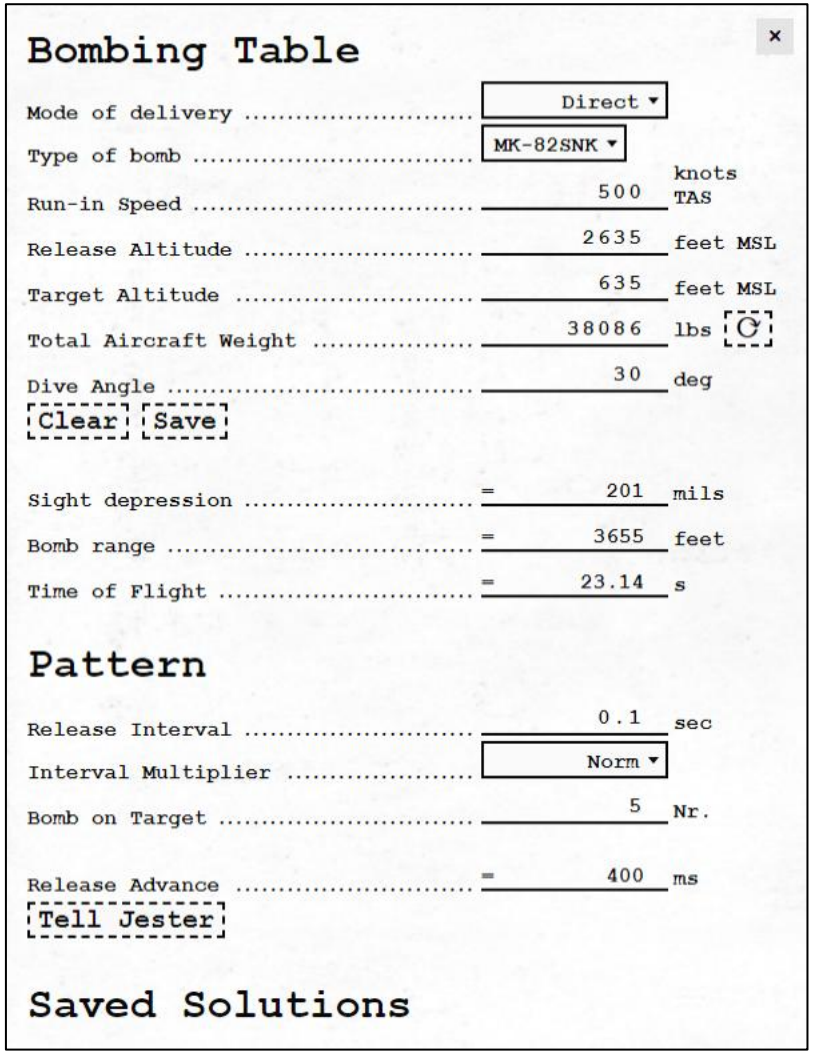
A – Determine Attack Profile

2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
   a) Select Direct Mode of delivery
   b) Select MK-82SNK HD Type of Bomb
   c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
   d) Select Target Altitude: 635 ft MSL (Mean Sea Level) – Obtained from F10 map
   e) Select Release Altitude: 2635 ft (MSL, Mean Sea Level)
      - Release Altitude (MSL) = Target Altitude (MSL) + Release Altitude (AGL, Above Ground Level)
        2635 ft MSL = 635 ft MSL + 2000 ft AGL
   f) Click on the Refresh button to calculate total aircraft weight: 38086 lbs
   g) Select desired Dive Angle: 30 deg
   h) Click SAVE.
   i) Sight Depression is calculated automatically: 201 mils
   j) If applicable (ripple bombing), select Bomb Number of Pattern on Target: As desired, 5th Bomb (of a total pattern of 9 bombs being dropped)
   k) If applicable (ripple bombing), select Release Interval: 0.1 sec
   l) If applicable (ripple bombing), select Interval Multiplier: NORM.
   m) Release Advance is calculated automatically: 400 ms
   Note: See Release Advance Setting & Bombing Pattern explanation here.
   n) If using the JESTER AI as the WSO, click TELL JESTER to set the Release Advance in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 30 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2635 ft	Bomb # of Pattern on Target: 5
Target Elevation: 635 ft MSL	
Total Aircraft Weight: 38086 lbs	

MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Sight Depression: 201 mils	Release Advance: 400 ms

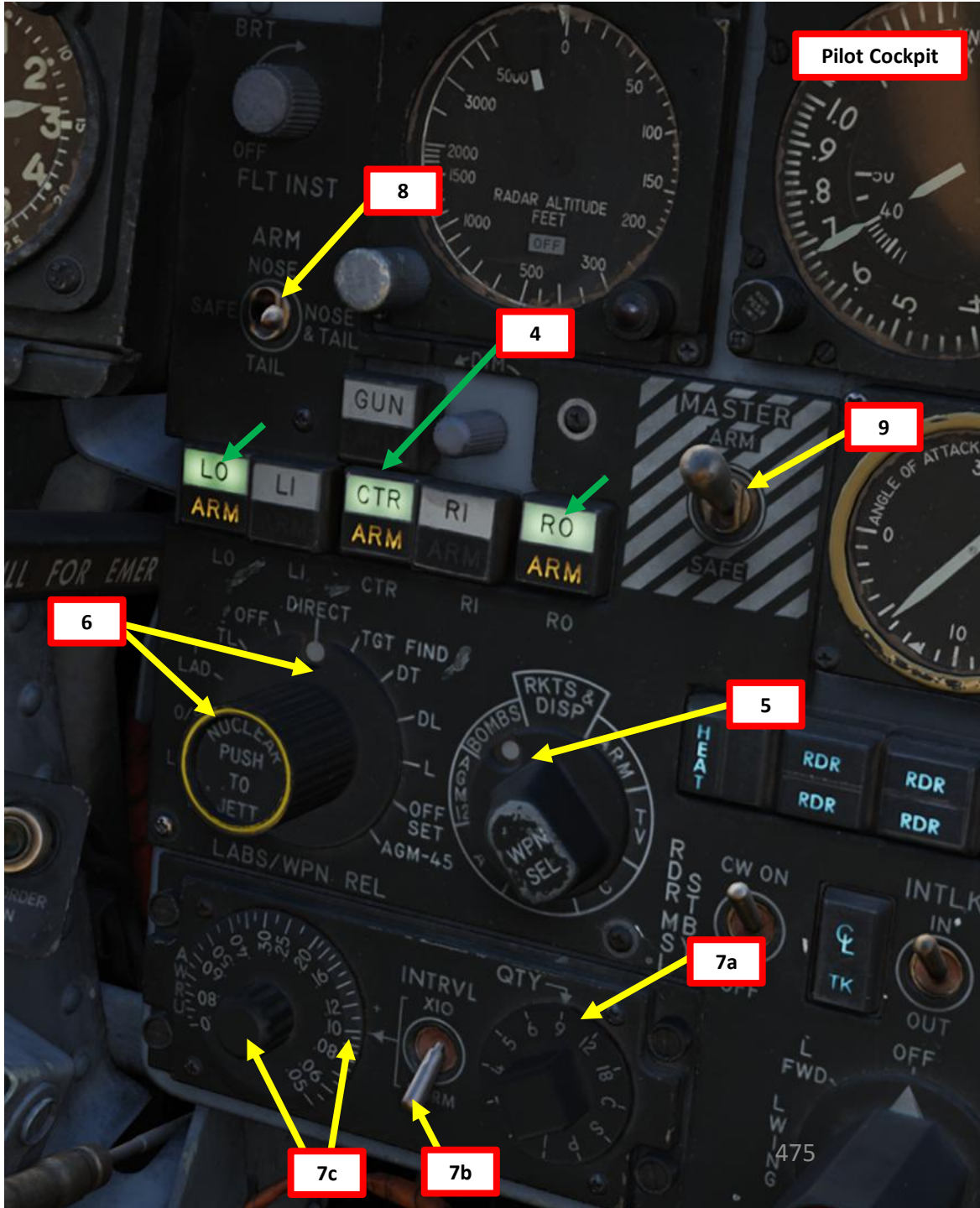


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

B – Weapon Setup

4. *[P]* Select desired Station Select Buttons. We will use CTR, LO and RO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
5. *[P]* Set Weapon Selector Knob – BOMBS
6. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
7. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop a total of 9 bombs)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
8. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT) for High Drag configuration
9. *[P]* Set Master Arm Switch – ARMED (UP)

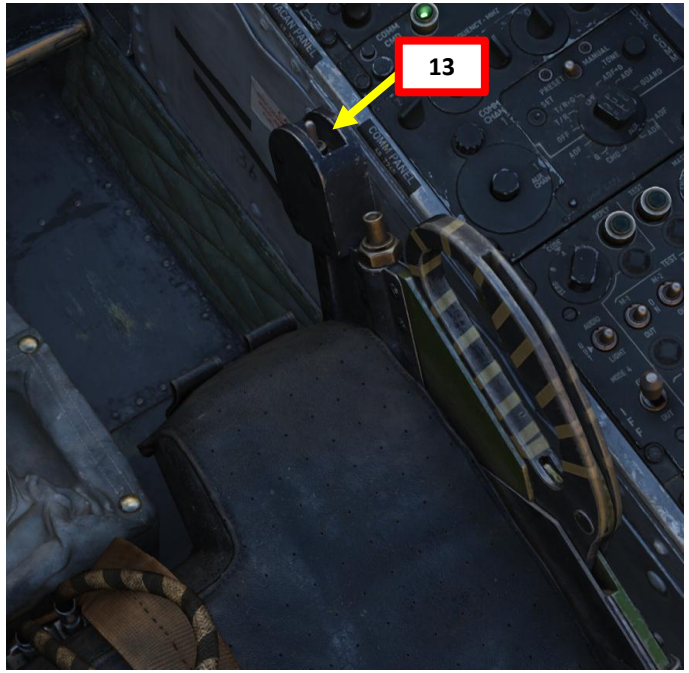
MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 30 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2635 ft	Bomb # of Pattern on Target: 5
Target Elevation: 635 ft MSL	
Total Aircraft Weight: 38086 lbs	

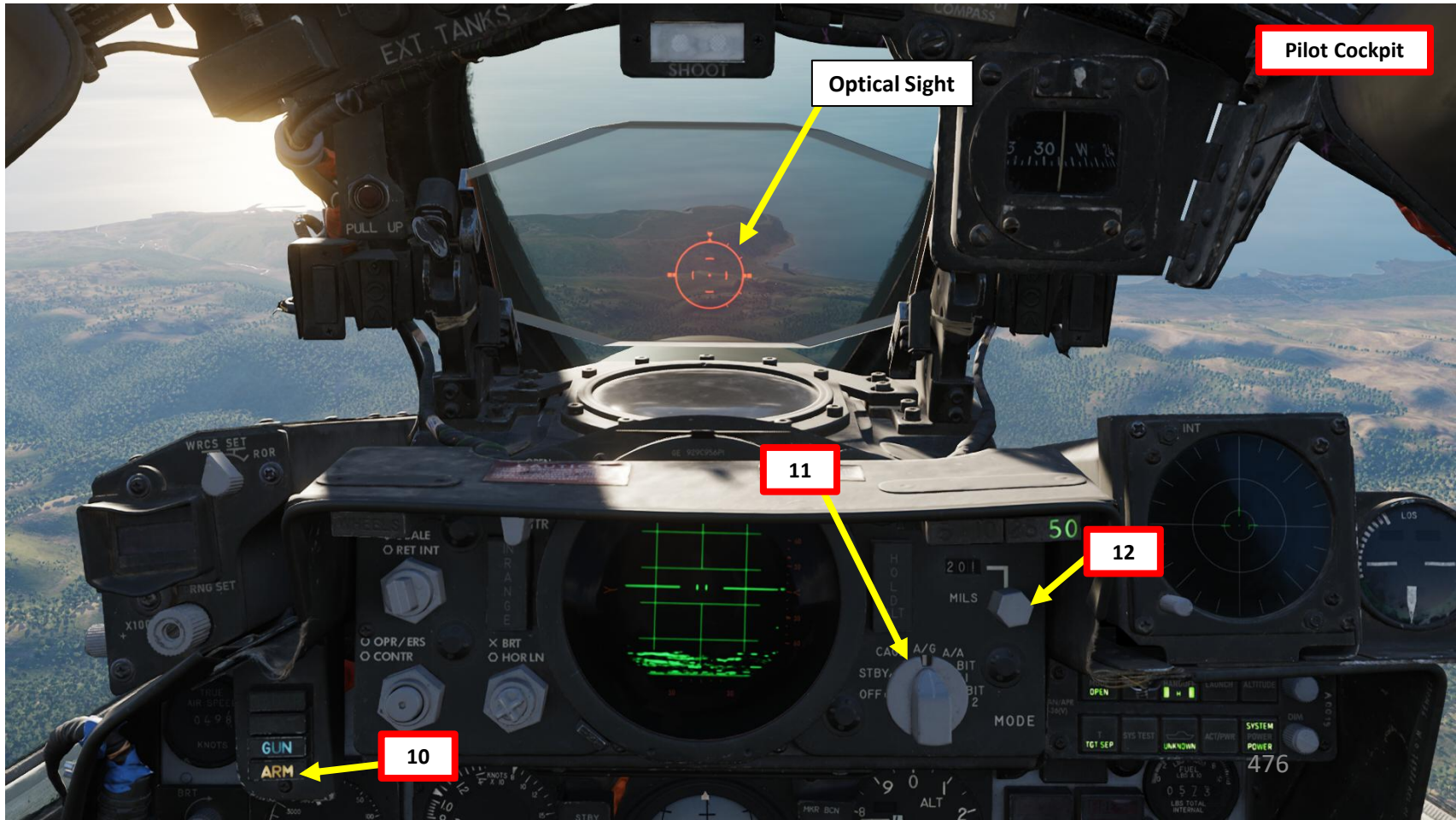


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

B – Weapon Setup

10. *[P]* Confirm ARM light is illuminated
11. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
12. *[P]* Set Reticle Depression Setting Knob to 201 Mils.
13. *[P]* Adjust Seat Position – As required to see the reticle.





MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Sight Depression: 201 mils	Release Advance: 400 ms

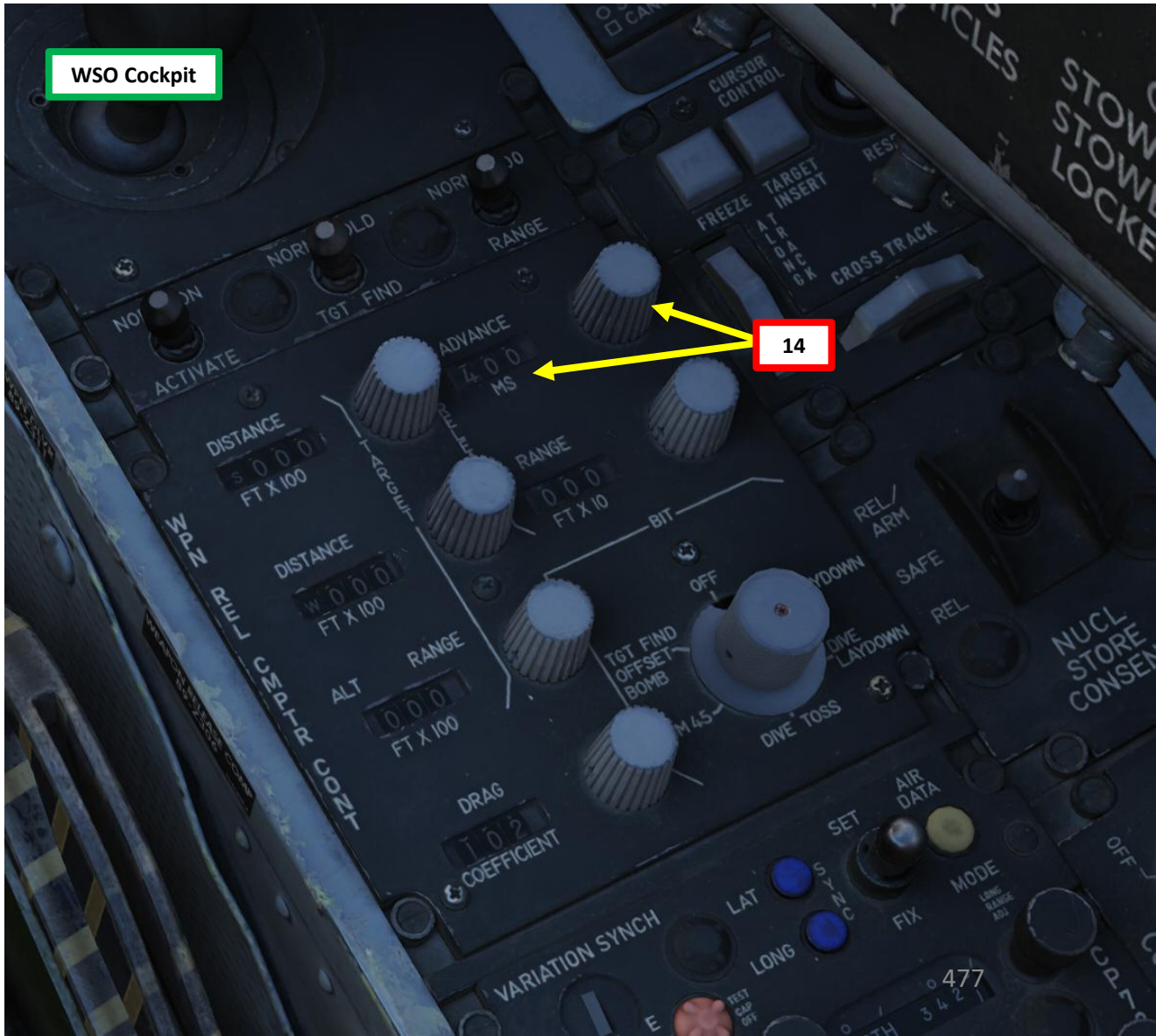
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

B – Weapon Setup

Note: This step can be performed by JESTER.

14. [WSO] Set Release Advance Setting: 400 ms (value computed from Bombing Table).

MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Sight Depression: 201 mils	Release Advance: 400 ms



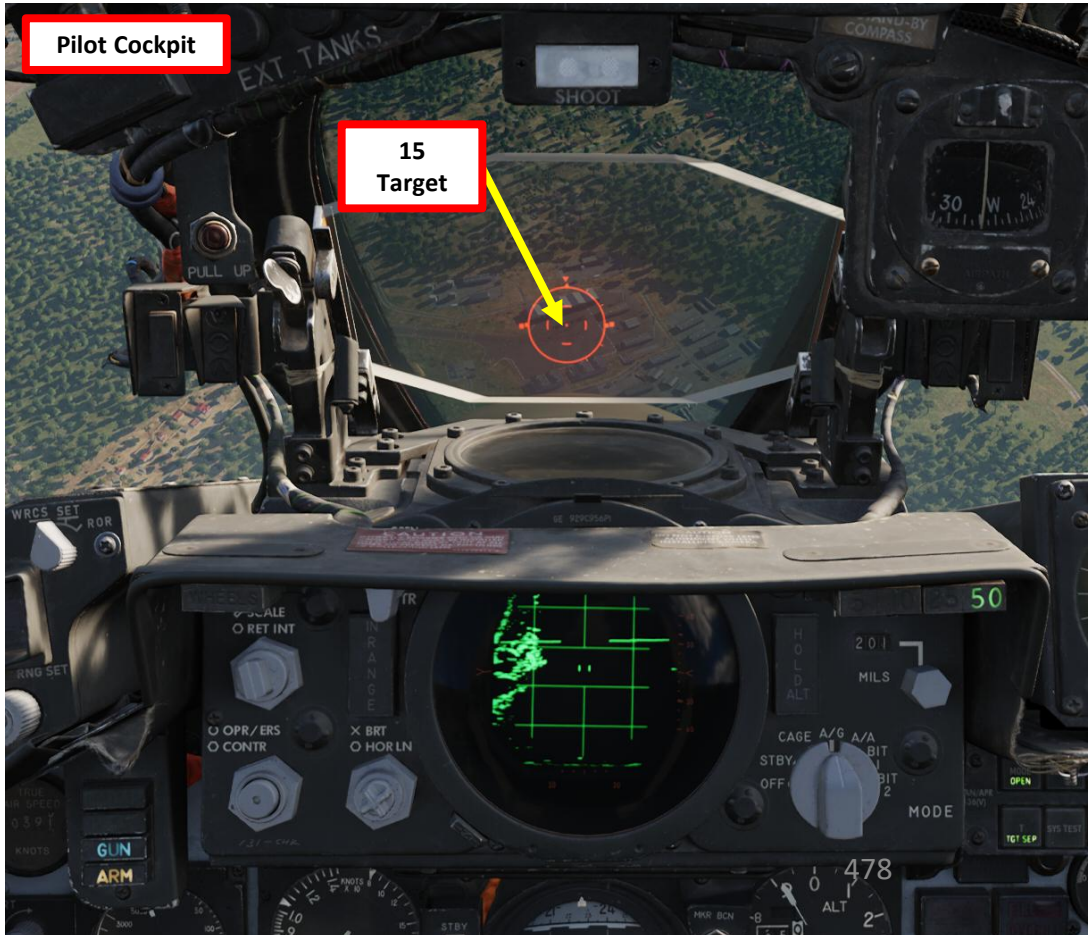
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

C – Perform Attack

15. *[P]* Once the target has been identified, throttle down, perform a 30 deg dive towards the target and maintain an airspeed of 450 kts indicated.

MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 30 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2635 ft	Bomb # of Pattern on Target: 5
Target Elevation: 635 ft MSL	
Total Aircraft Weight: 38086 lbs	



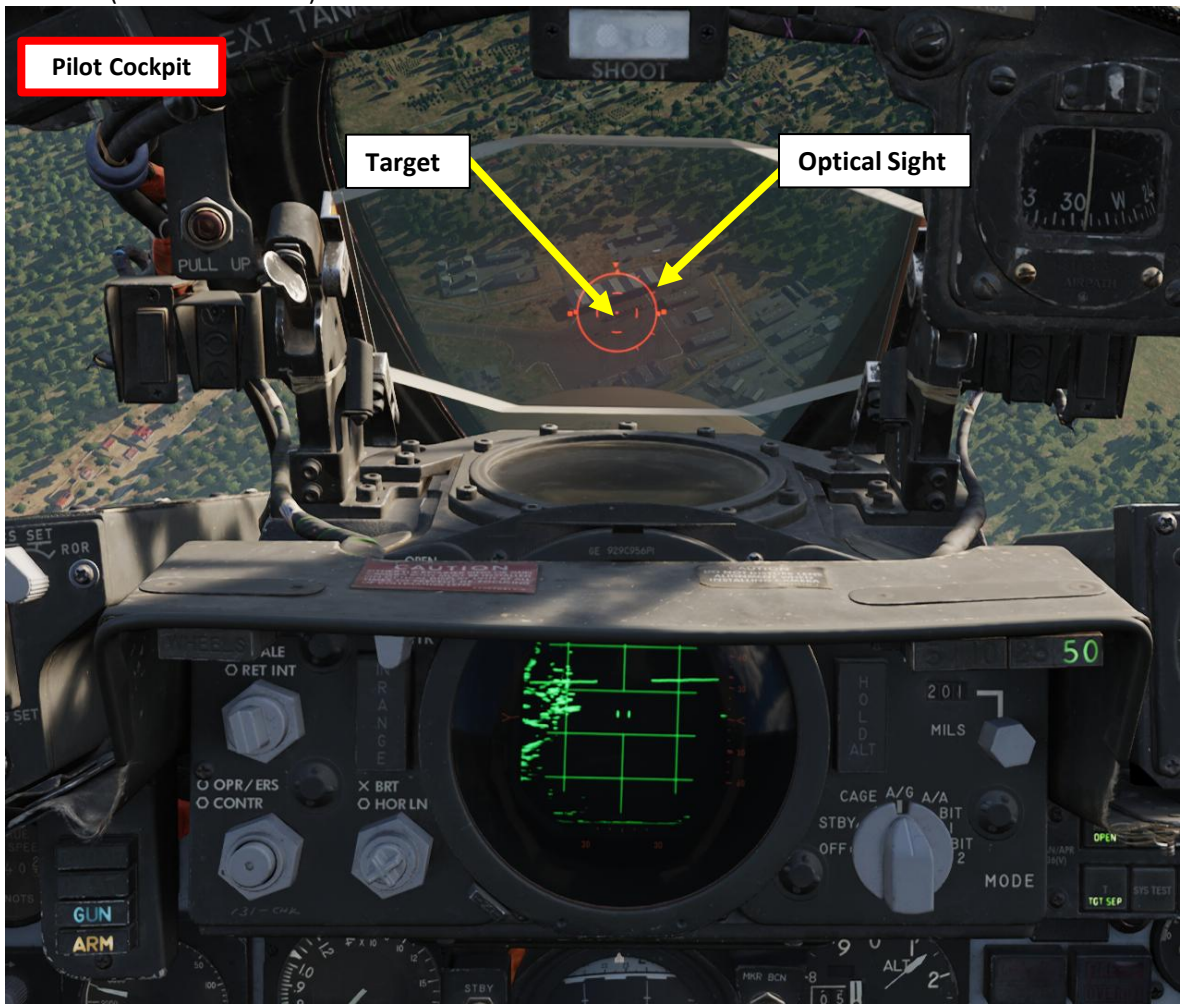


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

C – Perform Attack

16. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (450 kts indicated, 30 deg dive).
17. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
18. *[P]* When at release altitude (2635 ft MSL), press and hold the Bomb Release Button (RALT+SPACEBAR) until all bombs are released.







MK-82 Snake Eyes (High-Drag) Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Angle: 30 deg	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2635 ft	Bomb # of Pattern on Target: 5
Target Elevation: 635 ft MSL	
Total Aircraft Weight: 38086 lbs	

2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.2 – MK-82 Snake Eyes (High Drag): Direct Mode

C – Perform Attack

19. *[P]* When all bombs are released, begin the pullout maneuver, maintaining wings level.







2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

A – Determine Attack Profile

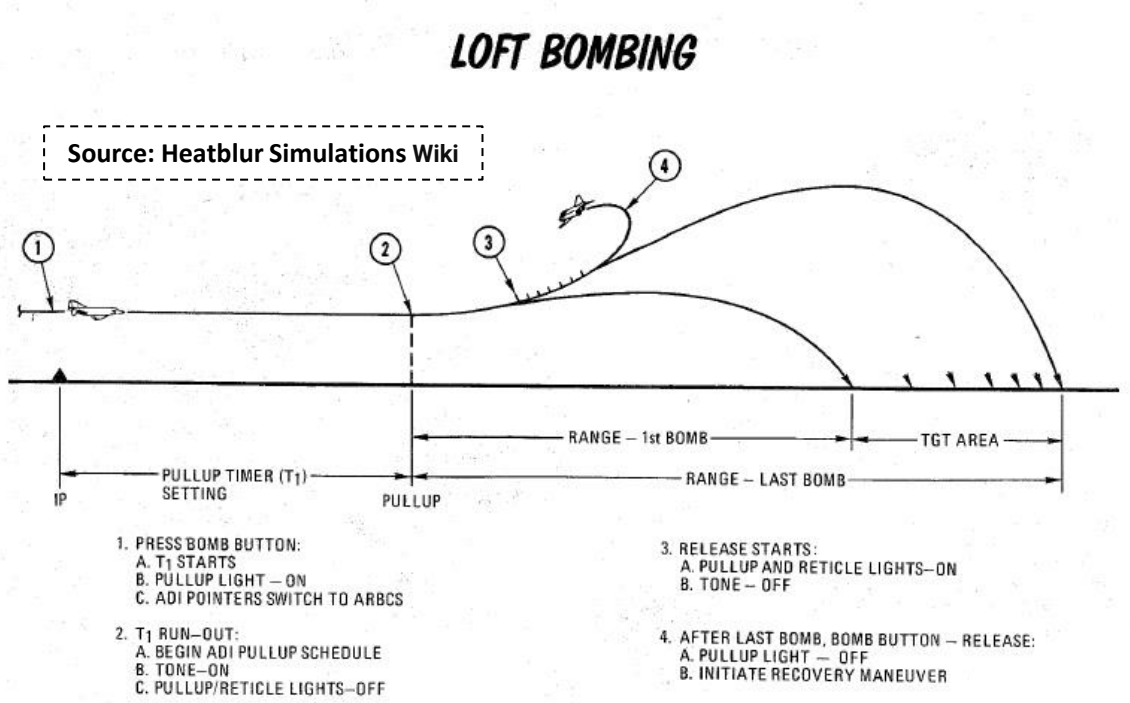
- Loft Mode is a rather inaccurate bombing mode; it was mainly meant to minimize exposure to enemy ground fire when employing nuclear weapons (and also minimize exposure to the nuclear blast itself), meaning that accuracy was not exactly the primary intent of this mode.

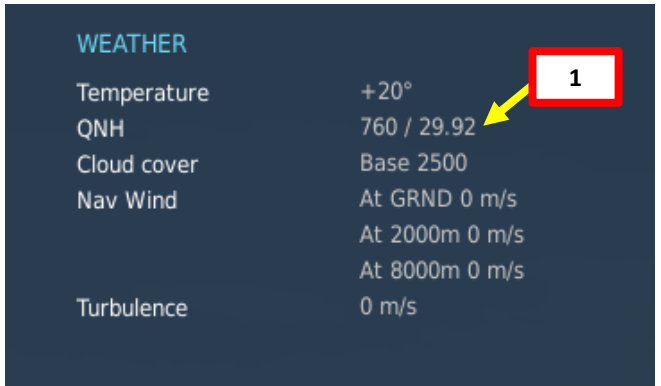
- In Loft mode, the aircraft is meant to transition from a low altitude to a higher one in a pull-up maneuver, lofting the released munitions at a pre-calculated point that reaches the target. Loft mode revolves around computing and setting a pull-up timer based on the desired release parameters, such as altitude, speed and loft angle. The pilot is meant to fly to the reference point, hold the bomb button and start initiating the pull-up maneuver the moment the aircraft gives the pull-up cue. Weapons automatically release when reaching the setup loft angle. This method is not very useful when employing unguided conventional bombs, but who cares about stuff like that in a flight simulator? Let's just see how it works in theory.

In this tutorial, we want to drop nine M117 bombs (ripple release) at an interval of 0.1 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.





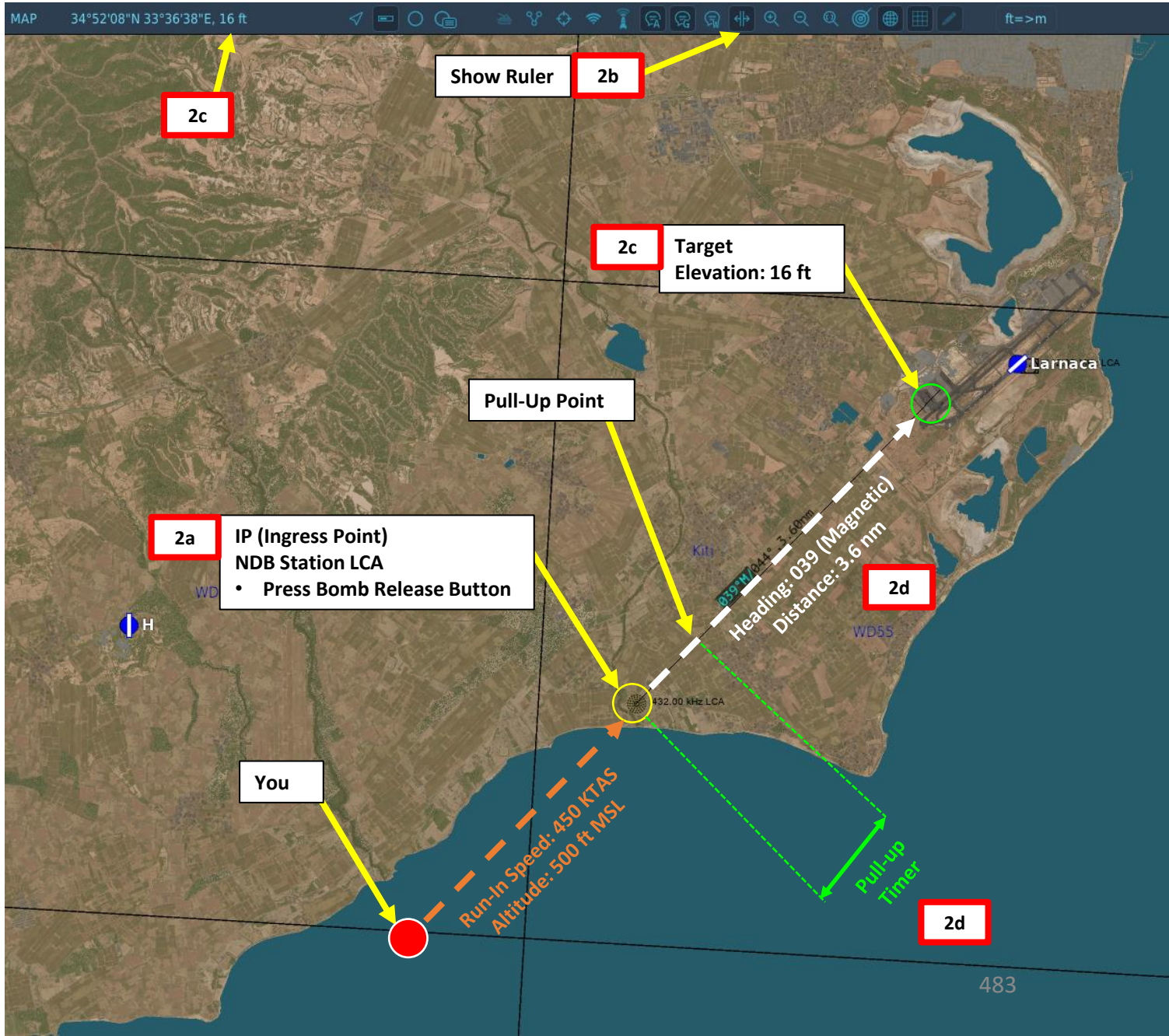


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

A – Determine Attack Profile

This method requires the pilot to overfly a pre-determined IP (Ingress Point or Initial Point), which is set on something that is easily recognizable visually. In this example, we will take a Non-Directional Beacon Station. Once flying over the IP, the pilot presses and holds the Bomb Button, starting a pullup timer.

2. Determine target and IP (Ingress Point):
    a) Determine what the Ingress Point will be. In this example, the IP is set on the NDB Station LCA.
    b) Use the "Show Ruler" function of the F10 map to determine the bearing and distance from the IP to the target. In this example, we get a **distance of 3.6 nm** and a **magnetic heading of 039**.
    c) Using the F10 map, find the target elevation. In this example, our **target** is the **Larnaca airport**, which has an **elevation of 16 ft** (approximated to 20 ft).
    d) Using the pre-determined IP distance, we can then generate a Loft profile and obtain the required pullup timer.



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

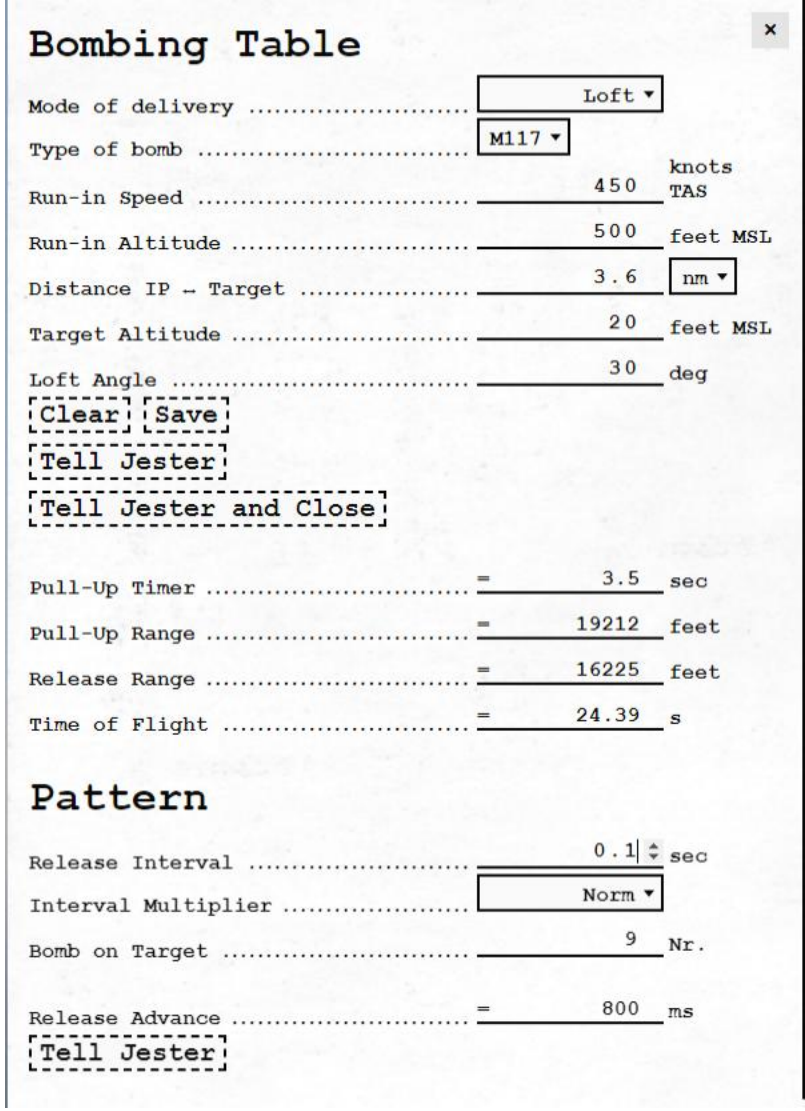
A – Determine Attack Profile

3. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
4. On Bombing Table Utility:
   a) Select Loft Mode of delivery
   b) Select M117 Type of Bomb
   c) Select Run-In Speed: 450 kts (True Airspeed, TAS)
   d) Select Run-In Altitude: 500 ft (MSL, Mean Sea Level)
   e) Select Distance from IP (Ingress Point) to Target: 3.6 nm
   f) Select Target Altitude: 20 ft MSL (Mean Sea Level) – Obtained from F10 map
   g) Select desired Loft Angle: 30 deg
   h) Click SAVE.
   i) Pull-Up Timer is calculated automatically: 3.5 sec
   j) If using the JESTER AI as the WSO, click TELL JESTER to set the Pull-Up Timer in the rear cockpit.
   k) If applicable (ripple bombing), select Bomb Number of Pattern on Target: As desired, 9th Bomb (of a total pattern of 9 bombs being dropped)
   l) If applicable (ripple bombing), select Release Interval: 0.1 sec
   m) If applicable (ripple bombing), select Interval Multiplier: NORM.
   n) Release Advance is calculated automatically: 800 ms
   Note: See Release Advance Setting & Bombing Pattern explanation here.
   o) If using the JESTER AI as the WSO, click TELL JESTER to set the Release Advance in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Run-In Airspeed: 450 KTAS	Release Interval: 0.1 sec
Run-In Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
Distance IP-Target: 3.6 nm	Bomb # of Pattern on Target: 9
Target Elevation: 20 ft MSL	
Loft Angle: 30 deg	

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Pull-Up Timer: 3.5 sec	Release Advance: 800 ms



2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

B – Weapon Setup

5. *[P]* Select desired Station Select Buttons. We will use CTR, LO and RO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
6. *[P]* Set Weapon Selector Knob – BOMBS
7. *[P]* Set Air-to-Ground Weapon Delivery Mode – Loft
8. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop a total of 9 bombs)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
9. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
10. *[P]* Set Master Arm Switch – ARMED (UP)

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Run-In Airspeed: 450 KTAS	Release Interval: 0.1 sec
Run-In Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
Distance IP-Target: 3.6 nm	Bomb # of Pattern on Target: 9
Target Elevation: 20 ft MSL	
Loft Angle: 30 deg	



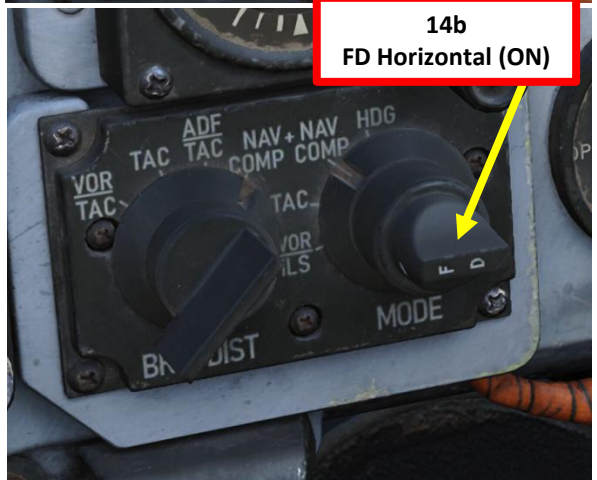
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

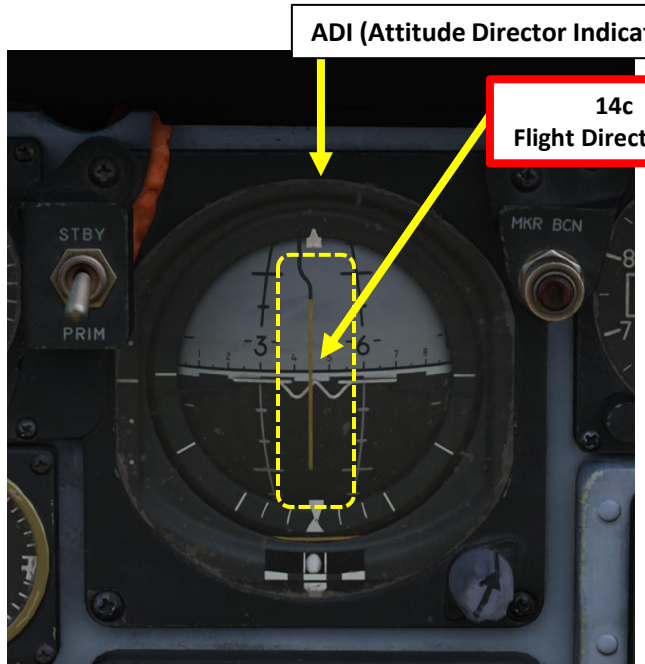
B – Weapon Setup

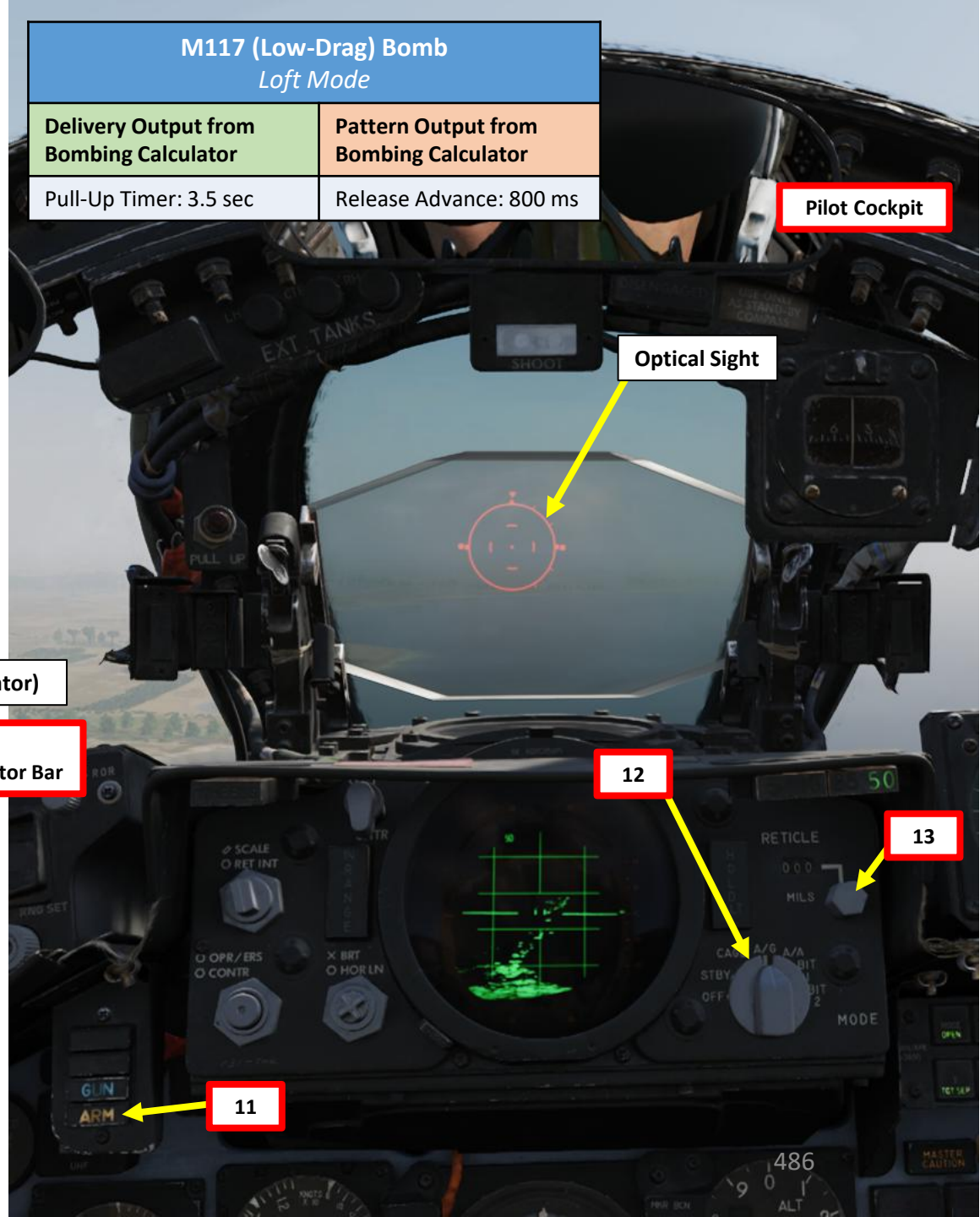
11. *[P]* Confirm ARM light is illuminated
12. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
13. *[P]* Set Reticle Depression Setting Knob to 0 Mils.
14. *[P]* Set Flight Director – ON.
    - Turn the inner "FD" knob in the Horizontal position (ON), then confirm the flight director is ON by checking that the yellow flight director bar is visible on the ADI (Attitude Director Indicator)

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Pull-Up Timer: 3.5 sec	Release Advance: 800 ms









2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

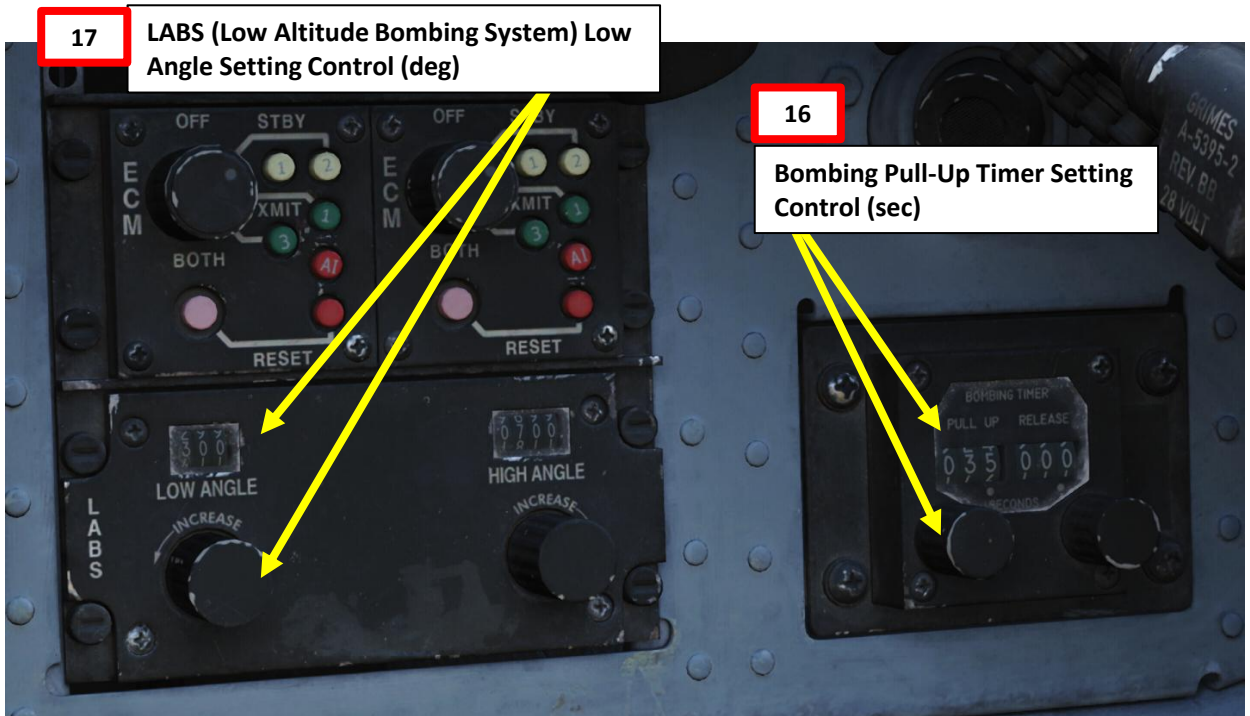
B – Weapon Setup

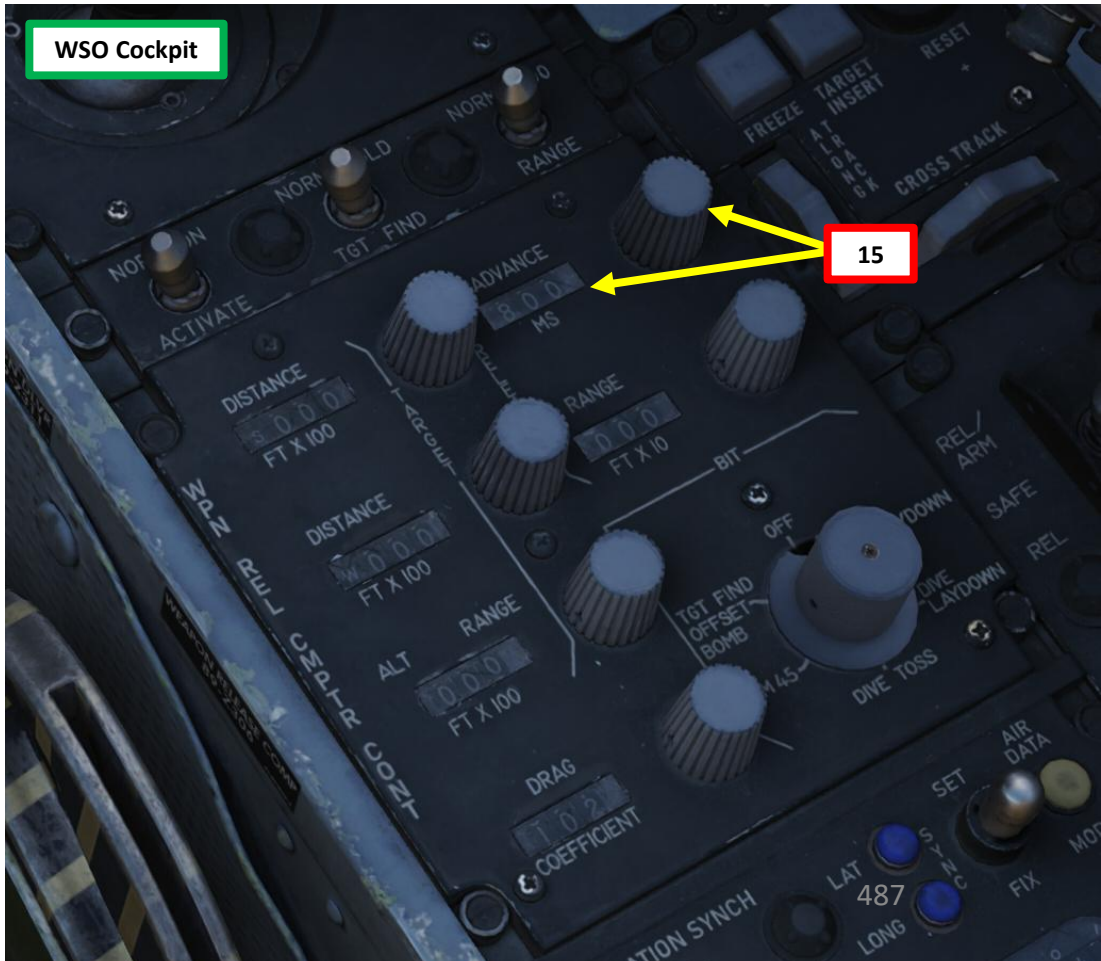
Note: This step can be performed by JESTER.

15. *[WSO]* Set Release Advance Setting: 800 ms (value computed from Bombing Table).
16. *[WSO]* Set Pull-Up Timer Value: 3.5 sec (value computed from Bombing Table).
17. *[WSO]* Set LABS Low Angle Setting to the desired Loft Angle (30 deg).

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Run-In Airspeed: 450 kts	Release Interval: 0.1 sec
Run-In Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
Distance IP-Target: 3.6 nm	Bomb # of Pattern on Target: 9
Target Elevation: 20 ft MSL	
Loft Angle: 30 deg	

M117 (Low-Drag) Bomb *Loft Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Pull-Up Timer: 3.5 sec	Release Advance: 800 ms

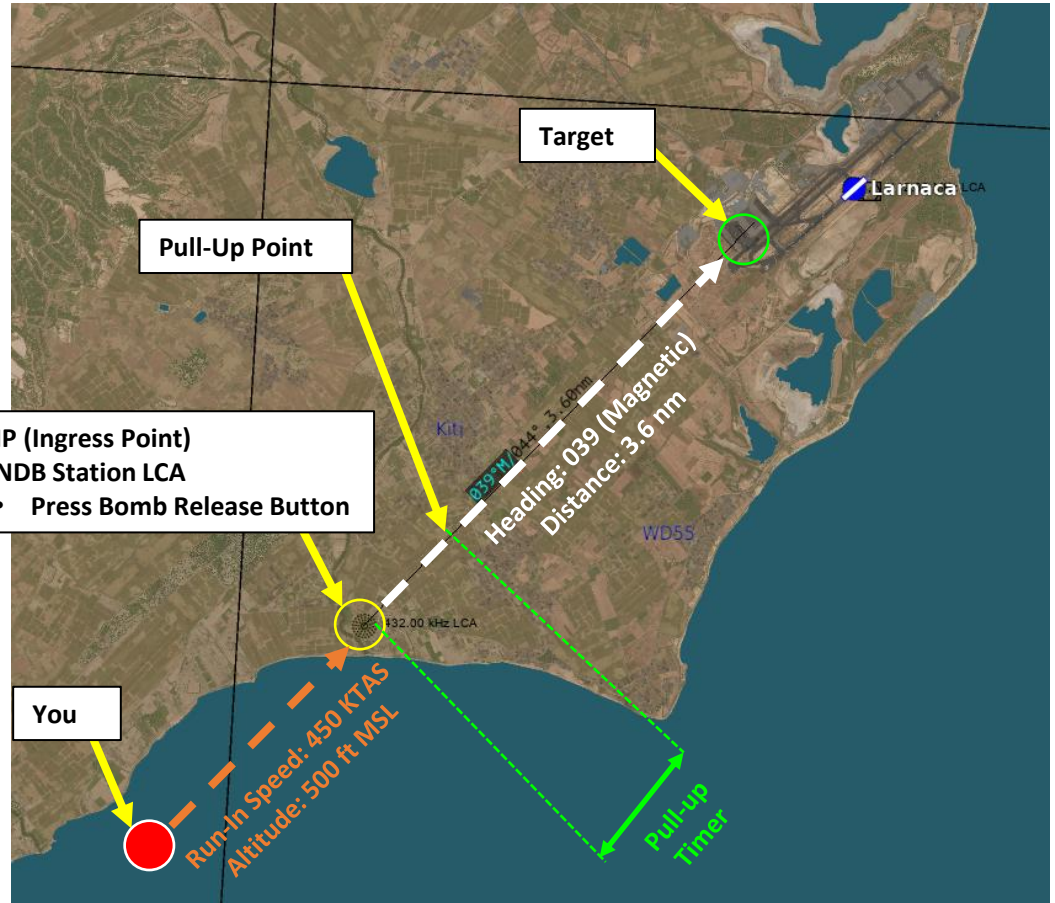


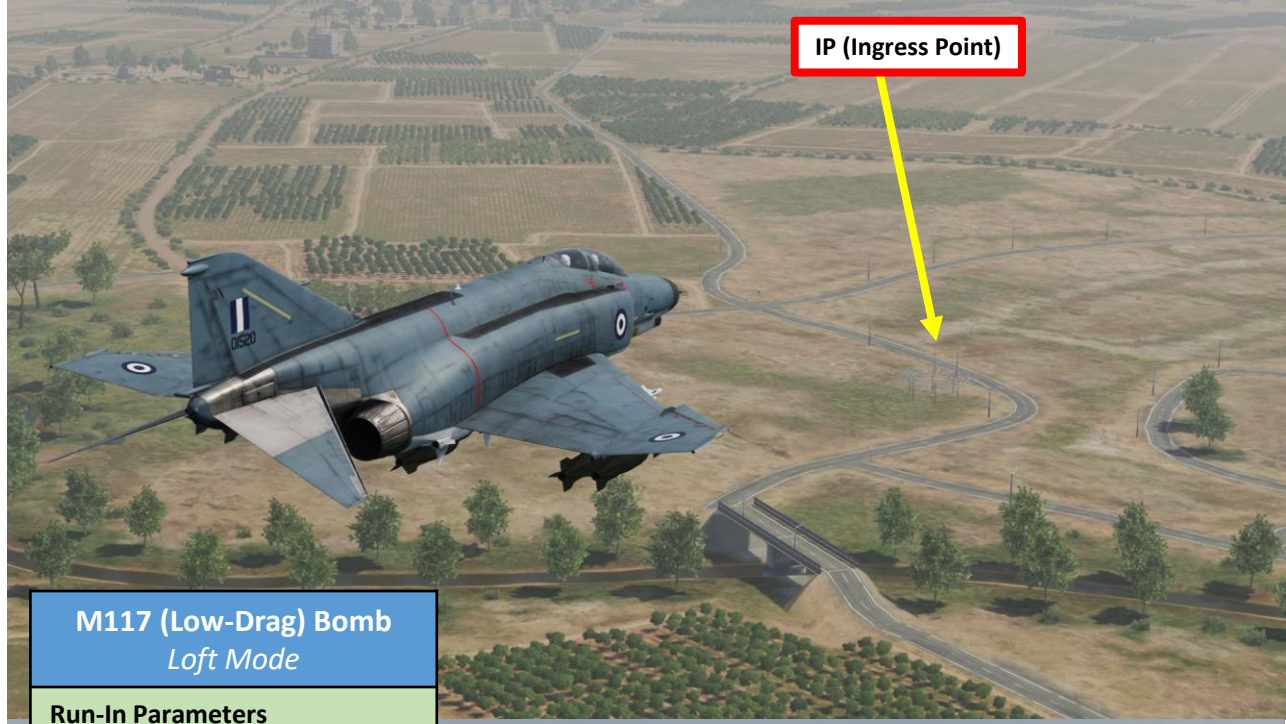


2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

C – Perform Attack

18. *[P]* Fly to the IP (Ingress Point) by maintaining the required run-in airspeed (450 KTAS), altitude (500 ft MSL) and heading (039 Magnetic). In this example, the IP is set on the NDB Station LCA.





M117 (Low-Drag) Bomb *Loft Mode*
Run-In Parameters
Run-In Airspeed: 450 kts
Run-In Altitude (MSL): 500 ft
Run-In Heading: 039 Magnetic



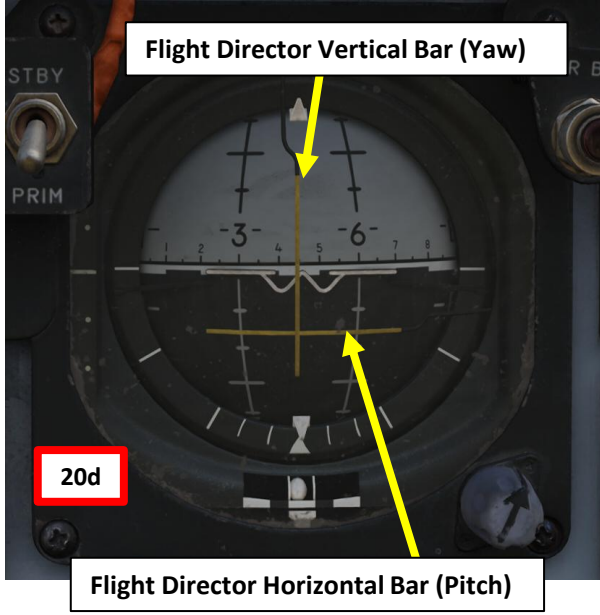
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

C – Perform Attack

19. *[P]* When aircraft is over the Ingress Point (IP) at the required run-in airspeed (450 KTAS), altitude (500 ft MSL) and heading (039 Magnetic), press and hold the Bomb Release Button (RALT+SPACEBAR).
20. *[P]* Once **Bomb Release Button is pressed and held, the bomb run is initiated:**
    a) The Pull-up Timer starts
    b) The LABS (Low Altitude Bombing System) Pull-Up Light Illuminates, indicating the pull-up timer has started
    c) The ARBCS (Attitude Reference & Bombing Computer Set) programs for a 4 G pull-up schedule (which will automatically release the selected munitions once the bombing run is initiated, timer runout has occurred, and pre-set LOW pitch (gyro) angle is achieved).
    d) The ARBCS overrides any other navigational guidance provided on the ADI (Attitude Director Indicator) and assumes command of the pointers to show deviation relative to the programmed attack profile.
        - The vertical pointer offsets in the direction requiring yaw input to maintain target alignment.
        - On approach to the loft point, the horizontal needle shows deviation from a 1.0 G flight path.
21. *[P]* Fly the aircraft to maintain run-in speed (450 KTAS) and keep the vertical and horizontal flight director bars centered.





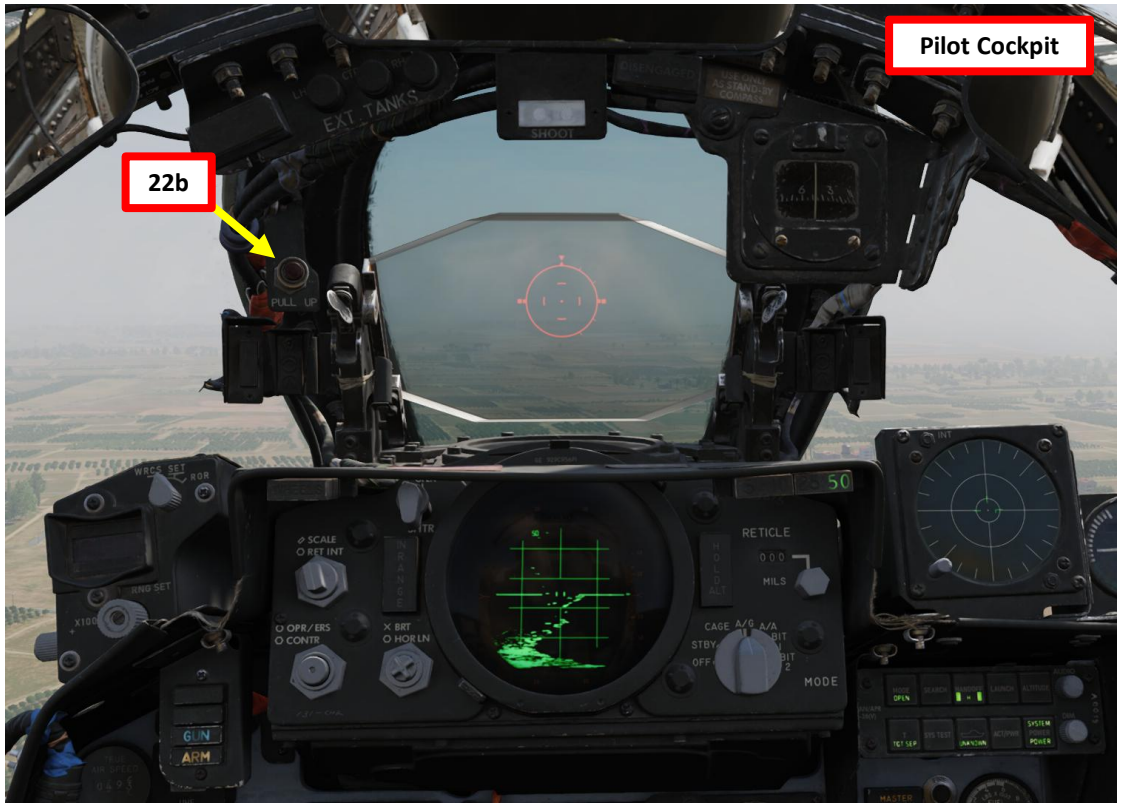




2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

C – Perform Attack

22. *[P]* When **aircraft is over the pull-up point**:
    a) The Pull-up Timer has run out (aircraft is determined to be over the pull-up point provided the pilot has maintained the expected run-in airspeed of 450 KTAS)
    b) The LABS (Low Altitude Bombing System) Pull-Up Light extinguishes, signaling the pilot to start the 4 G pull-up maneuver
    c) A continuous tone is audible
    d) Deviation of the horizontal flight director needle is relative to the desired constant 4 G pull, with the initial drift representing achieving 4 G of load in two seconds. Maintaining the horizontal needle centered means the pilot has increased and held G at the proper rate for maximum accuracy.
    e) Keep the Bomb Release Button pressed.







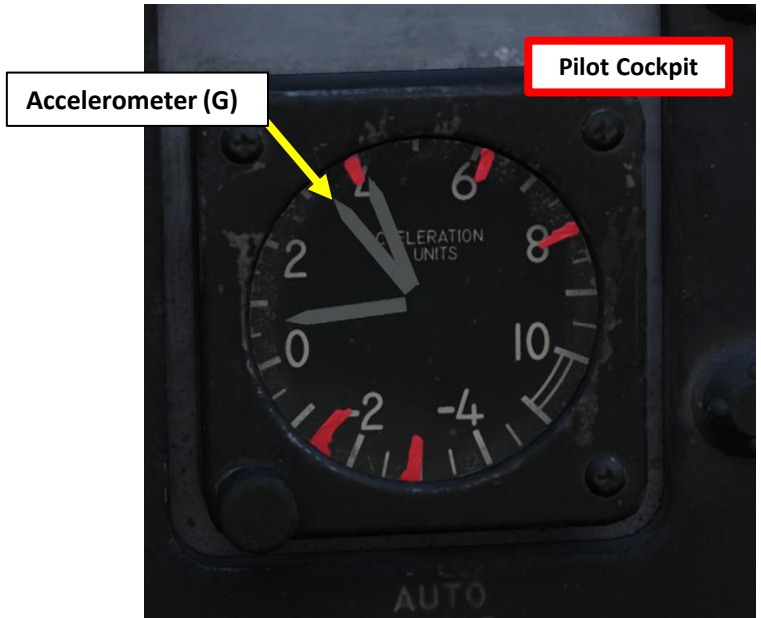
2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

C – Perform Attack

23. *[P]* Maneuver the aircraft to keep both the horizontal and vertical flight director bars centered. These bars guide the pilot to perform the 4 G pull up maneuver. Keep the Bomb Release Button pressed.









2 – AIR-TO-GROUND WEAPONS
2.1 – Unguided Bombs
2.1.3 – M117 (Low Drag): Loft Mode

C – Perform Attack

24. *[P]* Weapons automatically release when reaching the setup loft angle.
25. *[P]* When all bombs are released, stop pressing the Bomb Release Button and egress away (recovery maneuver) from the bomb blast radius.







2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions

Introduction

CBUs (Cluster Bomb Units) are generally used against "soft" targets. Some of them like the CBU-103 and CBU-105 use Wind Corrected Munition Dispenser kits to correct the effect of the wind on their trajectory, but they are not available for the DCS F-4E Phantom II.

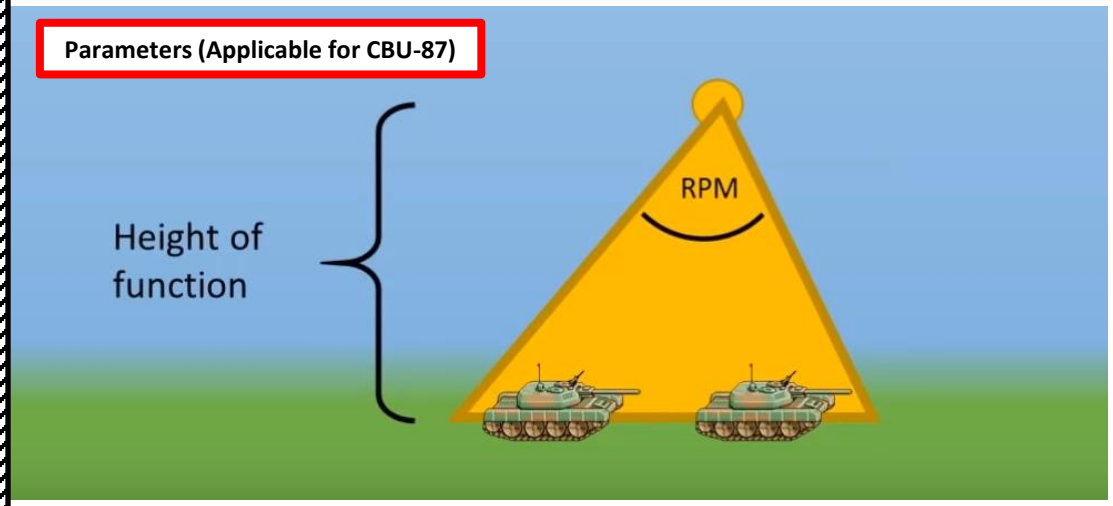
CLUSTER MUNITIONS			
WEAPON	**TYPE**	**WEAPON**	**TYPE**
MK-20 Rockeyes	490 lbs unguided cluster munitions (247 x HEAT bomblets)	***CBU-1A/A***	Unguided cluster munitions (19 dispenser tubes, 513 BLU-4B High Explosive bomblets)
CBU-87	950 lbs unguided all-purpose Combined Effects Munitions (CEM) (220 x bomblets). ***Fuze Setting:*** • ***N/T (Nose & Tail): Bomblets dispense using altitude proximity fuze setting*** • ***NOSE: Bomblets dispense after a preset timer (selectable on ground between 1.39 and 4.25 seconds)*** • ***TAIL: Dud (Disarmed)*** *Recommended HoF/RPM parameters: 1200 ft/2000 RPM*	***CBU-2/A***	Unguided cluster munitions (19 dispenser tubes, 361 BLU-3 High Explosive bomblets)
CBU-52B	760 lbs unguided cluster munitions (220 x High Explosive / Fragmentation) Cluster Bomblets	***CBU-2B/A***	Unguided cluster munitions (22 dispenser tubes, 418 BLU-3B High Explosive bomblets)
BL-755	580 lbs unguided cluster munitions (147 x HEAT bomblets). Used extensively during the Falklands War by the Royal Air Force. It was also used by the German Air Force, including the F-4F.		

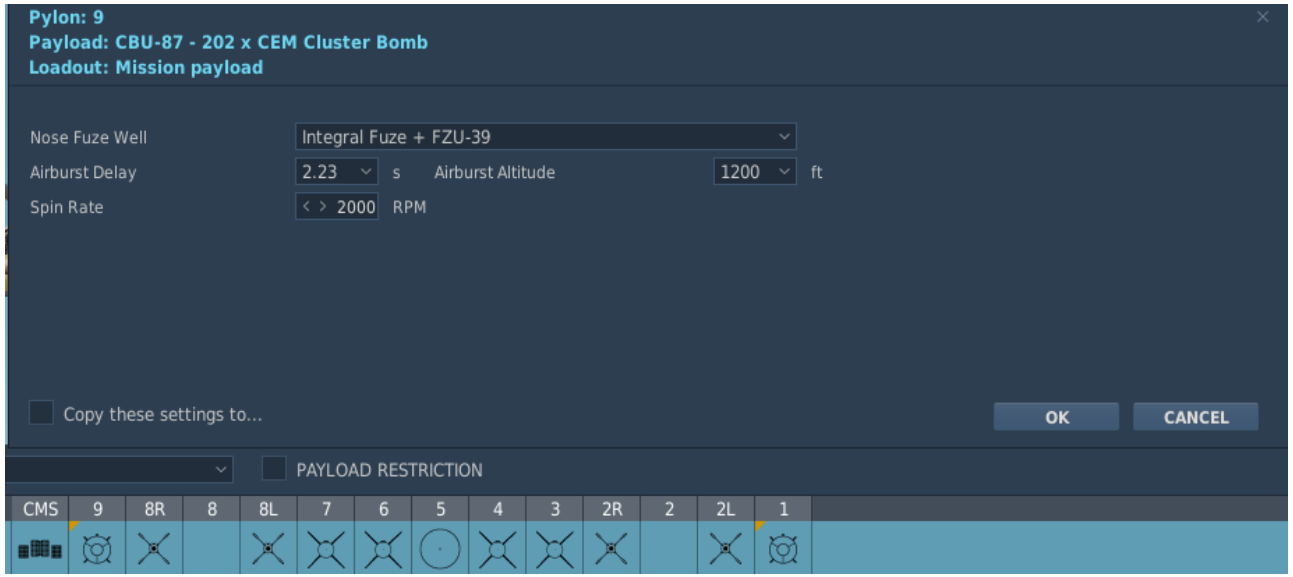
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions

Introduction

Keep in mind that there are parameters that we can adjust to improve the effectiveness of CBUs:

- **Burst Height of Function (HoF),** which determines at which height the bombs will release (burst height above ground level). It impacts area spread and accuracy. The greater the Height, the larger the covered area is (at the expense of density). This setting is mutually exclusive from Burst Time.
- **Burst Time**, which determines the time from bomb drop in seconds after which bomblets are released. This setting is mutually exclusive from Burst Height.
- **Spin Setting (RPM)**, which is the area spread of the bomblets that affects the concentration of fire available on the target. This parameter is applicable to the CBU-87 only. The greater the spin, the larger the covered area is (at the expense of density). Recommended value is experimental, but you can use a value of 2000 RPM.





2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

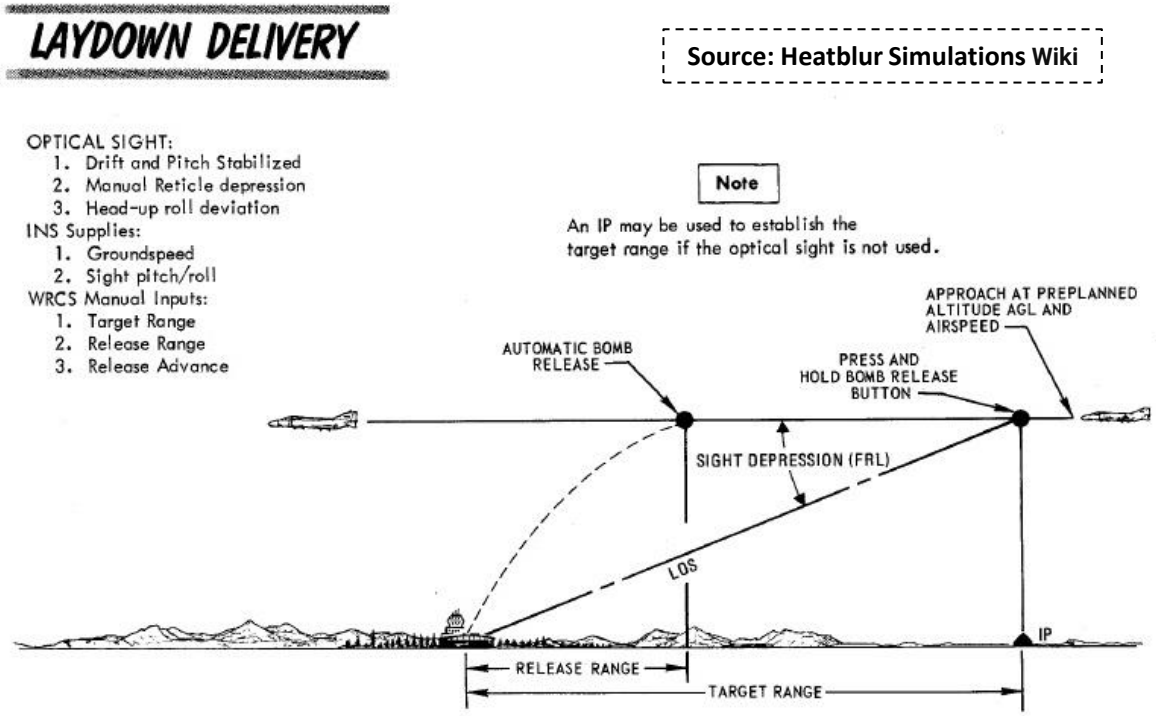
A – Determine Attack Profile

- Laydown mode can be considered as a precursor to modern CCRP (Continuously Computed Release Point) modes. In this mode, the target is designated by means of a distance to a point prior to the target (IP, Ingress Point), assuming that you are flying at a specific airspeed and altitude. Once over that point, the Bomb Release Button is held down and weapons automatically release after passing the setup release range. The INS (Inertial Navigation System) and WRCS (Weapon Release Computer Set) computes the moment weapons are released.

- As a visual aid, the optical sight should be depressed in a way that it will be exactly over the target when at the IP. That way, as soon as the pipper is over the target, the Bomb Release Button can be held down and weapons will impact.

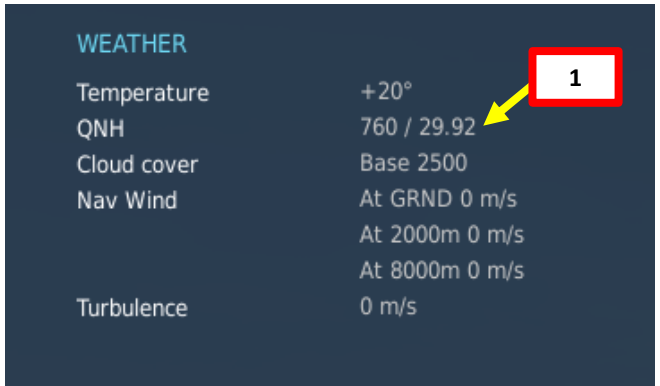
In this tutorial, we want to drop six MK-20s (ripple release) at an interval of 0.1 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.



Source: Heatblur Simulations Wiki





2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

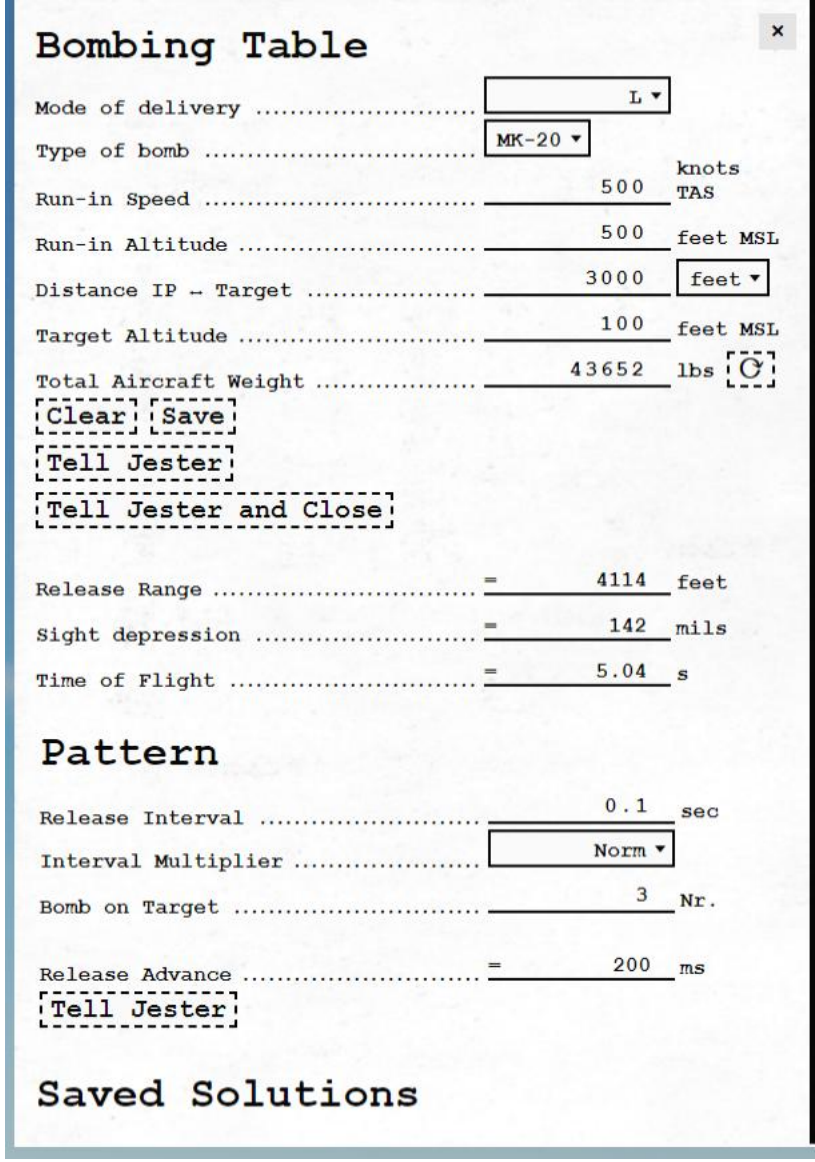
A – Determine Attack Profile

2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
   a) Select L (Laydown) Mode of delivery
   b) Select MK-20 Type of Bomb
   c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
   d) Select Distance from Ingress Point to Target (IP-Target Range): 3000 ft
   e) Select Target Altitude: 100 ft MSL (Mean Sea Level) – Obtained from F10 map
   f) Select Release Altitude: 500 ft (MSL, Mean Sea Level)
      - Release Altitude (MSL) = Target Altitude (MSL) + Release Altitude (AGL, Above Ground Level)
        500 ft MSL = 100 ft MSL + 400 ft AGL
   g) Click on the Refresh button to calculate total aircraft weight: 43652 lbs
   h) Click SAVE.
   i) If using the JESTER AI as the WSO, click TELL JESTER to set the Target Range in the rear cockpit.
   j) Release Range is calculated automatically: 4114 ft
   k) Sight Depression is calculated automatically: 142 mils
   l) If applicable (ripple bombing), select Bomb Number of Pattern on Target: As desired, 3rd Bomb (of a total pattern of 6 bombs being dropped)
   m) If applicable (ripple bombing), select Release Interval: 0.1 sec
   n) If applicable (ripple bombing), select Interval Multiplier: NORM.
   o) Release Advance is calculated automatically: 200 ms
   Note: See Release Advance Setting & Bombing Pattern explanation here.
   p) If using the JESTER AI as the WSO, click TELL JESTER to set the Release Advance and Release Range in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

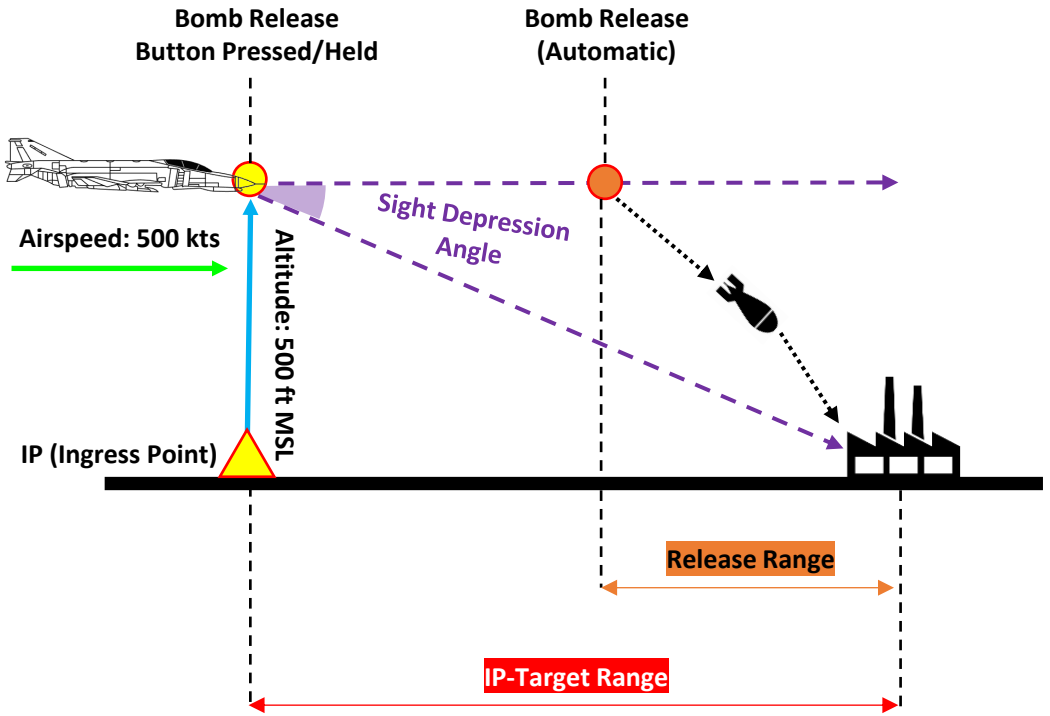
MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 400 ft Release Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
IP-Target Range: 3000 ft	Bomb # of Pattern on Target: 3
Target Elevation: 100 ft MSL	
Total Aircraft Weight: 43652 lbs	

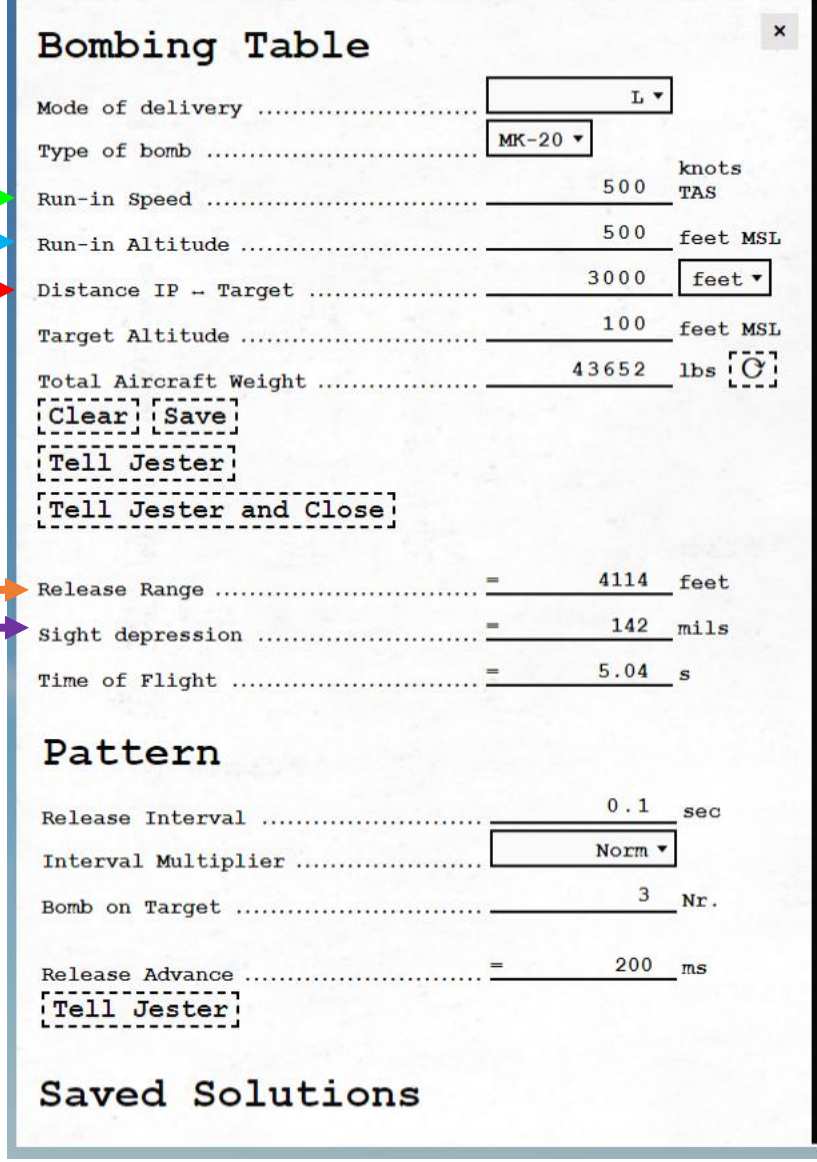
MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Release Range: 4114 ft	Release Advance: 200 ms
Sight Depression: 142 mils	



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

A – Determine Attack Profile



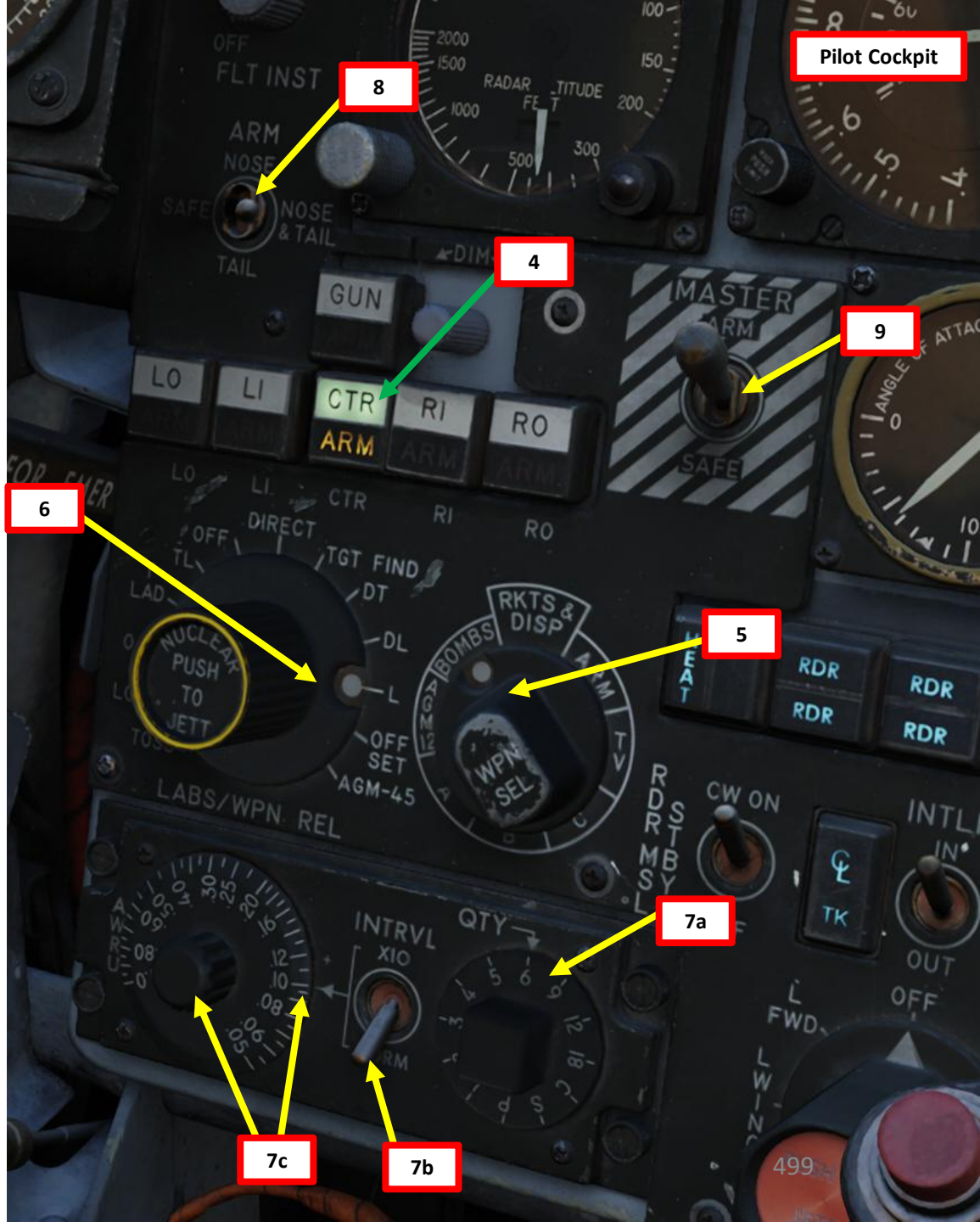


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

B – Weapon Setup

4. *[P]* Select desired Station Select Buttons. We will use CTR.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
5. *[P]* Set Weapon Selector Knob – BOMBS
6. *[P]* Set Air-to-Ground Weapon Delivery Mode – L (Laydown)
7. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop a total of 6 bombs)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
8. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
9. *[P]* Set Master Arm Switch – ARMED (UP)

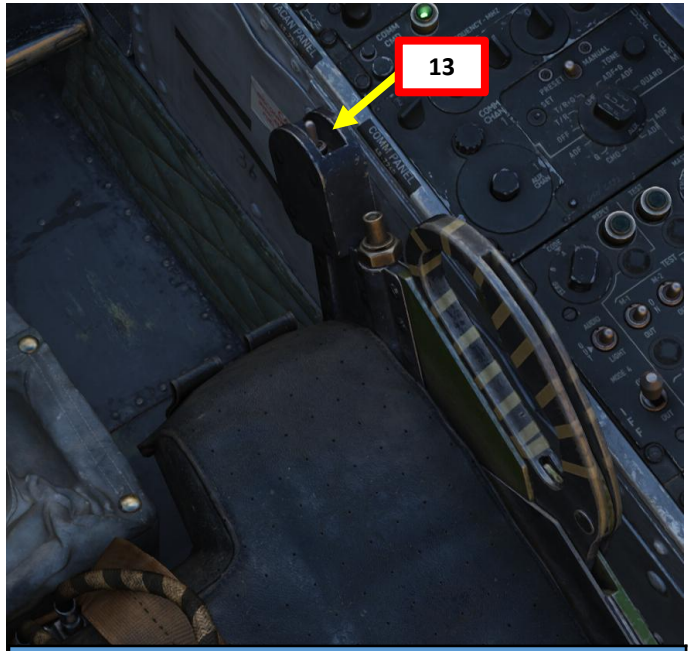
MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 400 ft Release Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
IP-Target Range: 3000 ft	Bomb # of Pattern on Target: 3
Target Elevation: 100 ft MSL	
Total Aircraft Weight: 43652 lbs	



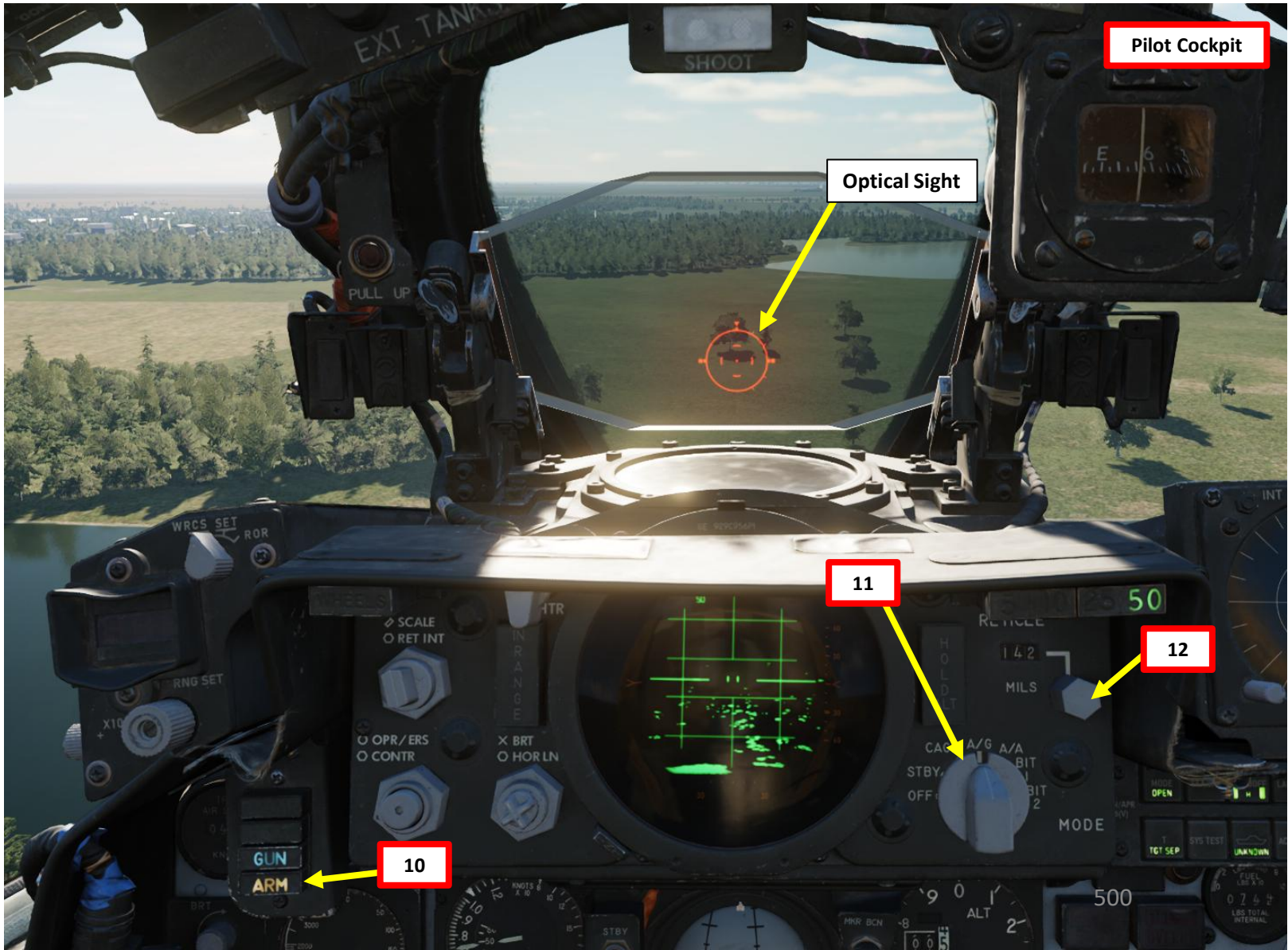
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

B – Weapon Setup

10. *[P]* Confirm ARM light is illuminated
11. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
12. *[P]* Set Reticle Depression Setting Knob to 142 Mils.
13. *[P]* Adjust Seat Position – As required to see the reticle.



MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Release Range: 4114 ft	Release Advance: 200 ms
Sight Depression: 142 mils	



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

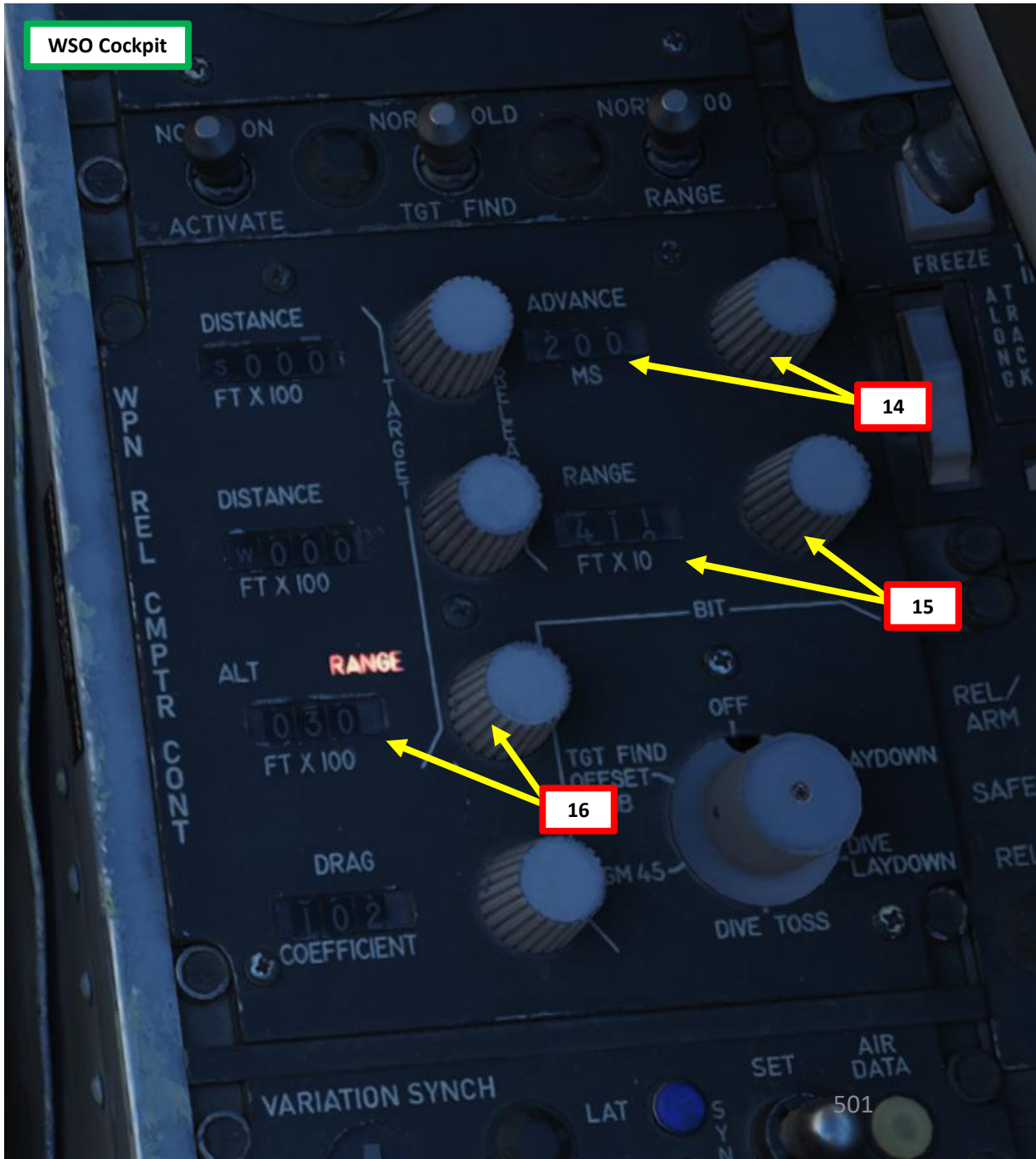
B – Weapon Setup

Note: These steps can be performed by JESTER.

14. *[WSO]* Set Release Advance Setting: 200 ms (value computed from Bombing Table).
15. *[WSO]* Set Release Range Setting: 4114 ft (value computed from Bombing Table).
16. *[WSO]* Set Target Range Setting: 3000 ft (determined when selecting bombing profile).

MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Release Range: 4114 ft	Release Advance: 200 ms
Sight Depression: 142 mils	

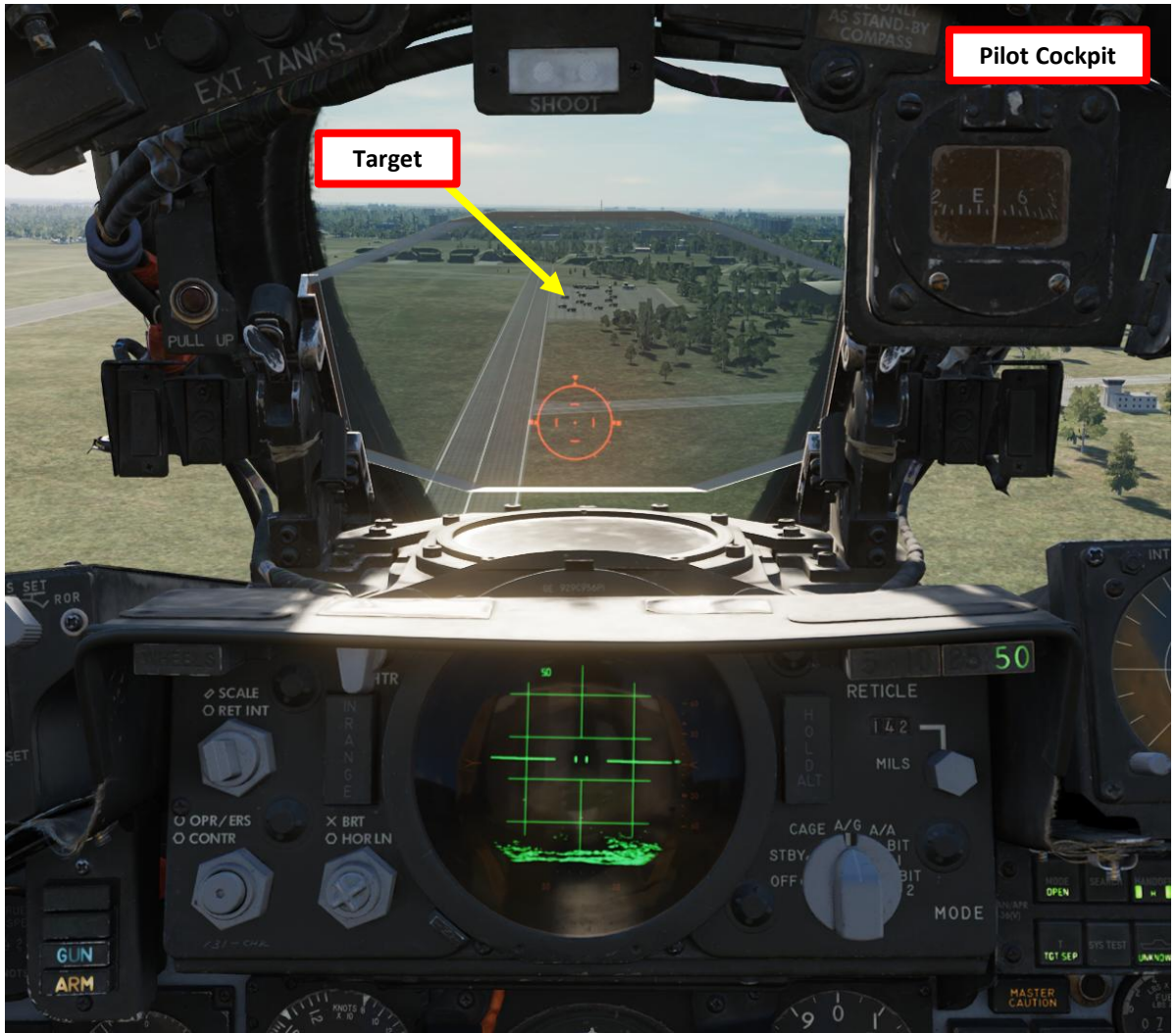
MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 400 ft Release Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
IP-Target Range: 3000 ft	Bomb # of Pattern on Target: 3
Target Elevation: 100 ft MSL	
Total Aircraft Weight: 43652 lbs	



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

C – Perform Attack

17. *[P]* Once the target has been identified, fly level towards the target at an altitude of 500 ft MSL and maintain an airspeed of 500 KTAS. Flying by these numbers is very important since the INS (Inertial Navigation System) and WRCS (Weapon Release Computer Set) use this information to compute when munitions are to be released.



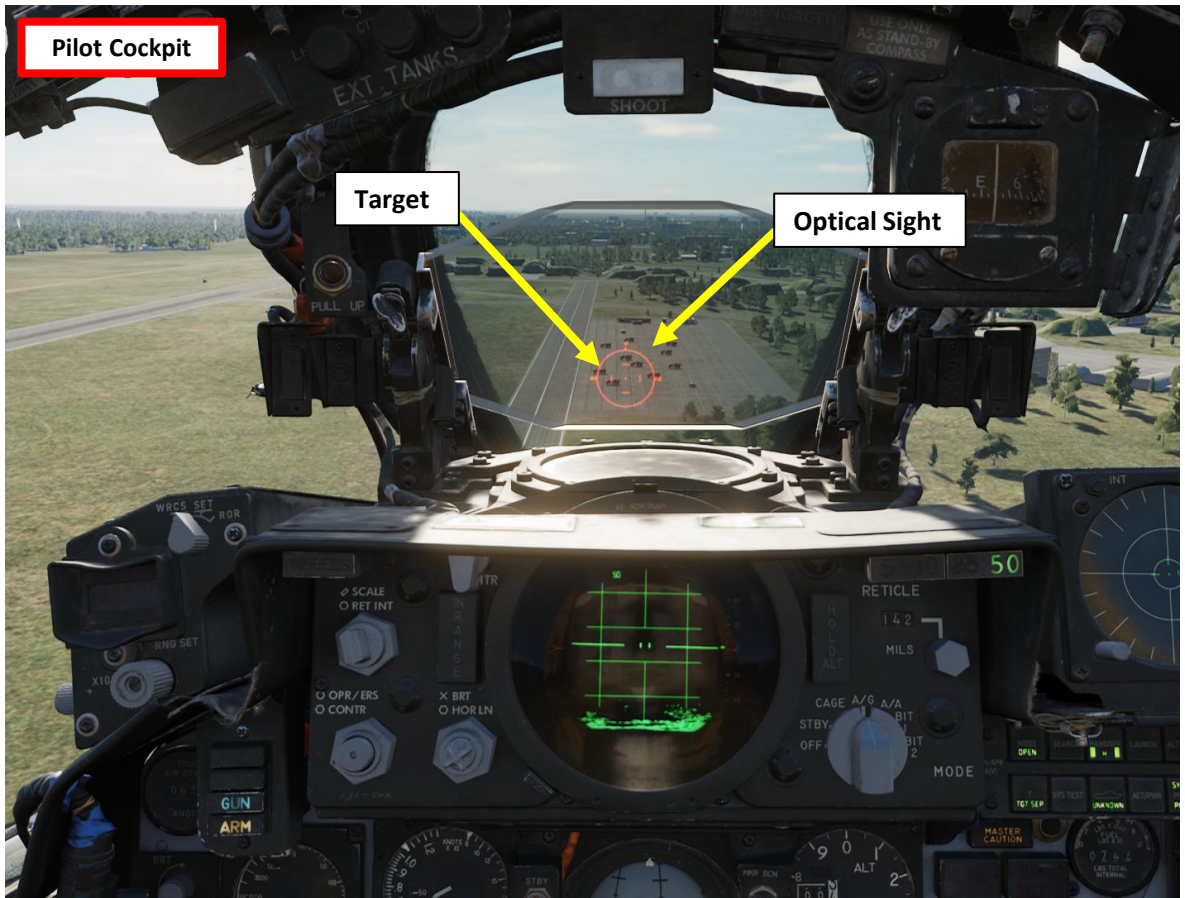
MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 400 ft Release Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
IP-Target Range: 3000 ft	Bomb # of Pattern on Target: 3
Target Elevation: 100 ft MSL	
Total Aircraft Weight: 43652 lbs	



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

C – Perform Attack

18. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (500 KTAS, 500 ft MSL).
19. *[P]* Once the pipper/reticle is over the intended target, you should be directly over the IP (Ingress Point) according to your current altitude, speed and sight depression setting. **Press and hold** the Bomb Release Button (RALT+SPACEBAR) until all munitions are released.
20. *[P]* While the bomb release button is held, the INS (Inertial Navigation System) and WRCS (Weapon Release Computer Set) will automatically release munitions according to the delivery data entered in the WRCS (Release Advance, Release Range and Target Range settings).





19 **Bomb Release Button**
- *Binding: RALT+SPACEBAR*



MK-20 Rockeyes Cluster Munitions *Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 400 ft Release Altitude (MSL): 500 ft	Interval Multiplier: Normal (x1)
IP-Target Range: 3000 ft	Bomb # of Pattern on Target: 3
Target Elevation: 100 ft MSL	
Total Aircraft Weight: 43652 lbs	

2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.1 – MK-20 Rockeyes: Laydown (L) Mode

C – Perform Attack

21. *[P]* When all munitions are released, begin pullout maneuver, maintaining wings level. This safe-escape manoeuver will avoid flying the aircraft into the frag envelope and suffering potential fragmentation damage







2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode



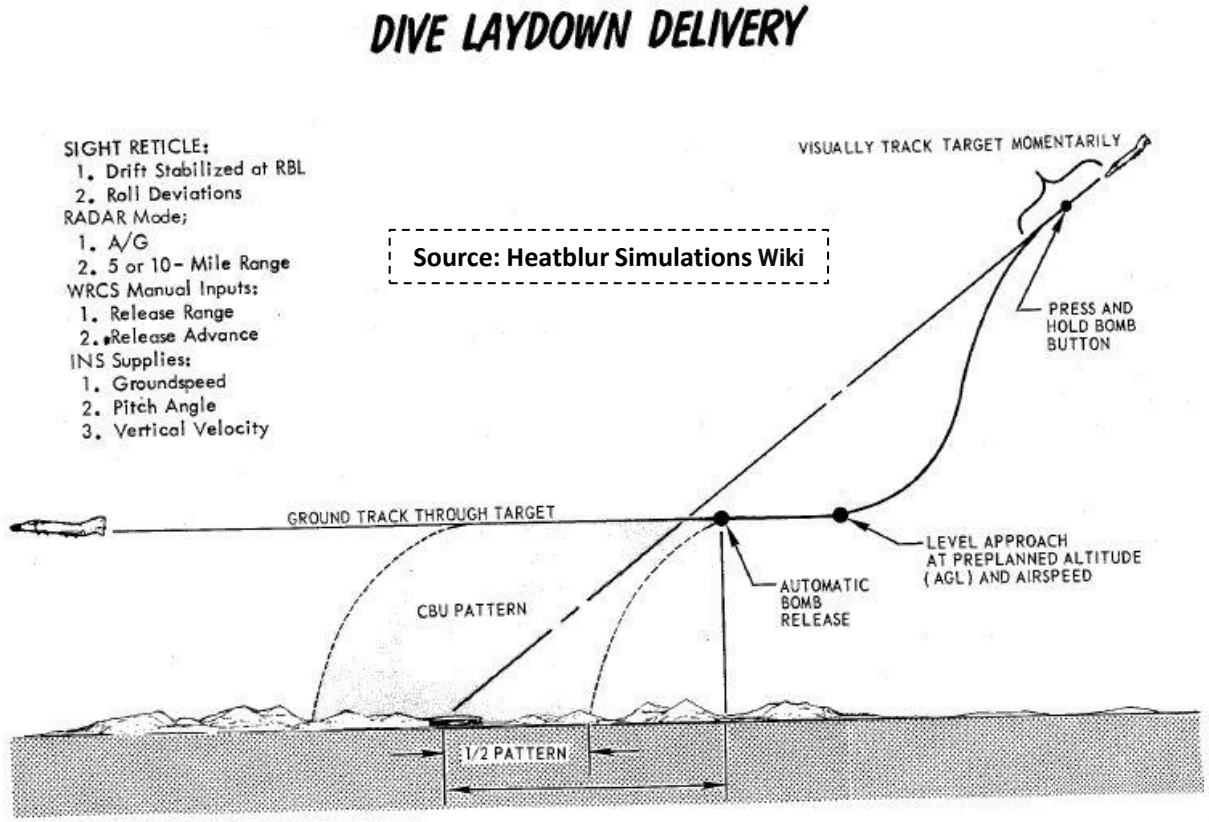
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

A – Determine Attack Profile

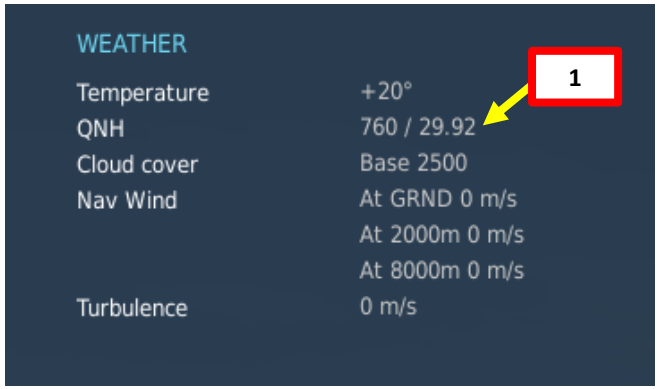
- Dive Laydown mode is a variation of the regular Laydown mode, where the target is designated by using the radar instead. The pilot flies a dive attack similar to the Dive Toss mode, while the WSO obtains accurate range information to the target by obtaining a radar lock. After target designation, the pilot levels out at the planned altitude and weapons release automatically at the set range to the target.
- Dive Laydown is mainly used for cluster munitions or high-drag ordnance.
- HOF (Height of Function, or Airburst Altitude of 1200 ft), Airburst Delay (2.23 s) and Spin Rate (2000 RPM) settings can be set for each CBU-87 via the ground crew interface.

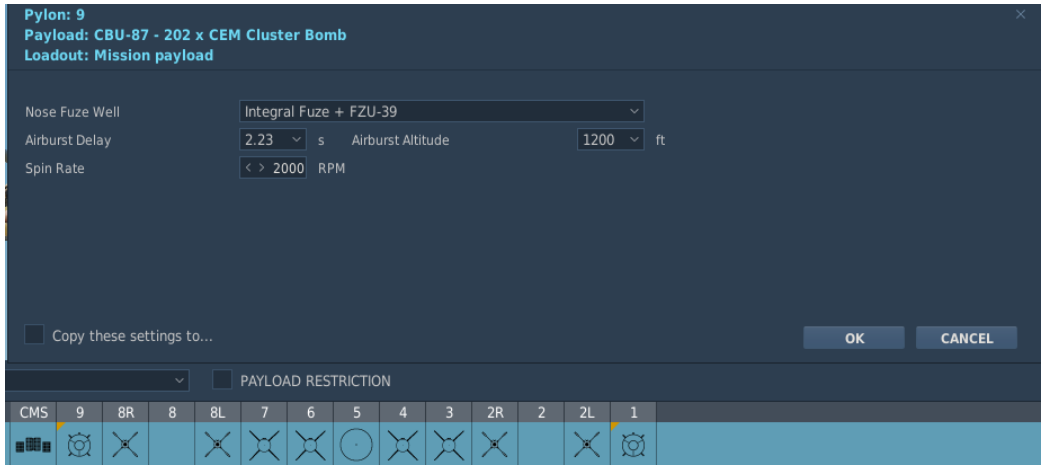
In this tutorial, we want to drop two CBU-87s (ripple release) at an interval of 0.1 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.









2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

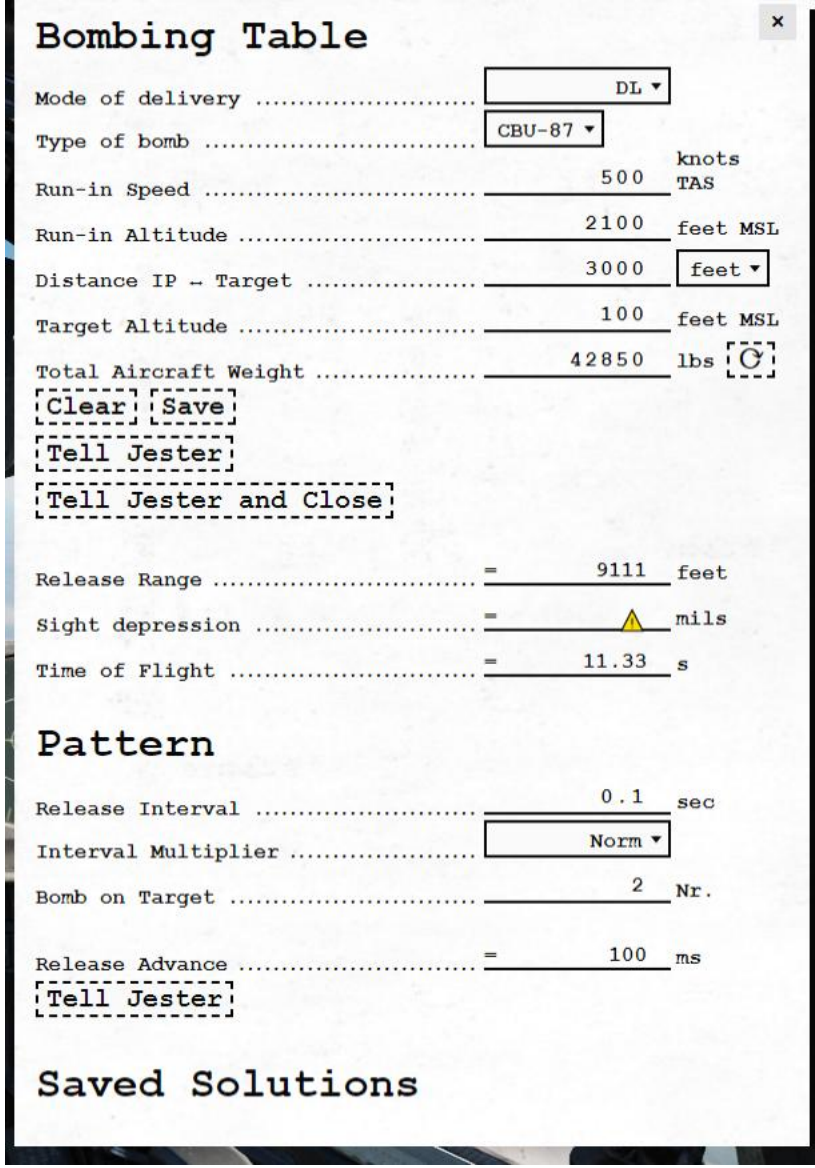
A – Determine Attack Profile

2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
   a) Select DL (Dive Laydown) Mode of delivery
   b) Select CBU-87 Type of Bomb
   c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
   d) Distance from Ingress Point to Target (IP-Target Range) is **not applicable to Dive Laydown delivery**
   e) Select Target Altitude: 100 ft MSL (Mean Sea Level) – Obtained from F10 map
   f) Select Release Altitude: 2100 ft (MSL, Mean Sea Level)
      - Release Altitude (MSL) = Target Altitude (MSL) + Release Altitude (AGL, Above Ground Level)
        2100 ft MSL = 100 ft MSL + 2000 ft AGL
   g) Click on the Refresh button to calculate total aircraft weight: 42850 lbs
   h) Click SAVE.
   i) Release Range is calculated automatically: 9111 ft
   j) Sight Depression is **not applicable to Dive Laydown delivery**
   k) If applicable (ripple bombing), select Bomb Number of Pattern on Target: As desired, 2nd Bomb (of a total pattern of 2 bombs being dropped)
   l) If applicable (ripple bombing), select Release Interval: 0.1 sec
   m) If applicable (ripple bombing), select Interval Multiplier: NORM.
   n) Release Advance is calculated automatically: 100 ms
   Note: See Release Advance Setting & Bombing Pattern explanation here.
   o) If using the JESTER AI as the WSO, click TELL JESTER to set the Release Advance and Release Range in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

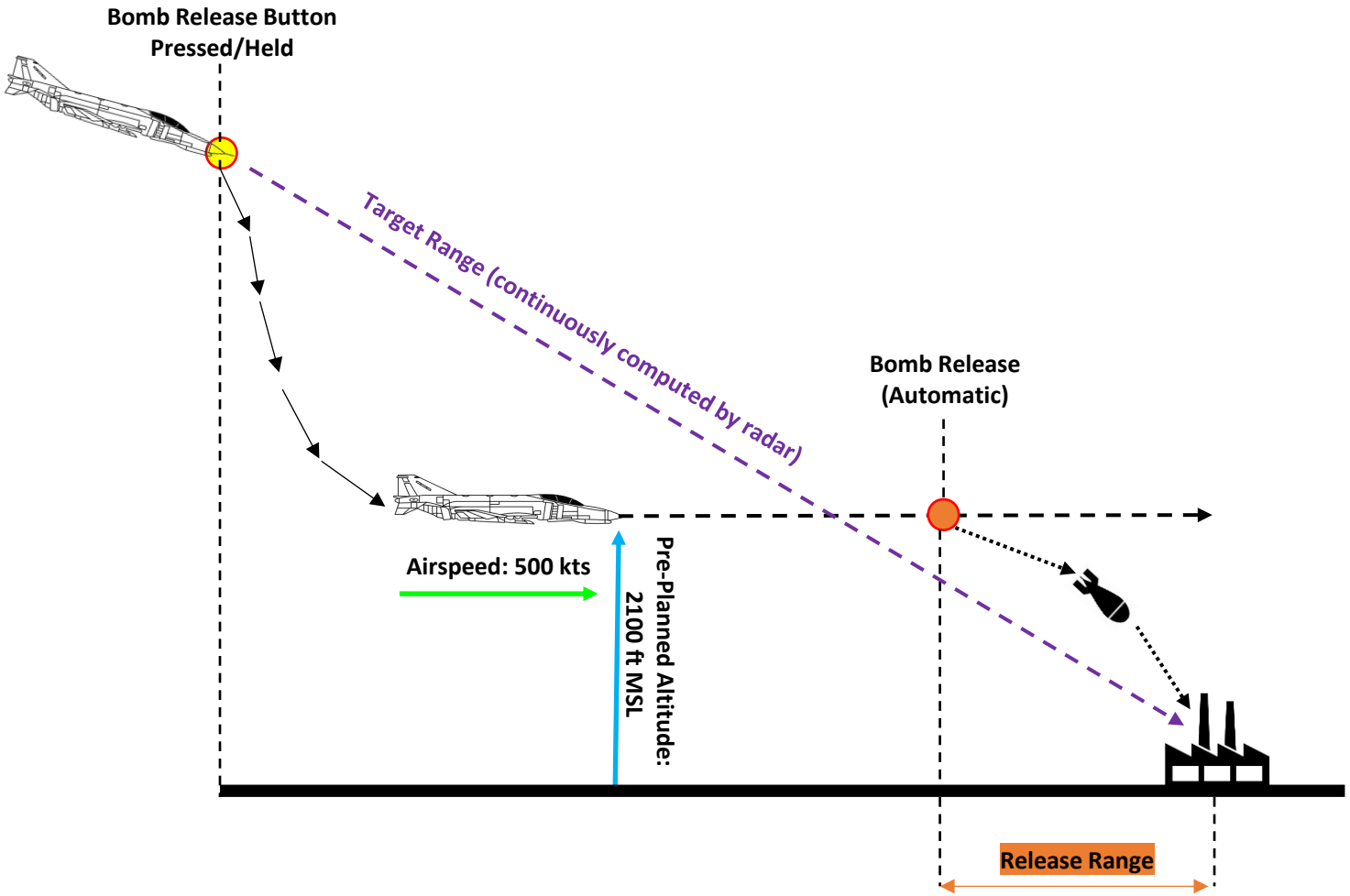
CBU-87 Cluster Munitions *Dive Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2100 ft	Interval Multiplier: Normal (x1)
Target Elevation: 100 ft MSL	Bomb # of Pattern on Target: 2
Total Aircraft Weight: 42850 lbs	

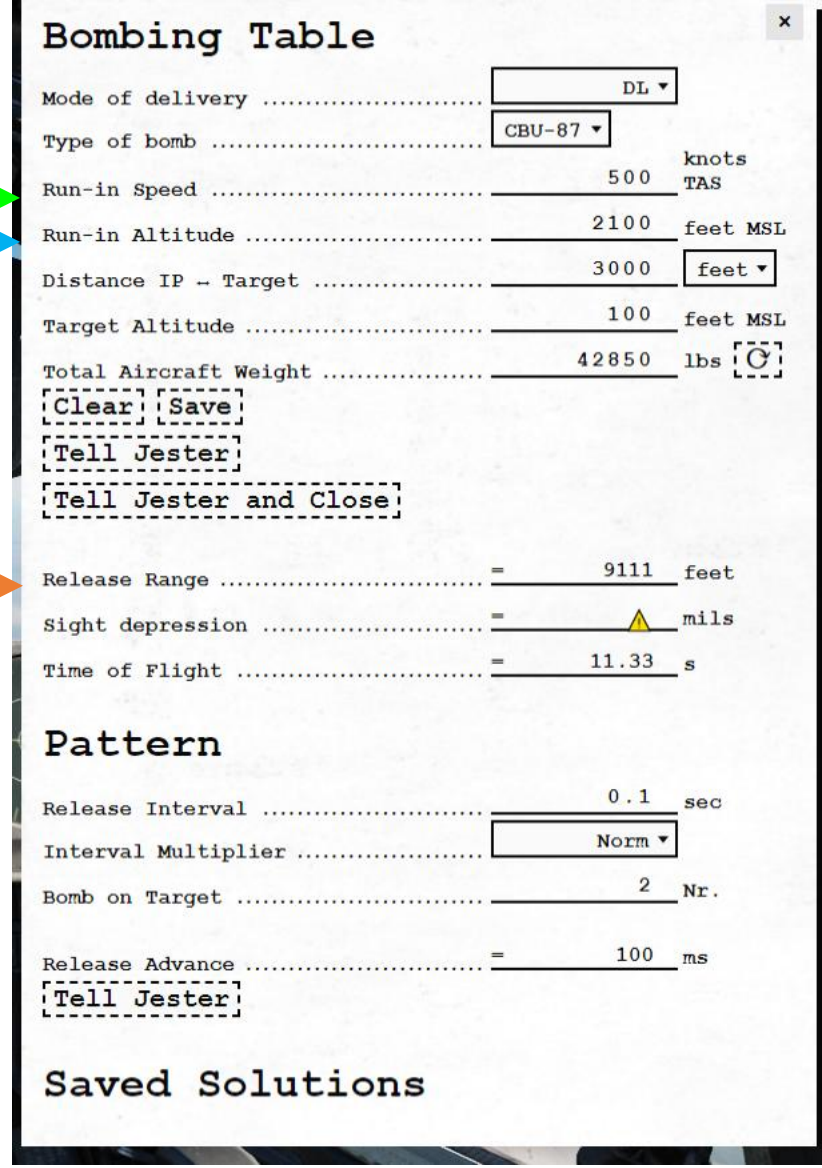
CBU-87 Cluster Munitions *Dive Laydown Mode*	
Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
Release Range: 9111 ft	Release Advance: 100 ms



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

A – Determine Attack Profile



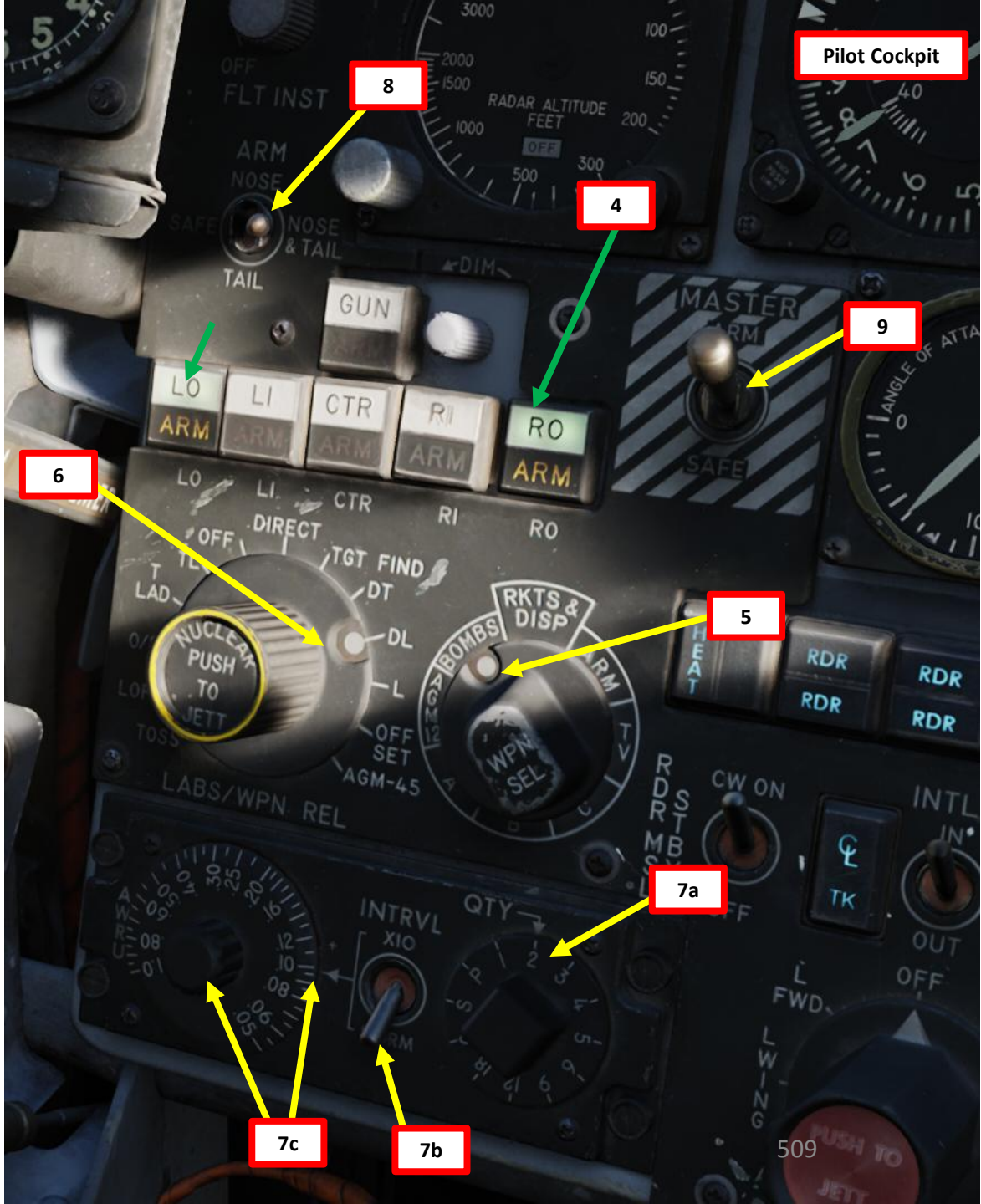


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

B – Weapon Setup

4. *[P]* Select desired Station Select Buttons. We will use LO and RO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
5. *[P]* Set Weapon Selector Knob – BOMBS
6. *[P]* Set Air-to-Ground Weapon Delivery Mode – L (Laydown)
7. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop a total of 2 bombs)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
8. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
   - N/T (Nose & Tail): Bomblets dispense using altitude proximity fuze setting
   - NOSE: Bomblets dispense after a preset timer (selectable on ground between 1.39 and 4.25 seconds)
   - TAIL: Dud (Disarmed)
9. *[P]* Set Master Arm Switch – ARMED (UP)

CBU-87 Cluster Munitions *Dive Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2100 ft	Interval Multiplier: Normal (x1)
Target Elevation: 100 ft MSL	Bomb # of Pattern on Target: 2
Total Aircraft Weight: 42850 lbs	

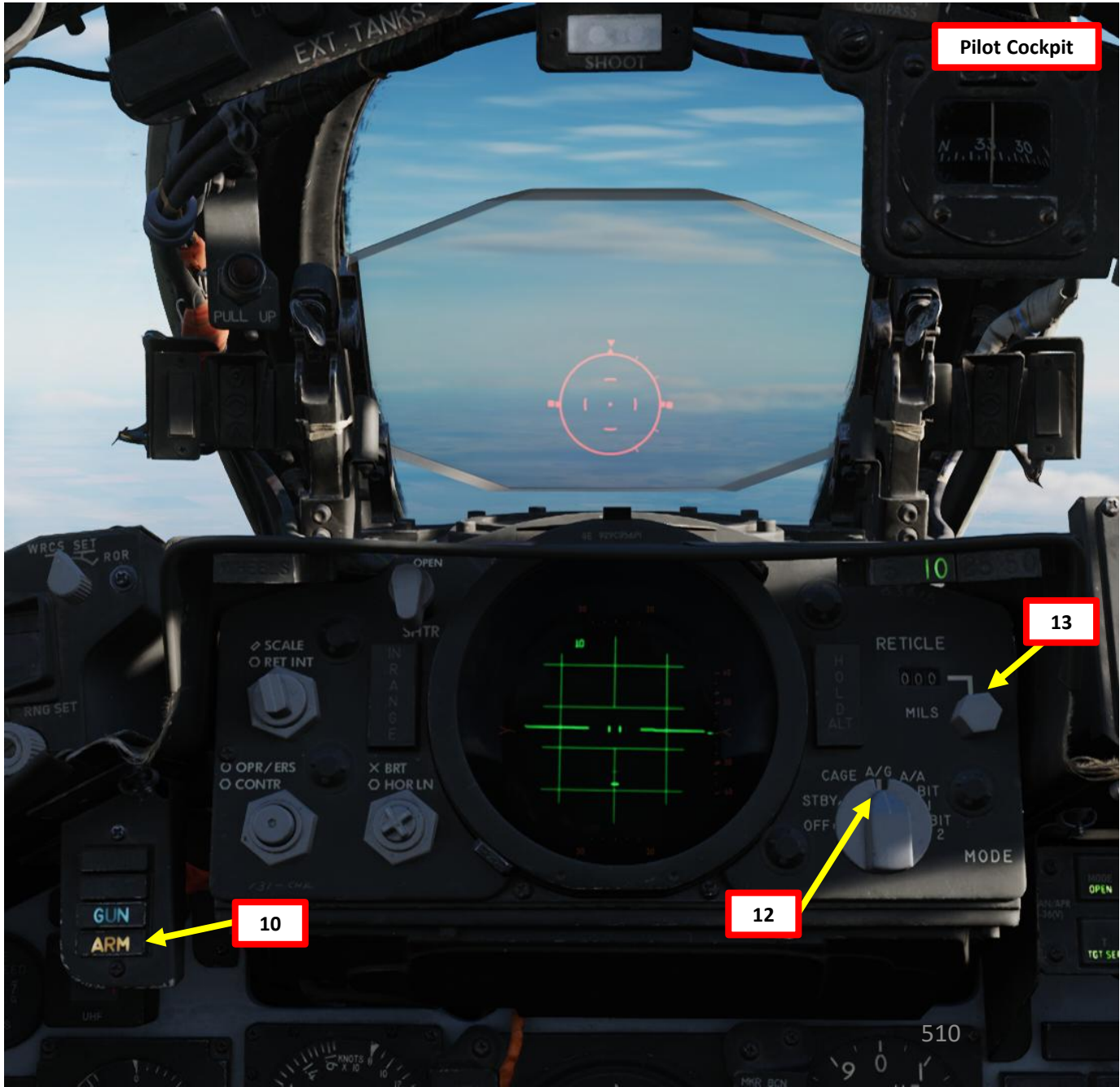


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

B – Weapon Setup

10. *[P]* Confirm ARM light is illuminated
11. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).
12. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
13. *[P]* In Dive Laydown Mode, the reticle automatically cages in elevation along the RBL (Radar Boresight Line). You can leave the Reticle Depression Setting Knob to 0 Mils.





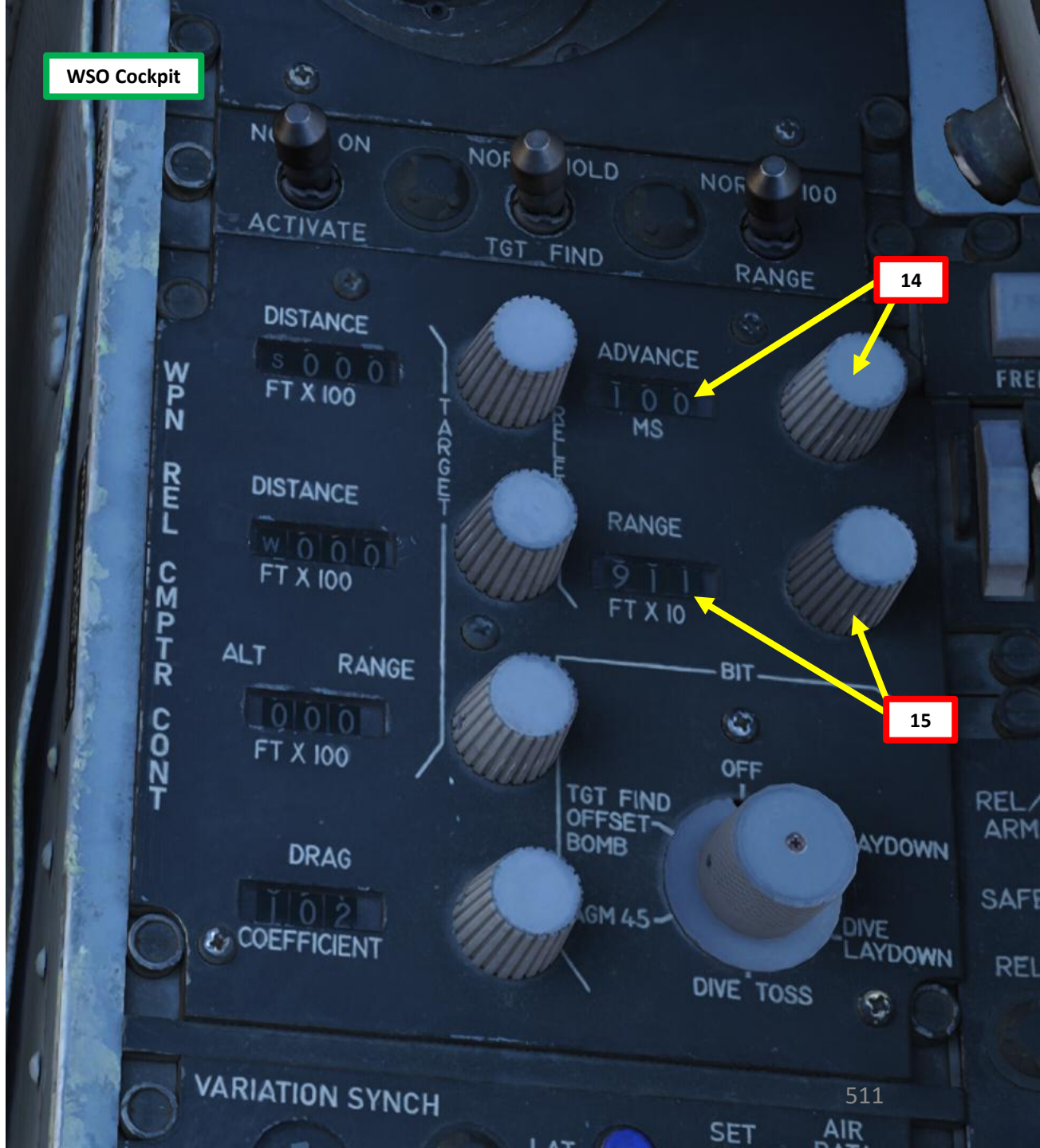
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

B – Weapon Setup

Note: These steps can be performed by JESTER.

14. *[WSO]* Set Release Advance Setting: 100 ms (value computed from Bombing Table).
15. *[WSO]* Set Release Range Setting: 9111 ft (value computed from Bombing Table).

CBU-87 Cluster Munitions *Dive Laydown Mode*		
	Delivery Output from Bombing Calculator	**Pattern Output from Bombing Calculator**
15	Release Range: 9111 ft	Release Advance: 100 ms

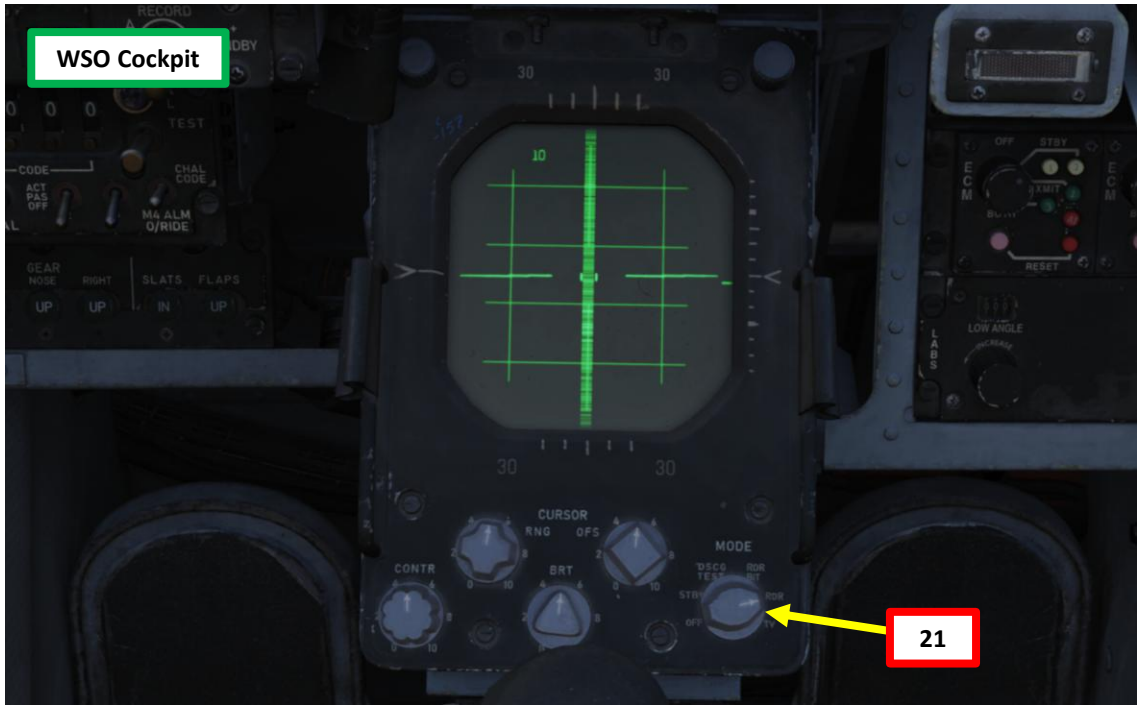


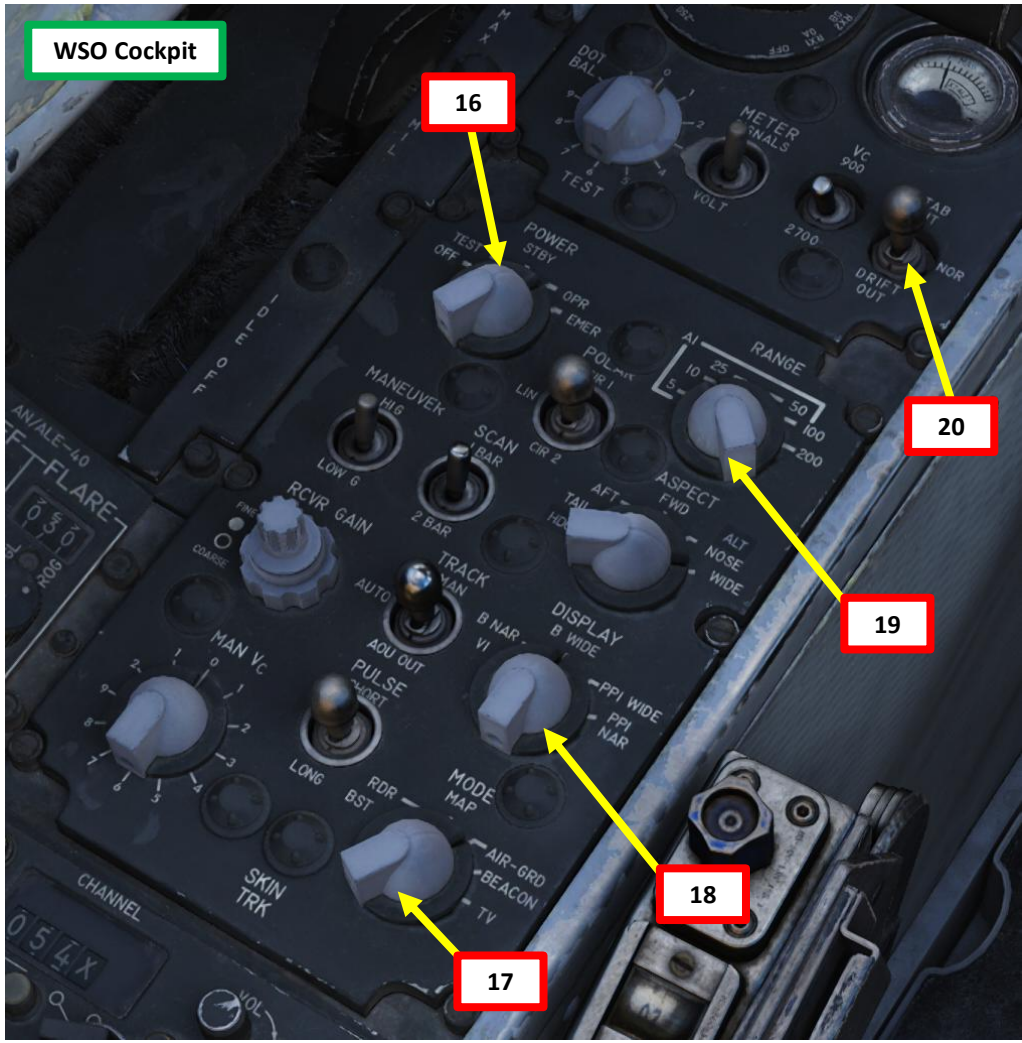
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

B – Weapon Setup

Note: These steps can be performed by JESTER.

16. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
17. *[WSO]* Set Radar Operation Mode – AIR-GRD (Air-to-Ground).
    - In this mode, the radar antenna is fixed to the radar boresight while also being stabilized in drift. AIR-GRD mode disables Angle Track operation and only uses Range Track. Once locked on the main lobe clutter (ground radar echo), it will be tracked in range.
18. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE.
19. *[WSO]* Set Radar Range Selector – 5 nm or 10 nm settings only. In this example, we will select 10 nm.
20. *[WSO]* Set Stab (Antenna Stabilization Mode) Switch – NORMAL (MIDDLE)
    - In case of an INS (Inertial Navigation System) failure, you can remove the drift correction by setting the Stab Switch to DRIFT OUT (AFT).
21. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).

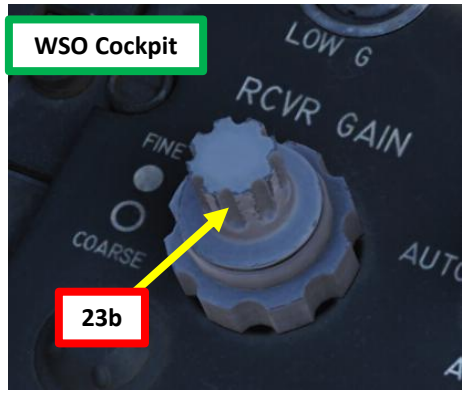


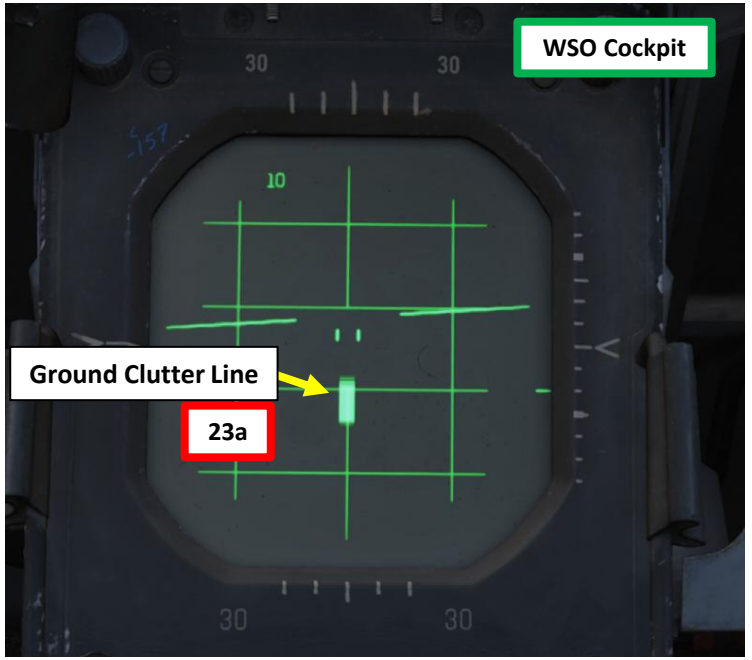


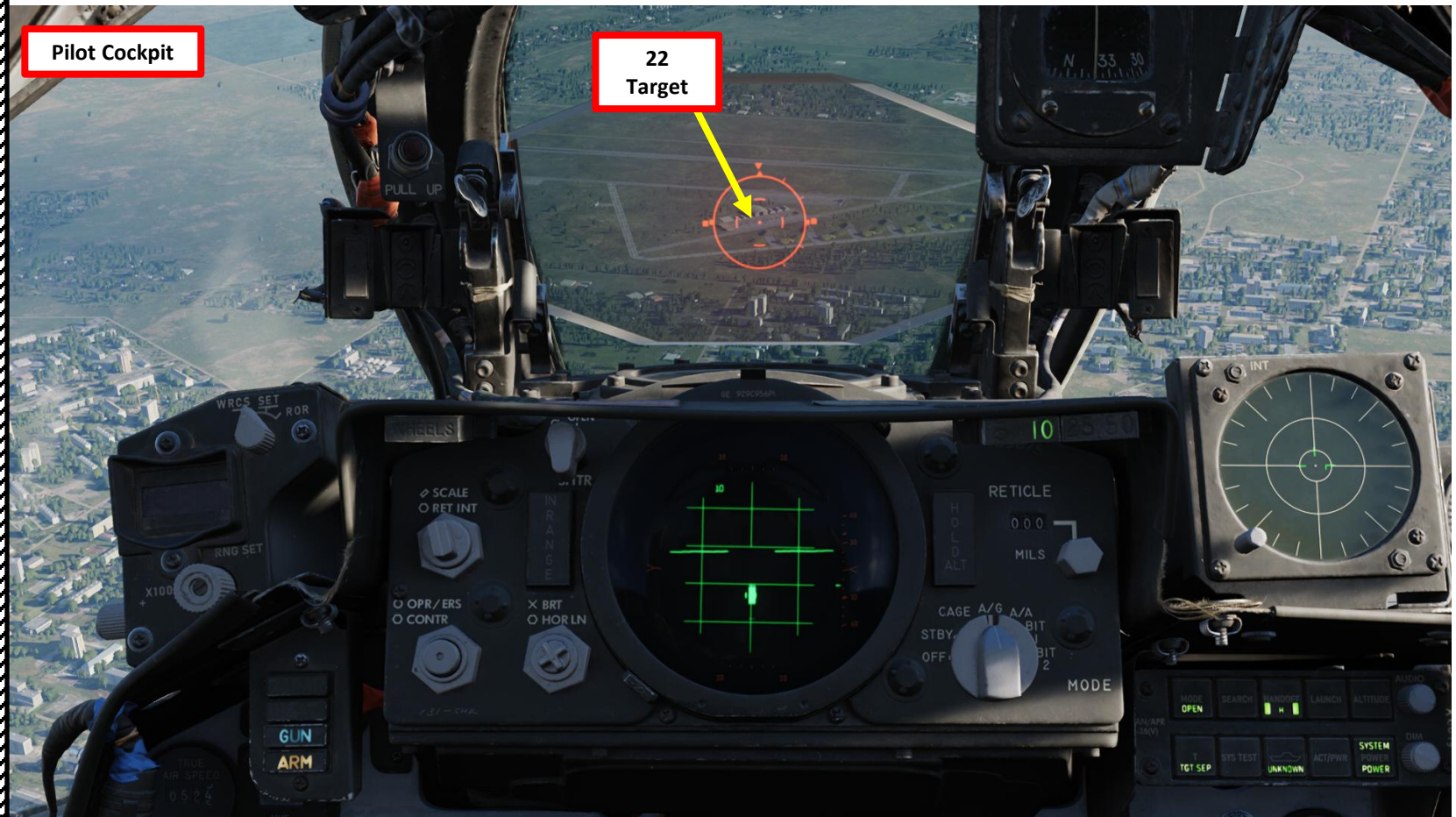
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

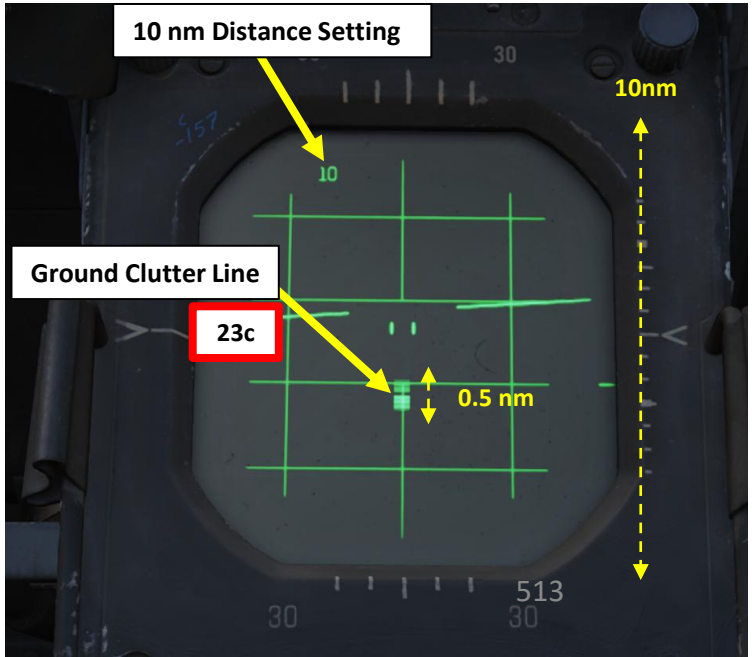
C – Perform Attack

22. *[P]* Once the target has been identified, throttle down, perform a 30-40 deg dive towards the target.
23. *[WSO]* As the aircraft is diving, adjust receiver gain to reduce radar clutter signal to 0.5 nm. This is done to prevent erroneous track of sidelobes which would result in incorrect ranging information.
    - In this example, we have a distance setting of 10 nm, therefore the ground clutter "line" should be as shown.





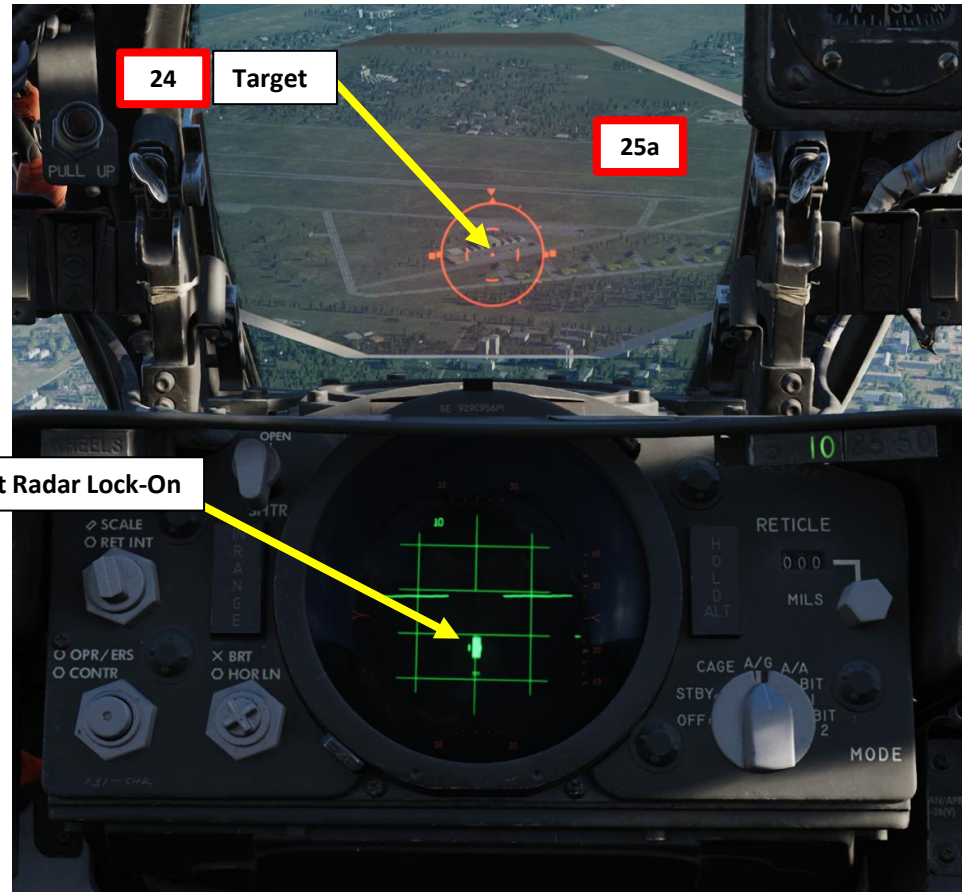


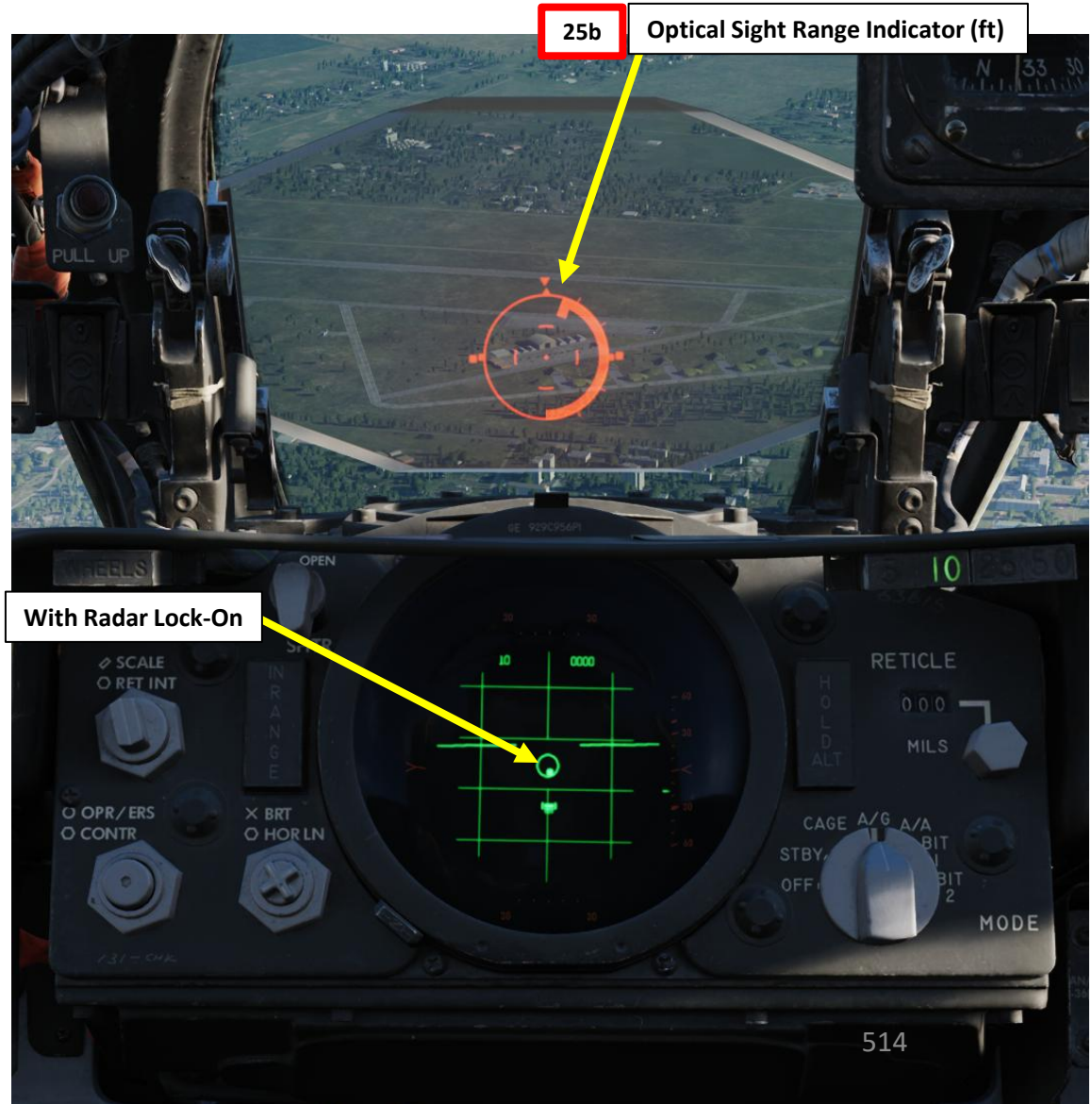


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

C – Perform Attack

24. *[P]* Steer aircraft to set the reticle on the target.
25. *[P]* When aircraft is stabilized and reticle is roughly on target, command JESTER to perform a radar lock on the target by using the JESTER Context Action binding ("V").
    - Once radar lock-on is acquired, the WSO should call out "Captured". Target range information should now be provided by the radar on the radar scope and on the optical sight as well.
    - Note: The radar lock-on process **in multicrew** is explained in more detail in the next page.





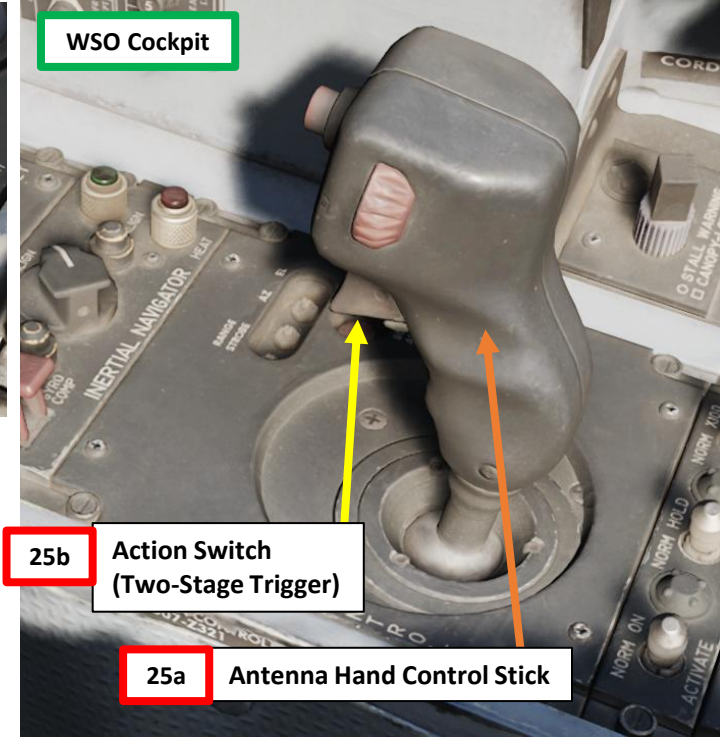
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

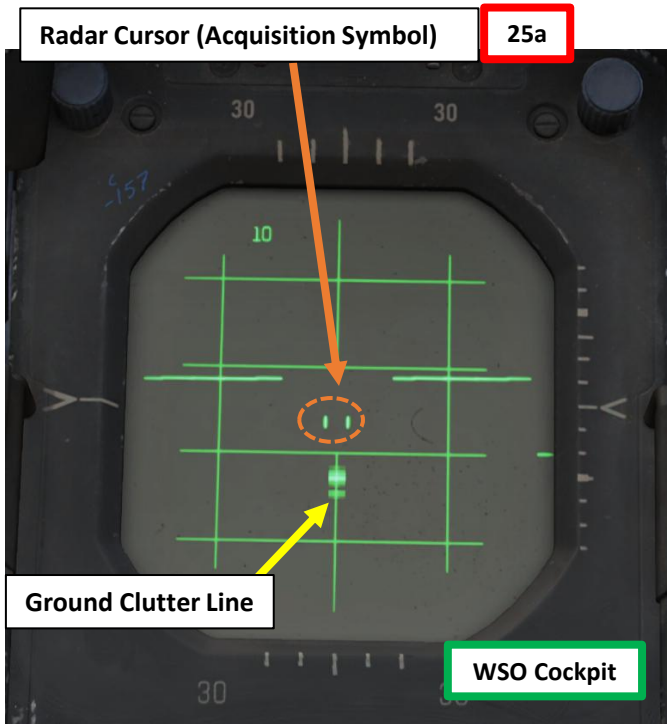
C – Perform Attack

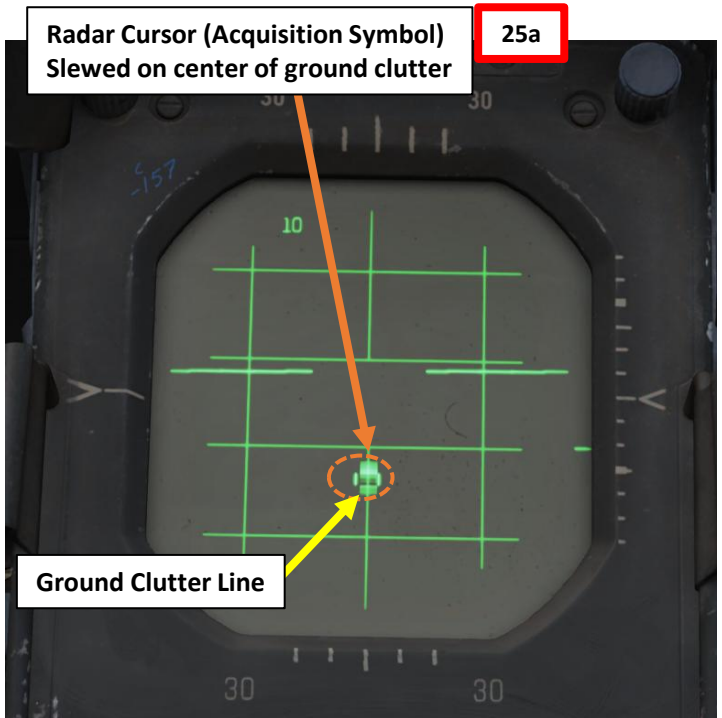
25. *[WSO]* To acquire radar lock-on on the target:
    a. Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the center of the ground clutter signal.
    b. Once the radar cursor is slewed over the ground clutter, press the Hand Control Stick Trigger's second detent (Full-Action). Release once the ASE (Allowable Steering Error) Circle becomes visible.
    c. Confirm radar lock-on, then call out to the pilot "Captured".
    d. Target range information should now be provided by the radar on the radar scope and on the optical sight as well.

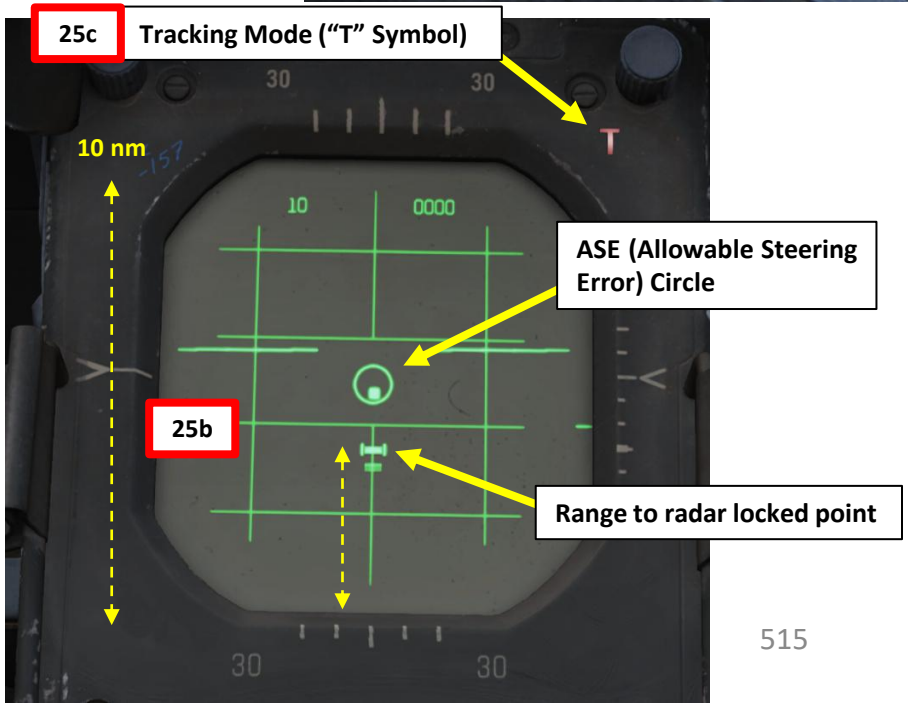
Note: Sometimes, false tracking can occur, which is indicated by a rapid decrease in slant range displayed on either the pilot's optical sight or the radar display. To correct this condition the following actions can be taken:
- Press Action Switch to half action, then release. Then, begin acquisition process again.









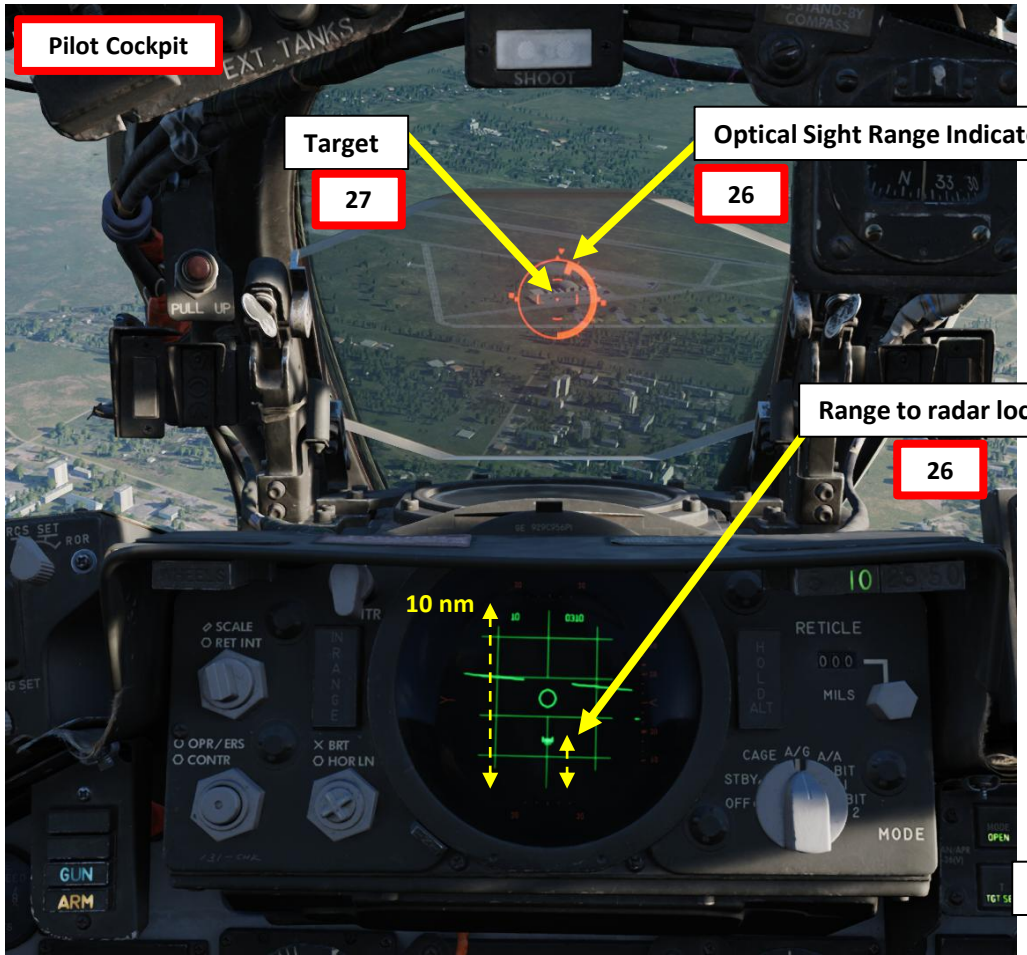


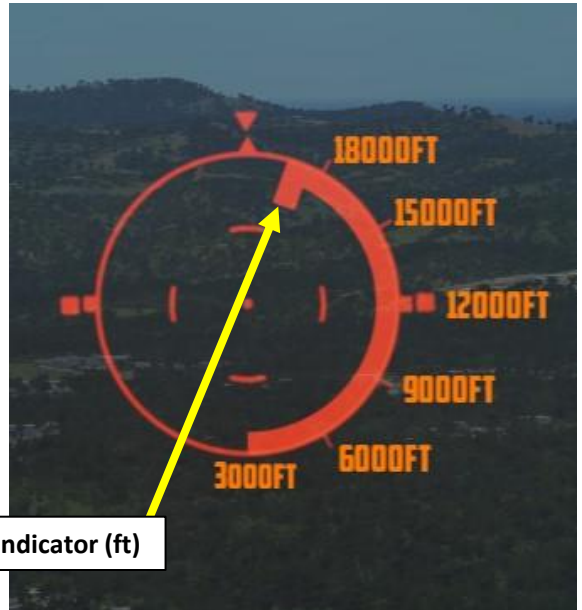
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

C – Perform Attack

26. *[P]* Once radar lock-on is achieved, target range information is provided by the radar on the radar scope and on the optical sight as well.
27. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
28. *[P]* Once the reticle is stabilized on target, **press and hold** the Bomb Release Button (RALT+SPACEBAR) to insert radar range to the WRCS (Weapon Release Computer Set), and then begin diving down to the attack profile's release altitude (2100 ft MSL), maintaining wings level.









2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

C – Perform Attack

29. *[P]* An audio tone indicates that the WRCS (Weapon Release Computer Set) has accepted the range from the radar when the bomb release button is pressed. This tone stays on until the munitions release automatically or the bomb release button is released.
30. *[P]* After the bomb release button is pressed, radar ground lock is no longer required.
31. *[P]* Dive down to the attack profile's release altitude (2100 ft MSL), maintaining wings level and an airspeed of 500 KTAS.

Remember: Bomb Release Button should be held all the way until munitions release.

CBU-87 Cluster Munitions *Dive Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2100 ft	Interval Multiplier: Normal (x1)
Target Elevation: 100 ft MSL	Bomb # of Pattern on Target: 2
Total Aircraft Weight: 42850 lbs	





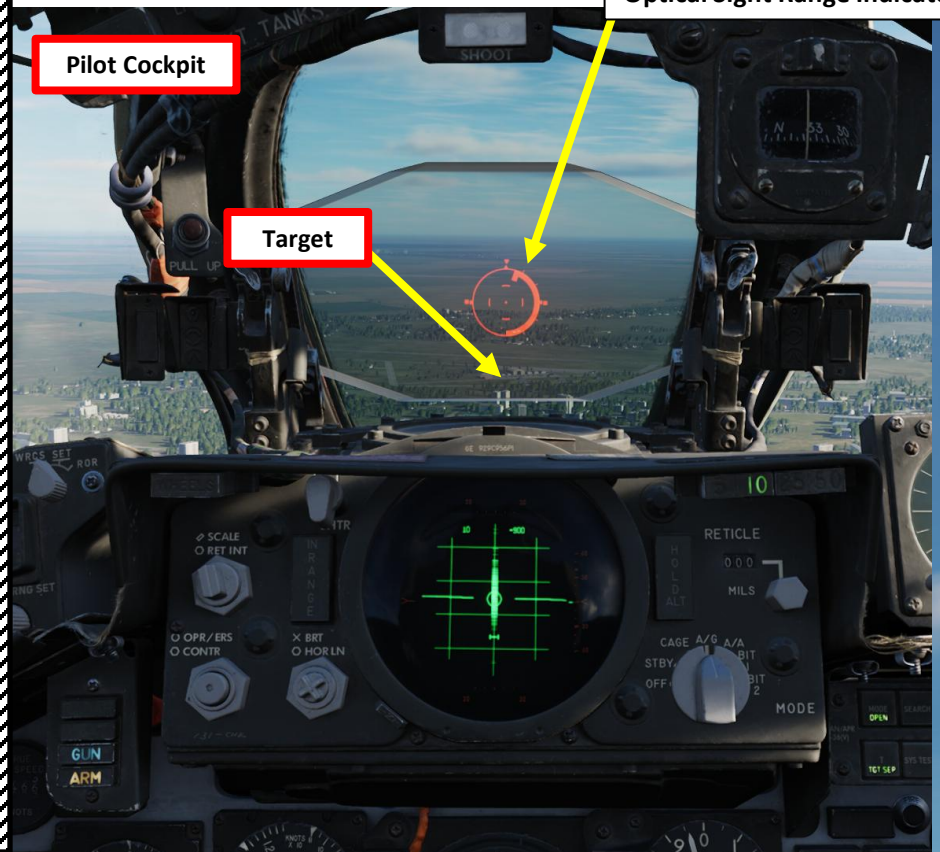
2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

C – Perform Attack

32. *[P]* Once at the release altitude, level off and maintain altitude and attack speed (500 KTAS) until munitions are released automatically. Flying by these numbers is very important since the INS (Inertial Navigation System), radar and WRCS (Weapon Release Computer Set) use this information to compute when munitions are to be released.

Remember: Bomb Release Button should be held all the way until munitions release.

CBU-87 Cluster Munitions *Dive Laydown Mode*	
Delivery Input Parameters	**Bombing Pattern Input Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.1 sec
Release Altitude (AGL): 2000 ft Release Altitude (MSL): 2100 ft	Interval Multiplier: Normal (x1)
Target Elevation: 100 ft MSL	Bomb # of Pattern on Target: 2
Total Aircraft Weight: 42850 lbs	





2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.2 – CBU-87: Dive Laydown (DL) Mode

C – Perform Attack

33. *[P]* When all munitions are released, begin pullout maneuver, maintaining wings level. This safe-escape manoeuver will avoid flying the aircraft into the frag envelope and suffering potential fragmentation damage







2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

A – Determine Attack Profile

- Compared to other cluster munitions, the CBU-1 is one of the older, more obscure types of ordnance. They are dispensers with 19 tubes, each loaded with either 27 BLU-4B, 19 BLU-3 or 22 BLU-3B HE bomblets. Technically, CBU-1s have more similarities with a rocket launcher than they have with a conventional bomb since tubes launch bomblets behind the aircraft.

- Upon impact with the ground, each bomblet discharges high velocity fragments in a radial pattern. In the case of the CBU-2/A and CBU-2B/A, the carried BLU-3 bomblets are loaded with steel balls suitable even for unarmored vehicles. The CBU-1A/A, carrying BLU-4B bomblets, is loaded with anti-personnel shrapnel material.

- With CBU-1, we will employ Direct Mode and fly a level bombing run at 100 ft above ground level and an airspeed of 400 kts.

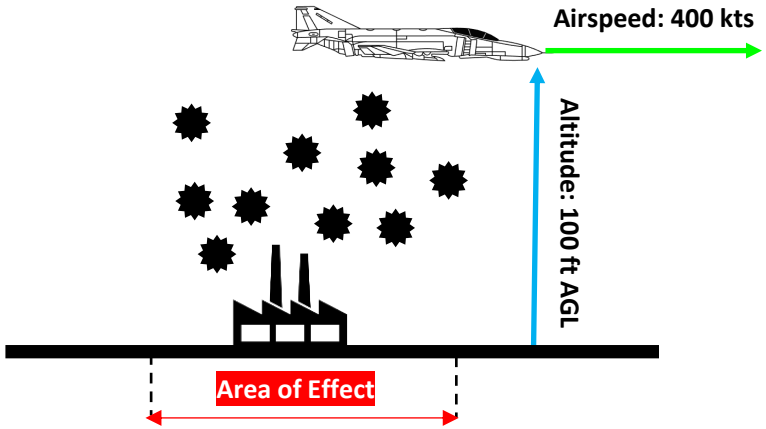
In this tutorial, we want to use two CBU-1A/A dispensers (ripple release) at an interval of 0.1 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.









2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

B – Weapon Setup

2. *[P]* Select desired Station Select Buttons. We will use LO and RO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – RKTS & DISP (Rockets & Dispensers)
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
5. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (C, Continuous)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.1 sec
6. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
7. *[P]* Set Master Arm Switch – ARMED (UP)

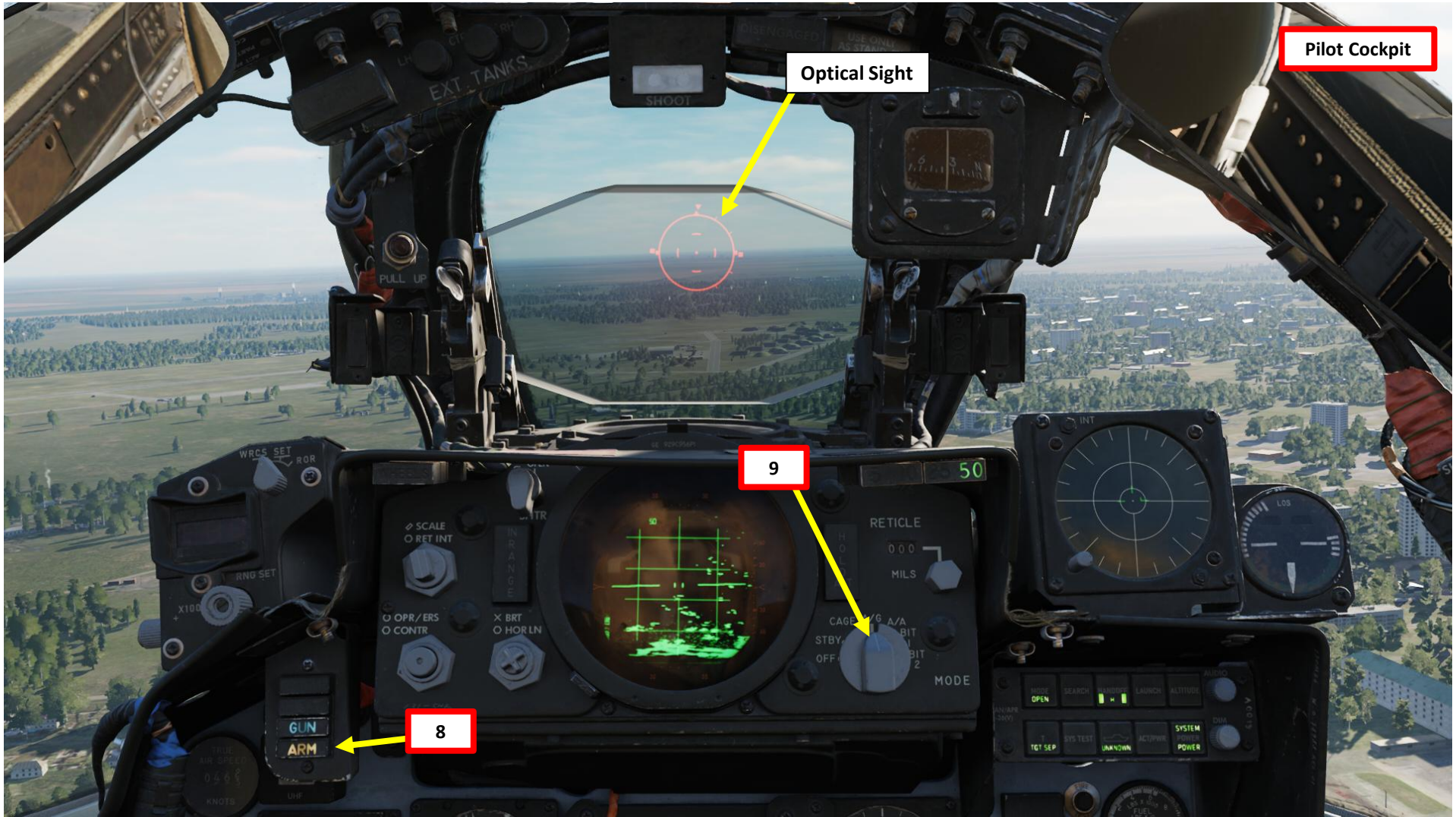
CBU-1 Cluster Munitions *Direct/Manual Mode*	
Delivery Parameters	**Bombing Pattern Parameters** *(only if releasing multiple bombs)*
Airspeed: 450 KTAS / 400 KIAS	Release Interval: 0.1 sec
Release Angle: 0 deg (Level)	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 100 ft	Quantity Setting: C (Continuous)



2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

B – Weapon Setup

8. *[P]* Confirm ARM light is illuminated
9. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)

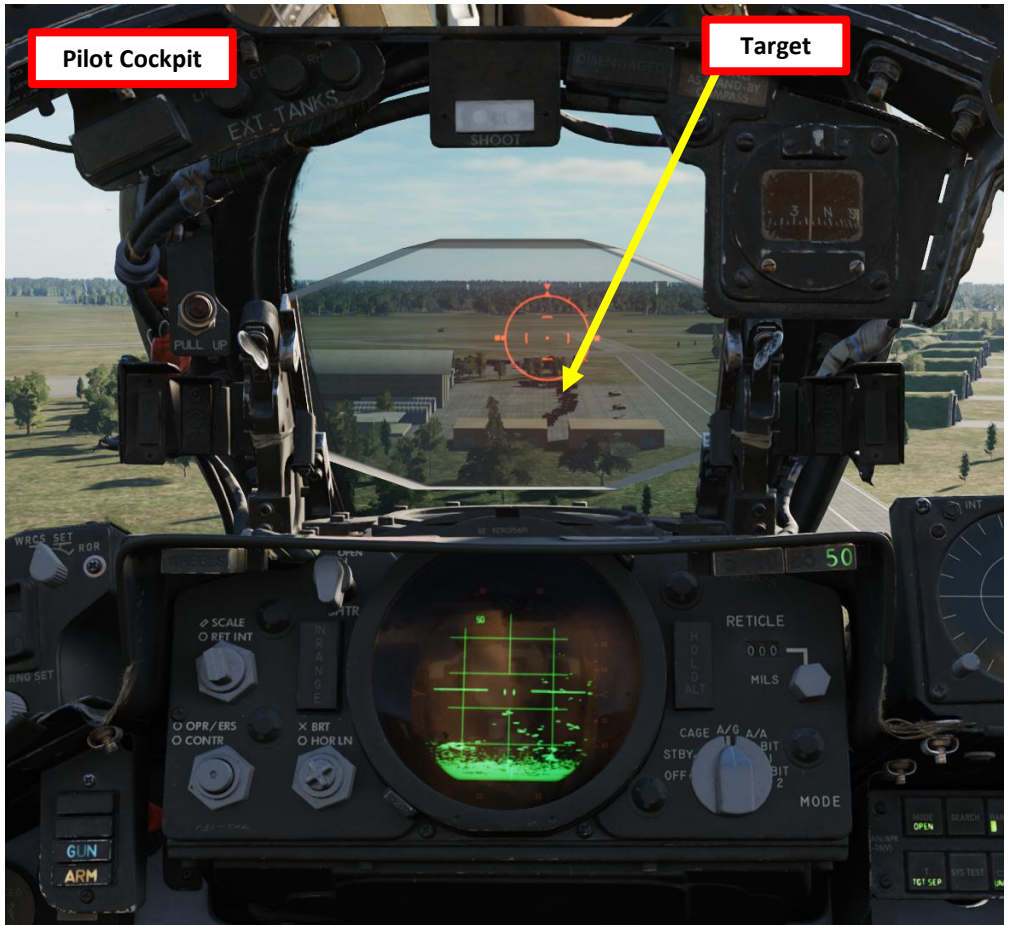


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

C – Perform Attack

10. *[P]* Once the target has been identified, set throttle to maintain 400 kts indicated and an altitude of 100 ft AGL. Prepare to fly over the target while maintaining wings level.

CBU-1 Cluster Munitions *Direct/Manual Mode*	
Delivery Parameters	**Bombing Pattern Parameters** *(only if releasing multiple bombs)*
Airspeed: 450 KTAS / 400 KIAS	Release Interval: 0.1 sec
Release Angle: 0 deg (Level)	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 100 ft	Quantity Setting: C (Continuous)





2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

C – Perform Attack

11. *[P]* When overflying the target at 100 ft AGL and 400 kts indicated, press and hold the Bomb Release Button (RALT+SPACEBAR) until all munitions are dispensed.
    - Yes, you will have to eyeball it.
12. *[P]* Maintain a straight line flight path while munitions are dispensed and for at least 2 seconds after release. Upon impact with the ground, each bomblet discharges high velocity fragments in a radial pattern.



Bomb Release Button
- *Binding: RALT+SPACEBAR*





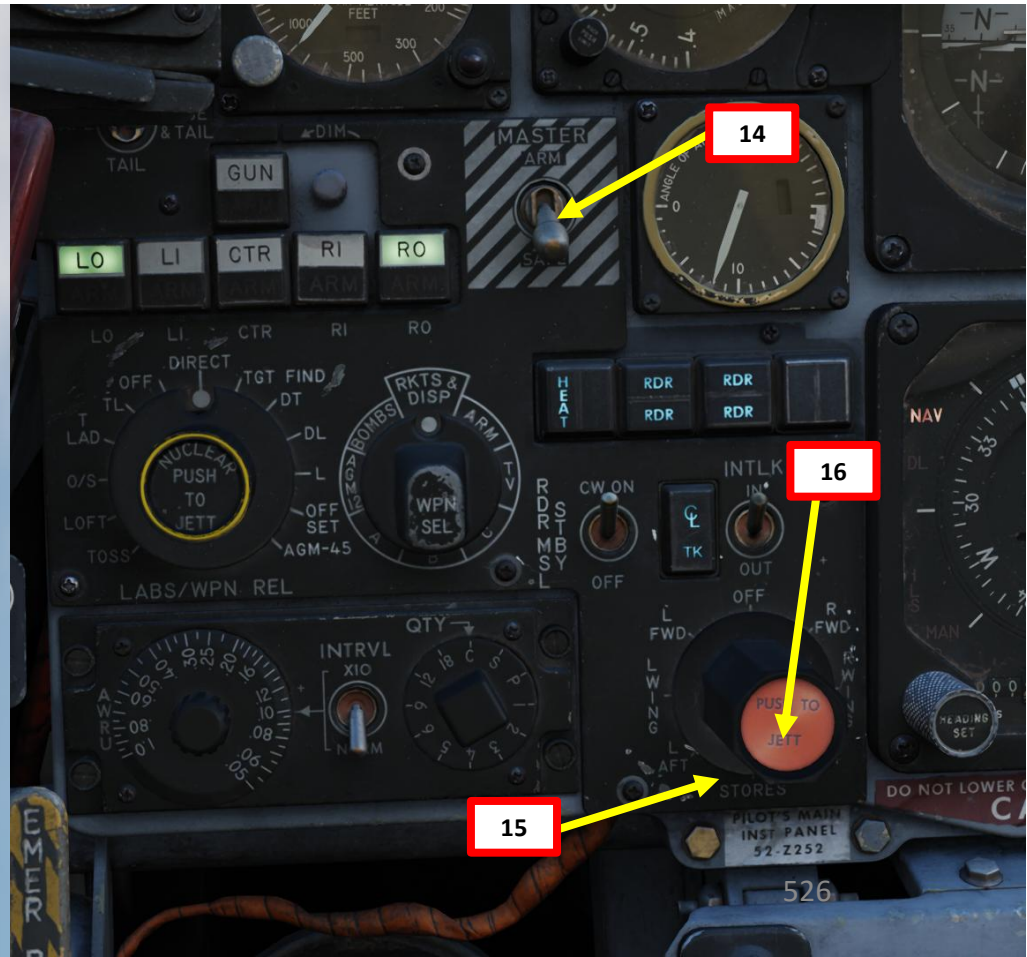


2 – AIR-TO-GROUND WEAPONS
2.2 – Cluster Munitions
2.2.3 – CBU-1A/A: Direct Mode

D – Jettison Dispensers

13. *[P]* After munitions have been dispensed, it is recommended to jettison the dispensers to prevent possible damage to the aircraft/runway caused by hung sub-munitions which may fall out upon landing.
14. *[P]* Set Master Arm Switch – SAFE (DOWN)
15. *[P]* Set Selective Jettison Control Knob – STORES (DOWN position).
    - This setting releases all weapon racks, rounds or drop tanks selected on the station buttons upon pressing PUSH TO JETT.
16. *[P]* Press the PUSH TO JETT button – IN. This will jettison the dispenser racks.





2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1 – GBU-12 Paveway II

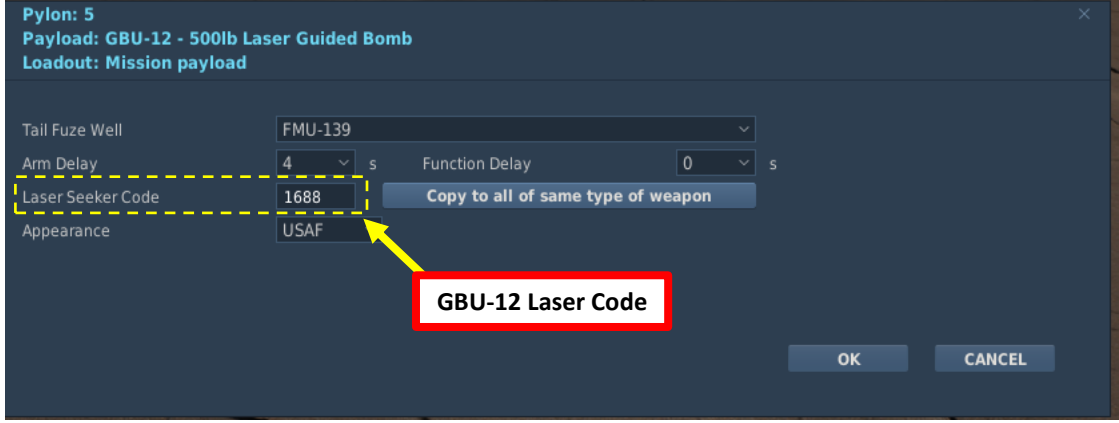


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1 – GBU-12 Paveway II

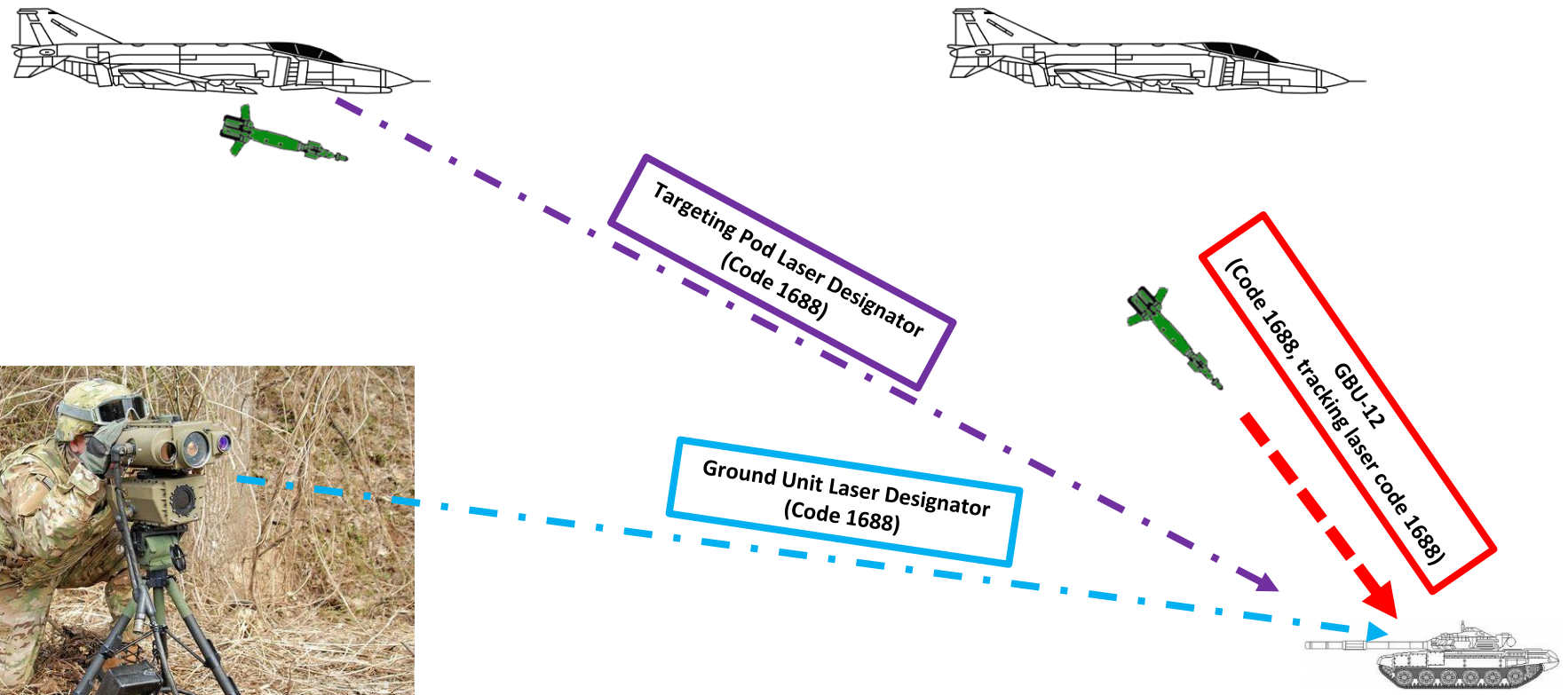
Introduction to Laser-Guided Bombs

The GBU-12 Paveway II is the laser-guided version of the Mk-82 unguided, general purpose bomb. The GBU-12 guides using the same principles as the GBU-10, the only difference being the bomb the LGB is based on. The seeker head on each laser guided bomb is set to track only a specific laser pulse rate frequency (PRF) code. These are manually set by the weapons load crew during ground operations (via Mission Editor) and may not be set from the cockpit during flight.

The F-4E can rely on a ground unit (or a friendly aircraft equipped with a targeting pod with its own laser designator) to lase the target if no targeting pod is equipped. The Pave Spike targeting pod has laser designator capability as well. The laser code of the GBU-12 must be the same as the laser code of the laser designator.





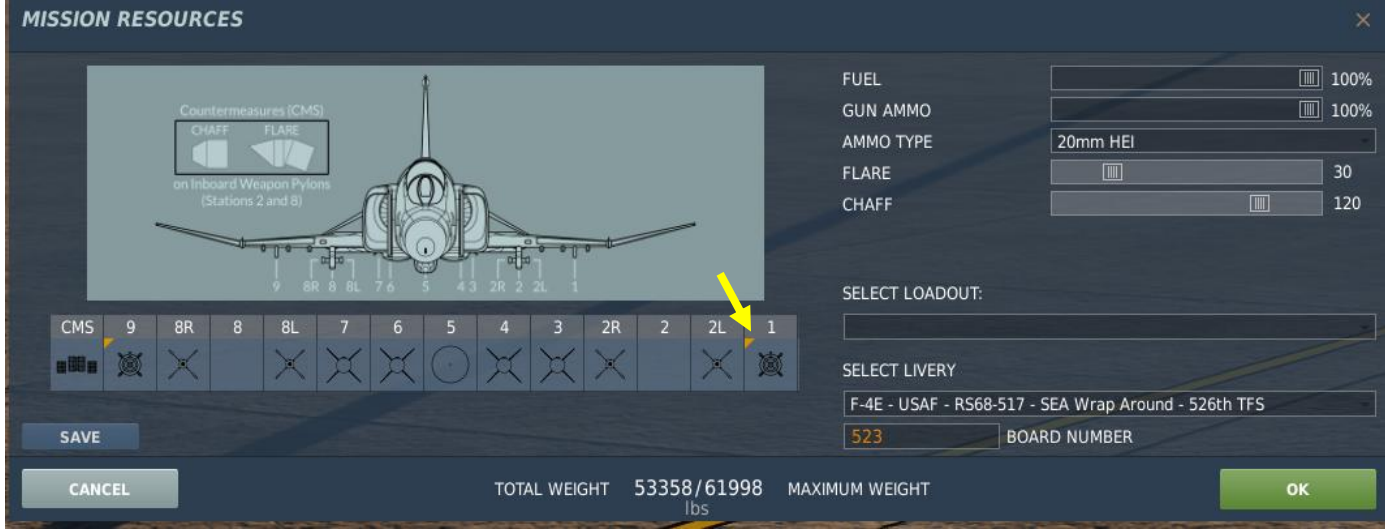


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1 – GBU-12 Paveway II

Setting GBU-12 Laser Code

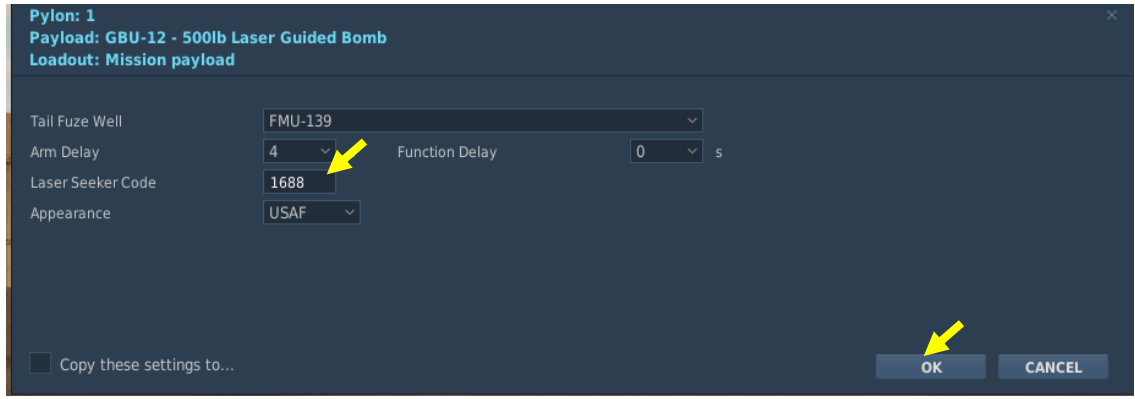
The GBU-12 laser code can currently be set from the Ground Crew menu. Laser code is changed by clicking on the yellow triangle on the GBU-12 station. If you are flying in multiplayer and do not know your GBU-12 code, you can assume it is "1688" by default.

Take note that setting the bomb laser code should be done when the engine is shut down.





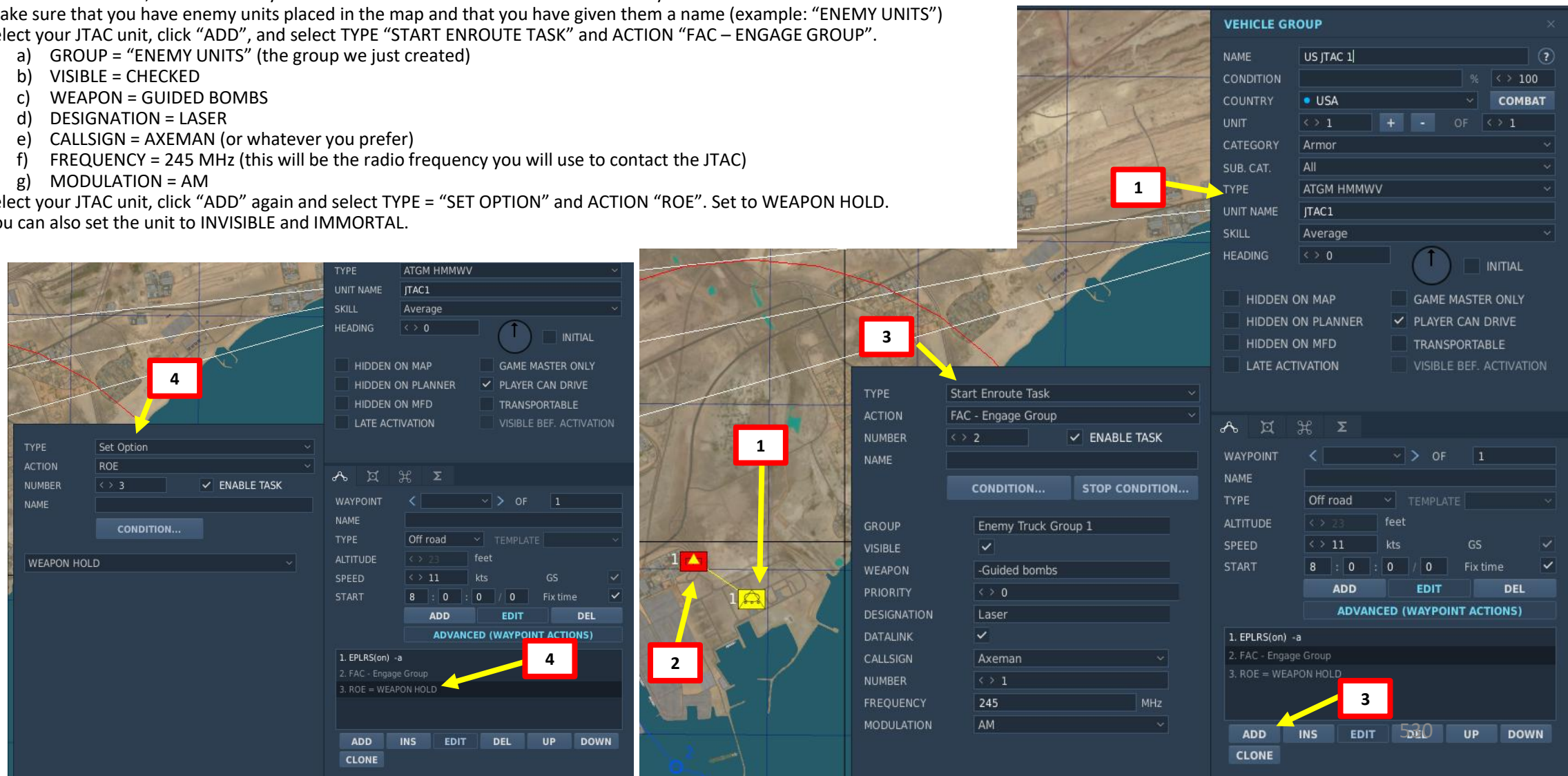




2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

A – Creation of a JTAC (Joint Terminal Attack Controller) to lase a target

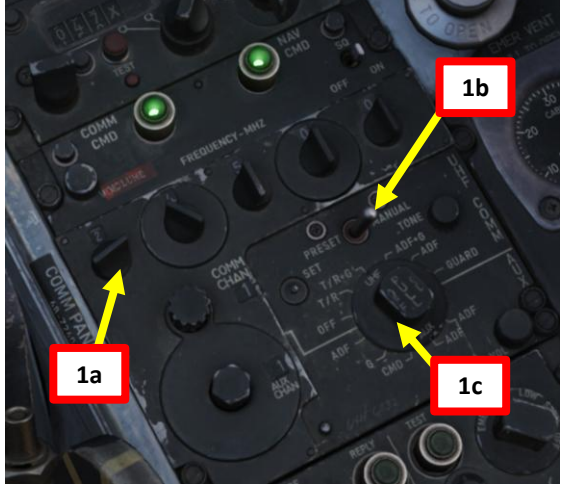
1. In the mission editor, insert a friendly "ATGM M1045 HMMWV TOW" unit. He will be your JTAC.
2. Make sure that you have enemy units placed in the map and that you have given them a name (example: "ENEMY UNITS")
3. Select your JTAC unit, click "ADD", and select TYPE "START ENROUTE TASK" and ACTION "FAC – ENGAGE GROUP".
    a) GROUP = "ENEMY UNITS" (the group we just created)
    b) VISIBLE = CHECKED
    c) WEAPON = GUIDED BOMBS
    d) DESIGNATION = LASER
    e) CALLSIGN = AXEMAN (or whatever you prefer)
    f) FREQUENCY = 245 MHz (this will be the radio frequency you will use to contact the JTAC)
    g) MODULATION = AM
4. Select your JTAC unit, click "ADD" again and select TYPE = "SET OPTION" and ACTION "ROE". Set to WEAPON HOLD.
5. You can also set the unit to INVISIBLE and IMMORTAL.

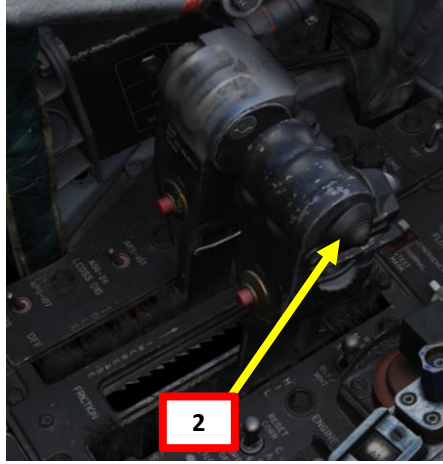


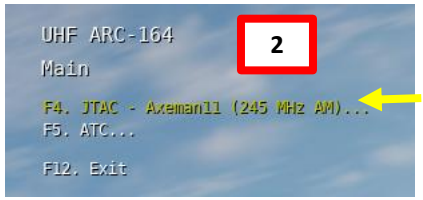
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

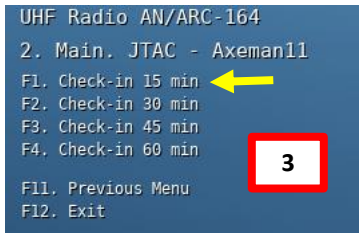
B – Contacting a JTAC (Joint Terminal Attack Controller) to request target lasing

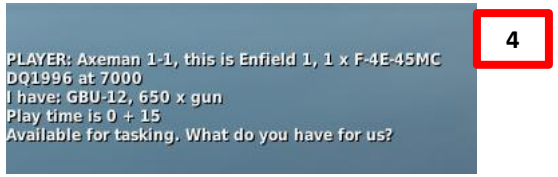
1. Set JTAC frequency to 245.00 MHz on the UHF radio.
2. Press "RSHIFT+\" (Microphone Push-to-Talk Switch – UHF) to communicate and select JTAC – AXEMAN (F4) in radio menu.
3. Select "CHECK-IN 15 MIN" (F1)
4. You will contact the JTAC and give him your altitude and ordnance available, plus your time available on station.
5. JTAC will answer "Type 2 in effect" and ask you when you are ready to receive a 9-liner.
6. Select "READY TO COPY" (F1) to receive 9-liner.
7. The JTAC will give you the 9-liner and ask you when you are ready for remarks.
8. Select "READY TO COPY REMARKS" (F1)
9. JTAC will give you remarks.
10. Select "9-LINE READBACK" to repeat the information you have been given and confirm it with the JTAC.
11. JTAC will confirm your readback and request you to tell him when you are inbound.
12. Select "IP INBOUND" (F1), the JTAC will tell you to CONTINUE or ABORT.
13. Select "LASER ON" to request the JTAC to lase targets.
14. Once targets are lased, you may now go on your bomb run.



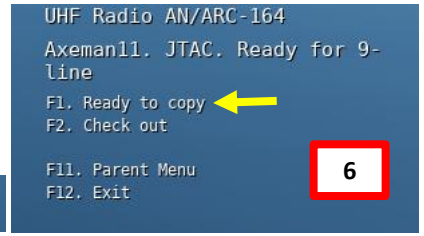


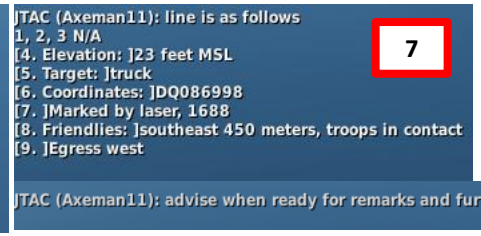


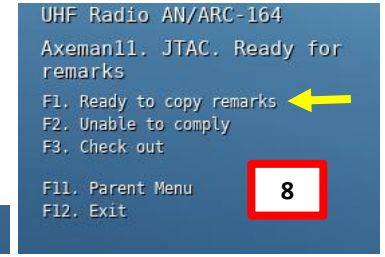


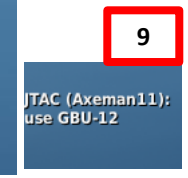


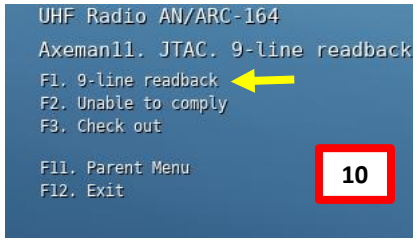




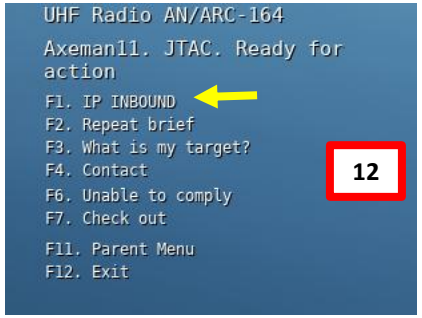


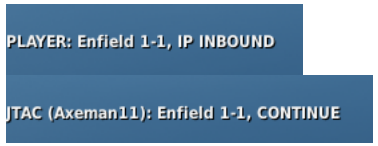


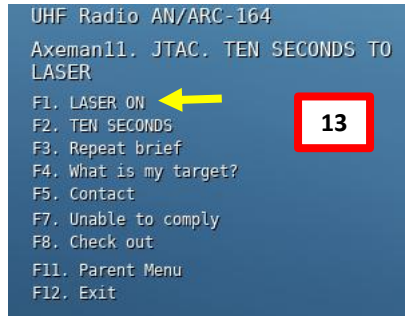














2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

B – Contacting a JTAC (Joint Terminal Attack Controller) to request target lasing

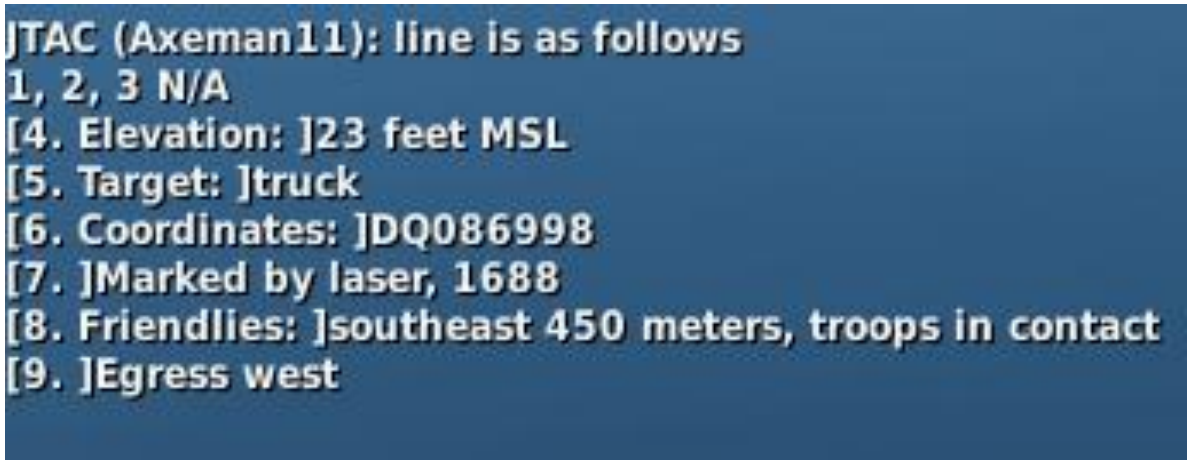
What is a CAS (Close Air Support) 9-liner and why is it important? The goal of a 9-liner is to provide you as much information as concisely as possible.

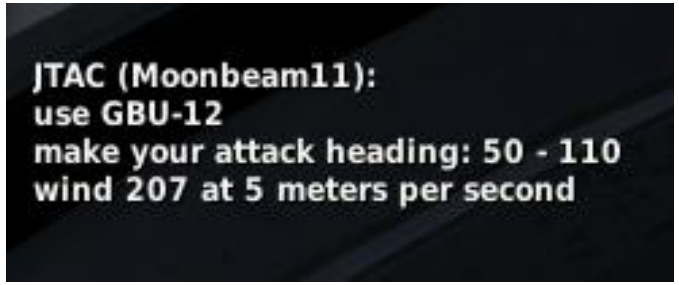
9-Liner

Line 1: IP/BP – Initial Point/Battle Position (N/A in our case)
Line 2: Heading from the IP to the Target (N/A in our case)
Line 3: Distance from the IP/BP to target (N/A in our case)
Line 4: Target elevation – 23 feet over Mean Sea Level (MSL)
Line 5: Target description: Truck.
Line 6: Target location: Grid coordinates of target
Line 7: Target Mark Type: Marked by laser on laser code 1688
Line 8: Location of Friendlies: JTAC located 450 meters Southeast of Target
Line 9: Egress semi-cardinal direction when departing from target: West

Remarks

Remarks generally include information about troops in contact or danger close, SEAD support in effect, hazards, weather or other threats. In our case, the JTAC wants us to use GBU-12s .





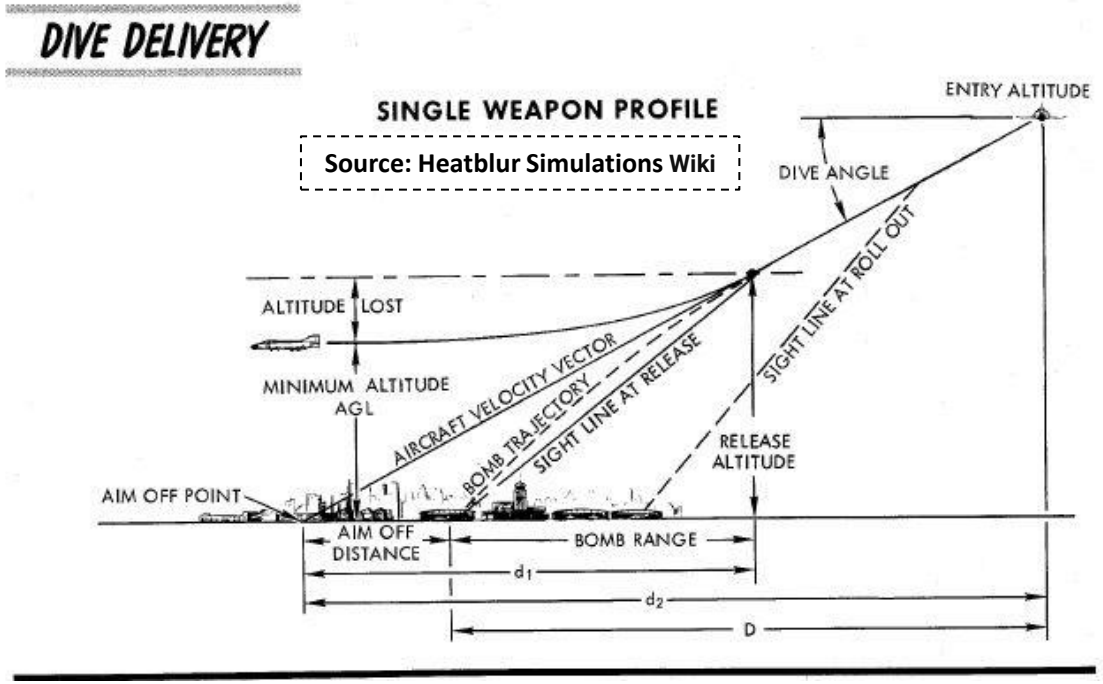
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

C – Determine Attack Profile

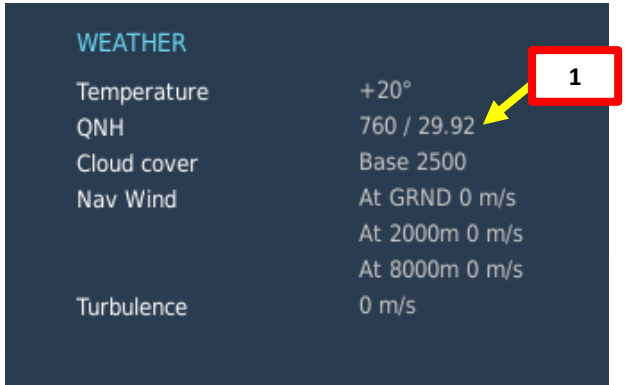
Direct Mode is considered to be the most basic/classic bombing mode of the F-4E; following a simple attack profile should be enough to successfully engage targets of opportunity. Both the ARBCS (Attitude Reference & Bombing Computer Set) and WRCS (Weapon Release Computer Set) are excluded from this release mode, and the pilot flies the profile as found for the intended munition in the bombing tables, setting the sight depression to match, and hand flying the aircraft to place the reticle/pipper directly onto the target in accordance with the desired type of attack.

In this tutorial, we want to drop a single GBU-12 laser-guided bomb, which will then be guided by the laser designator from the JTAC (Joint Terminal Attack Controller) on the ground.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.







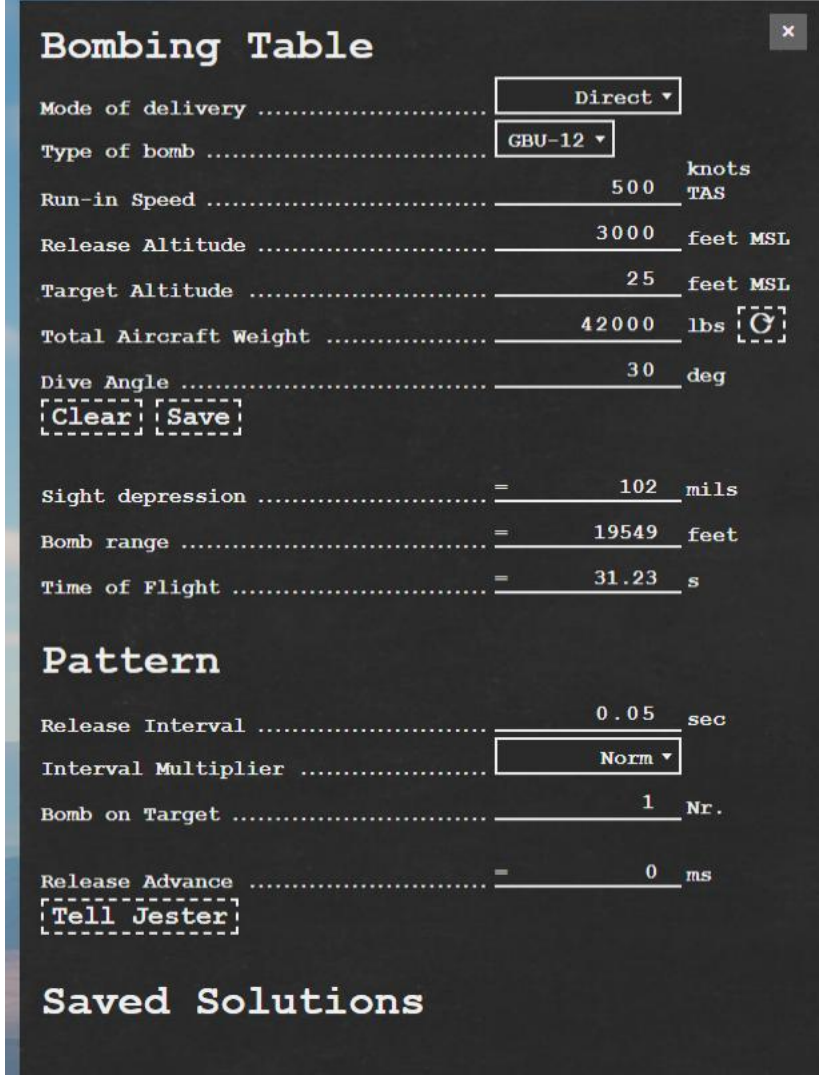
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

C – Determine Attack Profile

2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
    a) Select Direct Mode of delivery
    b) Select GBU-12 Type of Bomb
    c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
    d) Select Target Altitude: 25 ft MSL (Mean Sea Level) – Obtained from F10 map
    e) Select Release Altitude: 3000 ft (MSL, Mean Sea Level)
    f) Click on the Refresh button to calculate total aircraft weight: 42000 lbs
    g) Select desired Dive Angle: 30 deg
    h) Click SAVE.
    i) Sight Depression is calculated automatically: 102 mils

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

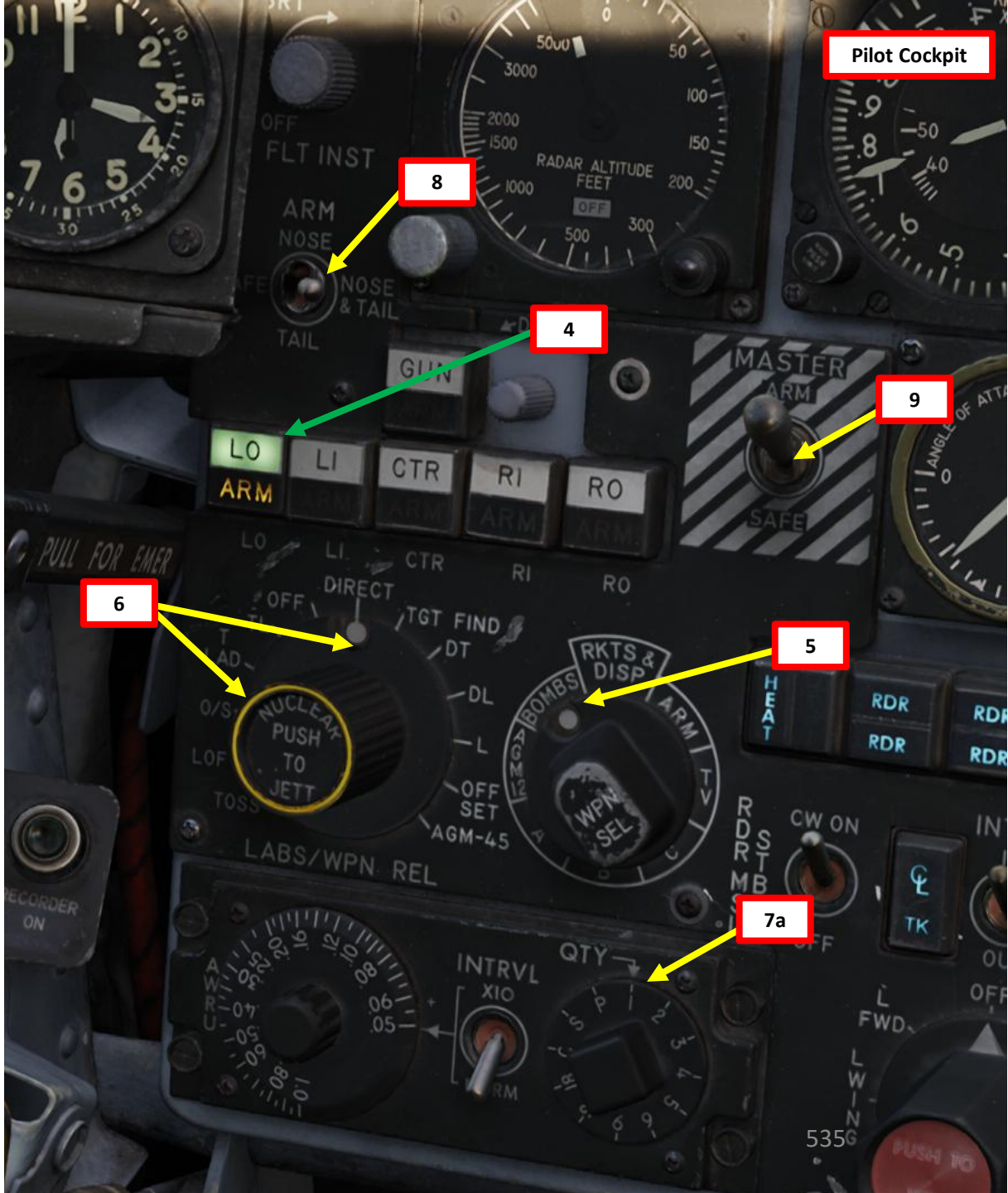
GBU-12 Laser-Guided Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Sight Depression: 102 mils
Release Angle: 30 deg	
Release Altitude (MSL): 3000 ft	
Target Elevation: 25 ft MSL	
Total Aircraft Weight: 42000 lbs	



2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

D – Weapon Setup

4. *[P]* Select desired Station Select Buttons. We will use LO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
5. *[P]* Set Weapon Selector Knob – BOMBS
6. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
7. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
    a) Set Store Quantity Knob – As desired (we will drop 1 bomb)
    b) Set Weapon Interval Selector Switch – Not applicable for single bomb.
    c) Set Weapon Release Interval Selector Knob – Not applicable for single bomb.
8. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
9. *[P]* Set Master Arm Switch – ARMED (UP)

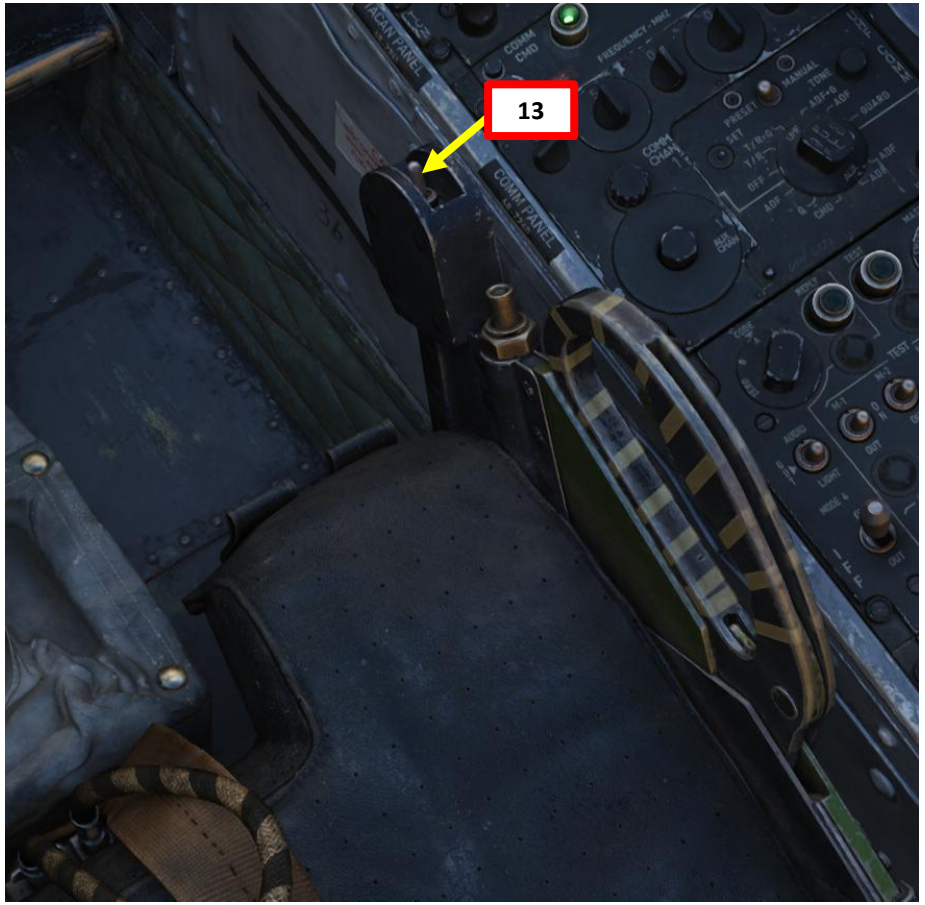


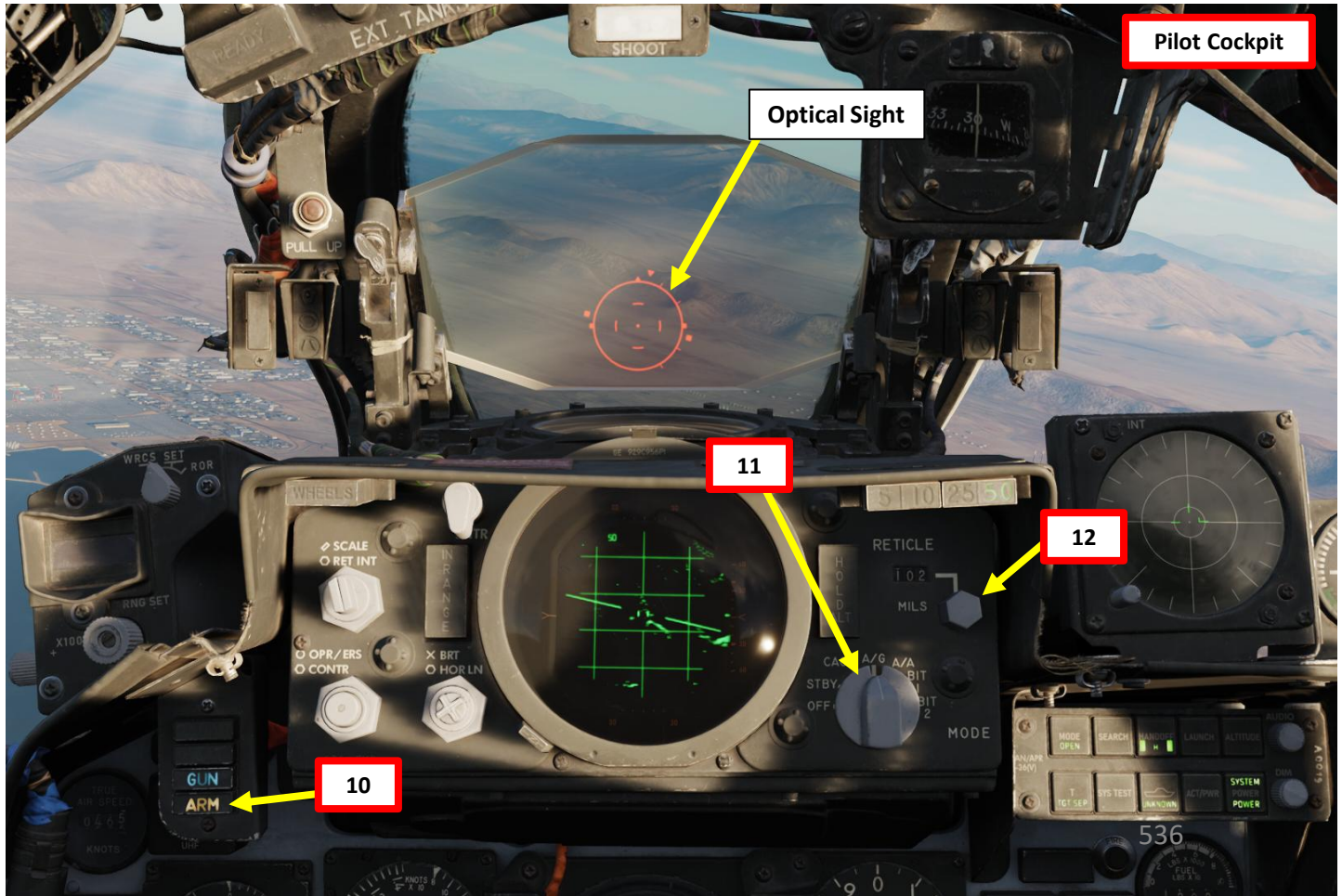
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

D – Weapon Setup

10. *[P]* Confirm ARM light is illuminated
11. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
12. *[P]* Set Reticle Depression Setting Knob to 102 Mils.
13. *[P]* Adjust Seat Position – As required to see the reticle.

GBU-12 Laser-Guided Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Sight Depression: 102 mils
Release Angle: 30 deg	
Release Altitude (MSL): 3000 ft	
Target Elevation: 25 ft MSL	
Total Aircraft Weight: 42000 lbs	



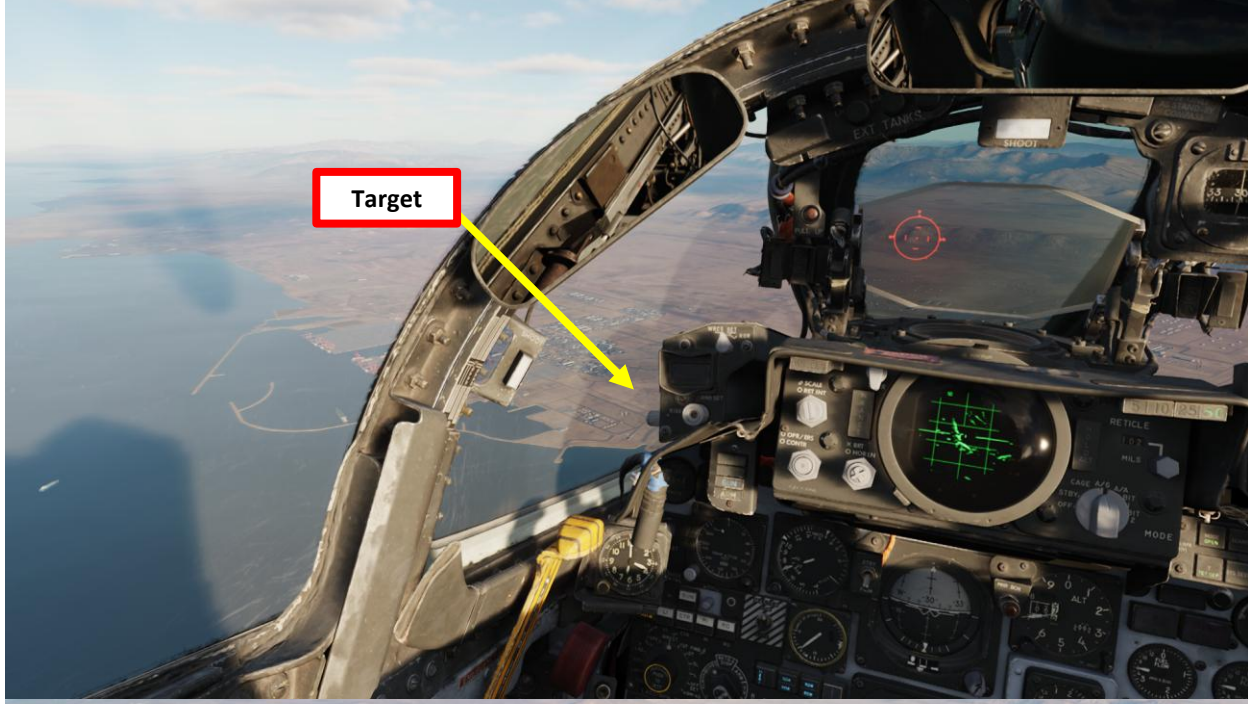


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

E – Perform Attack

14. *[P]* Approach the target and maintain it to your aircraft's 10 o'clock position. Fly at least 6000 ft above the target at 450 kts indicated or faster.
15. *[P]* Once the target has been identified, throttle down, perform a 30 deg dive towards the target and maintain an airspeed of 450 kts indicated.

GBU-12 Laser-Guided Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Sight Depression: 102 mils
Release Angle: 30 deg	
Release Altitude (MSL): 3000 ft	
Target Elevation: 25 ft MSL	
Total Aircraft Weight: 42000 lbs	

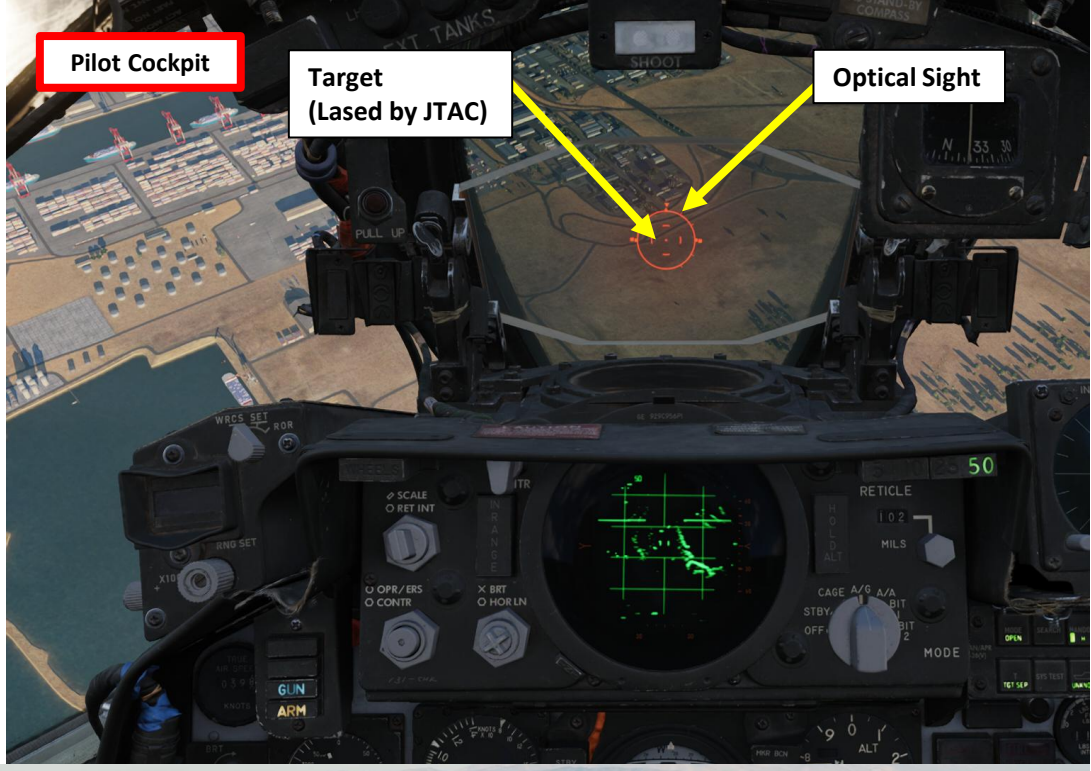




2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

E – Perform Attack

16. *[P]* Steer aircraft to set the reticle roughly on the target while maintaining attack profile parameters (450 kts indicated, 30 deg dive).
17. *[P]* When at release altitude (3000 ft MSL), press and hold the Bomb Release Button (RALT+SPACEBAR) until bomb is released.



GBU-12 Laser-Guided Bomb *Direct/Manual Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Sight Depression: 102 mils
Release Angle: 30 deg	
Release Altitude (MSL): 3000 ft	
Target Elevation: 25 ft MSL	
Total Aircraft Weight: 42000 lbs	



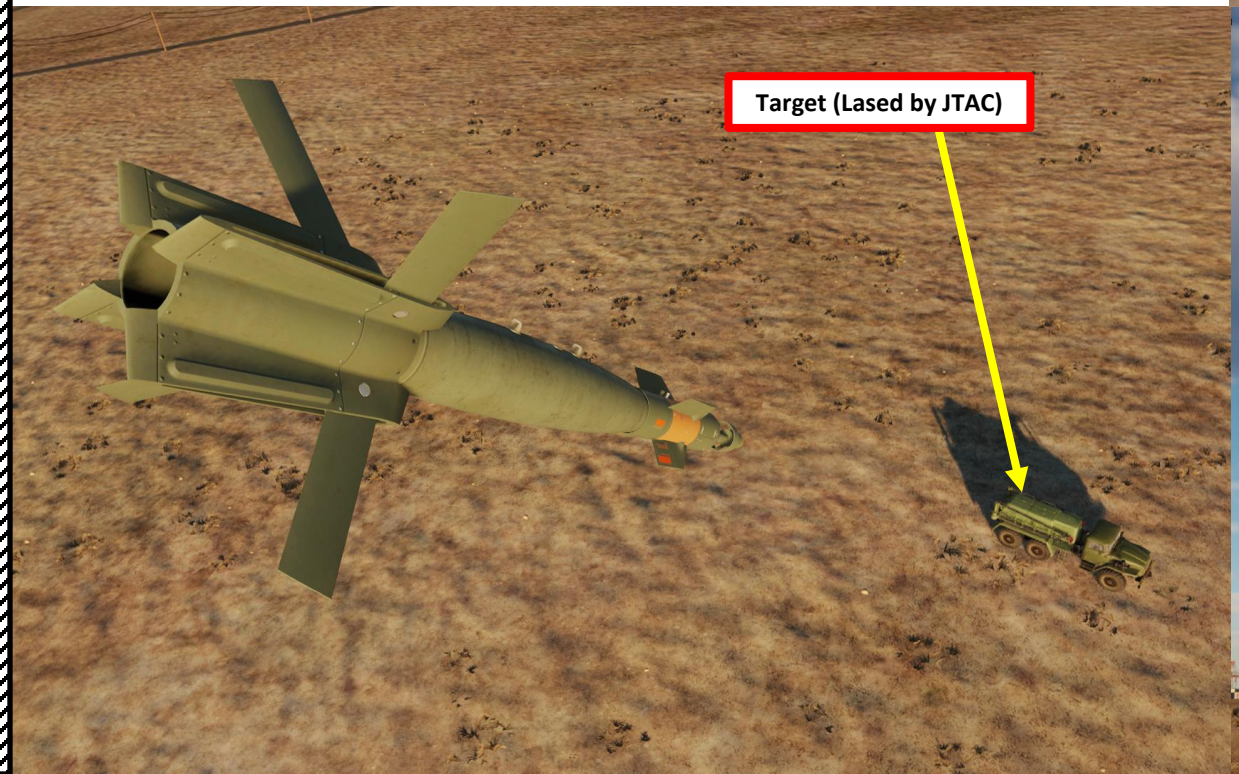


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

E – Perform Attack

18. *[P]* Once GBU-12 is falling, it will track the laser of the JTAC designating the target until impact.







2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.1 – GBU-12 Paveway II: Using JTAC & Direct Mode

E – Perform Attack

19. *[P]* After bomb release, recover from the dive with a 4 G pull up. This safe-escape manoeuver will avoid flying the aircraft into the frag envelope and suffering potential fragmentation damage.



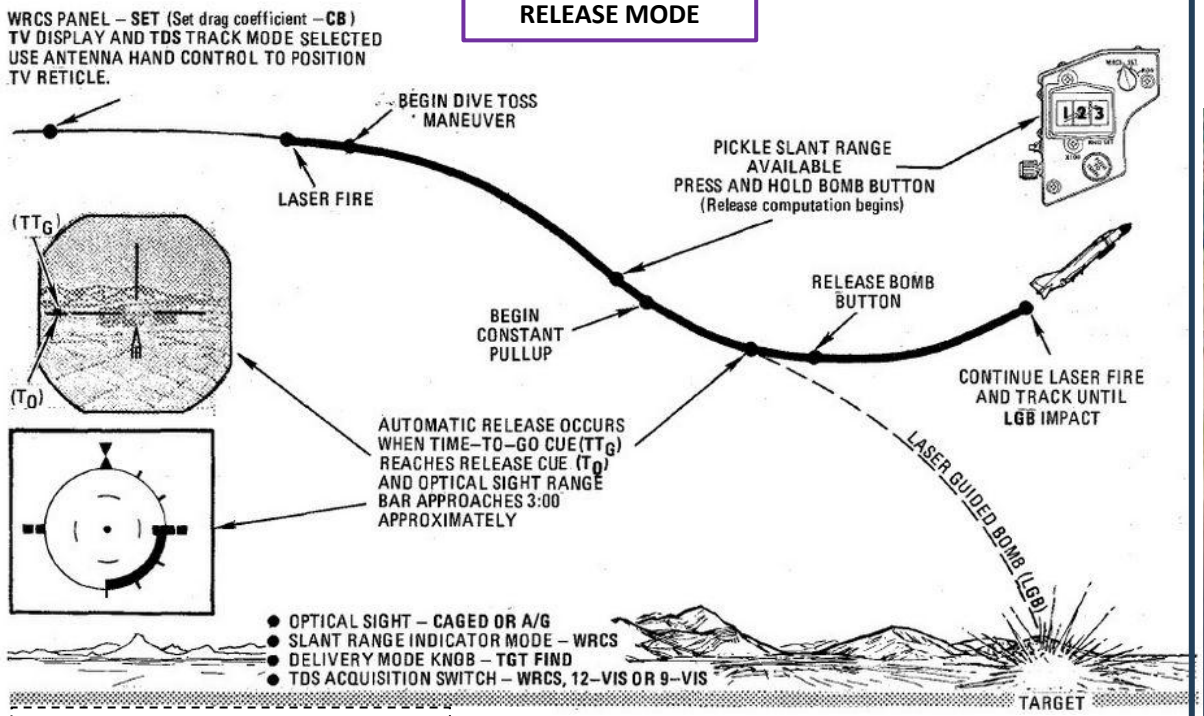
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

A – Determine Attack Profile & Release Mode

The main method of weapon delivery with the targeting pod is the **WRCS automatic release mode**. The WRCS (Weapon Release Computer Set) has to be integrated with the pod for it to be available, and the pilot must select TGT FIND as delivery mode, as well as WRCS on the range indicator. This mode works the same as the Dive Toss mode of the WRCS, just that it will use the pods computed slant range and target instead. The TTG (Time-to-Go) cue will move down and meet the T0 (Release) cue to indicate the time to release from maximally 15 seconds.

In this tutorial, we want to drop a single GBU-12 laser-guided bomb in WRCS Auto Release Mode with the targeting pod lasing the target.

WRCS AUTO RELEASE MODE



Source: Heatblur Simulations Wiki

Weapon Release Mode Selector

- *WRCS: Weapon Release Computer Set, also known as Automatic Delivery*



Pave Spike Targeting Pod Slant Range Indicator (x100 ft)

Air-to-Ground Weapon Delivery Mode Knob



2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

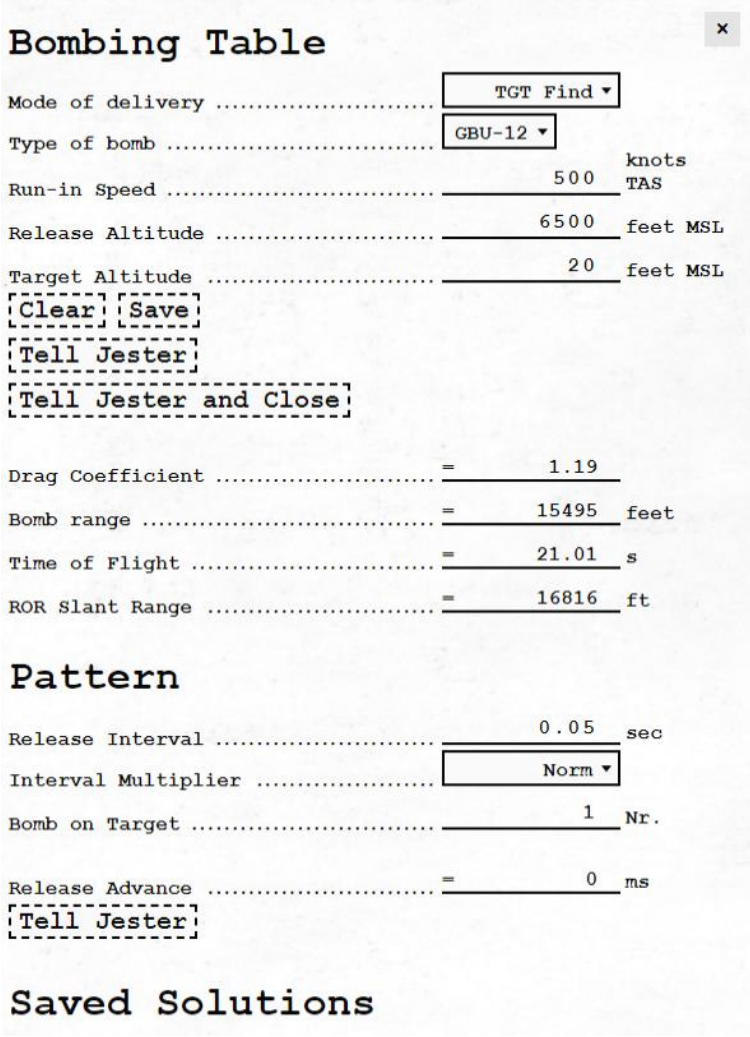
A – Determine Attack Profile & Release Mode

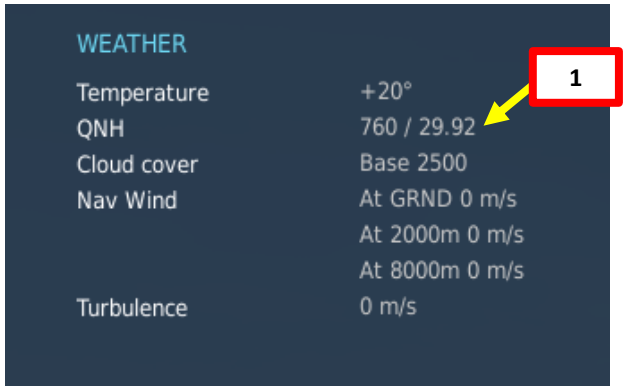
1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.
2. Select the « Bombing Table Utility » by pressing « RCTRL+B ».
3. On Bombing Table Utility:
   a) Select TGT FIND Mode of delivery
   b) Select GBU-12 Type of Bomb
   c) Select Run-In Speed: 450 kts (Indicated Airspeed, IAS) / 500 kts (True Airspeed, TAS)
   d) Select Target Altitude: 20 ft MSL (Mean Sea Level) – Obtained from F10 map
   e) Select Release Altitude: 6500 ft (MSL, Mean Sea Level)
   f) Click SAVE.
   g) Drag Coefficient is calculated automatically: 1.19
   h) If using the JESTER AI as the WSO, click TELL JESTER to set the drag coefficient and target altitude in the rear cockpit.

Note: the Bombing Table Utility can be closed by pressing « RCTRL+B ».

GBU-12 Laser-Guided Bomb *TGT FIND Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Drag Coefficient: 1.19
Release Altitude (MSL): 6500 ft	
Target Elevation: 20 ft MSL	







2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

Additional Note on ROR (Release On Range) Release Mode (Backup)

You can also use another Release Mode as a backup, which is called the **ROR (Release On Range) Mode**. The pilot must select TGT FIND as delivery mode, and ROR on the range indicator. Weapons will be released automatically, as soon as the computed slant range is less than the set desired release range. The range is configured on the range indicator, by setting the mode to SET and rotating the knob below the display. Best results are achieved during level flight.

Air-to-Ground Weapon Delivery Mode Knob



Weapon Release Mode Selector
- *SET: Display shows the desired release range used in the ROR mode*



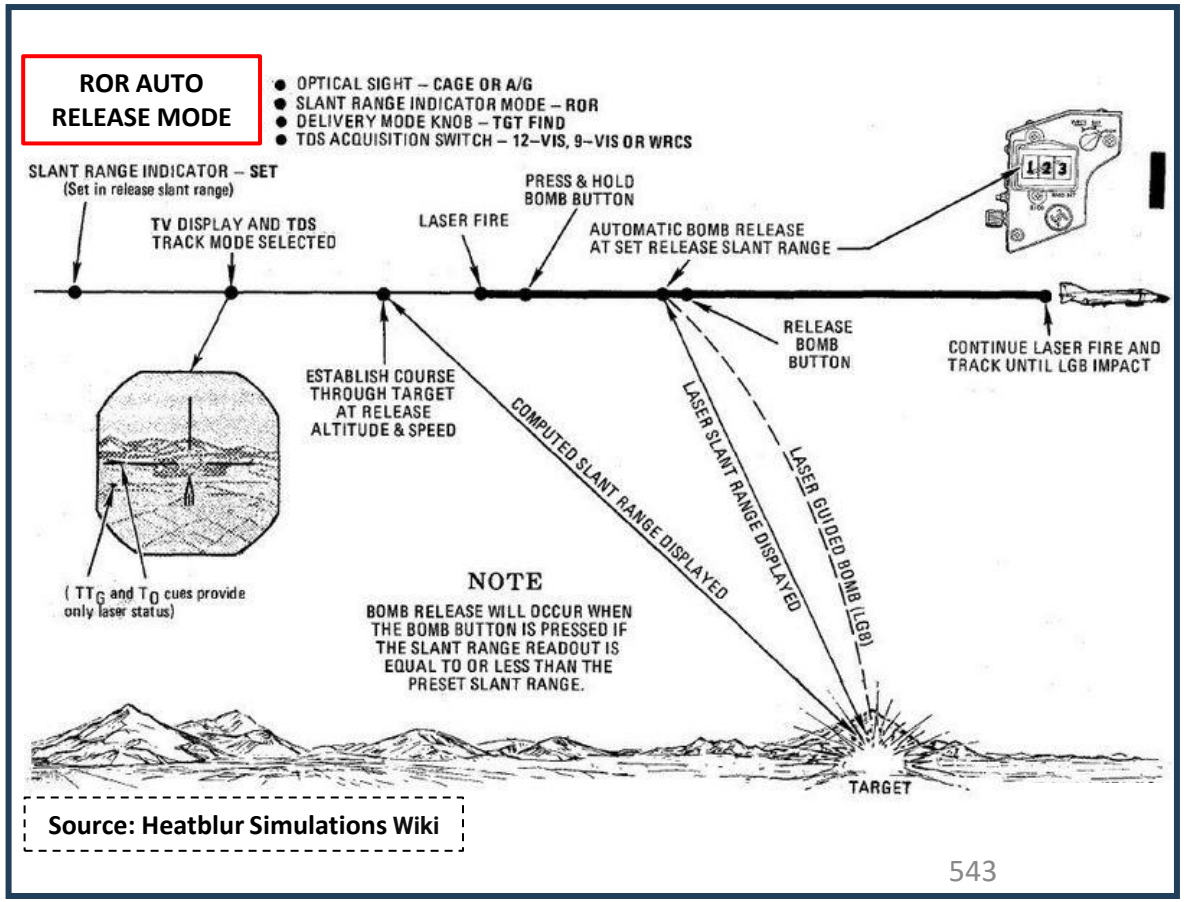
Weapon Release Range Setting Knob

Desired Release Range (x100 ft)

Weapon Release Mode Selector
- *ROR: Release On Range Mode*



Pave Spike Targeting Pod Slant Range Indicator (x100 ft)



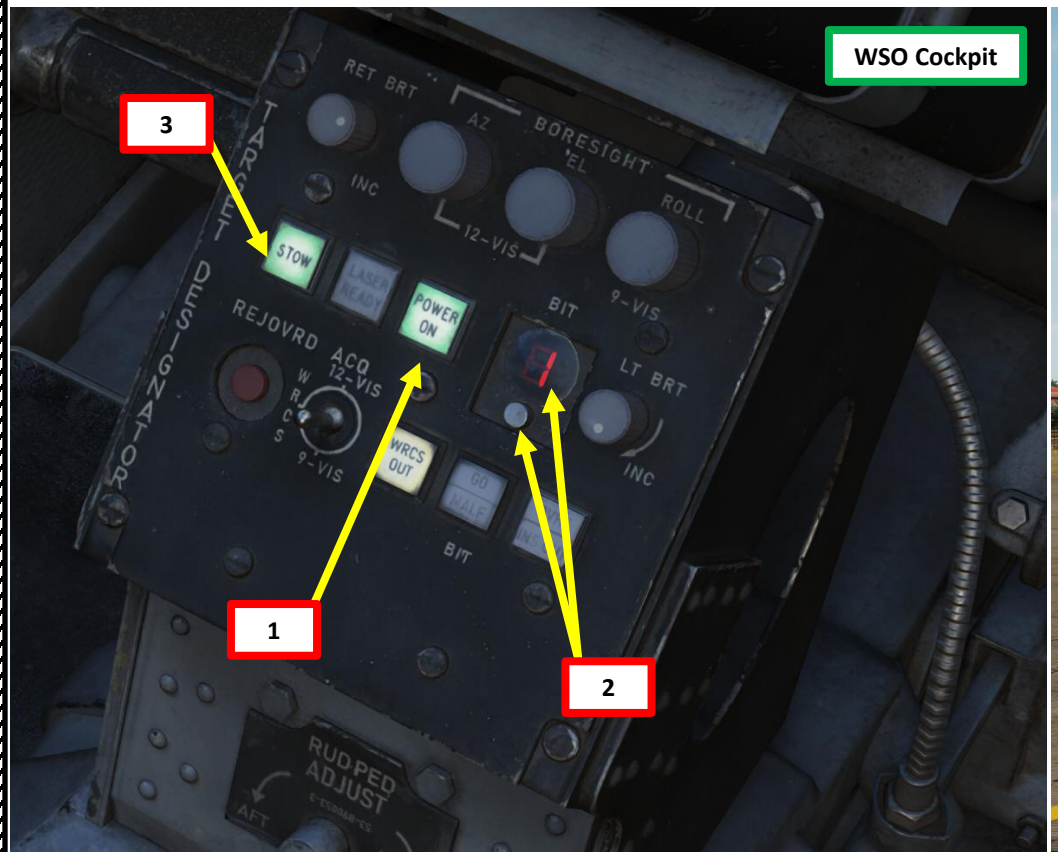
Source: Heatblur Simulations Wiki

2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

B – Power Up Targeting Pod & Set Laser Code

The power-up sequence of the targeting pod should be initiated on the ground prior to taxi and takeoff since flying while the pod is unpowered will allow the gimbals to move freely and potentially damage the pod itself.

1. *[WSO]* Set Target Designation Power On Button – ON
2. *[WSO]* Verify that the BIT (Built-In Test) indicator is set to "1".
    - Note: BIT "0" illuminates all lights on the Target Designator Set Panel and will inhibit pod operation.
3. *[WSO]* Set Target Designation Stow Button – ON.
    - The pod's head is stowed when the button is illuminated.



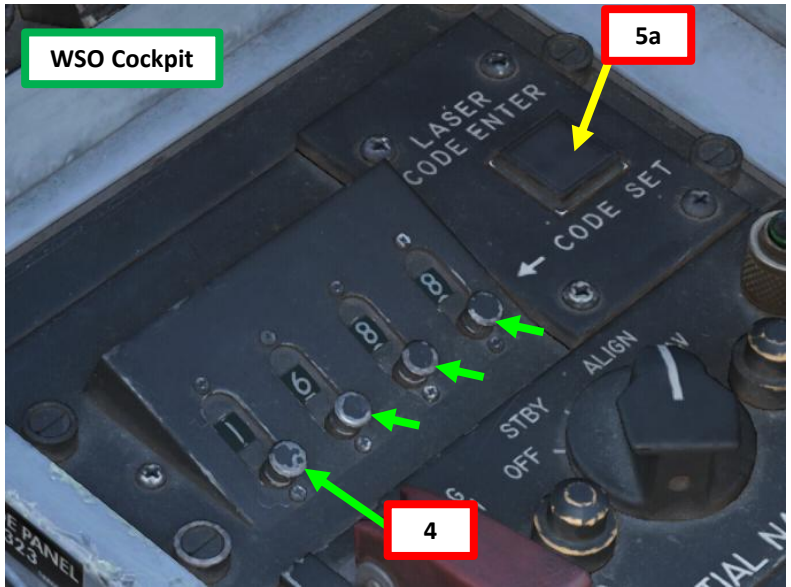


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

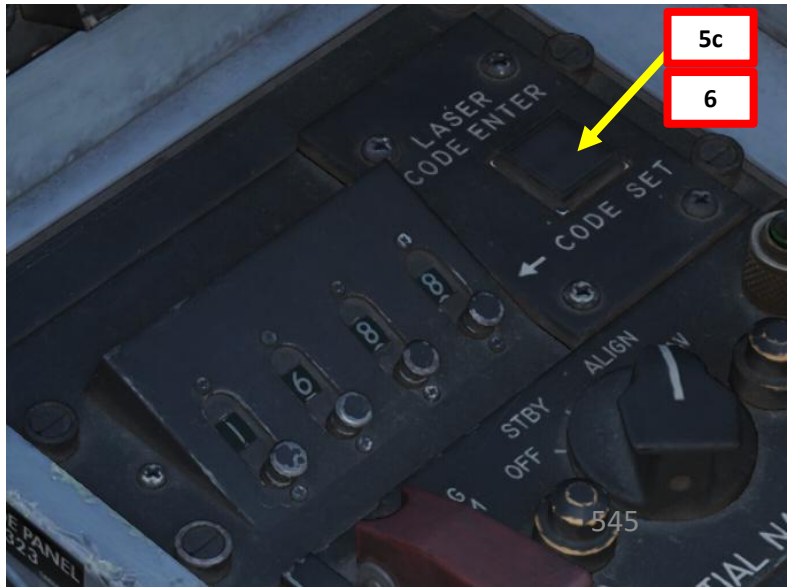
B – Power Up Targeting Pod & Set Laser Code

4. *[WSO]* Set laser designation code – As desired. We will select 1688.
5. *[WSO]* Press and hold the Laser Code Enter Button.
    - If the laser code is valid, the NO GO light will momentarily illuminate, then extinguish.
    - If the laser code is invalid, the NO GO light will remain illuminated.
6. *[WSO]* Release the Laser Code Enter Button.
7. *[WSO]* Once aircraft is airborne, set Target Designation Stow Button – OFF. This will un-stow the targeting pod.
    - The pod's head is un-stowed when the button is extinguished. Un-stowing the targeting pod takes about 5 seconds.
8. *[WSO]* Press the Laser Ready Button and ensure the LASER READY light is illuminated.





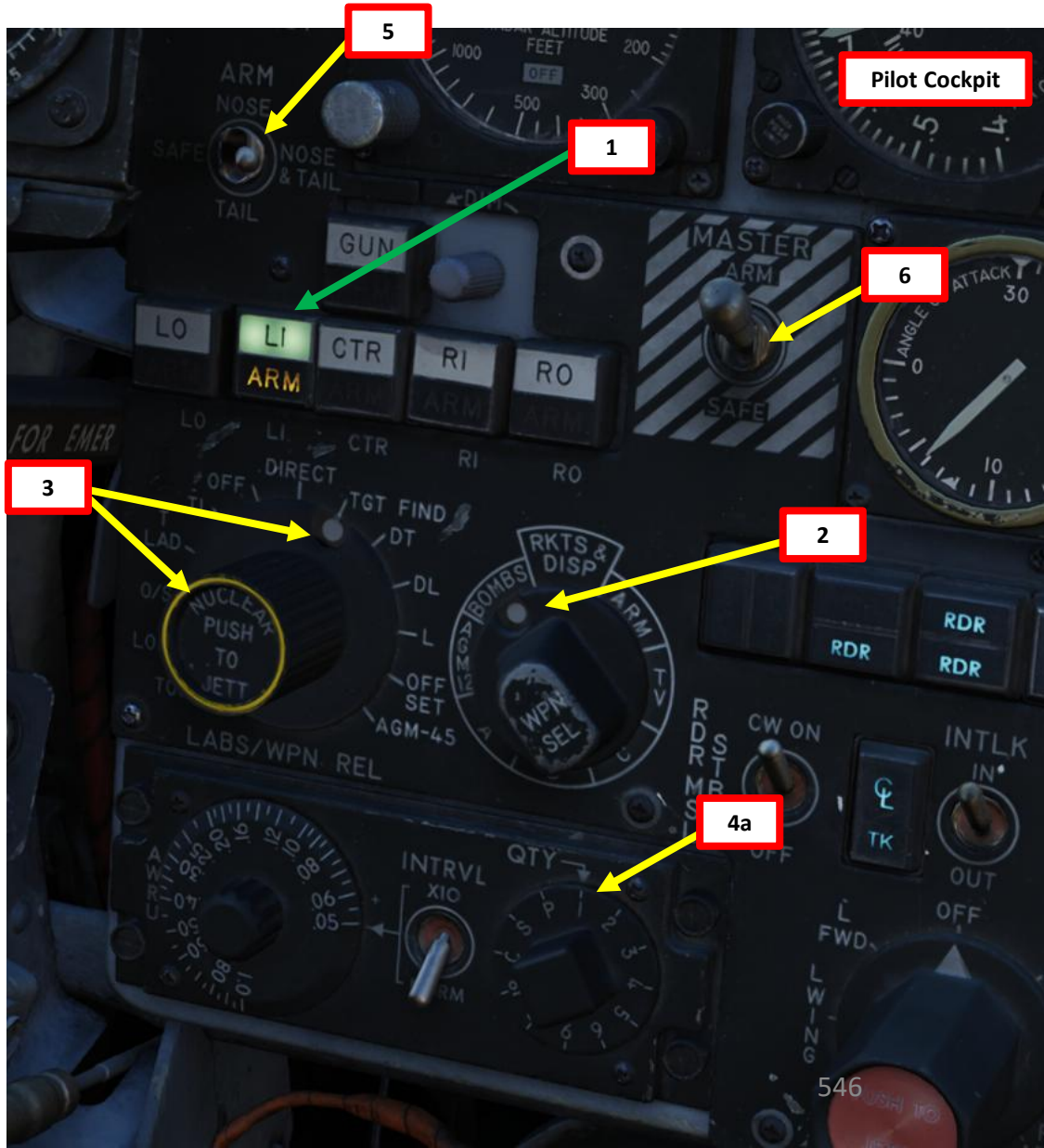




2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

C – Weapon & Sensor Setup

1. *[P]* Select desired Station Select Buttons. We will use LI.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Weapon Selector Knob – BOMBS
3. *[P]* Set Air-to-Ground Weapon Delivery Mode – TGT FIND (Target Find)
4. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (we will drop 1 bomb)
   b) Set Weapon Interval Selector Switch – Not applicable for single bomb.
   c) Set Weapon Release Interval Selector Knob – Not applicable for single bomb.
5. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
6. *[P]* Set Master Arm Switch – ARMED (UP)

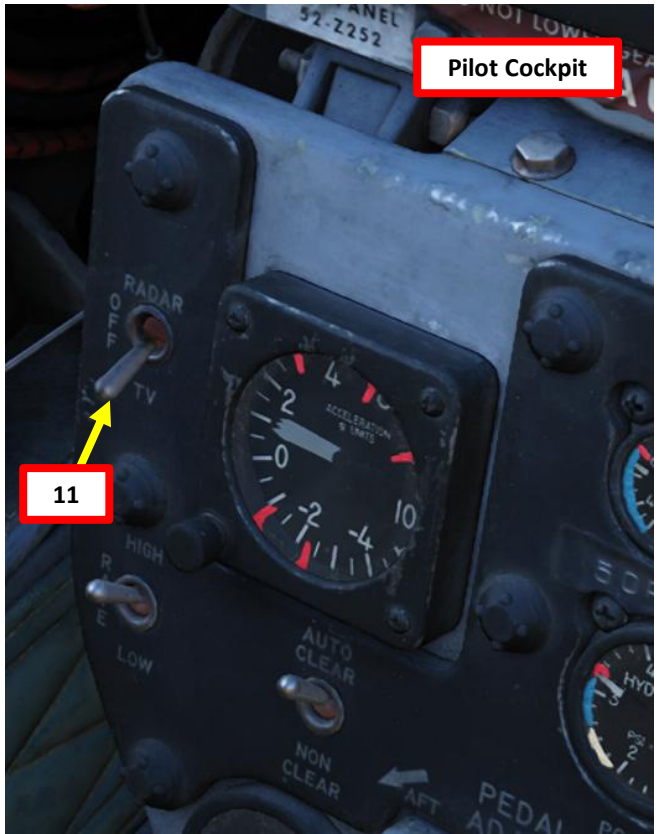


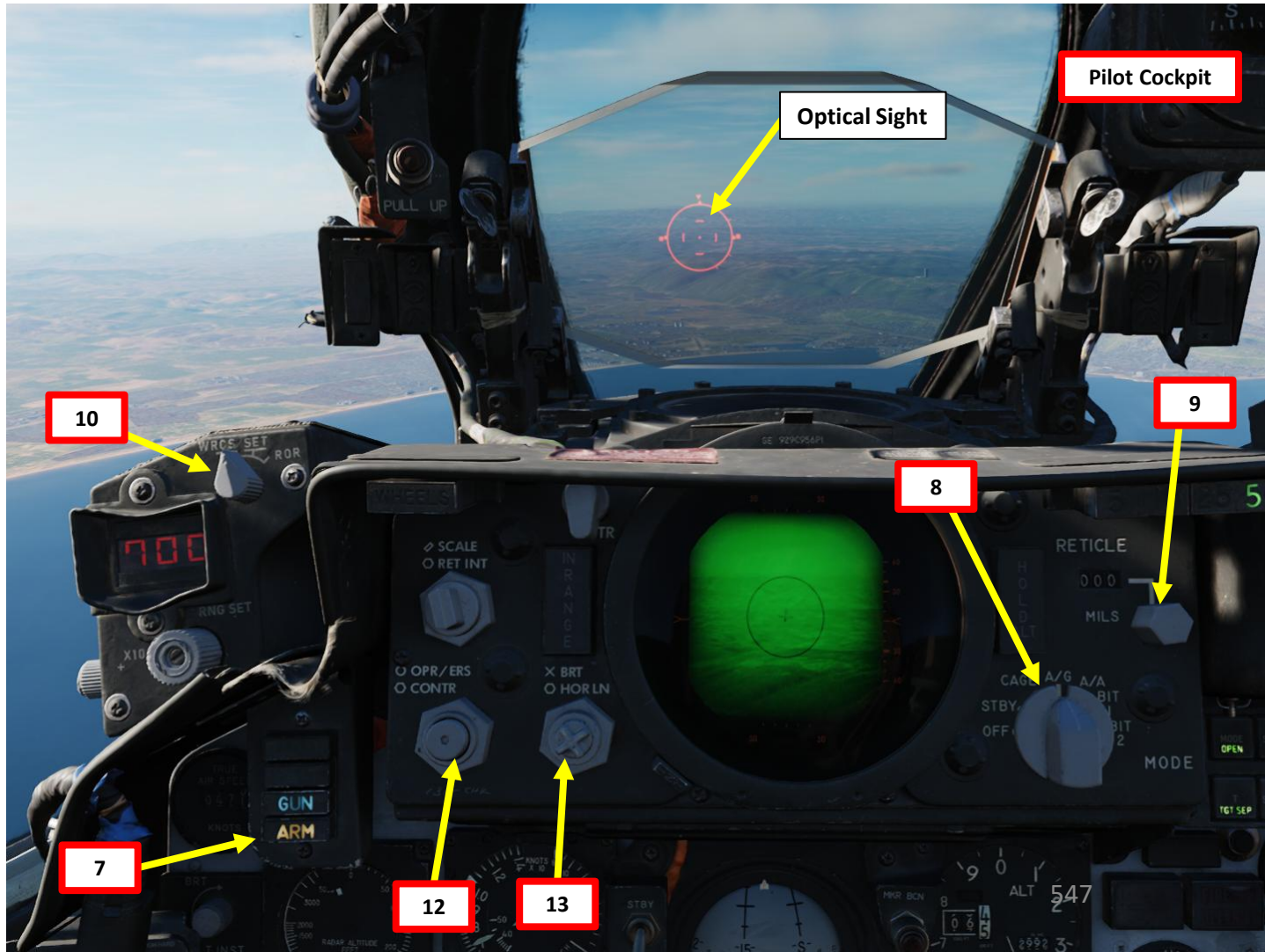
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

GBU-12 Laser-Guided Bomb *TGT FIND Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Drag Coefficient: 1.19
Release Altitude (MSL): 6500 ft	
Target Elevation: 20 ft MSL	

C – Weapon & Sensor Setup

7. *[P]* Confirm ARM light is illuminated
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Set Reticle Depression Setting Knob to 0 Mils.
10. *[P]* Set Weapon Release Mode Selector – WRCS (Weapon Release Computer Set) Automatic Mode.
11. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – TV (DOWN). This will display the targeting pod display repeater (provided the pod is set up from the WSO seat).
12. *[P]* Adjust Screen Contrast – As desired (Outer knob)
13. *[P]* Adjust Screen Brightness – As desired (Inner knob)





2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

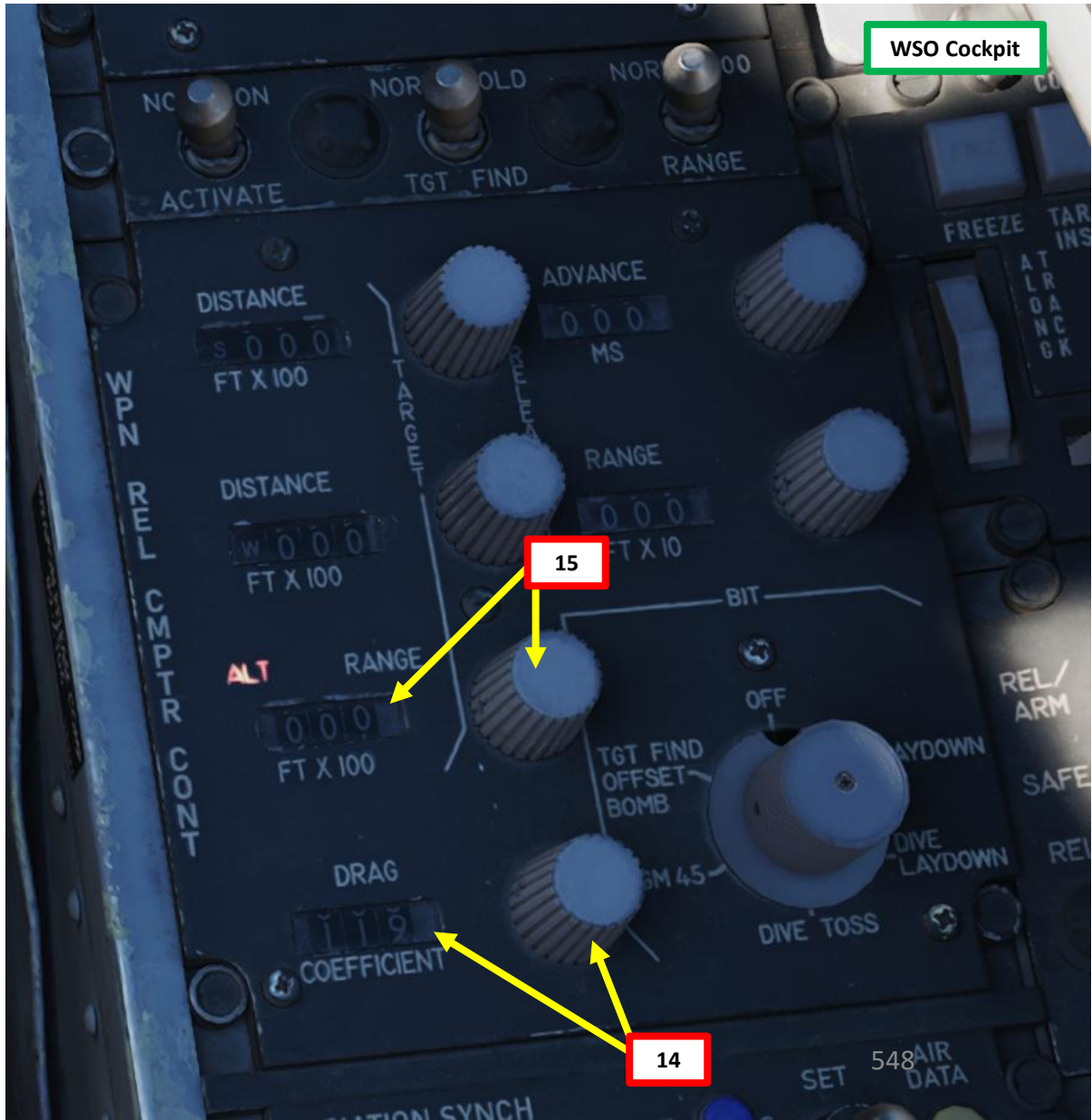
C – Weapon & Sensor Setup

Note: These steps can be performed by JESTER.

14. *[WSO]* Set Drag Coefficient: 1.19 (value computed from Bombing Table).
15. *[WSO]* Set Target Altitude Setting: 20 ft (value obtained from target elevation from F10 map).
    - The reason why we input the target's expected altitude is that the slant range measured by the targeting pod's laser is compared to the slant range **computed based on INS (Inertial Navigation System) and WRCS data** (which is derived from the aircraft barometric altitude and the target altitude set on the WRCS panel).

GBU-12 Laser-Guided Bomb *TGT FIND Mode*	
Delivery Input Parameters	**Delivery Output from Bombing Calculator**
Airspeed: 500 KTAS / 450 KIAS	Drag Coefficient: 1.19
Release Altitude (MSL): 6500 ft	
Target Elevation: 20 ft MSL	

15 14

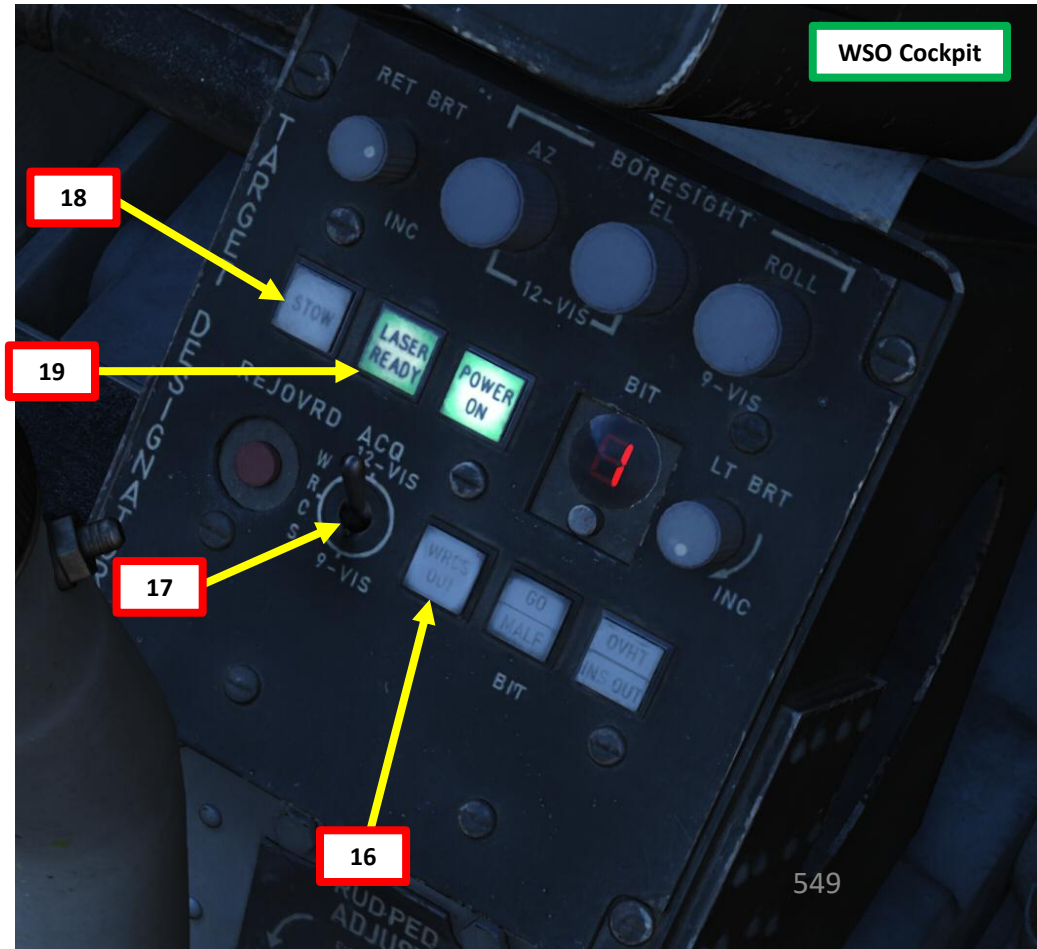


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

C – Weapon & Sensor Setup

16. *[WSO]* Verify that the WRCS OUT light is extinguished. This means that the targeting pod functionality is coupled with the Weapon Release Computer Set.
17. *[WSO]* Select desired acquisition mode using the Acquisition Mode Selector Switch. We will use 12-VIS (UP).
    - **12-VIS** (switch UP): visual line-of-sight of the pod is set to the 12 o'clock (front) position; 0 degrees roll, -2 degrees elevation, looking slightly nose down.
18. *[WSO]* Verify that the Target Designation Stow Button is set to OFF (extinguished) and the targeting pod is un-stowed. If not, press on the Target Designation Stow Button.
    - The pod's head is un-stowed when the button is extinguished. Un-stowing the targeting pod takes about 5 seconds.
19. *[WSO]* Verify that the LASER READY light is illuminated. If not, press on the Laser Ready Button.





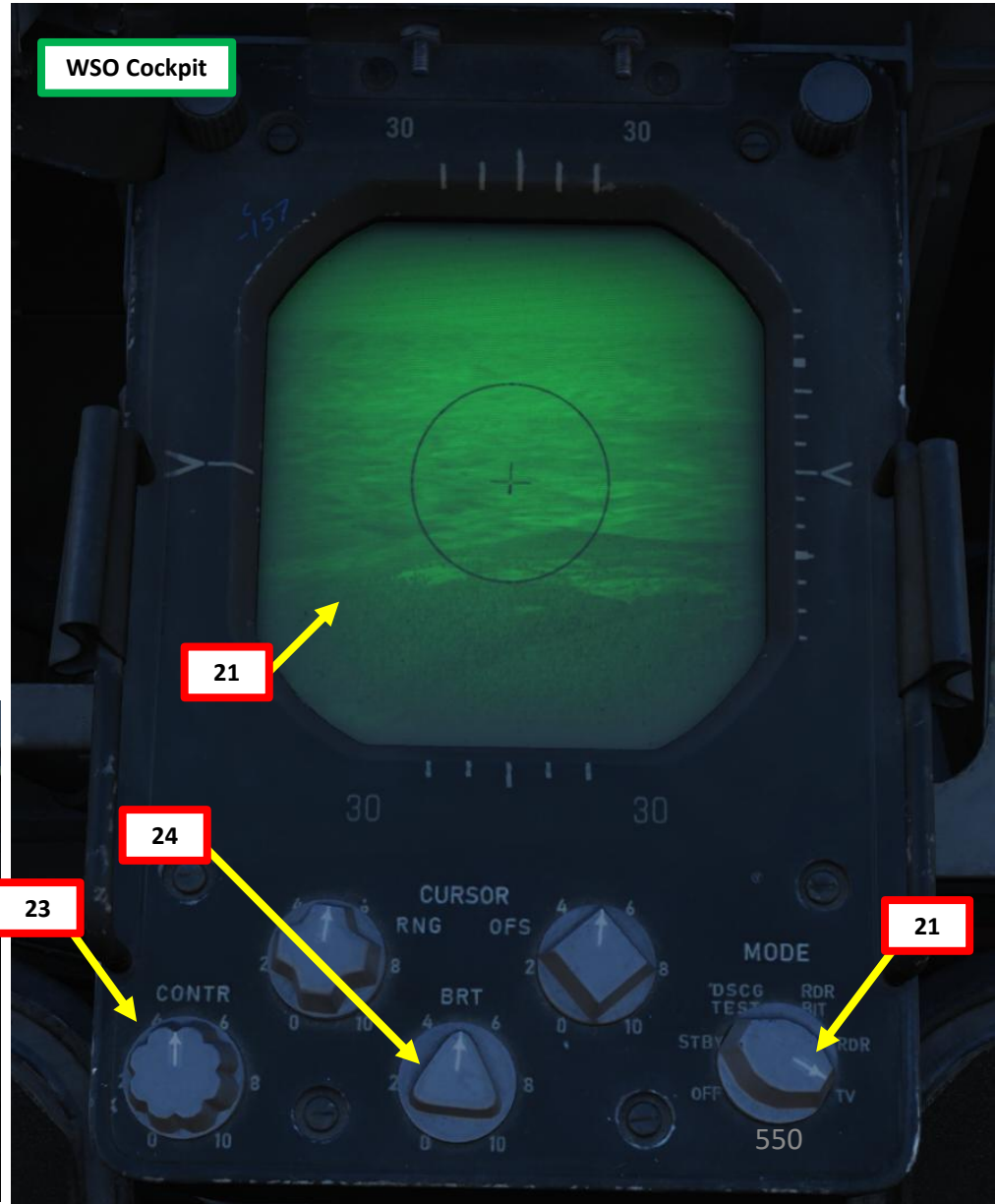
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

C – Weapon & Sensor Setup

20. *[WSO]* Set Video Select Button – ASQ-153.
21. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – TV
22. *[WSO]* Set Reticle Brightness – As desired.
    - Full counter-clockwise: reticle is black.
    - Full clock-wise: reticle is green.
23. *[WSO]* Adjust Screen Contrast – As desired.
24. *[WSO]* Adjust Screen Brightness – As desired.







2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

D – Designate & Lase Target

1. *[P]* Fly the aircraft to put the reticle roughly near the target since we are using the 12-VIS acquisition mode.
2. *[P]* Once the reticle is on the target, call out “Tracking” to the WSO to confirm the target is being held in sight.



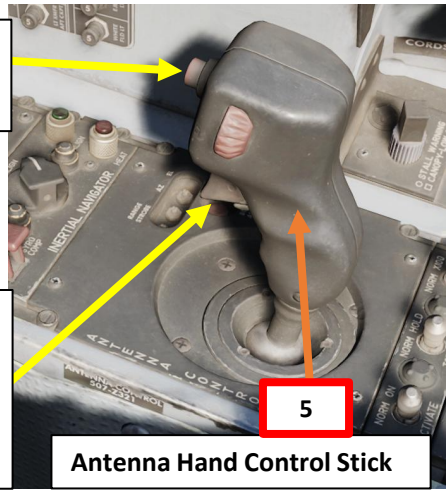


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

D – Designate & Lase Target

3. *[WSO]* Use the Challenge Button to toggle between WIDE and NARROW field-of-views.
4. *[WSO]* Press the Hand Control Stick Trigger's first detent (Half-Action), then release trigger. This will toggle between 12-VIS acquisition mode and Tracking Mode.
5. *[WSO]* Slew the targeting pod's reticle with the Hand Control Stick over the target.
6. *[WSO]* Both the **TTG (Time-to-Go) Cue and T0 (Release) Cue should be flashing**, meaning that the pod is in tracking mode (stabilized) but laser is not firing the laser yet.
    - Note: ground stabilization is rudimentary and needs constant correction with the stick for the target to be kept centered.
7. *[WSO]* Once the targeting pod is stabilized in tracking mode on the target, the WSO calls out to the pilot "Capture" to indicate that the pod is stabilized in tracking mode.

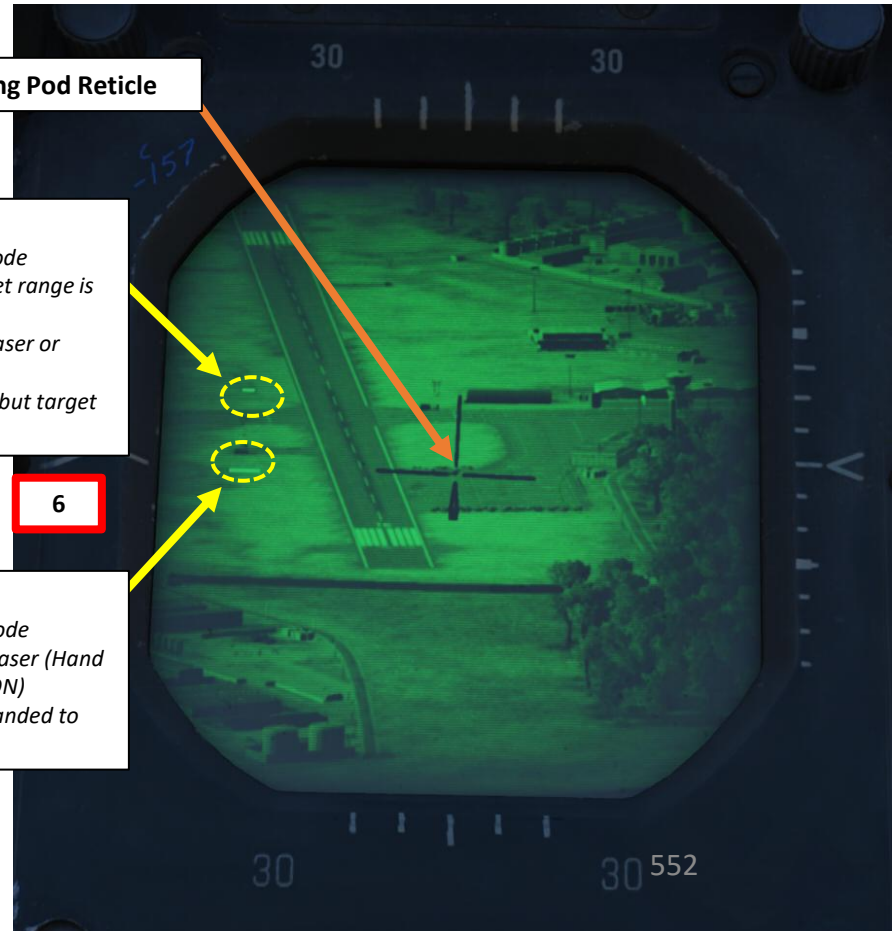
3 **Challenge Button**
- *If controlling the Pave Spike targeting pod, toggles the field of view between WIDE and NARROW.*



4 **Action Switch (Two-Stage Trigger)**
- *Half-Action and Release: Toggles between Acquisition Mode (12-Vis, 9-Vis, WRCS) and Tracking Mode*
- *Full-Action and Release: Toggles firing the laser*
- *If in Memory Mode or Acquisition Mode (12-Vis, 9-Vis, WRCS), Full-Action and Release will enter tracking mode and fire the laser.*







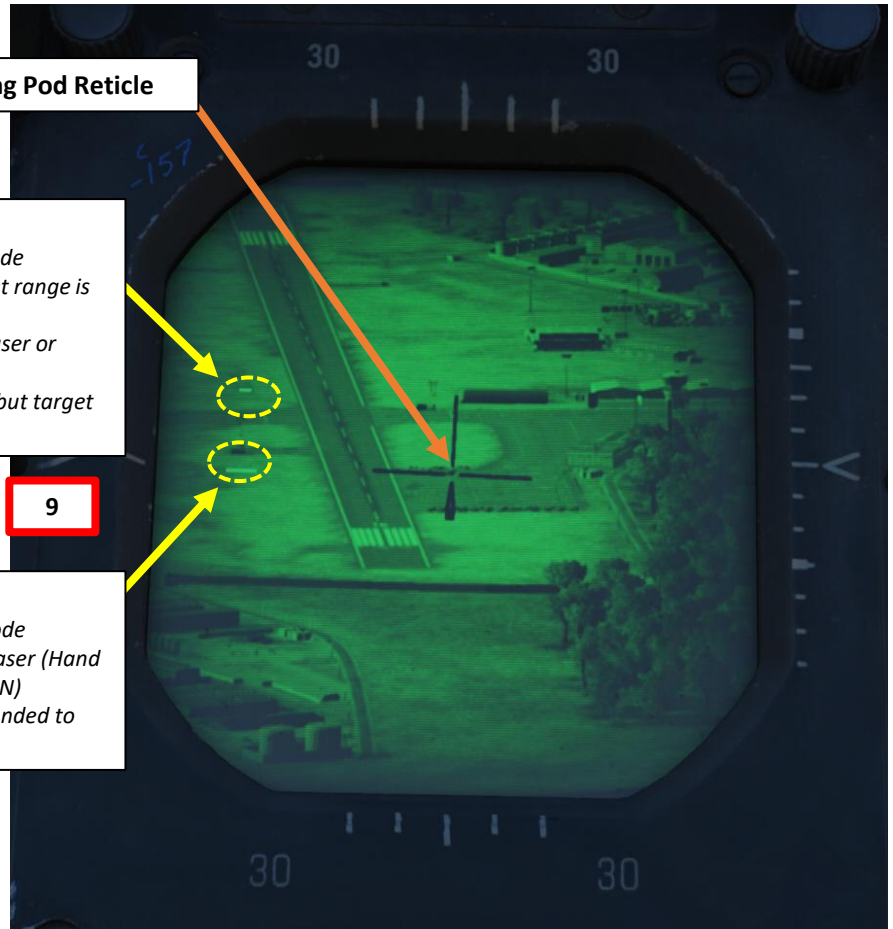
TTG (Time-to-Go) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is firing laser and target range is accepted*
- *Flashing Quickly: Pod is not firing laser or target is too far away*
- *Flashing Slowly: Pod is firing laser, but target range is rejected*

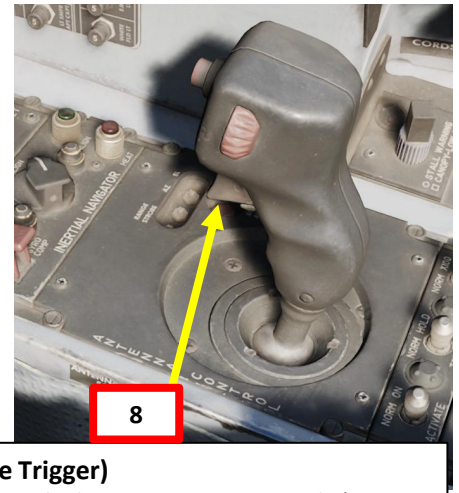
T0 (Release) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is commanded to fire laser (Hand Control Stick Trigger to FULL ACTION)*
- *Flashing Quickly: Pod is not commanded to fire laser*

2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

D – Designate & Lase Target

8. *[WSO]* Press the Hand Control Stick Trigger's second detent (Full-Action), then release trigger. This will toggle command firing the laser.
    - The laser has a maximum range of approximately 11 nm.
9. *[WSO]* When the target is within range and the laser is firing, **both the TTG (Time-to-Go) Cue and T0 (Release) Cue should be steady**, meaning that the pod is in tracking mode (stabilized) and that the laser is firing.
10. *[WSO]* Once a good target solution is acquired, the WSO calls out to the pilot "Acceptance" to indicate that the target is acquired.





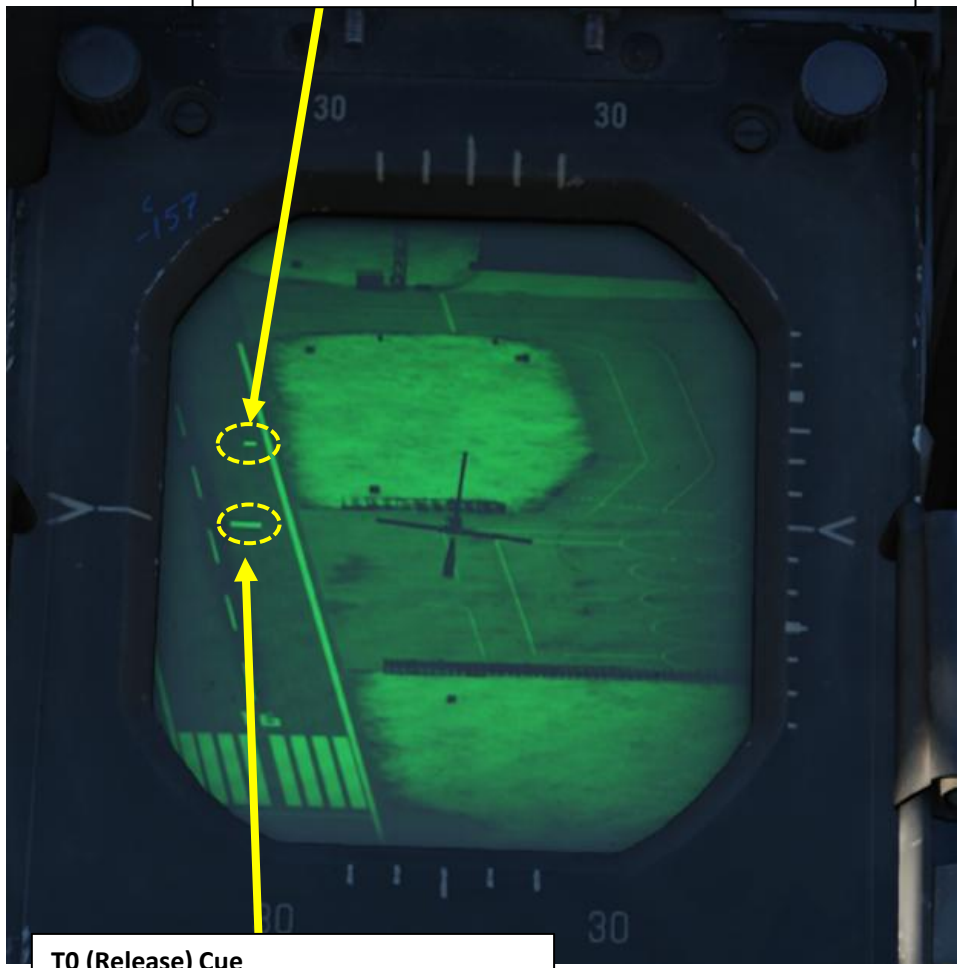
2 – AIR-TO-GROUND WEAPONS
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D – Designate & Lase Target

11. *[WSO]* As a general rule, the T0 cue indicates intention to fire the laser, while the TTG cue represents the outcome of the laser usage. If the slant range measured by the laser is not within +/- 20 % of the value computed from the INS & WRCS, it is rejected. This is indicated by TTG flashing slow.
12. *[WSO]* If the TTG Cue is flashing slowly (Pod is firing laser, but target range is rejected), you can force the system to use the laser-computed slant range to the target by pressing the Reject/Override Button.
    - Note: In practice, laser measured range is much more accurate than the slant range computed by the system. Hence, pilots developed a habit of always hitting the button whenever they fired the laser.
13. *[WSO]* As a rule of thumb, do not use the laser for longer than 15 minutes without allowing for cooling between uses. Limit continued slow and low-level flight while operating the pod to 30 minutes.



TTG (Time-to-Go) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is firing laser and target range is accepted*
- *Flashing Quickly: Pod is not firing laser or target is too far away*
- *Flashing Slowly: Pod is firing laser, but target range is rejected*

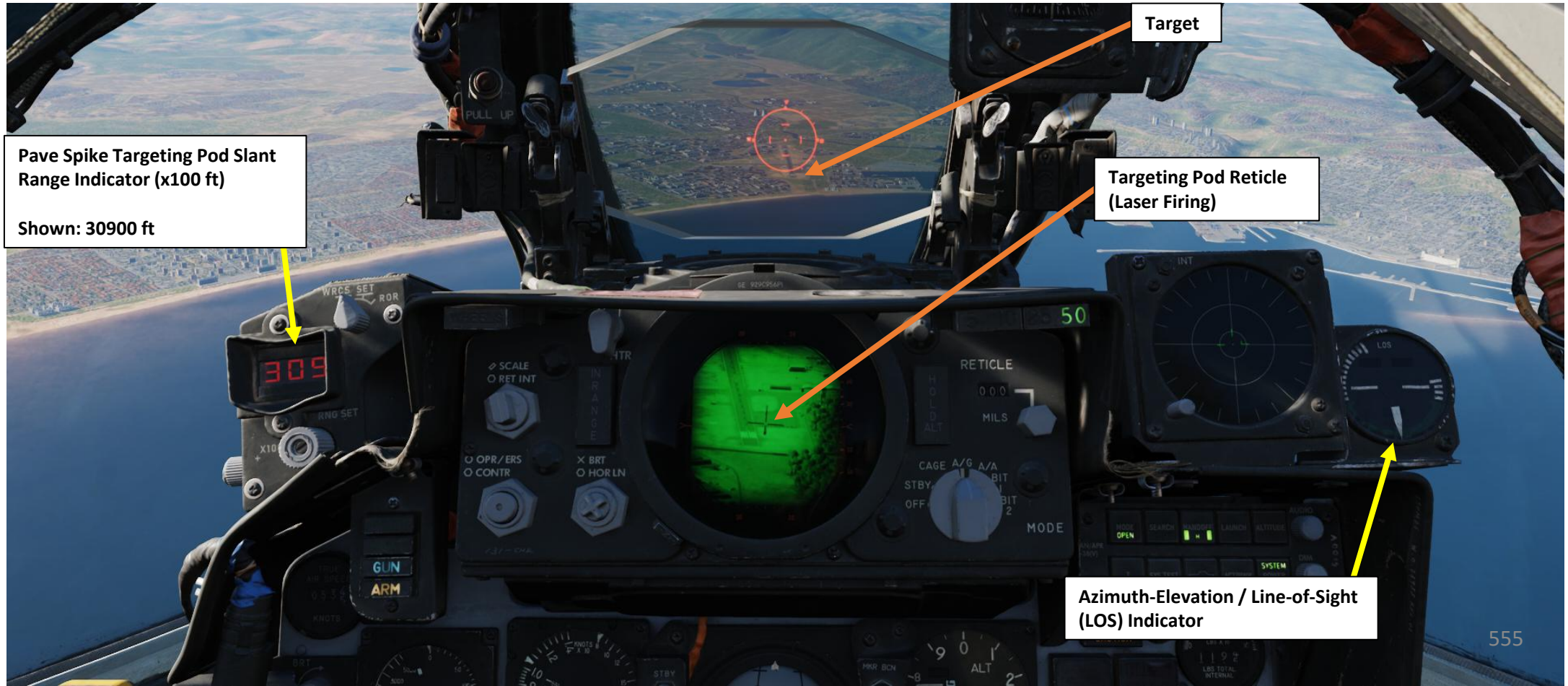


T0 (Release) Cue
- *Not Shown: Pod is not in TRACK Mode*
- *Steady: Pod is commanded to fire laser (Hand Control Stick Trigger to FULL ACTION)*
- *Flashing Quickly: Pod is not commanded to fire laser*

2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

E – Perform Attack

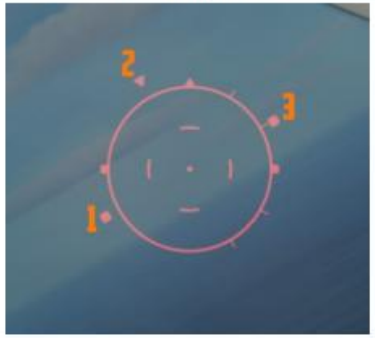
1. *[P]* The pilot should now fly the aircraft in order to keep the target within the targeting pod's line-of-sight and release ordnance based on what delivery mode is selected.
    - Keep in mind that the pod is located on the left side of the aircraft and that it will restrict the way the aircraft has to be flown.
2. *[WSO]* Both crew members should communicate to ensure the targeting pod stays on target. Here are a few brevity terms that may come in handy:
    - **Blanking**: Stores installed on the aircraft (like external fuel tanks) are masking the view.
    - **Ease Off**: Informs the pilot that the targeting pod is approaching masking limits.
    - **Bunt Left/Right**: Command to roll aircraft left/right to maintain or regain target line-of-sight.

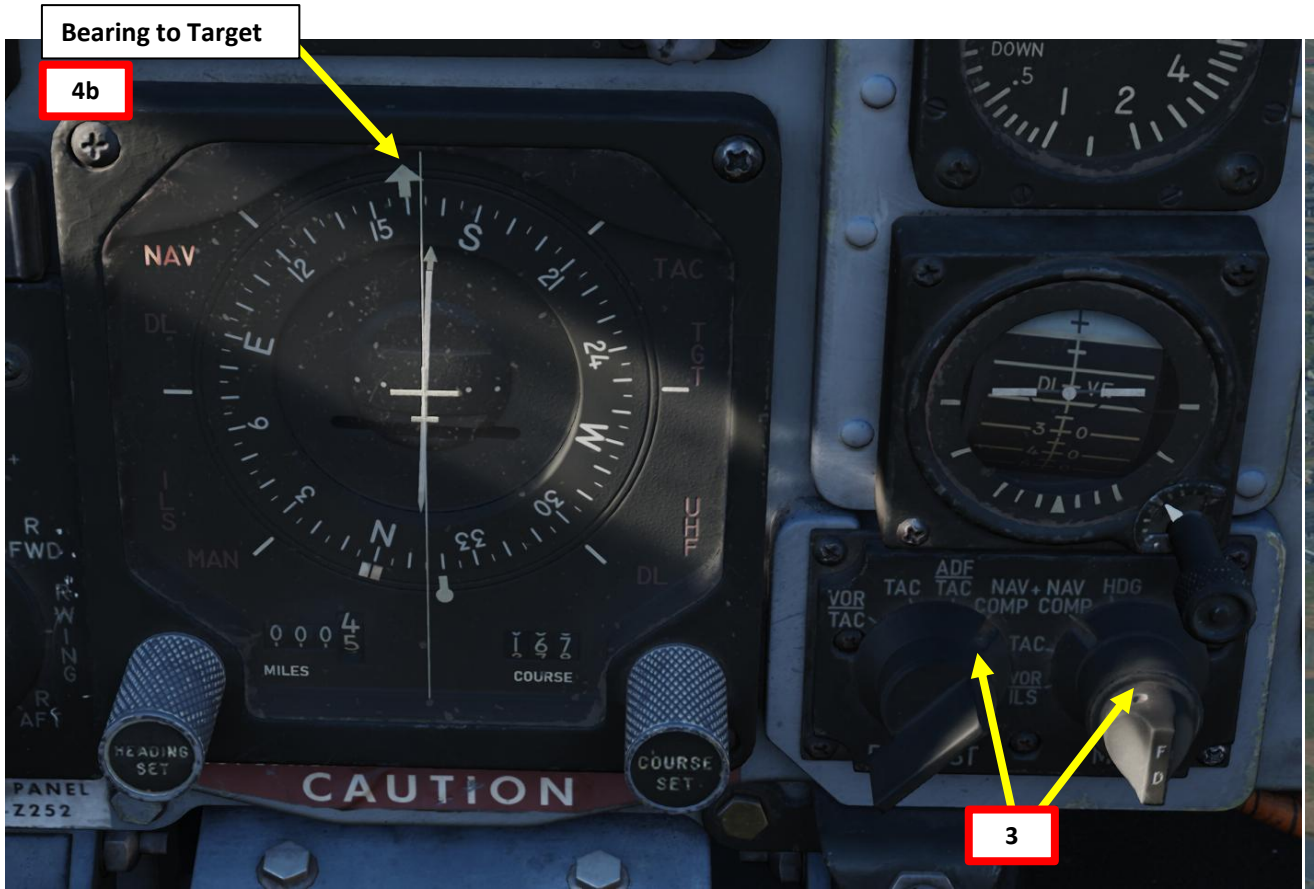


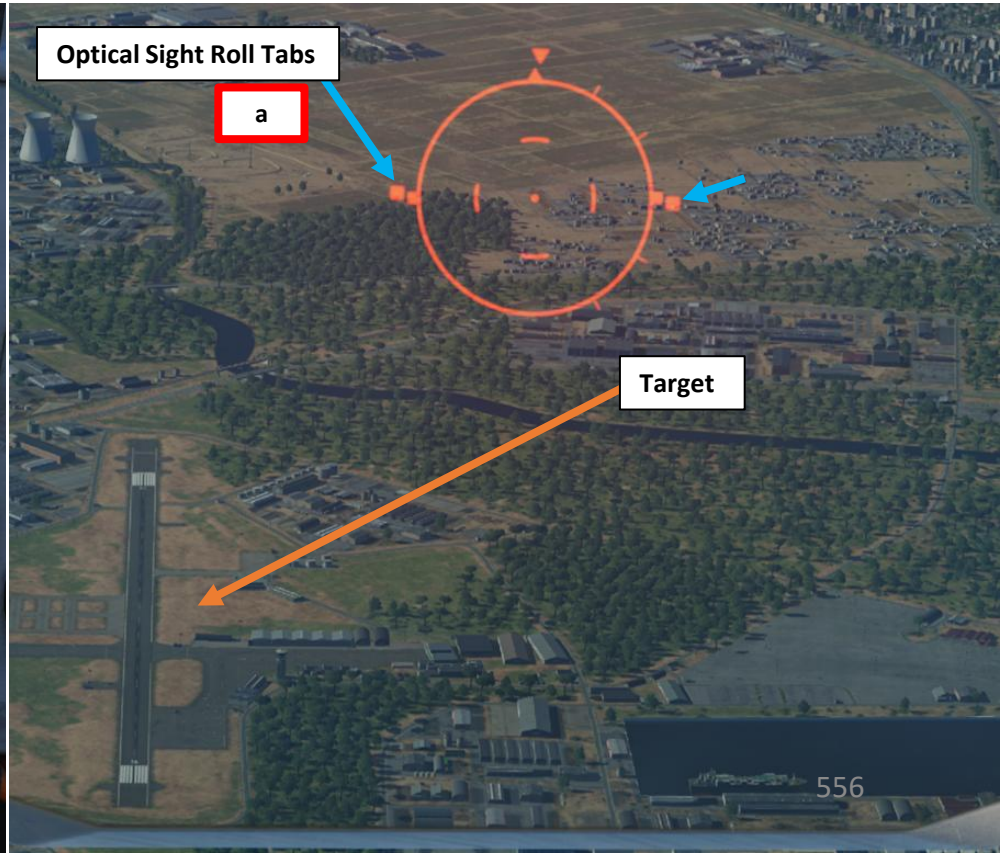
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

E – Perform Attack

3. *[P]* Verify that Navigation Mode Selector (Outer Knob) and Navigation Input Selector are both set to NAV COMP (Navigation Computer).
4. *[P]* When using TGT FIND Mode, there are steering cues that allow you to see where the target is:
    a) The optical sight roll tabs provide steering information from the WRCS. The position of the roll tabs, with respect to the fixed index tabs, indicates the angle between the ground track and course to the target.
    b) The HSI (Horizontal Situation Indicator) Bearing Needle points towards the target designated by the targeting pod.

Roll tab left roll	Roll tab right roll
	
1 left roll tab, 2 center roll tab, 3 right roll tab	*1 left roll tab, 2 center roll tab, 3 right roll tab*





2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

E – Perform Attack

5. *[P]* Start a dive towards the target. Once the target is designated and being lased by the targeting pod and a valid range is being computed, **press and hold the Bomb Release Button** (RALT+SPACEBAR) to insert laser range to the WRCS (Weapon Release Computer Set), and then begin the pullout maneuver, maintaining wings level.
6. *[P]* An audio tone indicates that the WRCS (Weapon Release Computer Set) has accepted the range from the laser when the bomb release button is pressed. This tone stays on until the bomb releases automatically or the bomb release button is released.

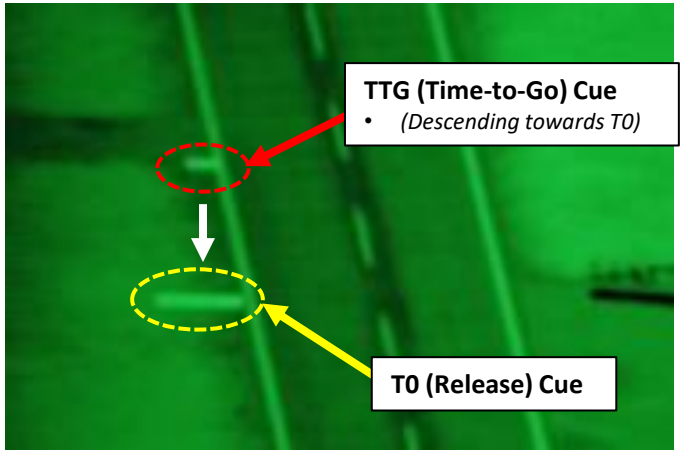




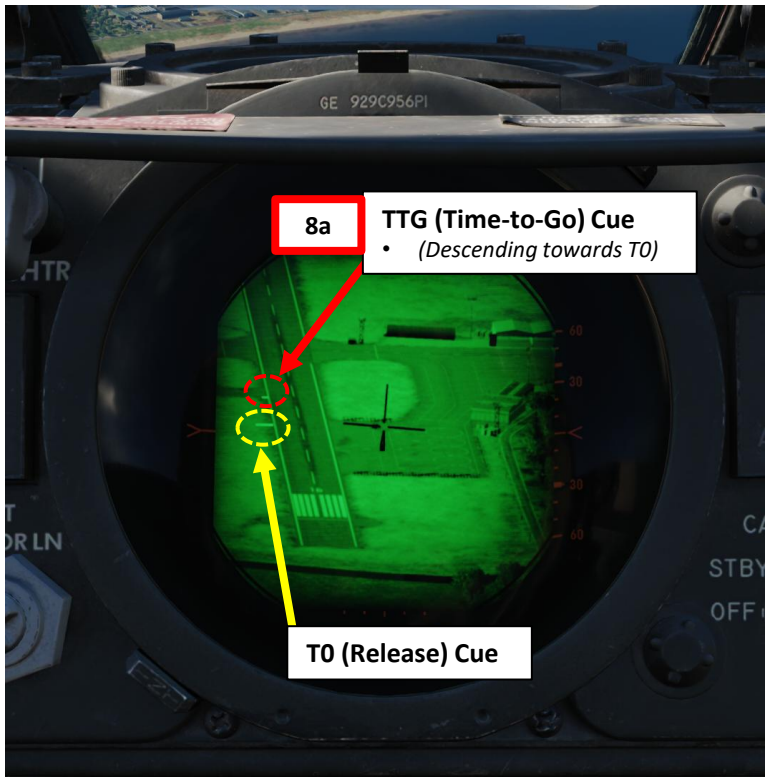
2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

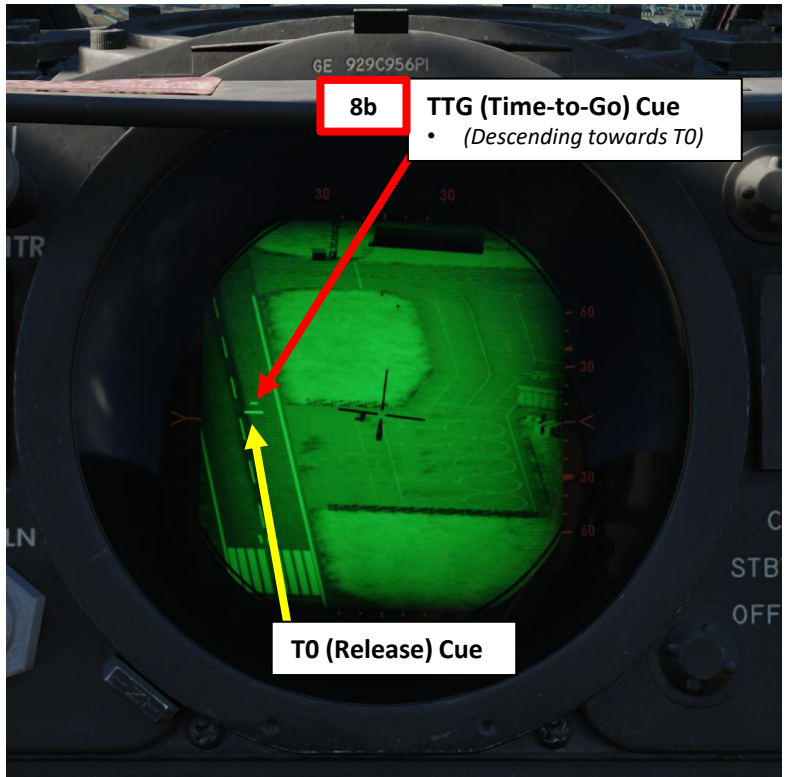
E – Perform Attack

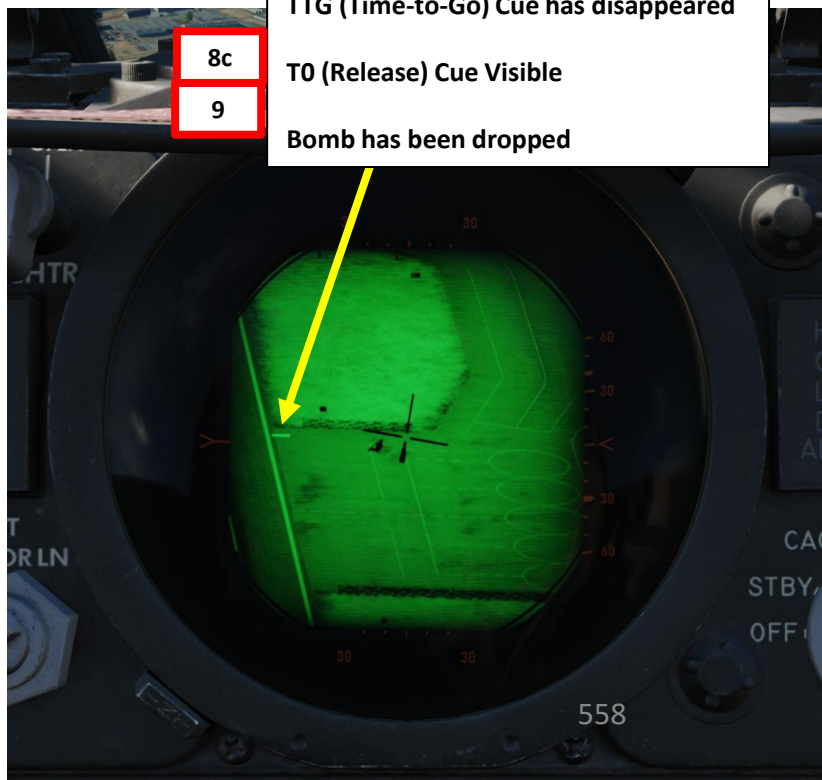
7. *[P+WSO]* After the bomb release button is pressed and held, the laser should still be firing to compute accurate range.
    - **Remember: keep the bomb release button pressed and held all the way until ordnance is released.**
8. *[P+WSO]* As the aircraft is approaching the computed release point of the bomb, the TTG (Time-to-Go) cue will move down and meet the T0 (Release) cue to indicate the time to release from maximally 15 seconds.
9. *[P]* At the point where the bomb computed trajectory will intersect the target, the WRCS (Weapon Release Computer Set) provides the release signal, dropping ordnance.







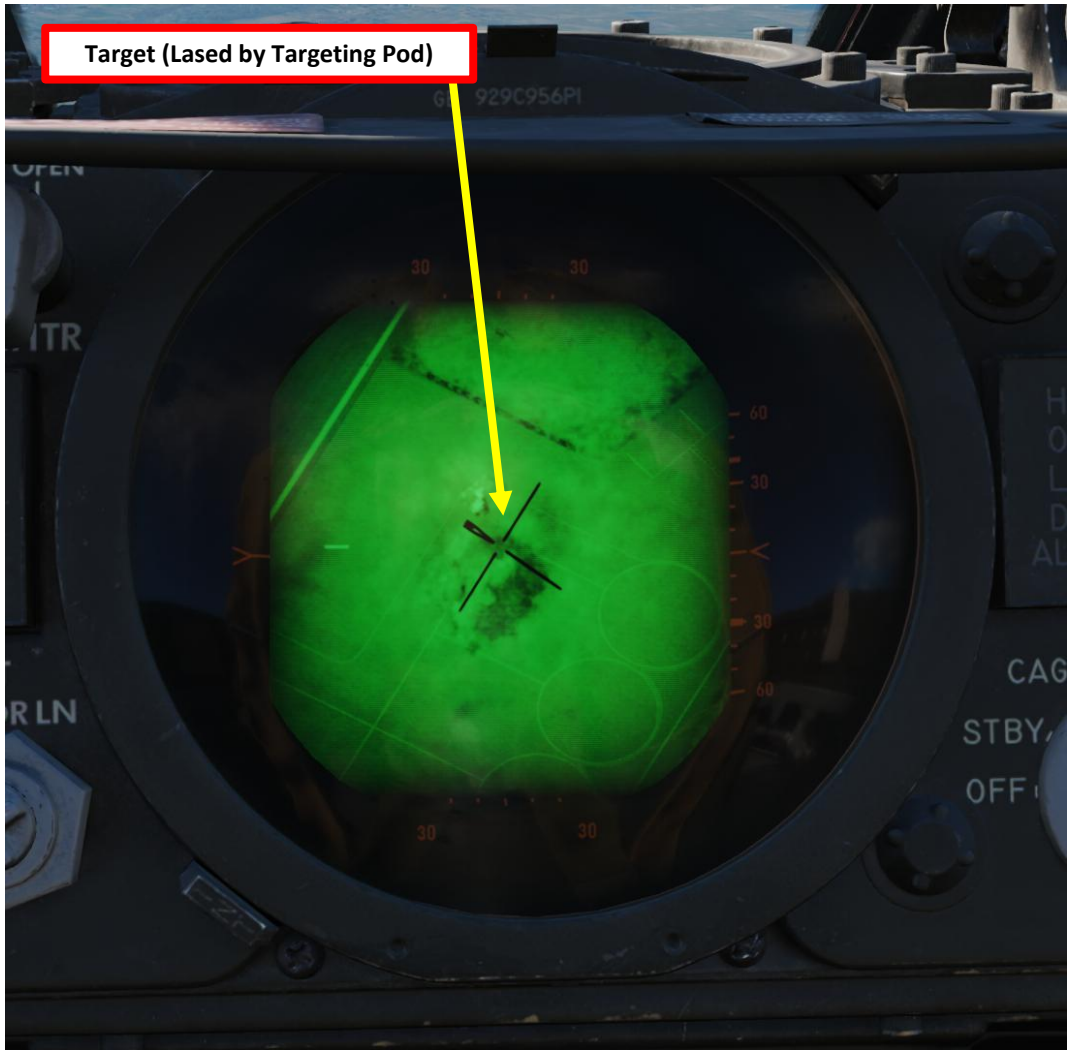


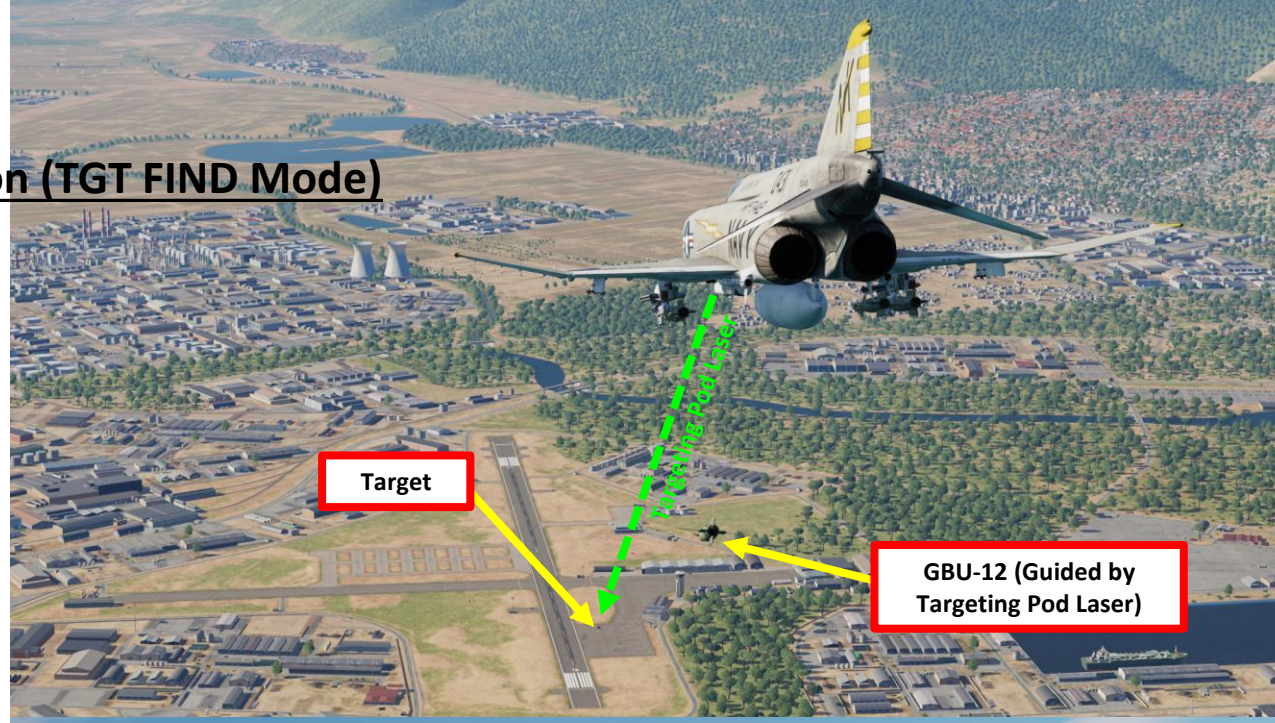


2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

E – Perform Attack

10. *[WSO]* Keep the targeting pod lasing the target; this laser will guide the GBU-12 all the way until impact.



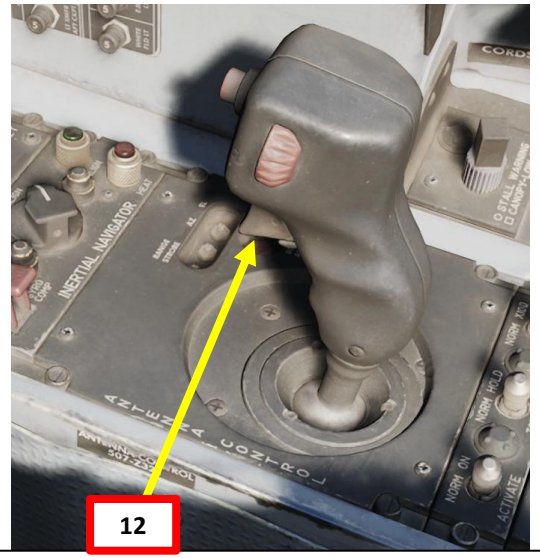




2 – AIR-TO-GROUND WEAPONS
2.3 – Laser-Guided Bombs
2.3.1.2 – GBU-12 Paveway II: Targeting Pod Designation (TGT FIND Mode)

E – Perform Attack

11. *[P]* After bomb impact, egress away from target.
12. *[WSO]* To stop firing the laser, press the Hand Control Stick Trigger's second detent (Full-Action), then release trigger.



Action Switch (Two-Stage Trigger)
- *Half-Action and Release: Toggles between Acquisition Mode (12-Vis, 9-Vis, WRCS) and Tracking Mode*
- *Full-Action and Release: Toggles firing the laser*
- *If in Memory Mode or Acquisition Mode (12-Vis, 9-Vis, WRCS), Full-Action and Release will enter tracking mode and fire the laser.*



2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode



2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

A – Determine Attack Profile

- The BLU-107 Durandal is an air-dropped, specialized anti-runway bomb originally developed by the French company Matra, utilizing its dual charge warhead, is designed to penetrate and disable airport runways to hinder enemy aircraft operations and subsequent repair. Designed to be dropped from low altitudes, the bomb deploys a parachute to slow its descent before a rocket booster propels it into the runway where it then detonates its primary charge once penetrating the runway and its secondary charge is detonated soon after (the delay in between each charge was programmable on later models).

- With Durandals, we will employ Direct Mode and fly a level run at 500 ft above ground level and an airspeed of 500 kts true airspeed (or 450 kts indicated airspeed).

In this tutorial, we want to use twelve Durandals (ripple release) at an interval of 0.5 sec.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.





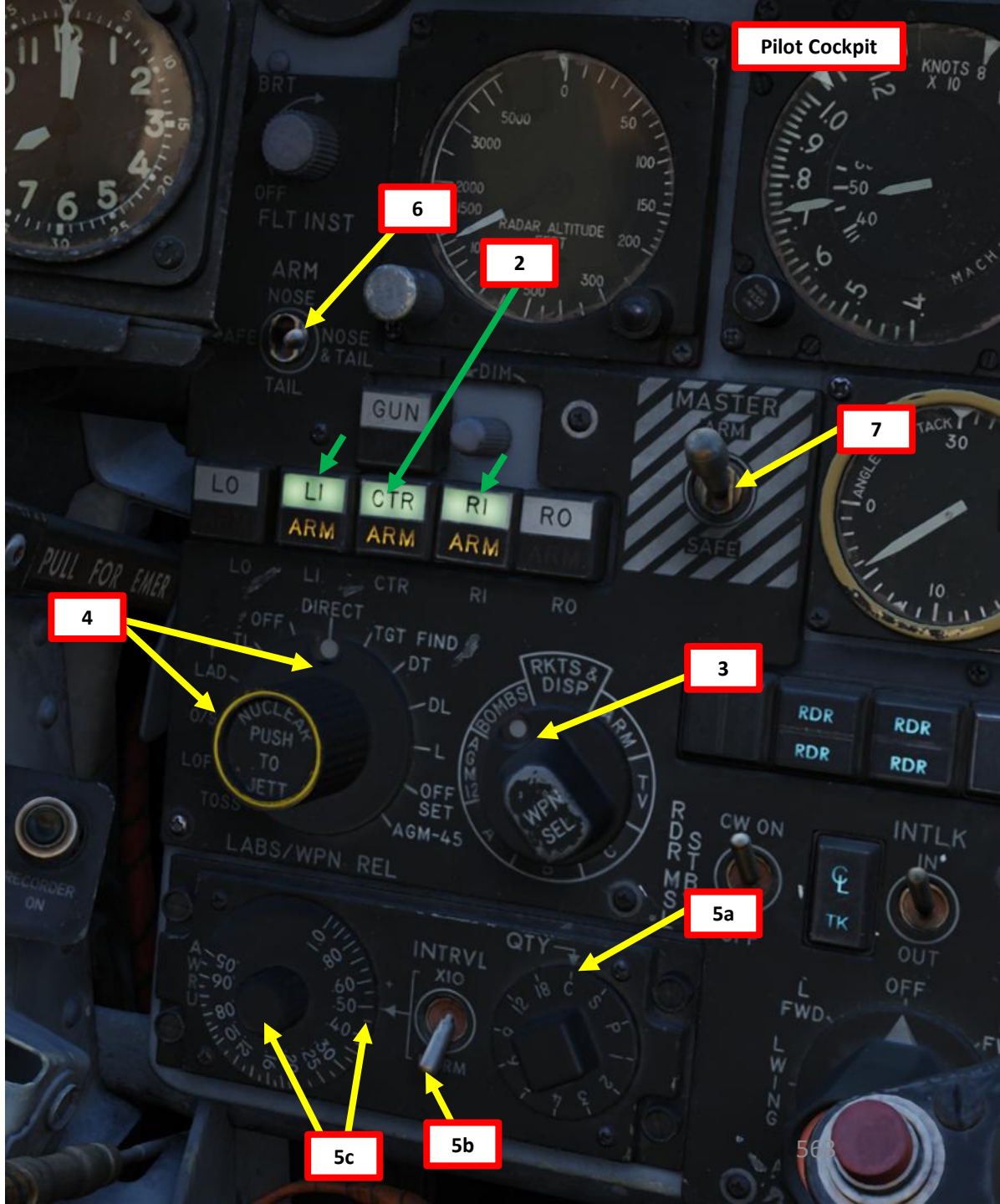


2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

B – Weapon Setup

2. *[P]* Select desired Station Select Buttons. We will use CTR, LI and LO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – BOMBS
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
5. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
   a) Set Store Quantity Knob – As desired (C, Continuous)
   b) Set Weapon Interval Selector Switch – NORMAL x1 (DOWN)
   c) Set Weapon Release Interval Selector Knob – 0.5 sec
6. *[P]* Set Fuzing Arming Switch – NOSE & TAIL (RIGHT)
7. *[P]* Set Master Arm Switch – ARMED (UP)

BLU-107 Durandal *Direct/Manual Mode*	
Delivery Parameters	**Bombing Pattern Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.5 sec
Release Angle: 0 deg (Level)	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 500 ft	Quantity Setting: C (Continuous)
Sight Depression: 125 mils	

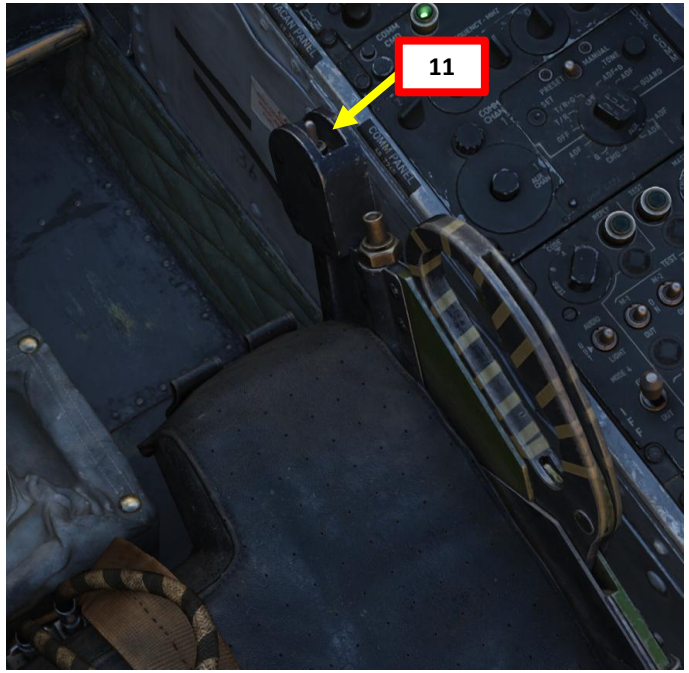


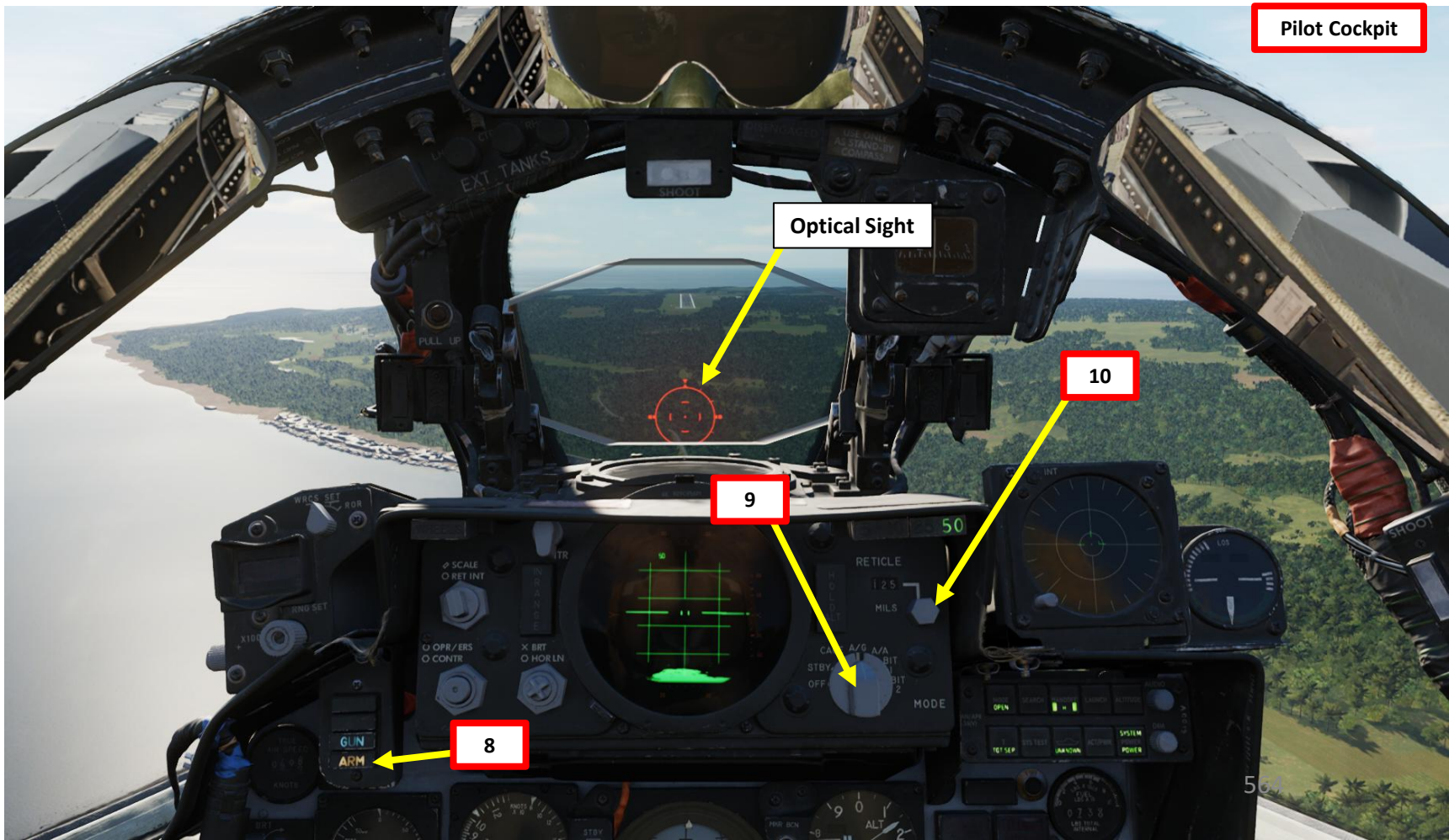
2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

B – Weapon Setup

8. *[P]* Confirm ARM light is illuminated
9. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
10. *[P]* Set Reticle Depression Setting Knob to 125 Mils.
11. *[P]* Adjust Seat Position – As required to see the reticle.

BLU-107 Durandal *Direct/Manual Mode*	
Delivery Parameters	**Bombing Pattern Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.5 sec
Release Angle: 0 deg (Level)	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 500 ft	Quantity Setting: C (Continuous)
Sight Depression: 125 mils	



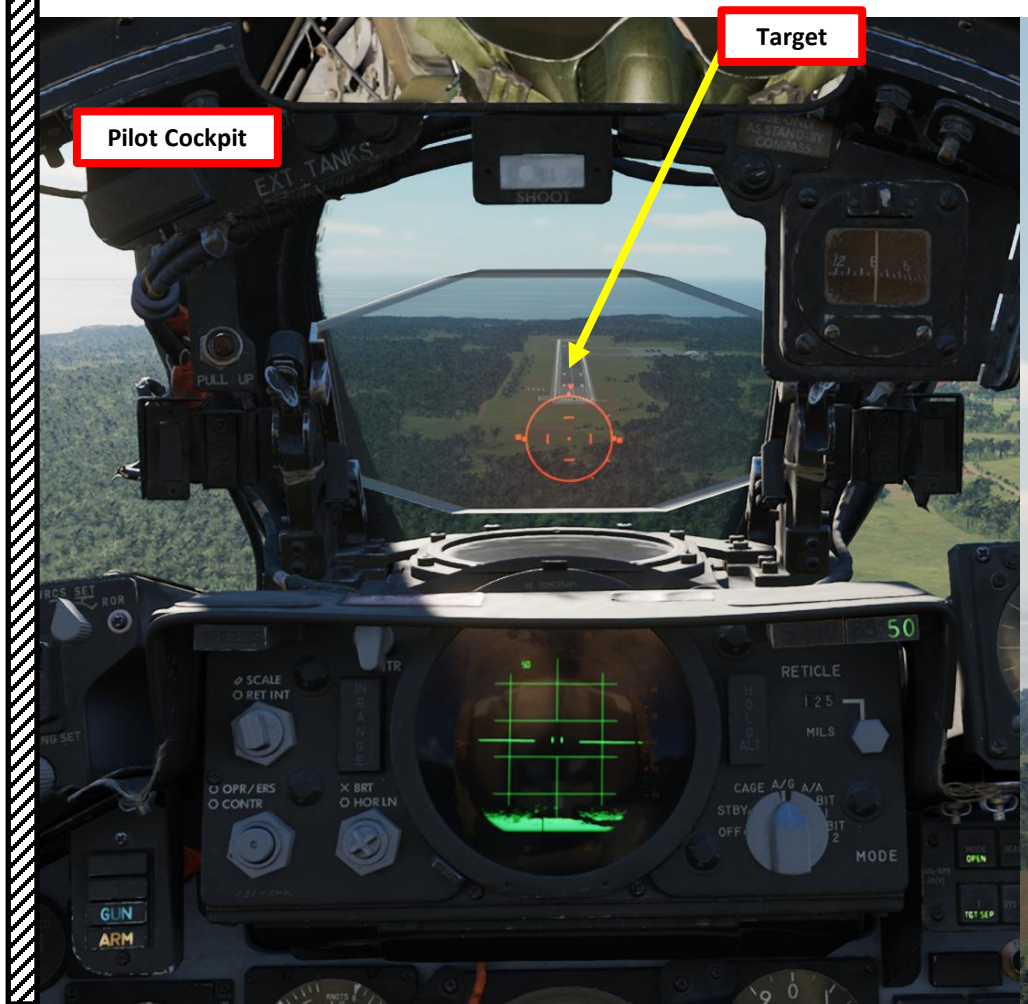


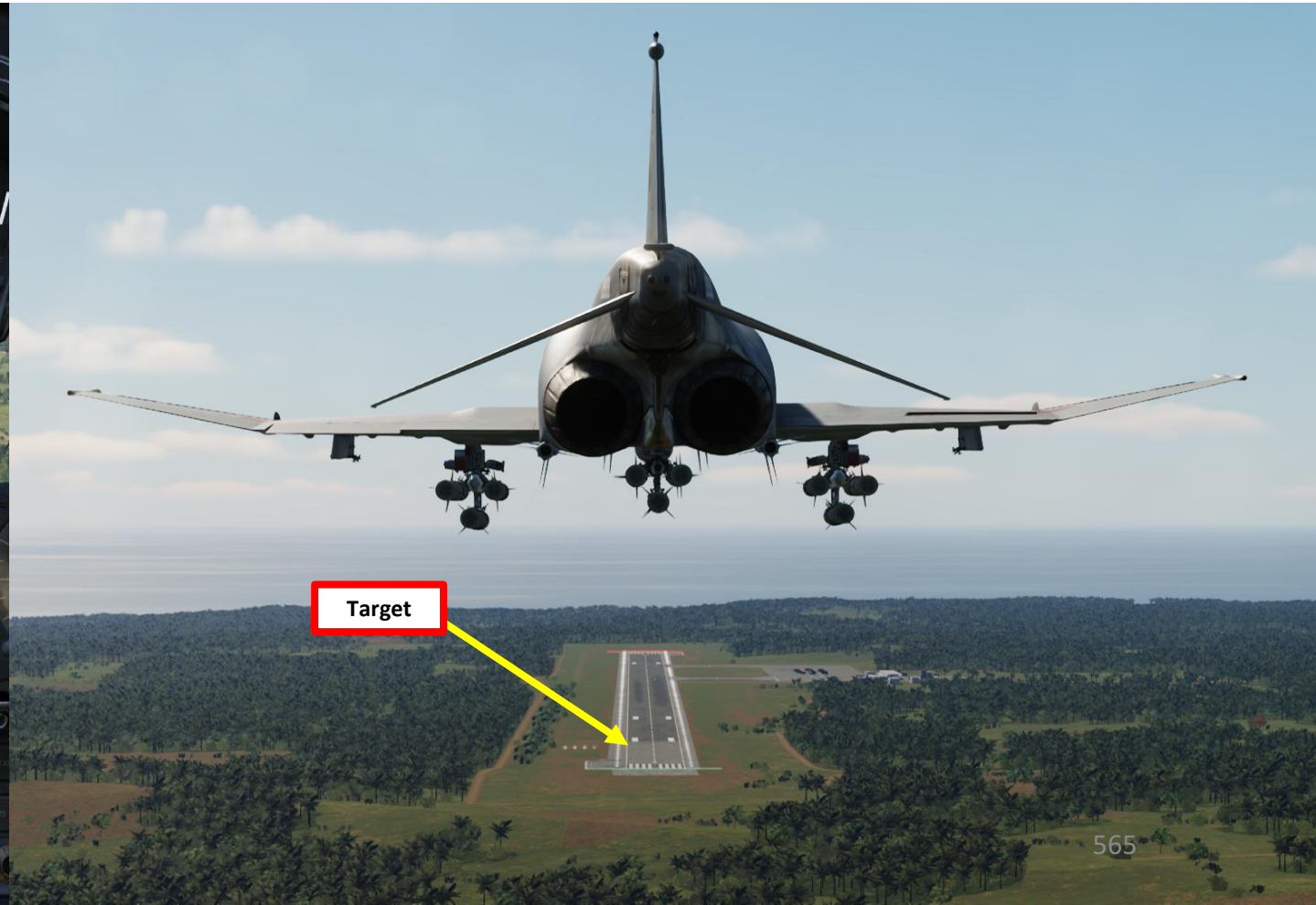
2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

C – Perform Attack

12. *[P]* Once the target has been identified, set throttle to maintain 450 kts indicated and an altitude of 500 ft AGL. Prepare to fly over the target while maintaining wings level.

BLU-107 Durandal *Direct/Manual Mode*	
Delivery Parameters	**Bombing Pattern Parameters** *(only if releasing multiple bombs)*
Airspeed: 500 KTAS / 450 KIAS	Release Interval: 0.5 sec
Release Angle: 0 deg (Level)	Interval Multiplier: Normal (x1)
Release Altitude (AGL): 500 ft	Quantity Setting: C (Continuous)
Sight Depression: 125 mils	





2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

C – Perform Attack

13. *[P]* When reticle/pipper is on the target at 500 ft AGL and 450 kts indicated, press and hold the Bomb Release Button (RALT+SPACEBAR) until all bombs are released.



Bomb Release Button
- *Binding: RALT+SPACEBAR*







2 – AIR-TO-GROUND WEAPONS
2.4 – Anti-Runway Bombs
2.4.1 – BLU-107 Durandal: Direct Mode

C – Perform Attack

14. *[P]* Once all bombs are released, perform safe-escape manoeuver by pulling 4 Gs; this will avoid flying the aircraft into the frag envelope and suffering potential fragmentation damage.
15. *[P]* Durandals are used against hard/reinforced targets like runways. The forward half of the bomb holds the explosives, the penetrator and the fuse. The aft half contains the booster, the 4 stabilizing fins and the deployable chute. Just after the bomb is released, the parachute is deployed, separating the bomb from the aircraft and slowing it down. A short delay after, the parachute is jettisoned and the booster rocket is fired, accelerating the bomb into the ground. After penetration is achieved, the bomb explodes… creating a crater.







2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)



2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)

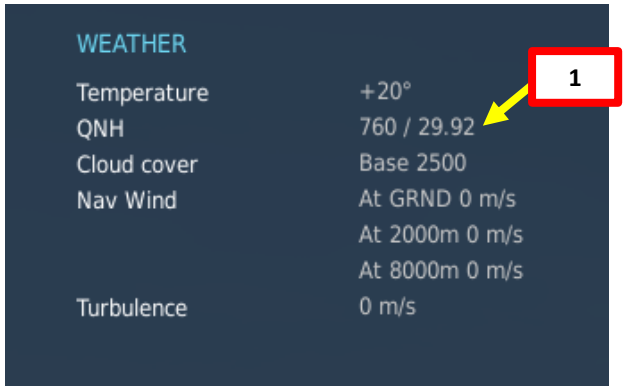
A – Determine Attack Profile

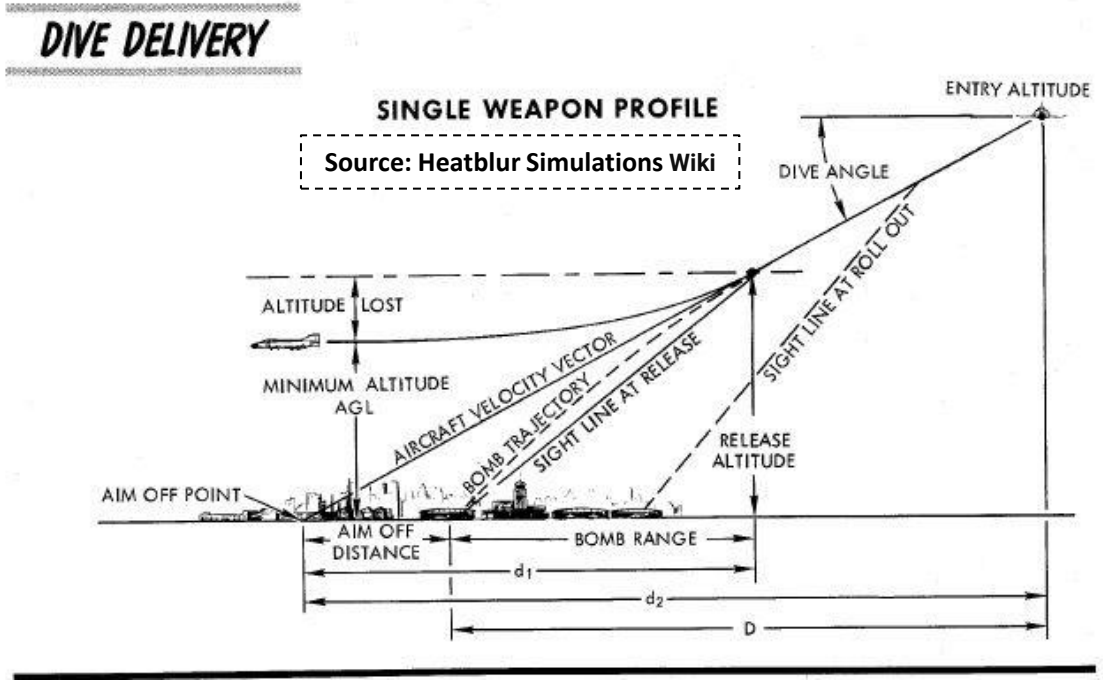
Direct Mode is considered to be the most basic/classic attack mode of the F-4E; following a simple attack profile should be enough to successfully engage targets of opportunity. Both the ARBCS (Attitude Reference & Bombing Computer Set) and WRCS (Weapon Release Computer Set) are excluded from this release mode, and the pilot flies the profile as found in the profile table, setting the sight depression to match, and hand flying the aircraft to place the reticle/pipper directly onto the target in accordance with the desired type of attack.

In this tutorial, we want to launch rockets. We will use an attack profile of 3000 ft, 400 kts (indicated), a dive angle of 30 deg and a sight depression of 15 mils.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.







Rocket Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
2500	450 – 500	10	30
2500	425 – 475	20	25
3000	400 – 425	30	15
3000	400 – 425	45	0 - 10

Variant	Description
White Phosphor	For marking target areas
HE	Against infantry and light armored targets
HEAT	Against armored targets, such as vehicles

2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)

B – Weapon Setup

2. *[P]* Select desired Station Select Buttons. We will use LO and RO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – RKTS & DISP (Rockets & Dispensers)
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
5. *[P]* Set AWRU (Aircraft Weapons Release Unit) Control Panel
    a) Set Store Quantity Knob – As desired (we will launch 6 rockets)
6. *[P]* Set Master Arm Switch – ARMED (UP)

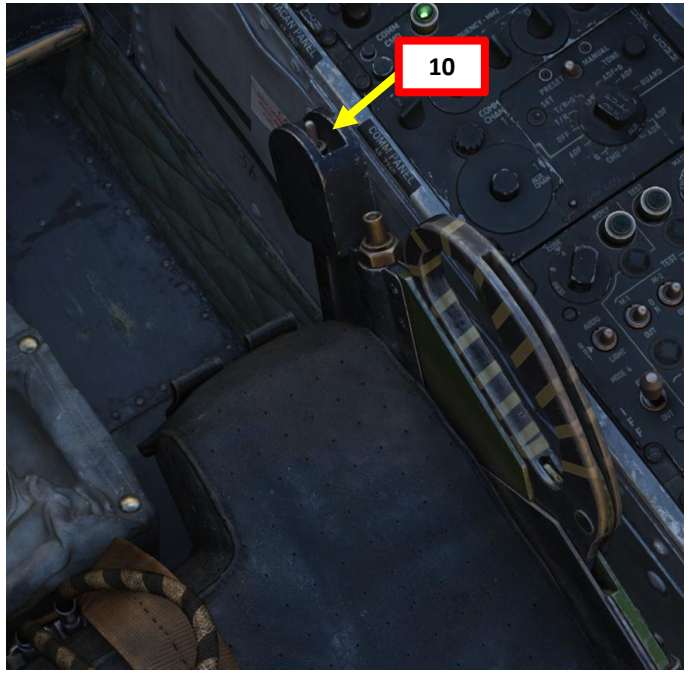


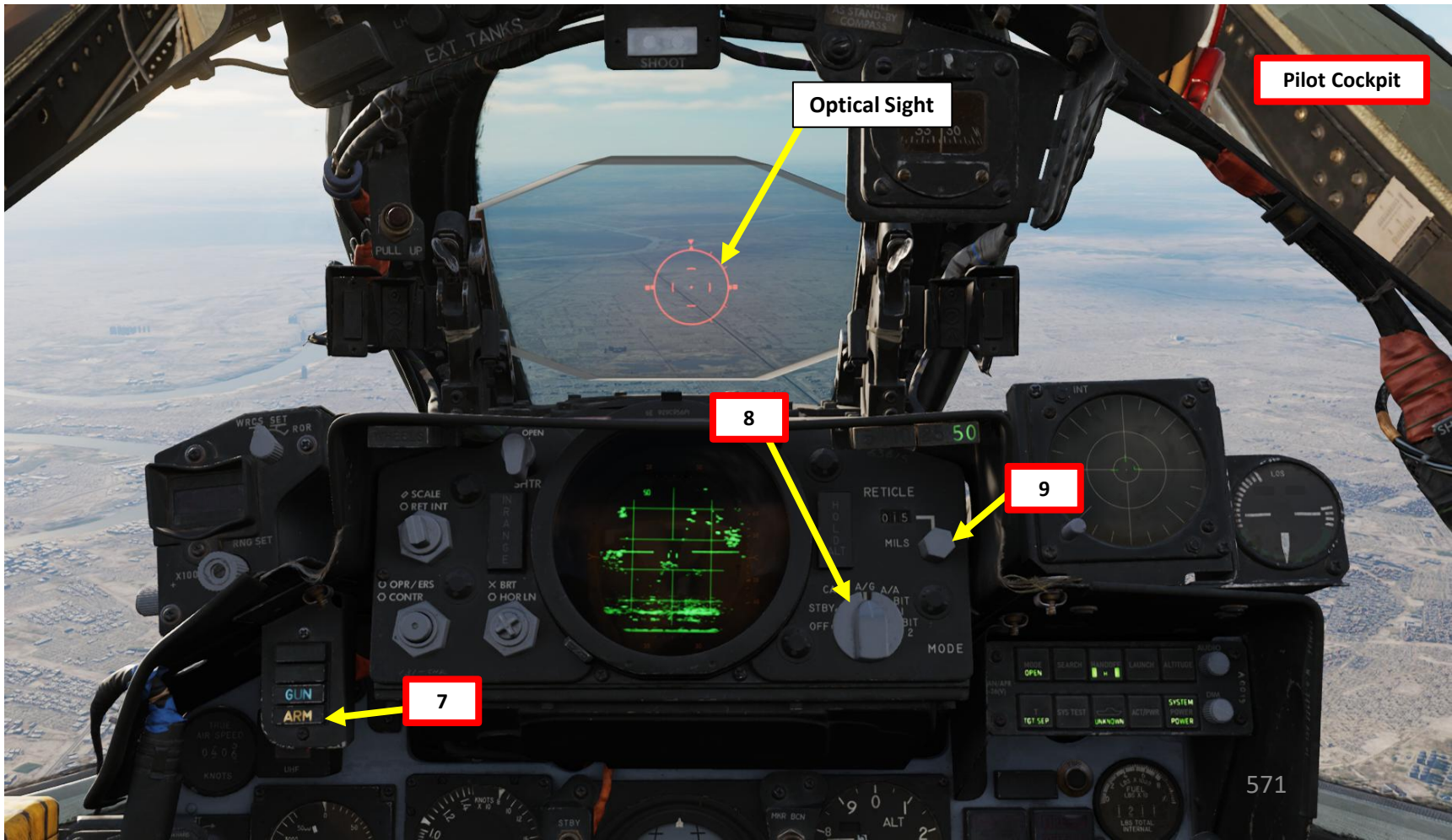
2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)

B – Weapon Setup

7. *[P]* Confirm ARM light is illuminated
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Set Reticle Depression Setting Knob to 15 Mils.
10. *[P]* Adjust Seat Position – As required to see the reticle.

Rocket Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
2500	450 – 500	10	30
2500	425 – 475	20	25
3000	400 – 425	30	15 ←
3000	400 – 425	45	0 - 10



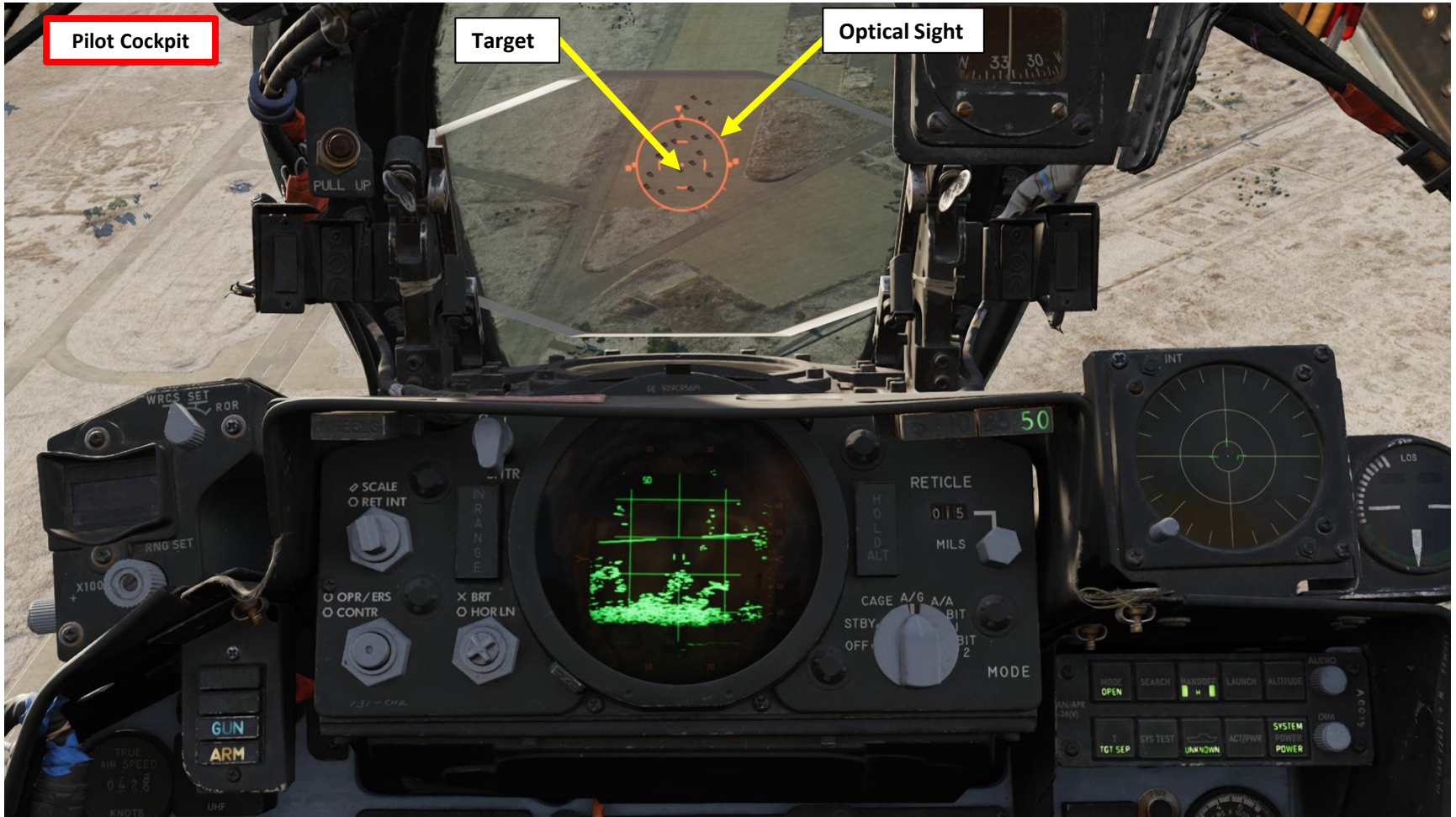


2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)

C – Perform Attack

11. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (400 kts indicated, 30 deg dive).
12. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
13. *[P]* When at release altitude (3000 ft AGL), press and hold the Bomb Release Button (RALT+SPACEBAR) until rockets are fired.

Rocket Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
2500	450 – 500	10	30
2500	425 – 475	20	25
3000	400 – 425	30	15
3000	400 – 425	45	0 - 10





2 – AIR-TO-GROUND WEAPONS
2.5 – Rockets
2.5.1 – Hydra 70 (2.75 in) FFAR (Folding-Fin Aerial Rocket)

C – Perform Attack

14. *[P]* When rockets are fired, begin the pullout maneuver, maintaining wings level.







2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground



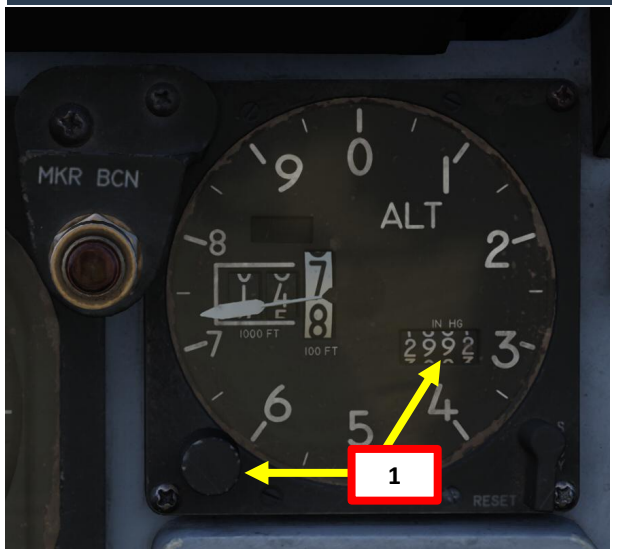
2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground

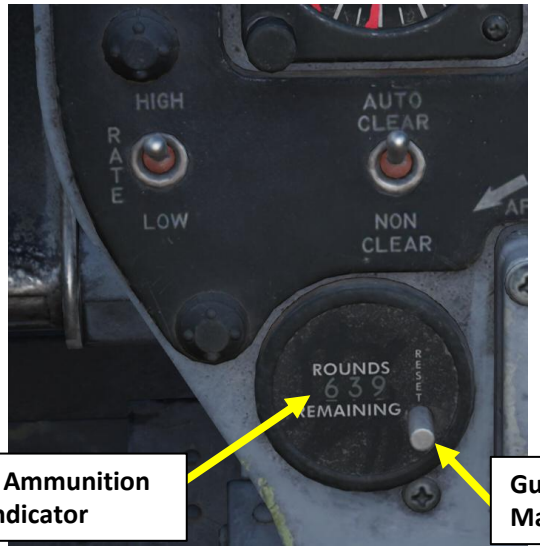
A – Determine Attack Profile

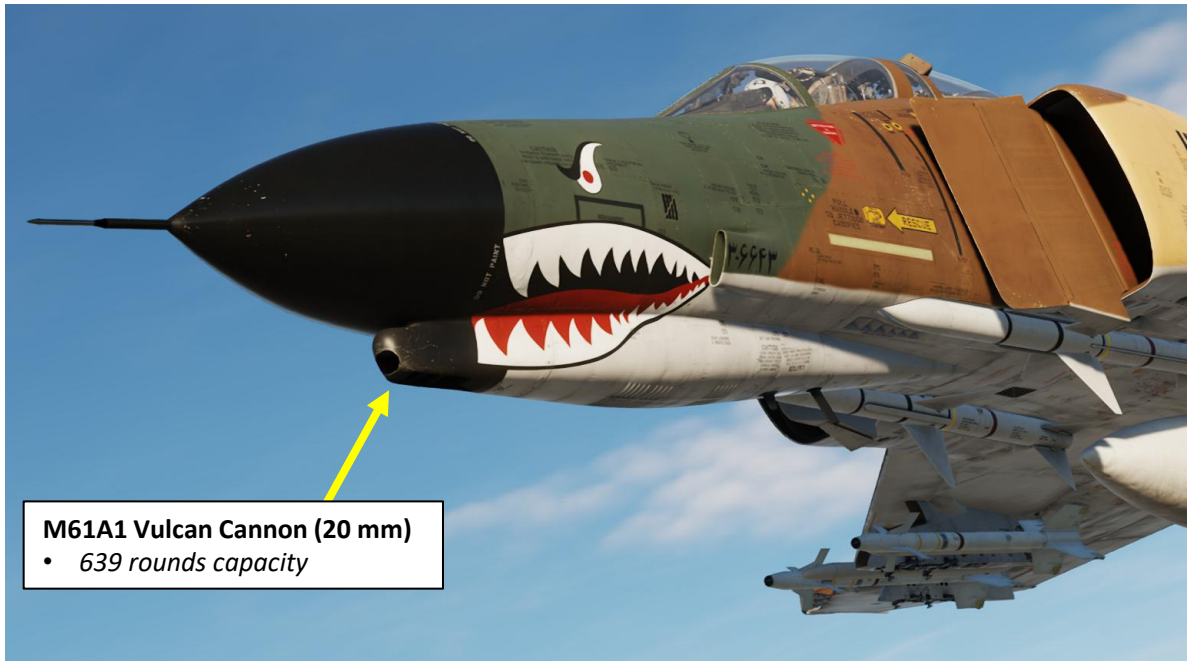
In this tutorial, we will use the internal M61A1 gun with an attack profile of 1000 ft, 425 kts (indicated), a dive angle of 15 deg and a sight depression of 45 mils.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.









Internal M61A1 Gun Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
3000	425 – 450	10 – 15	100 – 110
2500	425 – 450	10 – 15	80 – 90
2000	425 – 450	10 – 15	70
1500	425 – 450	10 – 15	50 – 55
1000	425 – 450	10 – 15	40 – 45

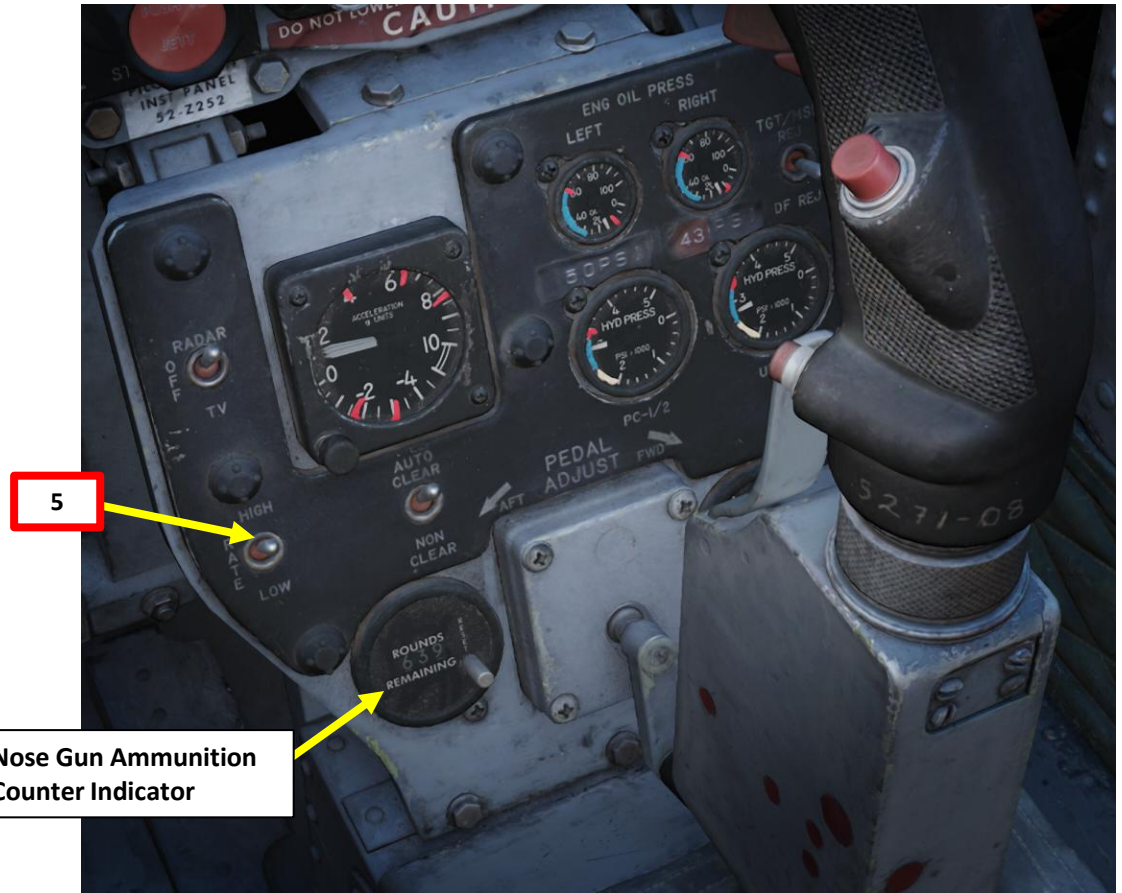


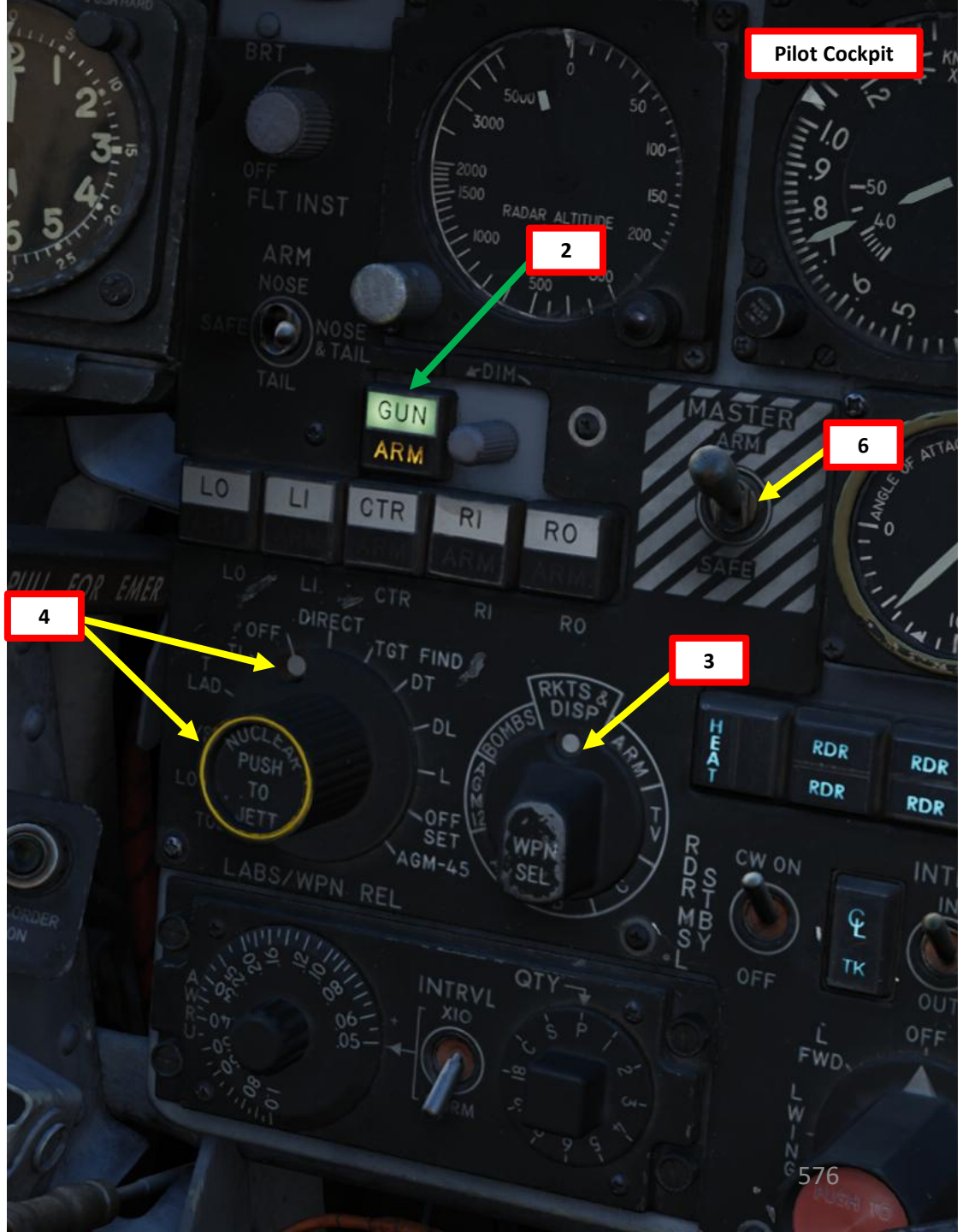
Ammunition Types (20 mm)
- ***HEI: High Explosive Incendiary***
- ***API: Armor Piercing Incendiary***
- ***AP&HE: Armor Piercing & High Explosive***
- ***TP: Training Practice, inert rounds***

2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground

B – Weapon Setup

2. *[P]* Select GUN Button.
3. *[P]* Set Weapon Selector Knob – Any position except TV or ARM.
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – OFF
5. *[P]* Set Gun Fire Rate Switch – As desired
    - UP: High Rate of Fire (6000 rounds/min)
    - DOWN: Low Rate of Fire (4000 rounds/min)
6. *[P]* Set Master Arm Switch – ARMED (UP)



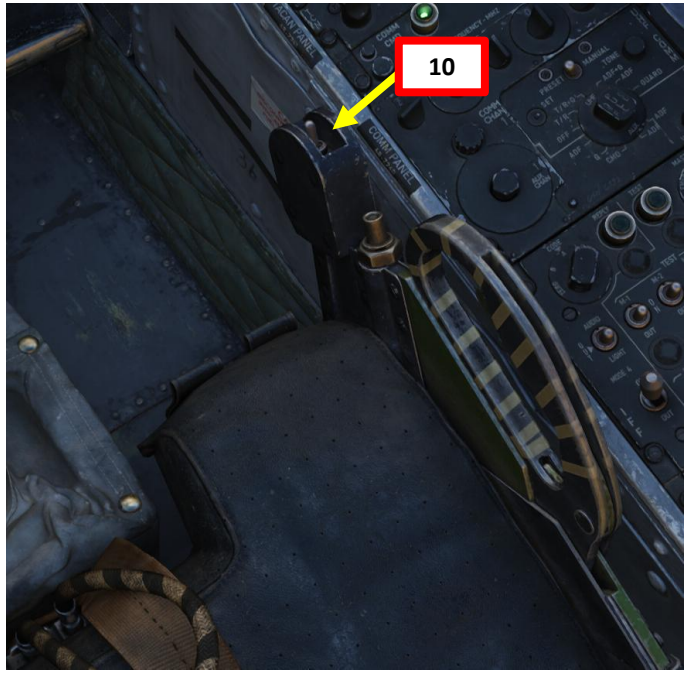


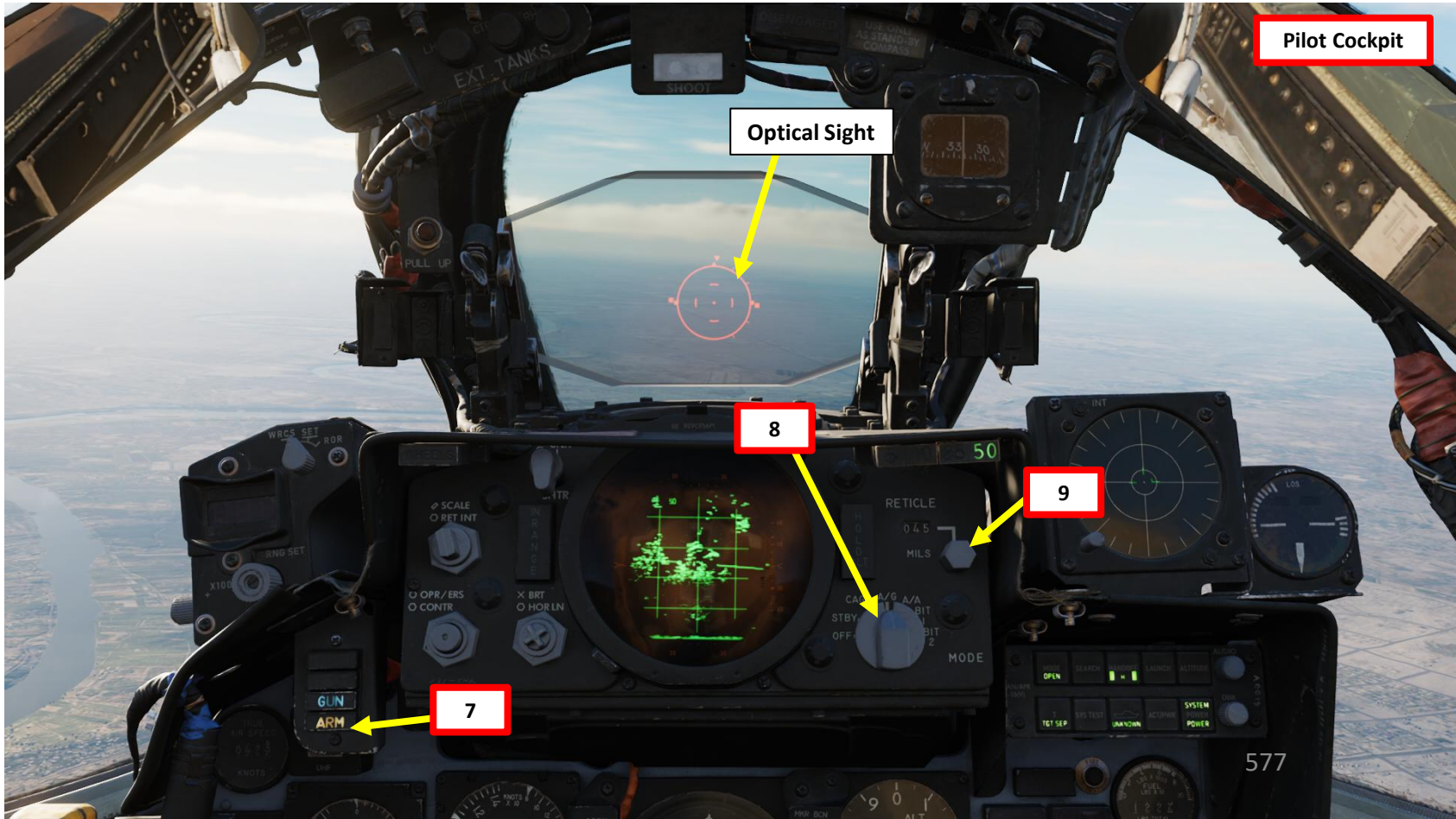
2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground

B – Weapon Setup

7. *[P]* Confirm ARM light is illuminated
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Set Reticle Depression Setting Knob to 45 Mils.
10. *[P]* Adjust Seat Position – As required to see the reticle.

Internal M61A1 Gun Diving Attack Profile			
Altitude (ft)	Diving Speed (kts Calibrated)	Dive Angle (deg)	Optical Sight Depression (mils)
3000	425 – 450	10 – 15	100 – 110
2500	425 – 450	10 – 15	80 – 90
2000	425 – 450	10 – 15	70
1500	425 – 450	10 – 15	50 – 55
1000	425 – 450	10 – 15	40 – 45 ←



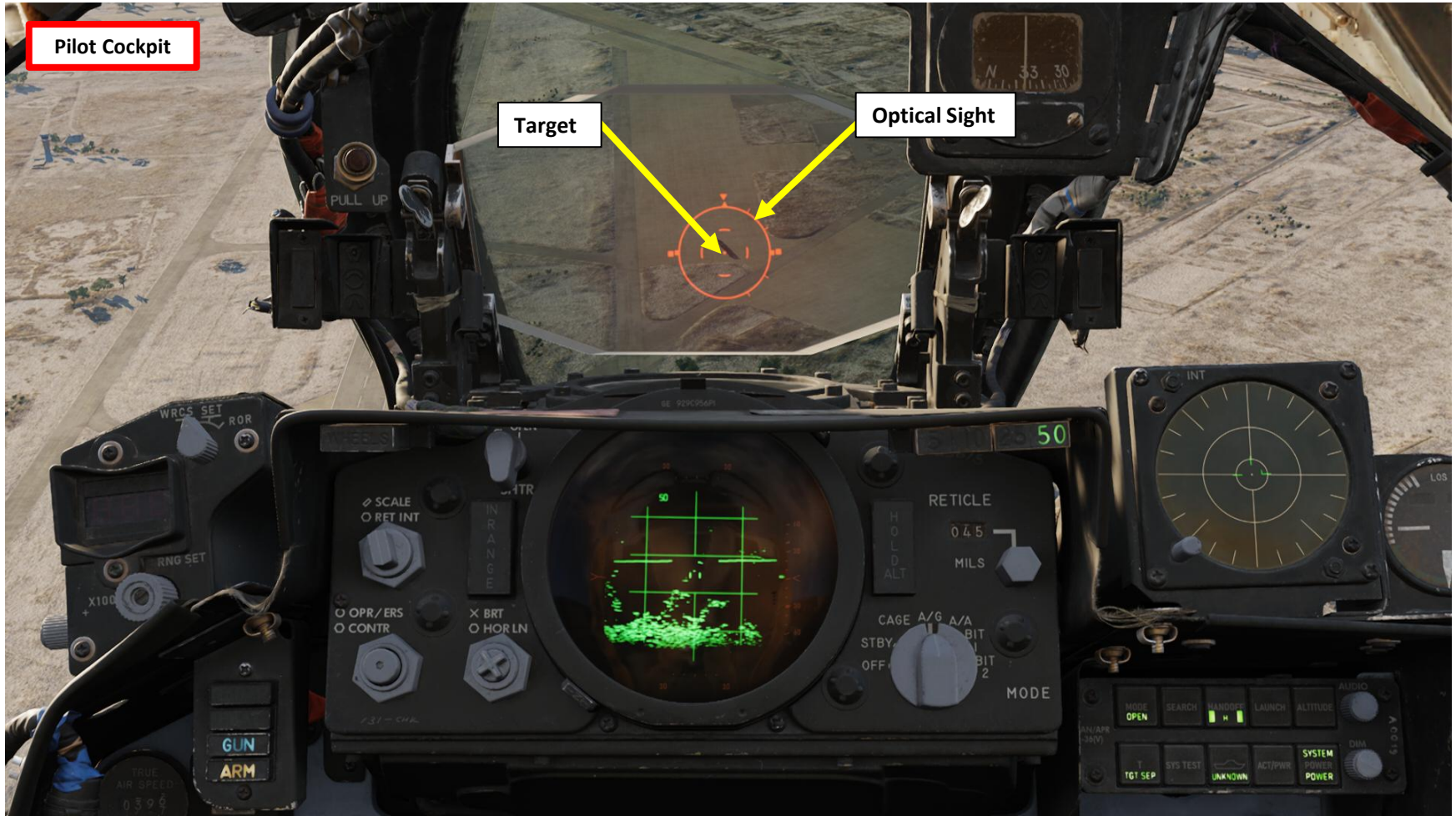


2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground

C – Perform Attack

11. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (425 kts indicated, 15 deg dive).
12. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
13. *[P]* When at release altitude (1000 ft AGL), squeeze the Trigger's second detent (Full Action) (SPACEBAR) to fire the internal gun.

Internal M61A1 Gun Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
3000	425 – 450	10 – 15	100 – 110
2500	425 – 450	10 – 15	80 – 90
2000	425 – 450	10 – 15	70
1500	425 – 450	10 – 15	50 – 55
1000	425 – 450	10 – 15	40 – 45





Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Ground

C – Perform Attack

14. *[P]* Accumulated gas is vented by ram air entering the Gun Purge Door on the nose of the aircraft. The door is held closed by hydraulic pressure and will automatically open to release the gas from firing the gun. It closes after the gas pressure has reduced below a threshold or the gun is de-energized, for example when switching Master Arm or all rounds have been fired. The venting process takes between 10 seconds to 1 minute, depending on the burst duration.





2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)



2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)

A – Determine Attack Profile

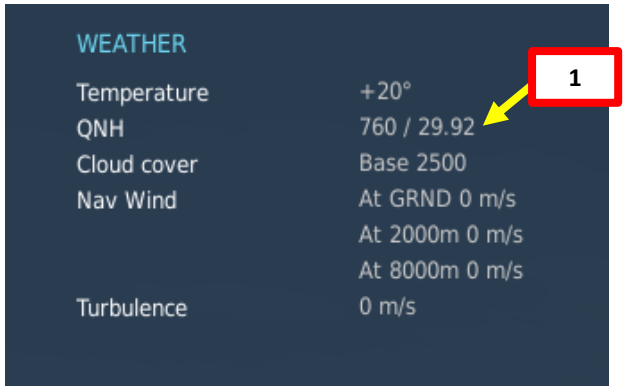
In this tutorial, we will use wing-mounted SUU-23 gun pods with an attack profile of 1000 ft, 425 kts (indicated), a dive angle of 15 deg and a sight depression of 15 mils.

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.



SUU-23 Gun Pod (20 mm)
- *1200 rounds capacity*
- *No ammunition count indicator*



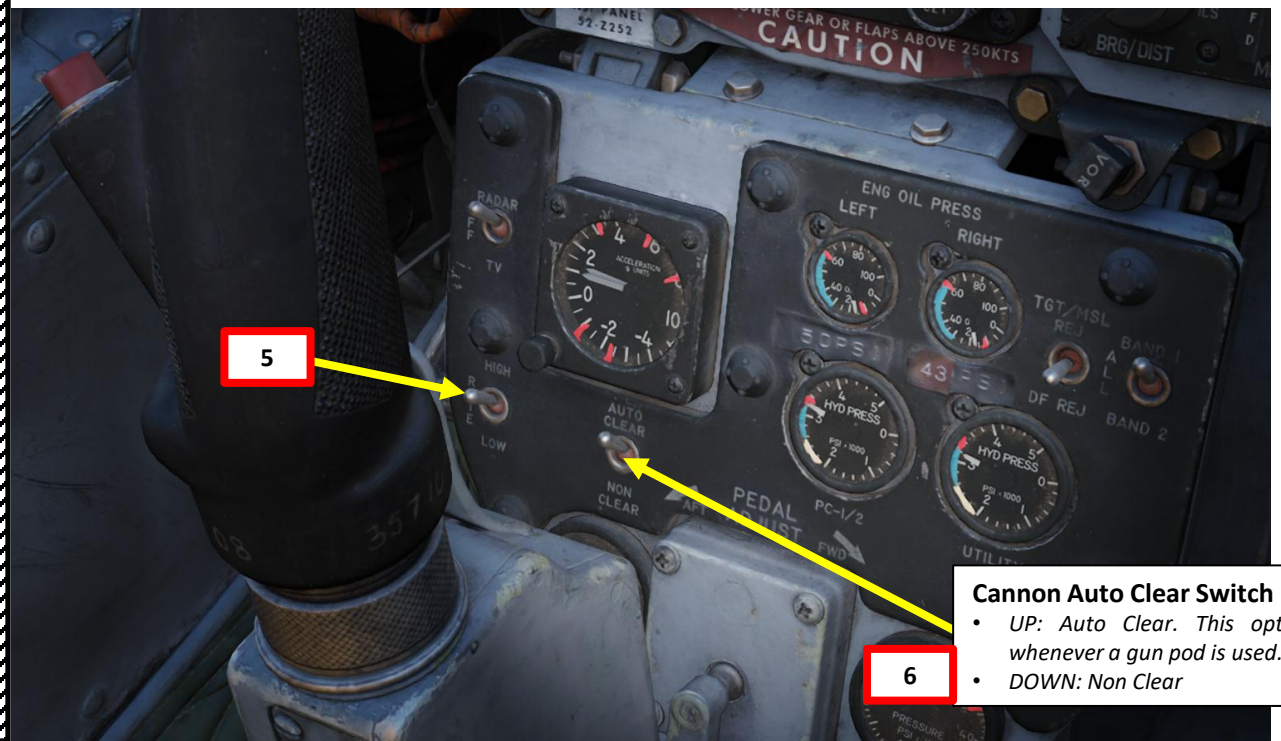


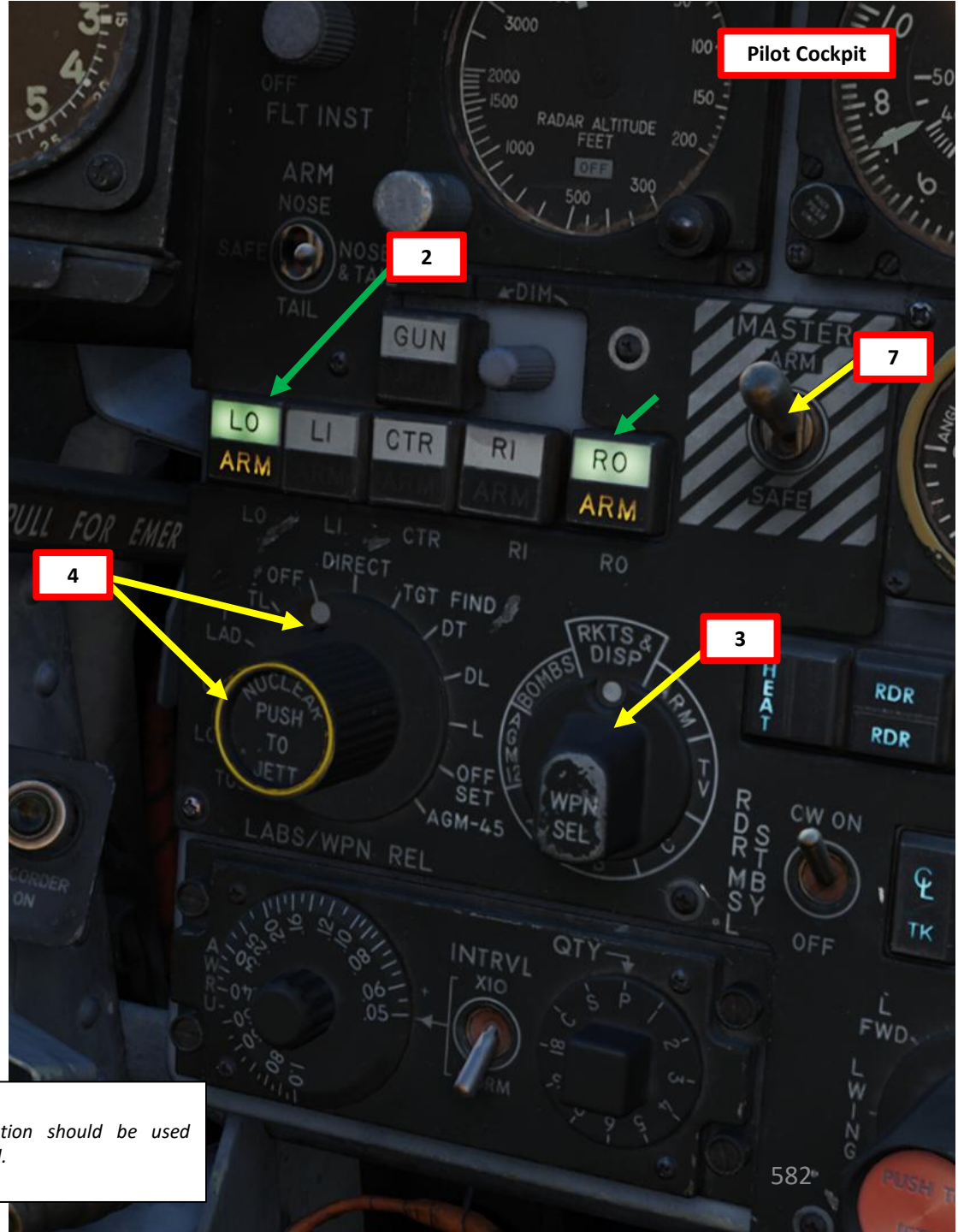
External SUU-23 Gun Pod Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
3000	425 – 450	10 – 15	80 – 85
2500	425 – 450	10 – 15	65
2000	425 – 450	10 – 15	50
1500	425 – 450	10 – 15	30
1000	425 – 450	10 – 15	10 – 15

2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)

B – Weapon Setup

2. *[P]* Select desired Station Select Buttons. We will use LO and RO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – Any position except TV or ARM.
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – OFF
5. *[P]* Set Gun Fire Rate Switch – As desired
    - UP: High Rate of Fire (6000 rounds/min)
    - DOWN: Low Rate of Fire (4000 rounds/min)
6. *[P]* Set Cannon Auto Clear Switch – AUTO CLEAR (UP).
    - The cannon will fire approximately between 5 and 11 rounds from the point the pilot has released the trigger to clear all bolt actions in the cannon. This spin-down takes approximately one second during which the gun cannot be fired again during this operation. This only applies to externally carried gun pods and not to the main gun.
7. *[P]* Set Master Arm Switch – ARMED (UP)





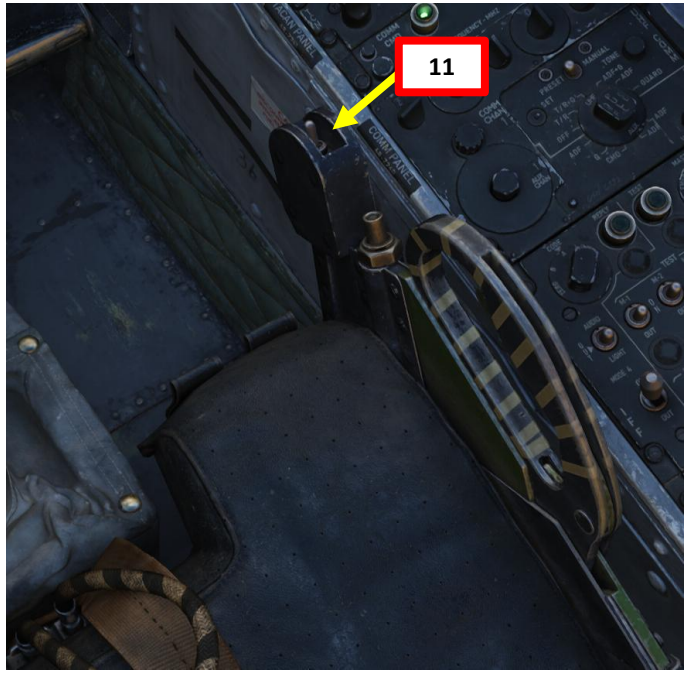
Cannon Auto Clear Switch
- *UP: Auto Clear. This option should be used whenever a gun pod is used.*
- *DOWN: Non Clear*

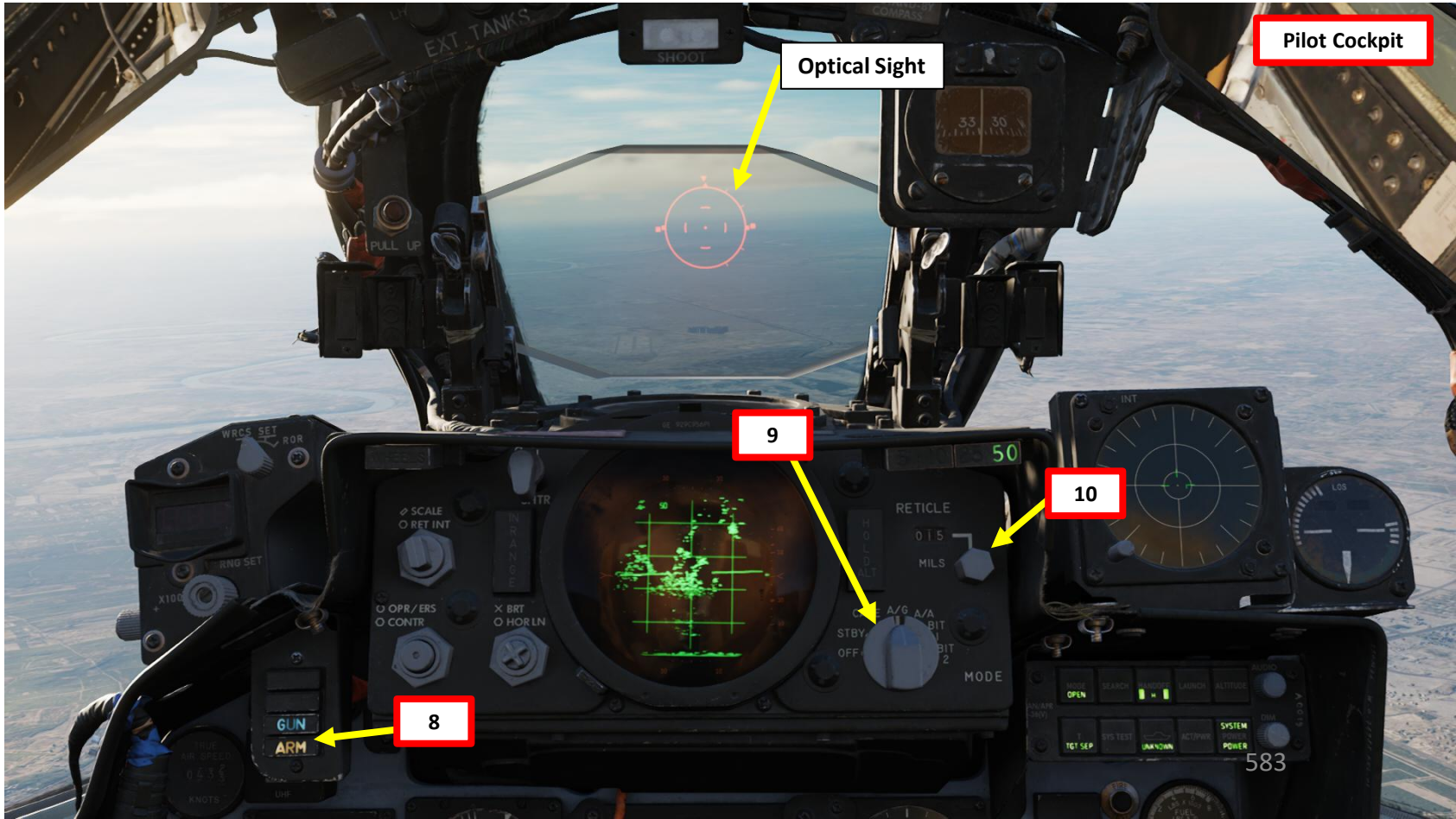
2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)

B – Weapon Setup

8. *[P]* Confirm ARM light is illuminated
9. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
10. *[P]* Set Reticle Depression Setting Knob to 15 Mils.
11. *[P]* Adjust Seat Position – As required to see the reticle.

External SUU-23 Gun Pod Diving Attack Profile			
Altitude (ft)	**Diving Speed (kts Calibrated)**	**Dive Angle (deg)**	**Optical Sight Depression (mils)**
3000	425 – 450	10 – 15	80 – 85
2500	425 – 450	10 – 15	65
2000	425 – 450	10 – 15	50
1500	425 – 450	10 – 15	30
1000	425 – 450	10 – 15	10 – 15 ←





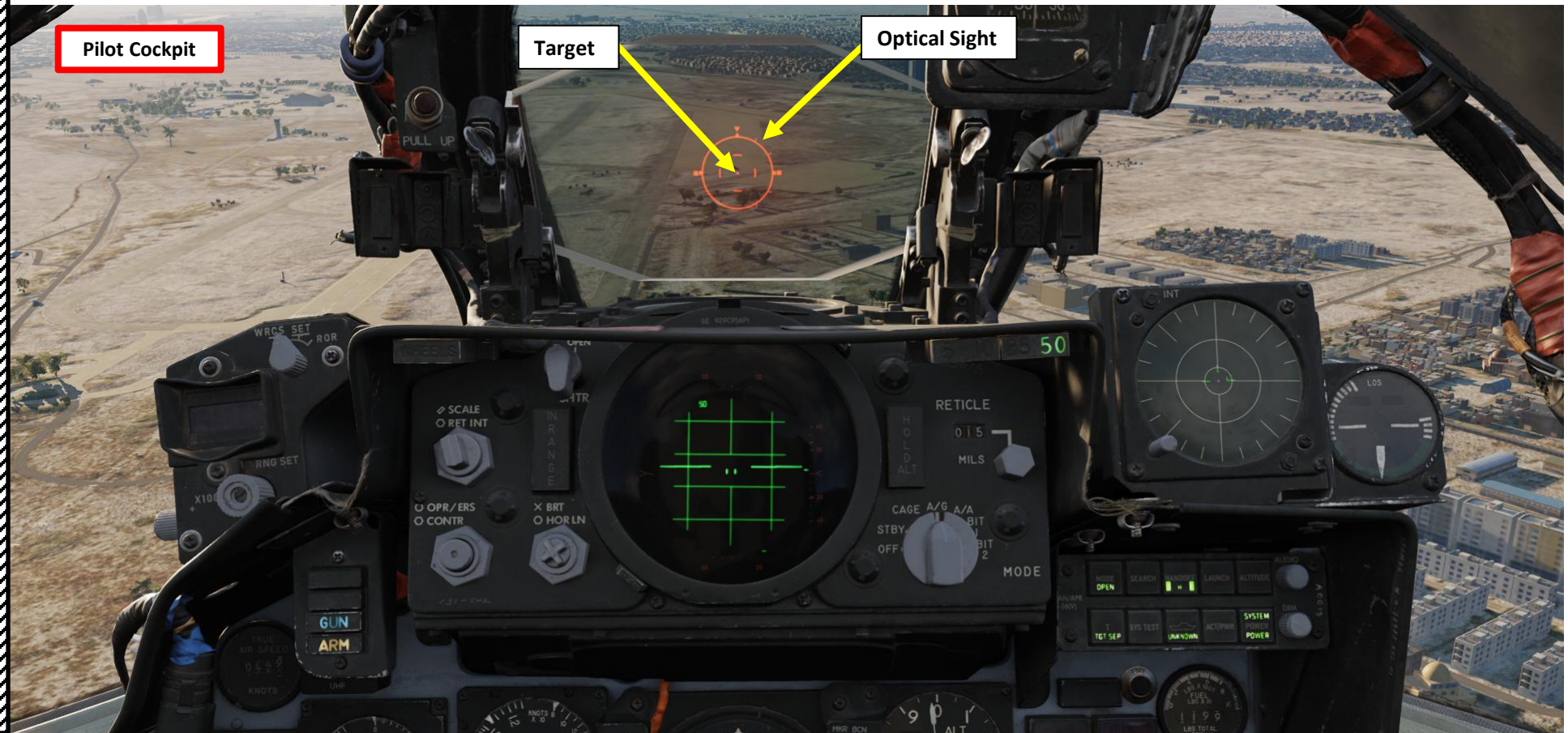
2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)

C – Perform Attack

12. *[P]* Steer aircraft to set the reticle on the target while maintaining attack profile parameters (425 kts indicated, 15 deg dive).
13. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target, wings level.
14. *[P]* When at release altitude (1000 ft AGL), squeeze the Trigger's second detent (Full Action) (SPACEBAR) to fire the selected gunpods.

External SUU-23 Gun Pod Diving Attack Profile

Altitude (ft)	Diving Speed (kts Calibrated)	Dive Angle (deg)	Optical Sight Depression (mils)
3000	425 – 450	10 – 15	80 – 85
2500	425 – 450	10 – 15	65
2000	425 – 450	10 – 15	50
1500	425 – 450	10 – 15	30
1000	425 – 450	10 – 15	10 – 15





Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

2 – AIR-TO-GROUND WEAPONS
2.6 – Guns
2.6.2 – SUU-23 Gun Pods (20 mm)

C – Perform Attack







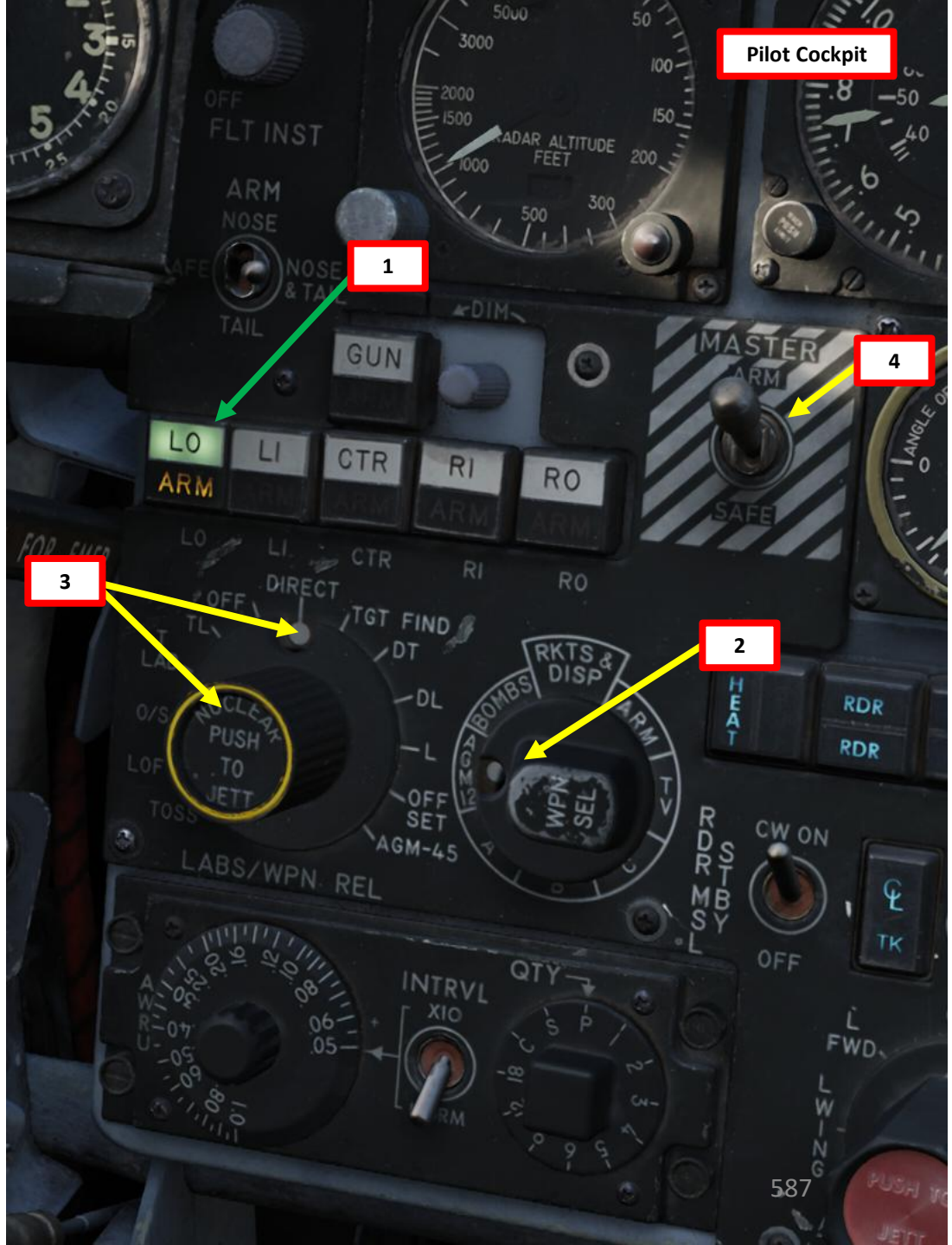
2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup

A – Weapon Setup

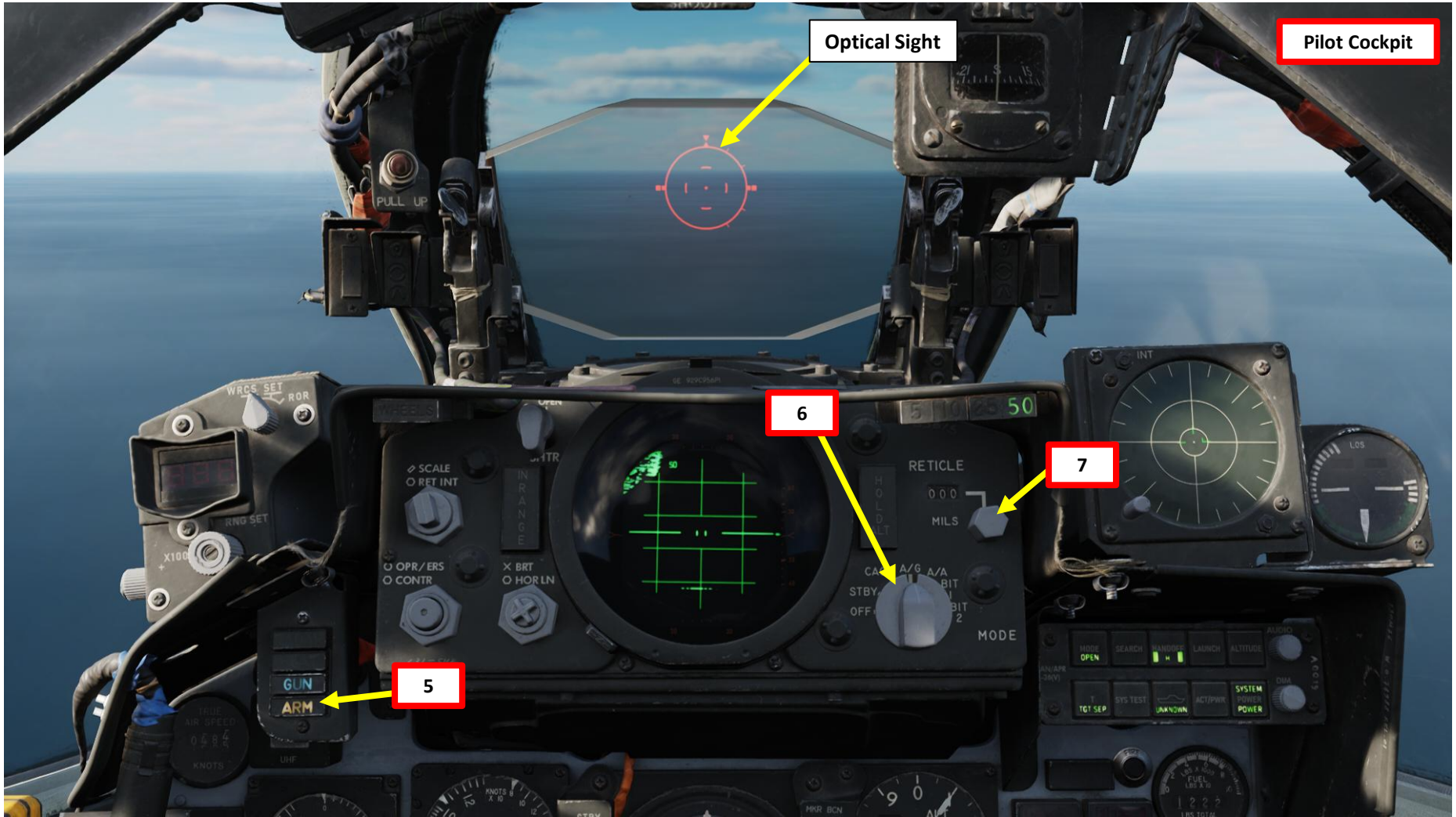
1. *[P]* Select desired Station Select Button. We will use LO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Weapon Selector Knob – AGM-12.
3. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
4. *[P]* Set Master Arm Switch – ARMED (UP)



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup

A – Weapon Setup

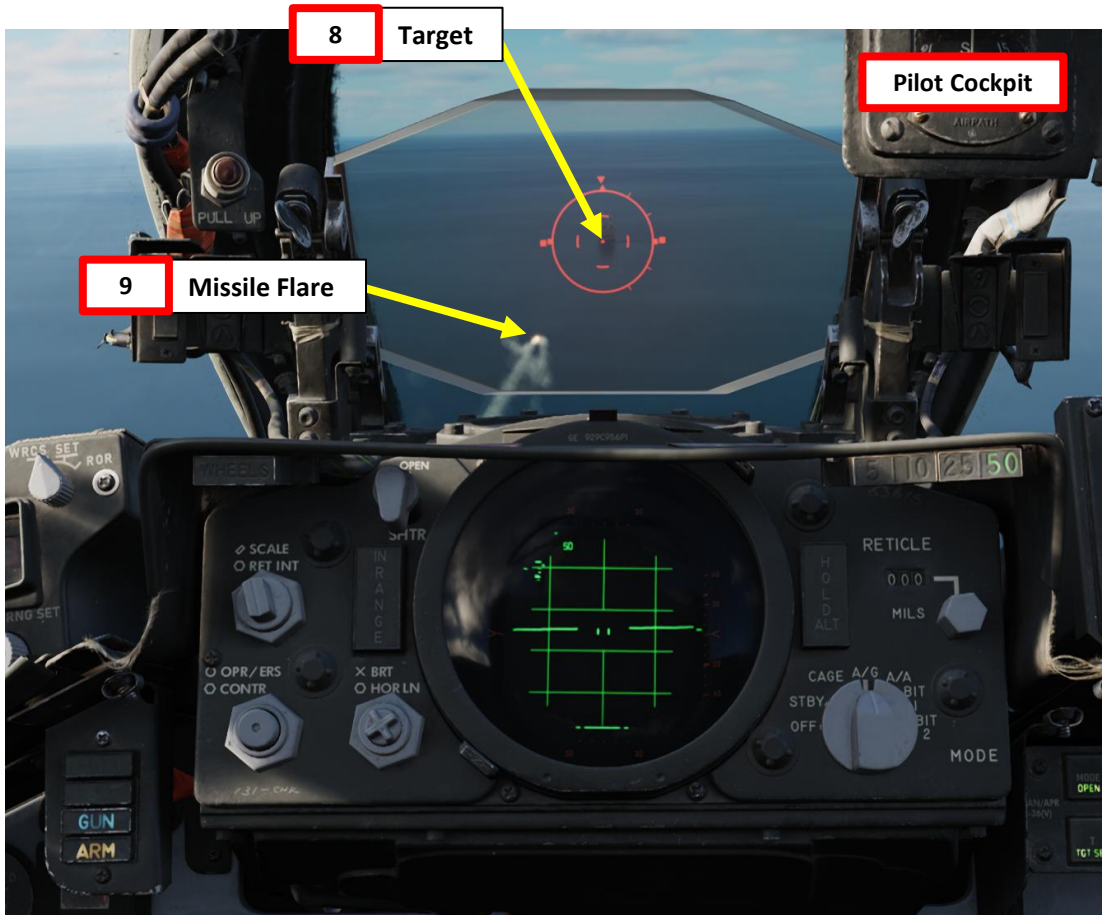
5. *[P]* Confirm ARM light is illuminated
6. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
7. *[P]* Set Reticle Depression Setting Knob to 0 Mils.



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup

B – Perform Attack

8. *[P]* Steer aircraft to set the reticle roughly on the target.
9. *[P]* Once the reticle is stabilized on target and you are within a 7 nm range, press and hold the Bomb Release Button (RALT+SPACEBAR) to fire missile.
10. *[P]* Missile trajectory is tracked visually by the pilot with flare on the missile.



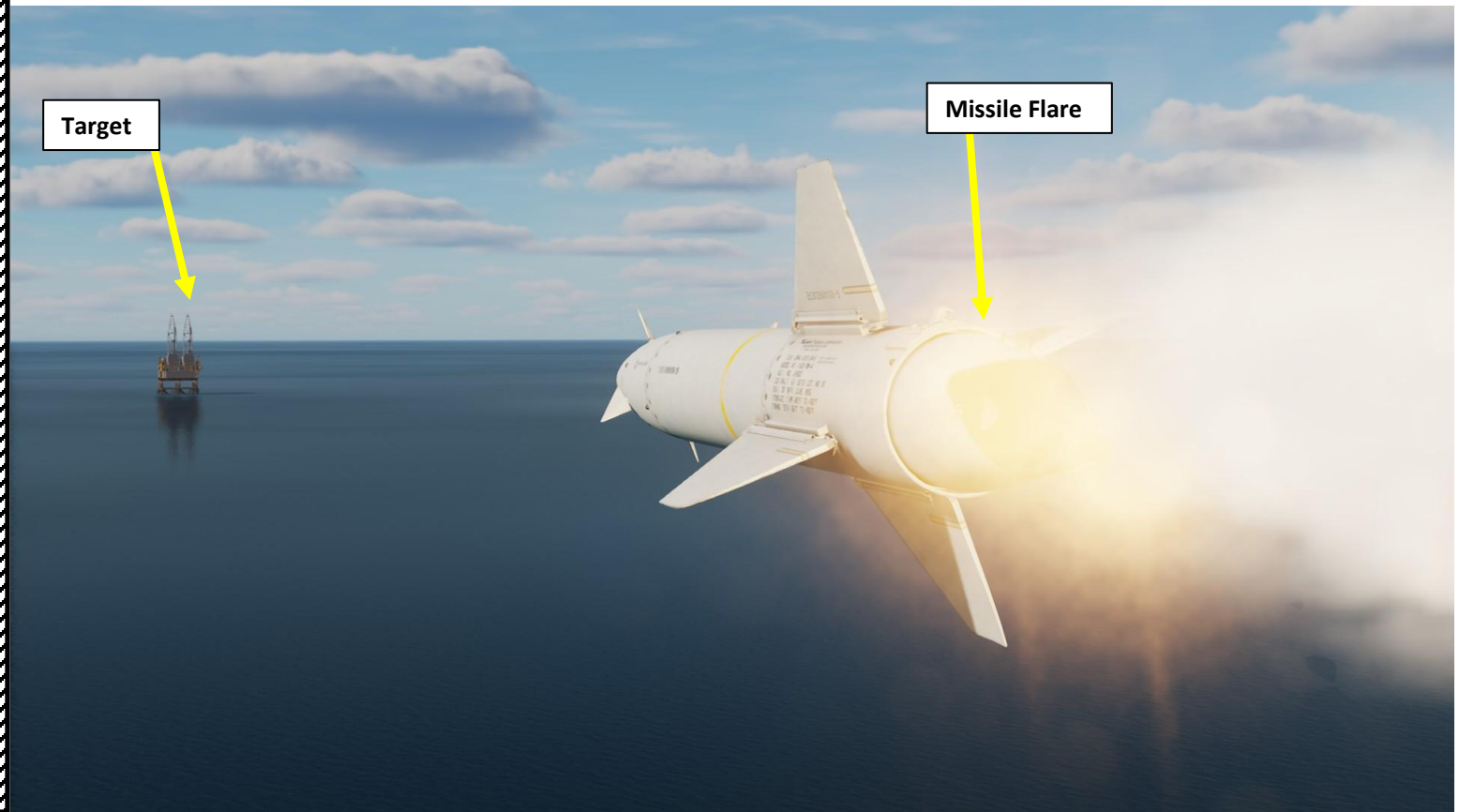




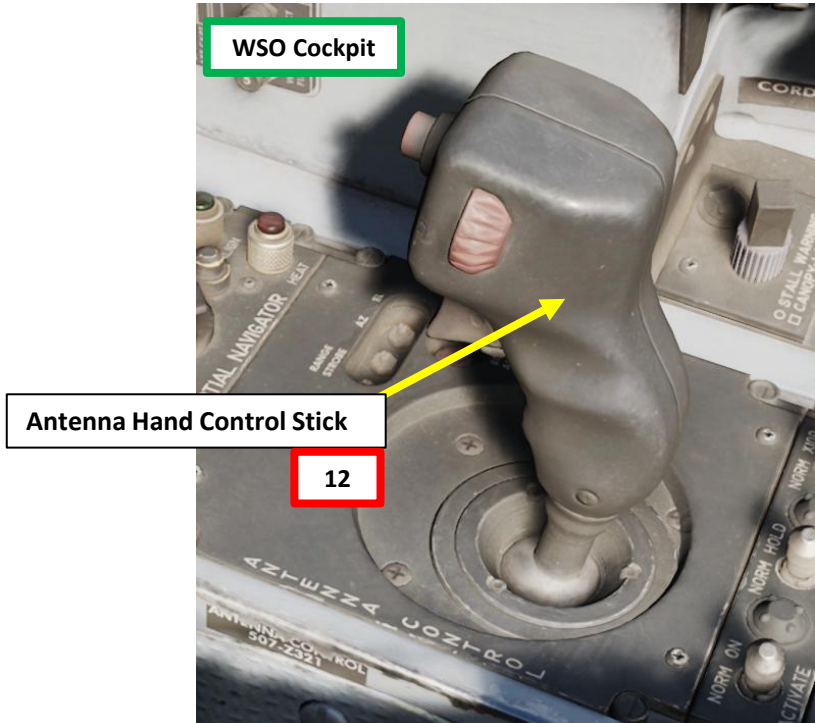
2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup

B – Perform Attack

11. *[P]* Once missile is fired, steering commands are sent to the missile via radio by utilizing the lower UHF antenna of the Phantom.
12. *[P]* Steer the missile remotely using the **"Forward Hand Control" mini-stick (Weapon Slew Axes Bindings)** in the front cockpit. Look at the smoke trail and missile flare to estimate its trajectory visually until target impact.
    - Note: Alternatively, the WSO can use the Antenna Hand Control Stick to steer the missile as well, but the visibility in the rear cockpit makes this task almost impossible. This method should be used as a backup in case the pilot's Forward Hand Control mini-stick is inoperative and the pilot can provide vocal commands/corrections to the WSO based on what he sees from the front cockpit. Yes, this sounds like a terrible plan.
13. *[P]* Once missile impacts the target, pull away and evade blast radius.







2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.1 – AGM-12 Bullpup

B – Perform Attack



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

Introduction

Entering service in 1972, the AGM-65 air to surface missile provided the Phantom II with a direct-fire long range weapon, capable of destroying armor, mechanized infantry, and other targets with electro-optical and later infrared imaged accuracy.

The F-4E was capable of carrying up to six between the two inboard wing pylons. The AGM-65 Maverick has an approximate maximum range of 12 nautical miles.

Employment of the Maverick is shared between both cockpits, with the pilot responsible for stores and mode selection, and initial seeker placement. From the point the seeker head is stabilized on the intended target area, either crew member can direct the final intended contrast target.

Missile Variant	Warhead	Field-of-View	Description
AGM-65A	462 lbs	Wide	• TV-Guided (Tracks Contrast)
AGM-65B	462 lbs	Narrow	• TV-Guided (Tracks Contrast)
AGM-65D	462 lbs	Wide & Narrow	• IR-Guided (Tracks Infrared Thermal Imagery)
AGM-65G	675 lbs	Wide & Narrow	• IR-Guided (Tracks Infrared Thermal Imagery) • Optimized for larger targets





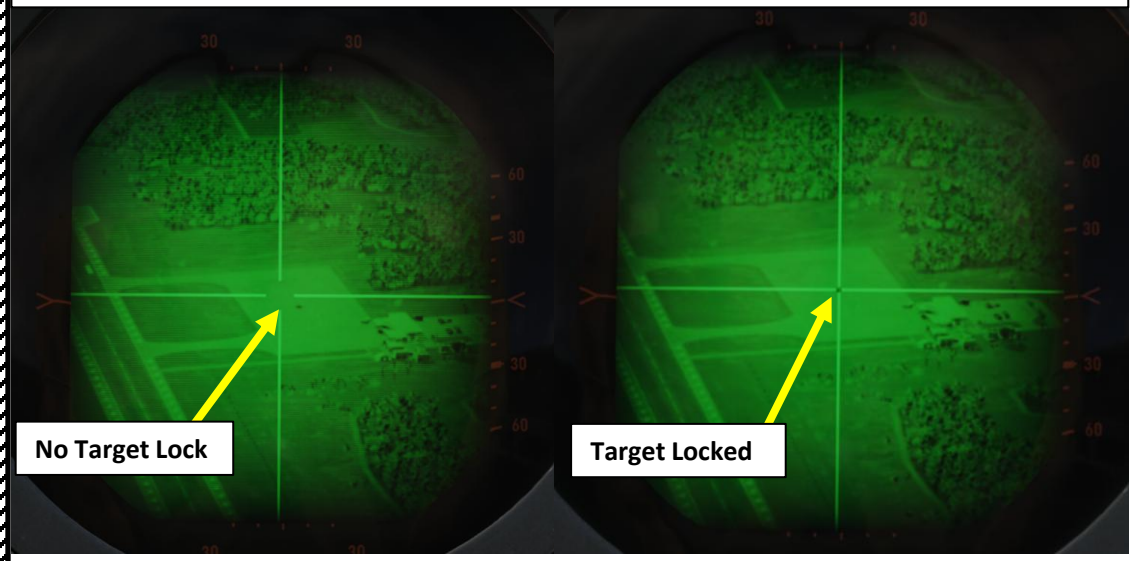




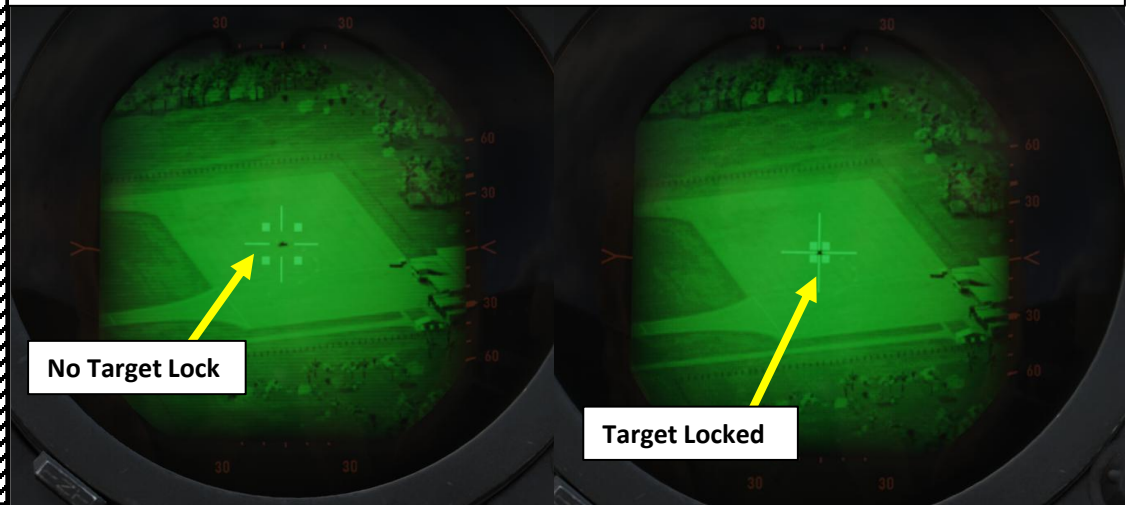
2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

Introduction

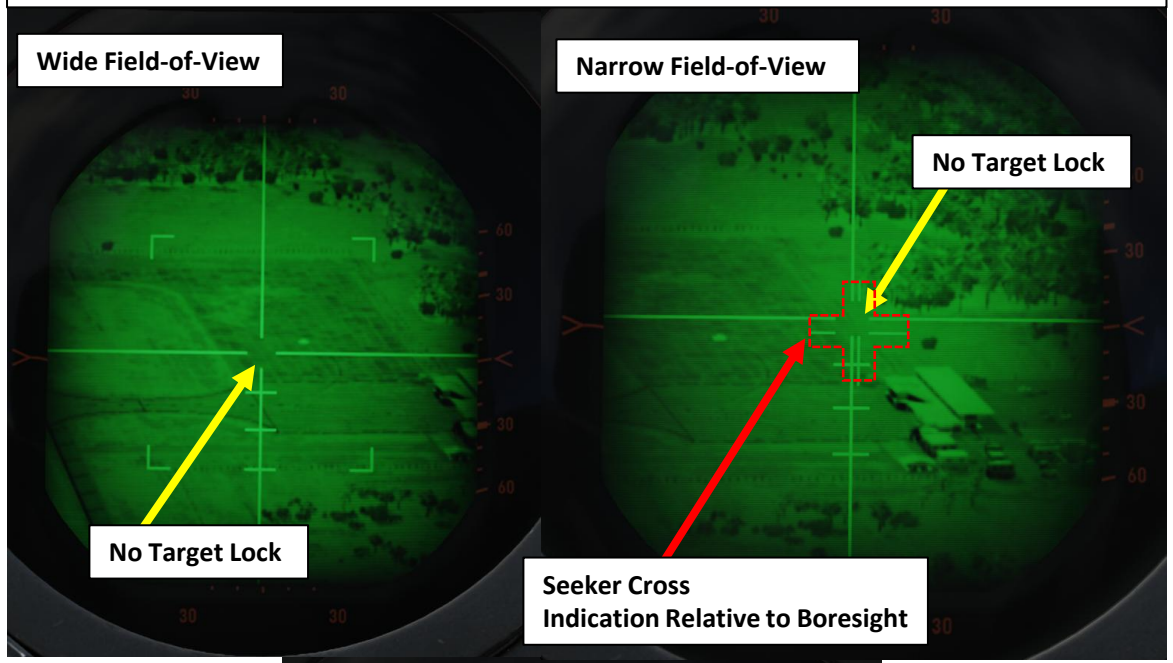
AGM-65A (TV-Guided) – Symbology

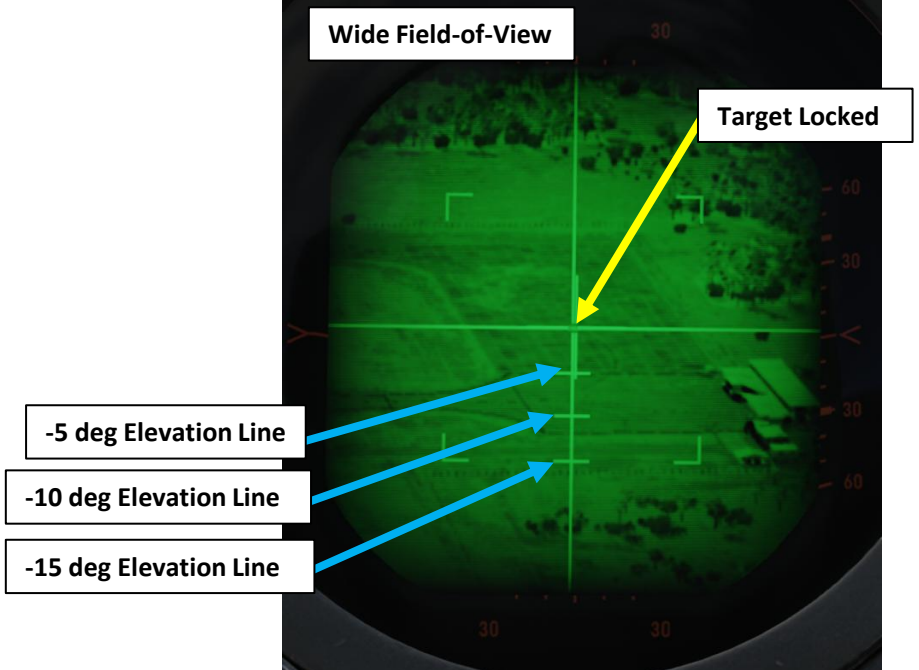


AGM-65B (TV-Guided) – Symbology



AGM-65D/G (IR-Guided) – Symbology



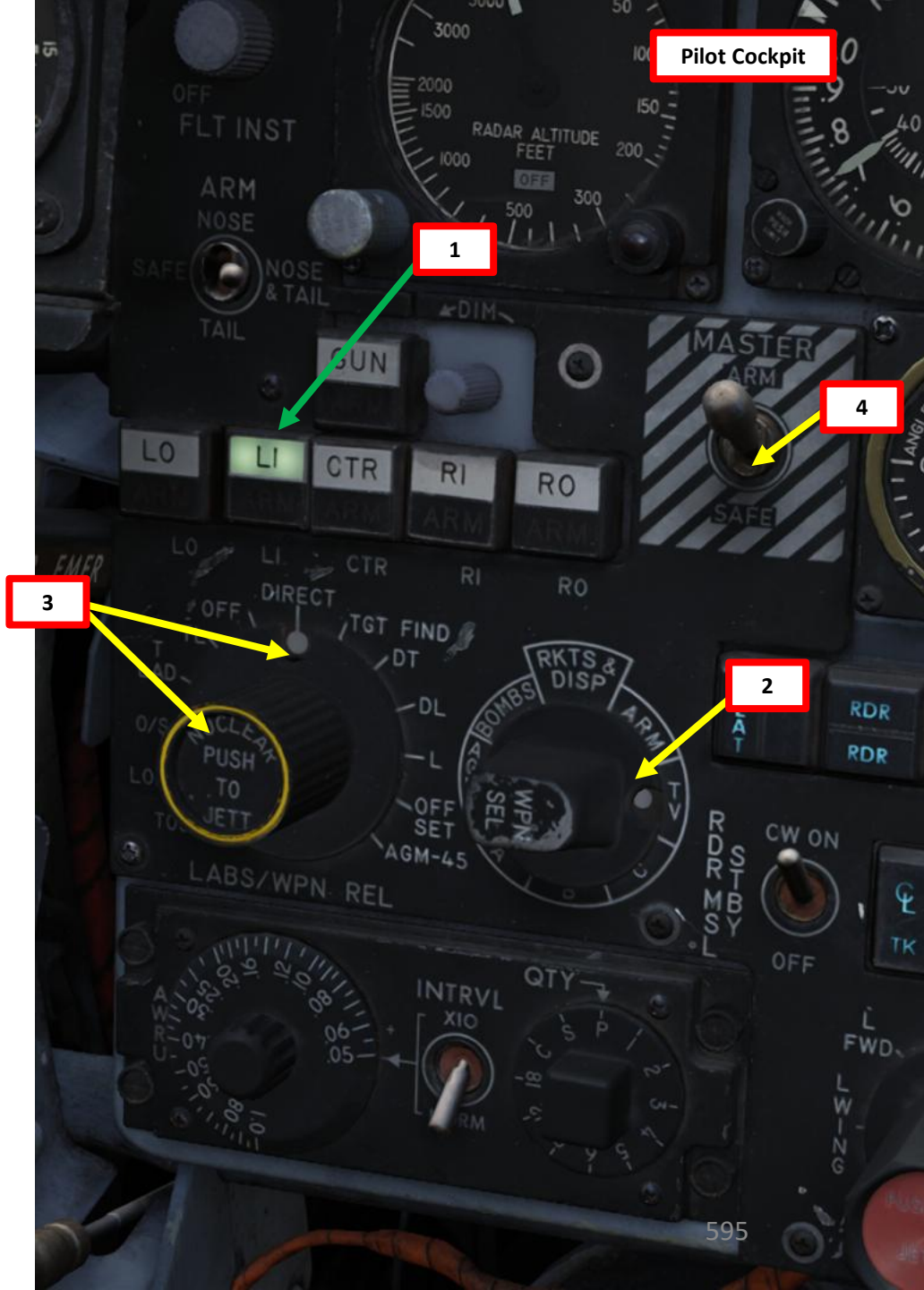


2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

A – Weapon Setup

1. *[P]* Select desired Station Select Buttons. We will use LI.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Weapon Selector Knob – TV.
3. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
4. *[P]* Set Master Arm Switch – ARMED (UP)
5. *[P]* Once station is selected, Direct mode is set and TV weapon is selected, a three-minute warm-up period is required before Maverick missiles can be employed. When missile warm-up sequence is complete, the ARM light should illuminate on the selected station.

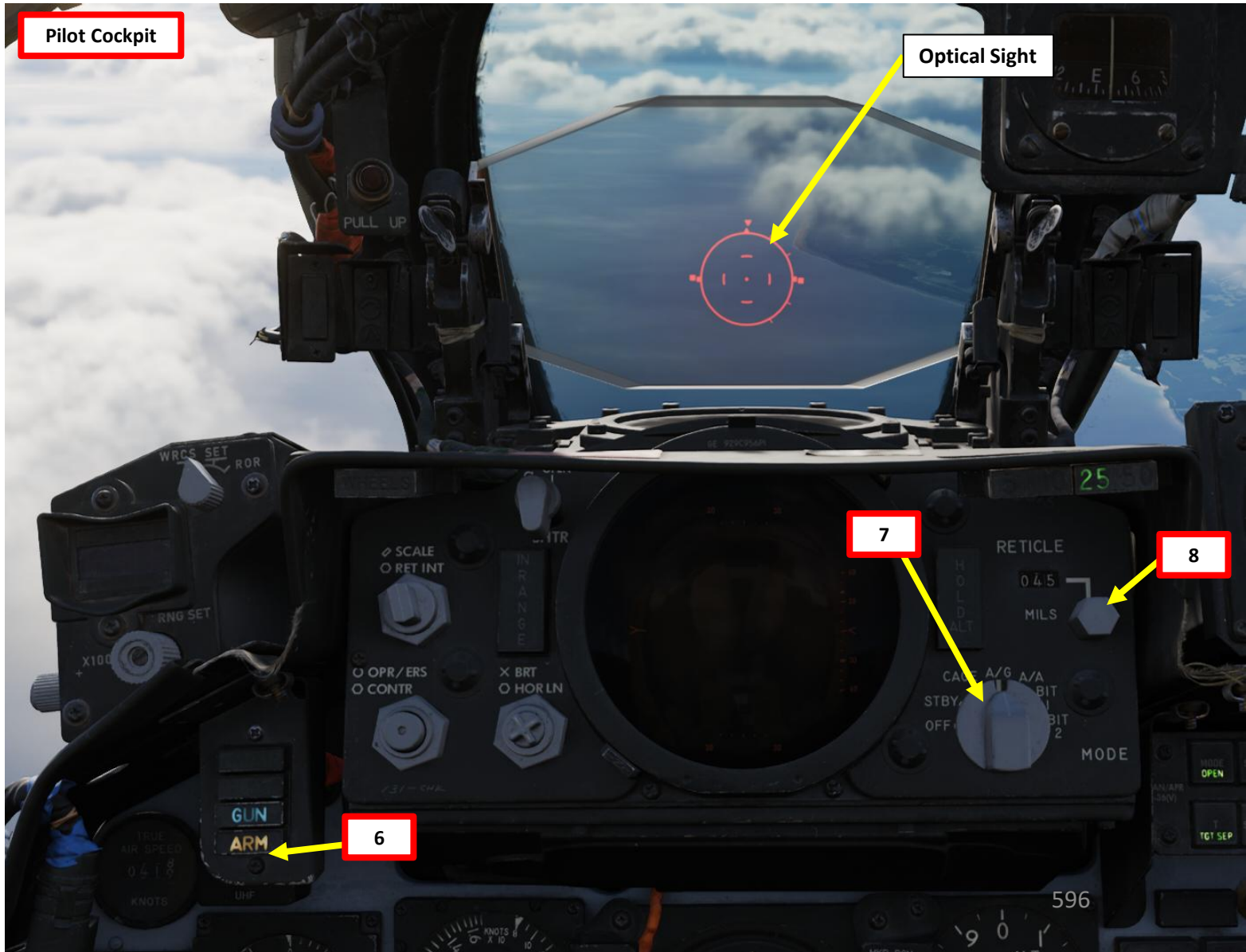




2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

A – Weapon Setup

6. *[P]* Confirm ARM light is illuminated
7. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
8. *[P]* Set Reticle Depression Setting Knob to 45 Mils. This will make the optical sight roughly match the boresight line of the missile, meaning that the sight should point where the missile will be looking when boresighted.



2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

A – Weapon Setup

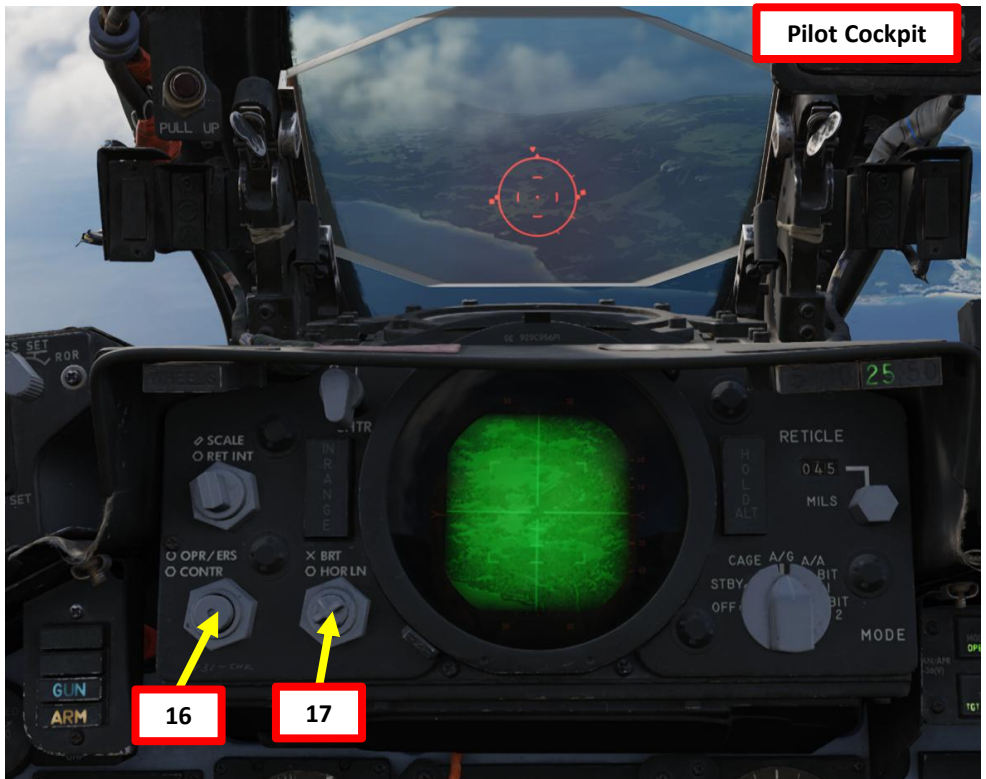
10. *[P/WSO]* To jettison the missile's protective dome cover, uncage the missile and display Maverick video feed, squeeze the flight stick trigger's second detent (Full Action) (SPACEBAR)
11. *[WSO]* Set Video Select Button – WEAPON.
12. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – TV
13. *[WSO]* Adjust Screen Contrast – As desired.
14. *[WSO]* Adjust Screen Brightness – As desired.
15. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – TV (DOWN). This will display the TV feed from the Maverick seeker.
16. *[P]* Adjust Screen Contrast – As desired (Outer knob)
17. *[P]* Adjust Screen Brightness – As desired (Inner knob)

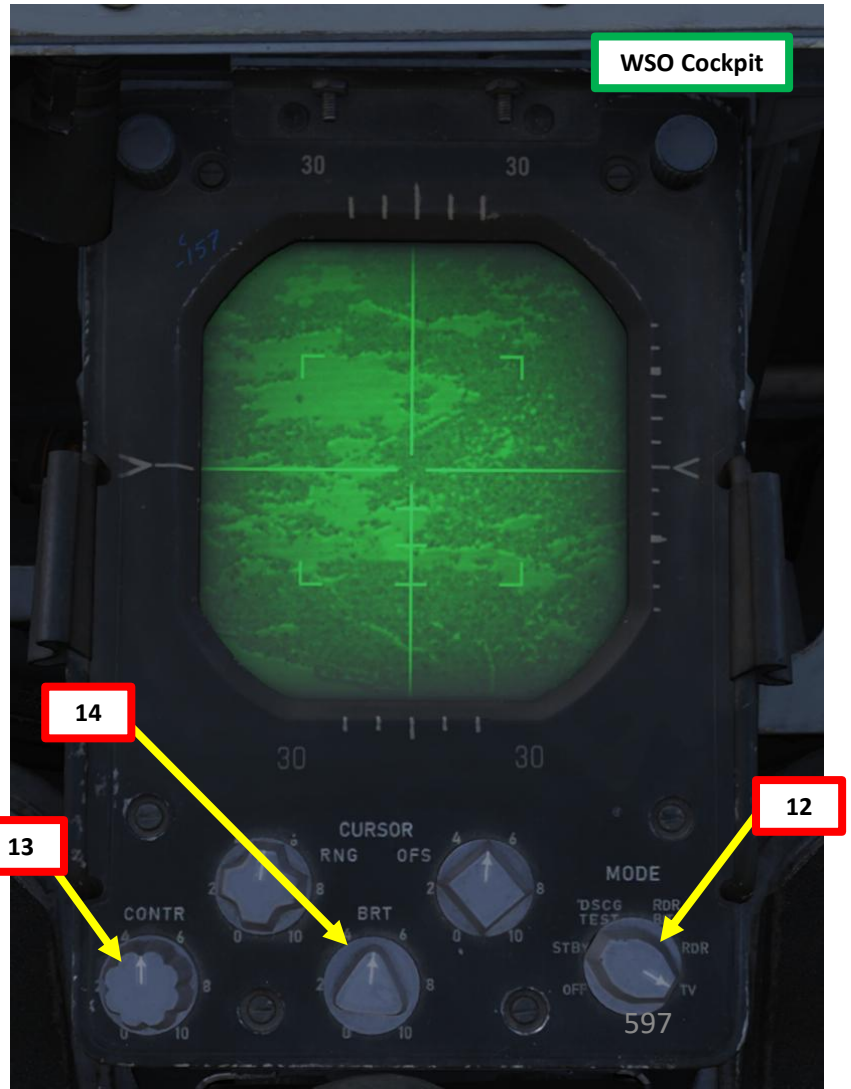






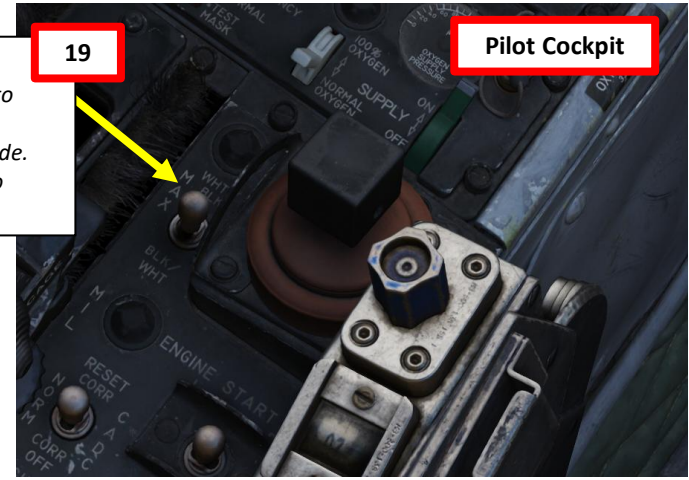
Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*





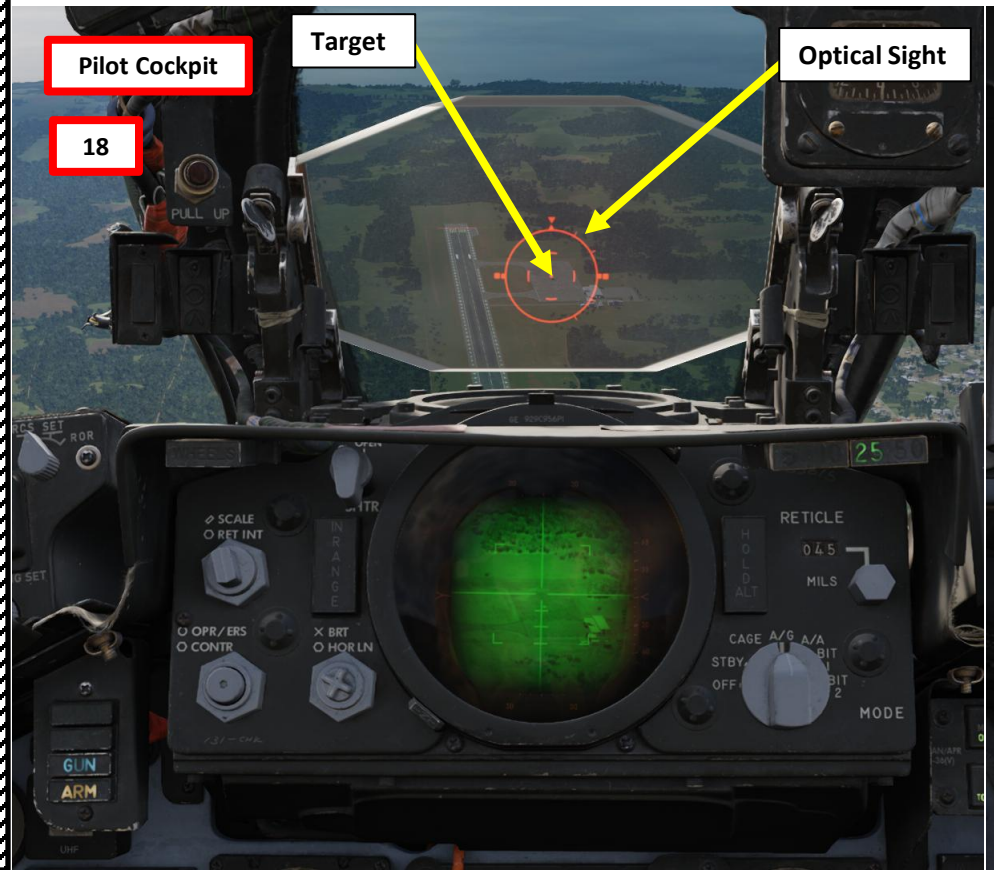
2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

Target Contrast Switch
- *FWD: WHT/BLK (White/Black), programs the Maverick missile seeker to track a light target on a dark background.*
- *MIDDLE: AUTO, Programs the missile to use its automatic tracking mode.*
- *AFT: BLK/WHT (Black/White), programs the Maverick missile seeker to track a dark target on a light background.*

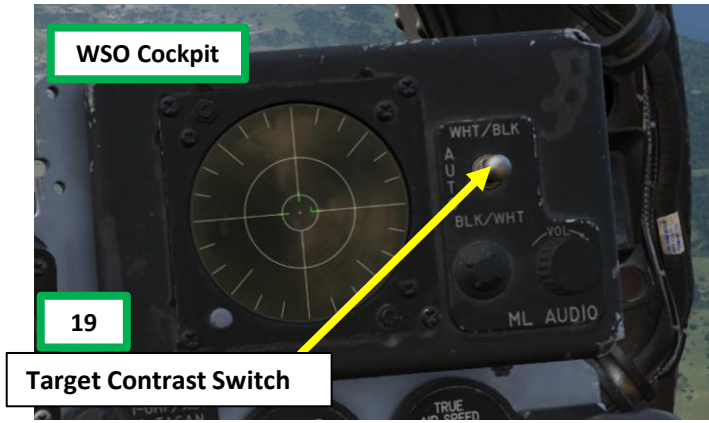


B – Perform Attack

18. *[P]* Steer aircraft to set the optical sight's reticle roughly on the target; the optical sight roughly match the boresight line of the missile.
19. *[P/WSO]* Set Target Contrast Switch – AUTO. This can be done either from the **pilot** or **WSO** cockpit.
20. *[P]* If the selective Maverick missile is defective or you want to step to another missile, set the Target/Missile Reject Switch in the TGT/MSL REJ (UP) position.
    - If six Mavericks are equipped the station with the uncaged and active Maverick is cycled. To cycle the other station simply de-arm the active station, and select the other.





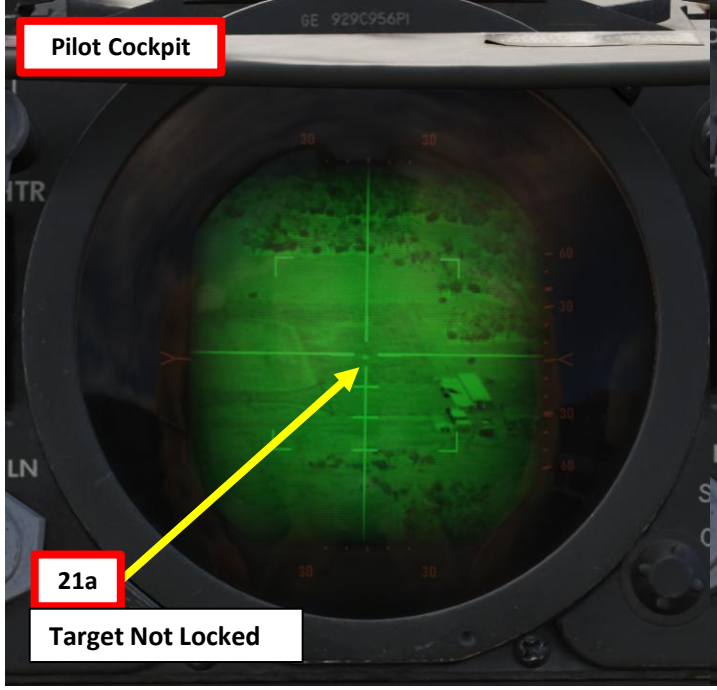




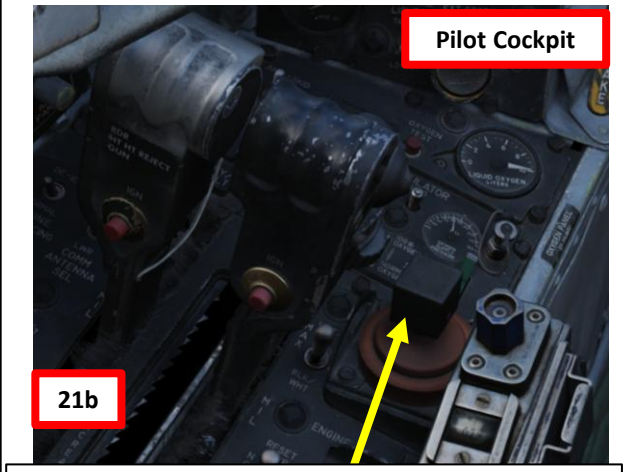
2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

B – Perform Attack

21. To slew the missile line-of-sight and lock on a target:
    - *[P]*: Press and hold the Air Refueling Release (ARR) Button, slew the seeker on the target with using the "Forward Hand Control" mini-stick (Weapon Slew Axes Bindings), then release the Air Refueling Release (ARR) Button to lock.
    - *[WSO]*: Press the Hand Control Stick Trigger's first detent (Half-Action), slew the seeker on the target with the Hand Control Stick, press the Hand Control Stick Trigger's second detent (Full-Action) to lock, then release.
22. **Step only applicable to AGM-65D/G**: To toggle between narrow and wide field-of-view, squeeze either the **pilot's** or **WSO's** flight stick Trigger's second detent (Full Action) (SPACEBAR)





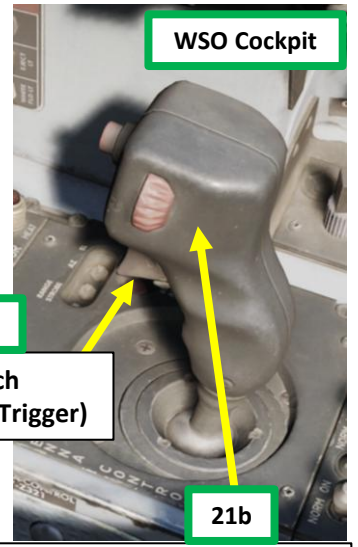


Forward Hand Control
- *Joystick enabling the Pilot to control and steer guided Weapons such as Maverick or Bullpup missiles.*



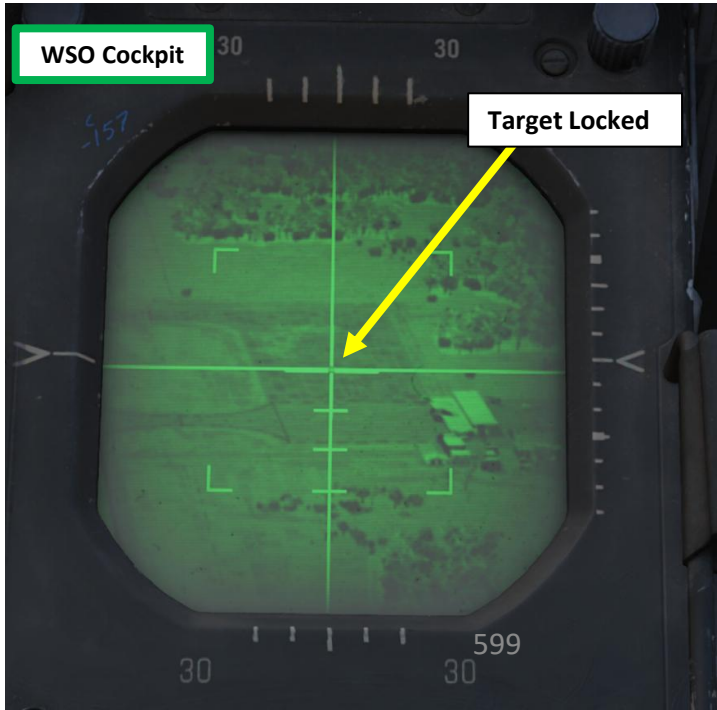
Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

Air Refueling Release Button
- *Binding: S*



Action Switch (Two-Stage Trigger)

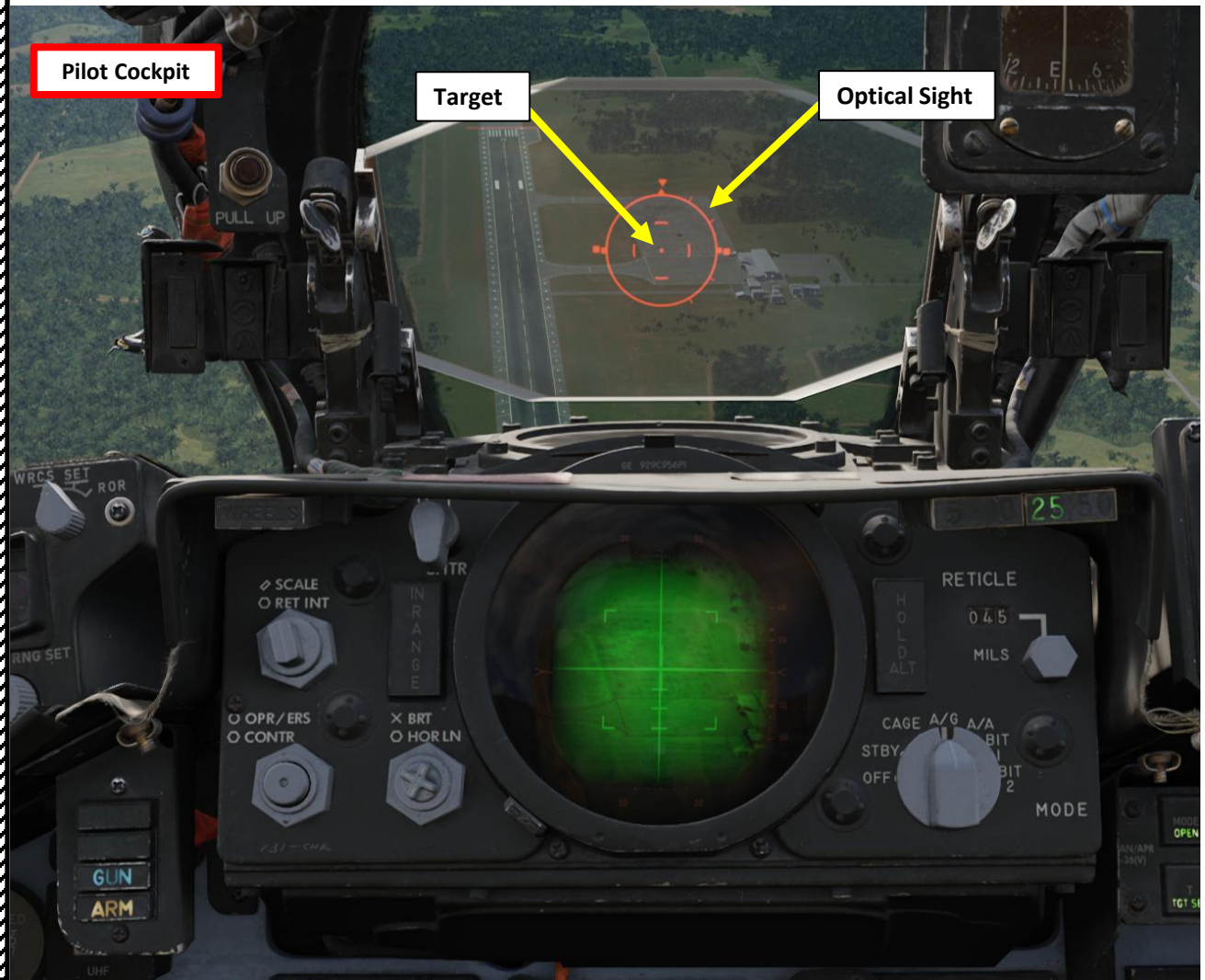
Antenna Hand Control Stick

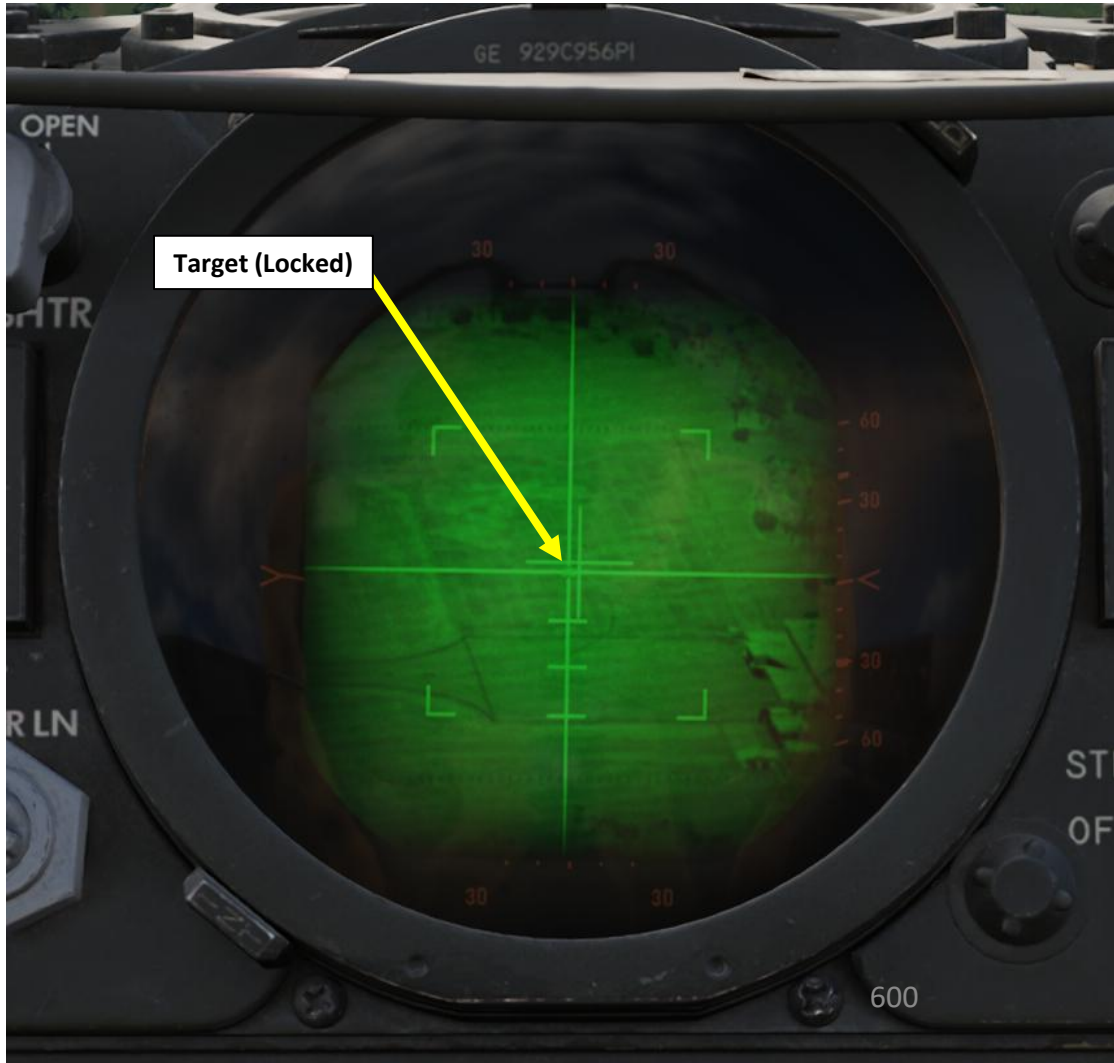


2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

B – Perform Attack

23. *[P]* Steer the aircraft to ensure the optical sight is roughly centered with the target and the missile gimbal limits are respected.



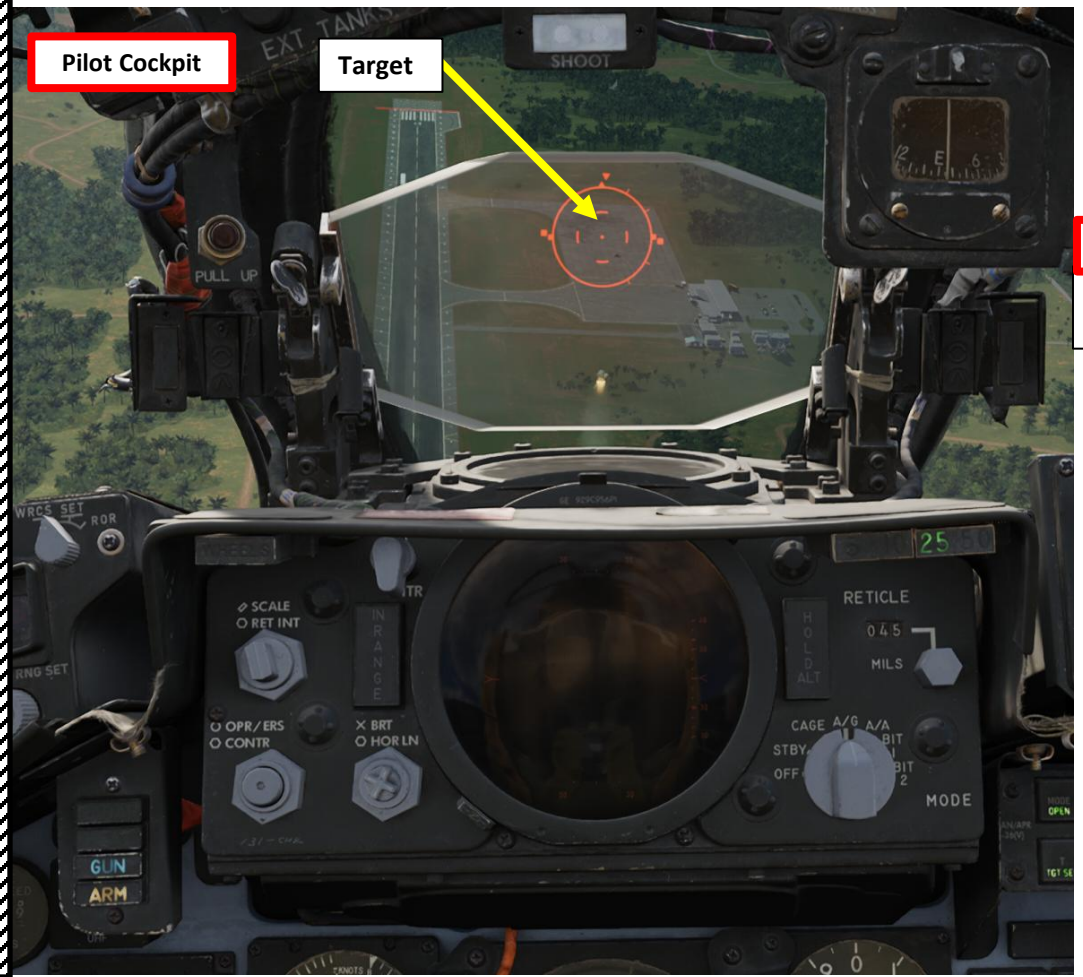


2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

B – Perform Attack

24. *[P]* Press and hold the Bomb Release Button (RALT+SPACEBAR) to fire missile.



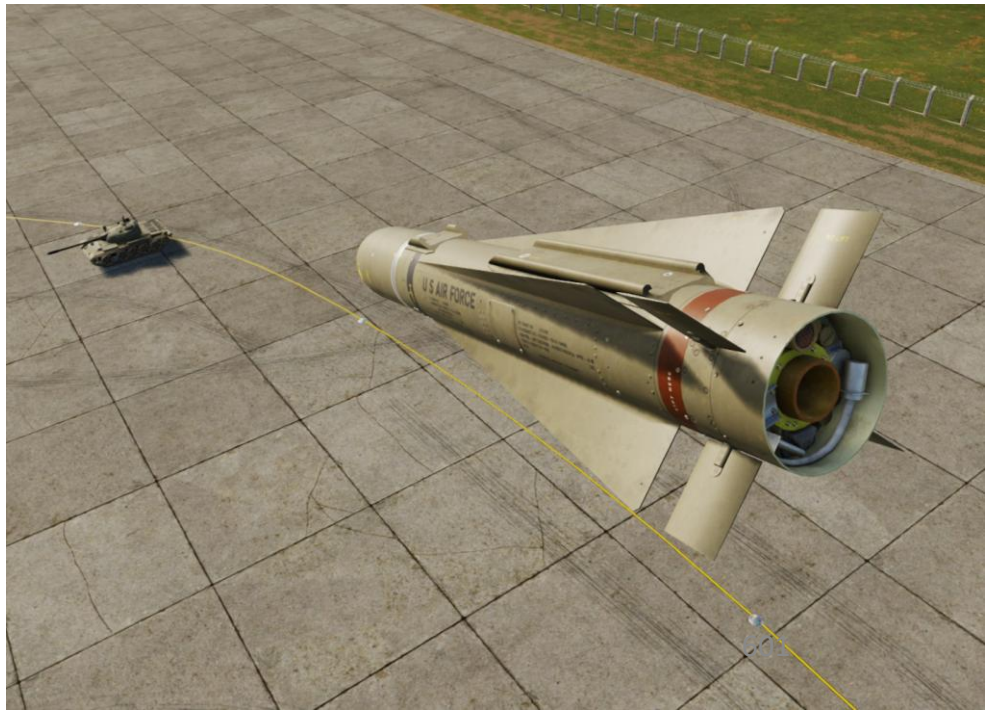


28

Bomb Release Button

- *Binding: RALT+SPACEBAR*





2 – AIR-TO-GROUND WEAPONS
2.7 – Air-to-Ground Missiles
2.7.2 – AGM-65 Maverick

B – Perform Attack



2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

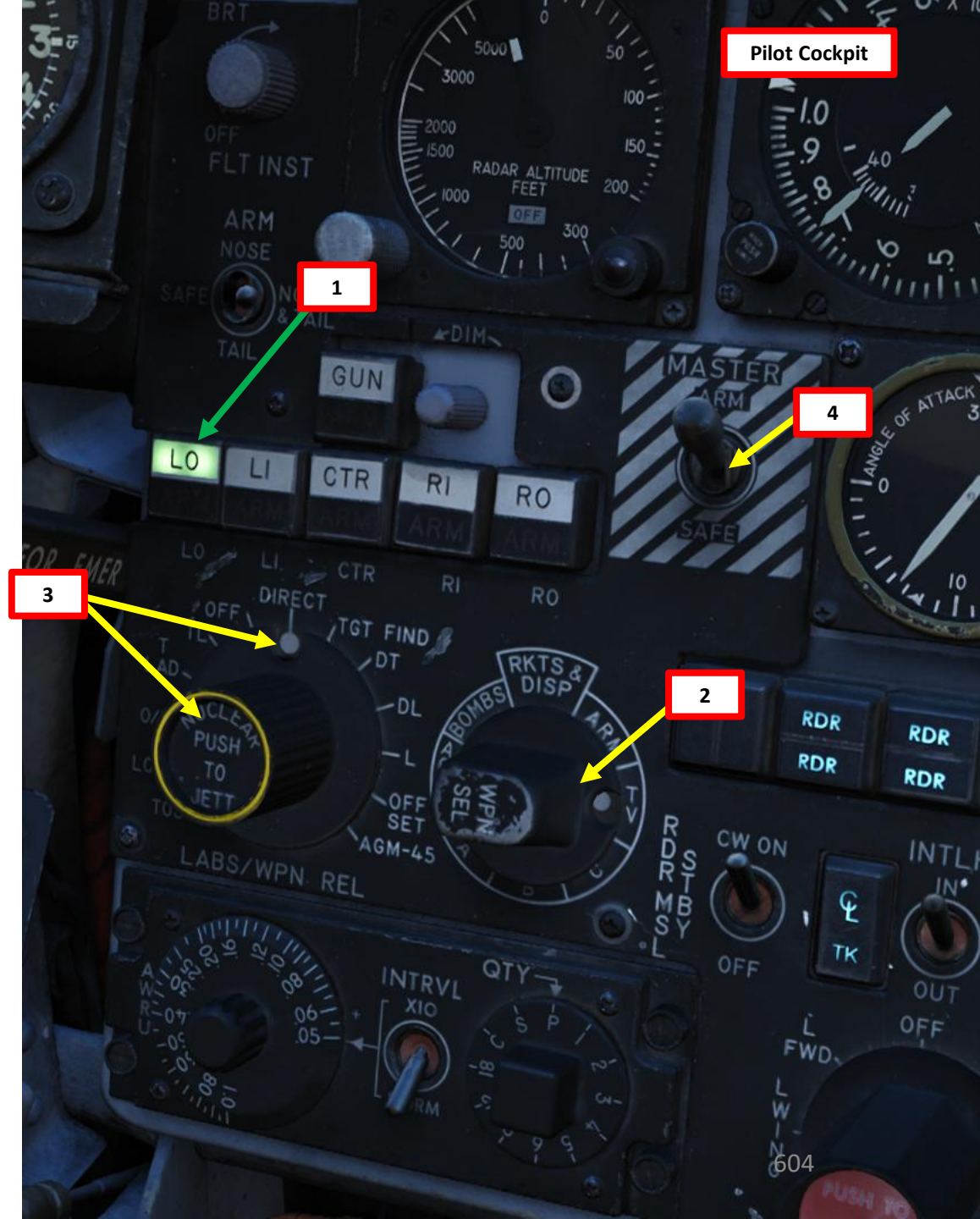


2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

A – Weapon Setup

1. *[P]* Select desired Station Select Buttons. We will use LO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Weapon Selector Knob – TV.
3. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
4. *[P]* Set Master Arm Switch – ARMED (UP)
5. *[P]* Once station is selected, Direct mode is set and TV weapon is selected, a three-minute warm-up period is required before the GBU-8 can be employed. When warm-up sequence is complete, the ARM light should illuminate on the selected station.





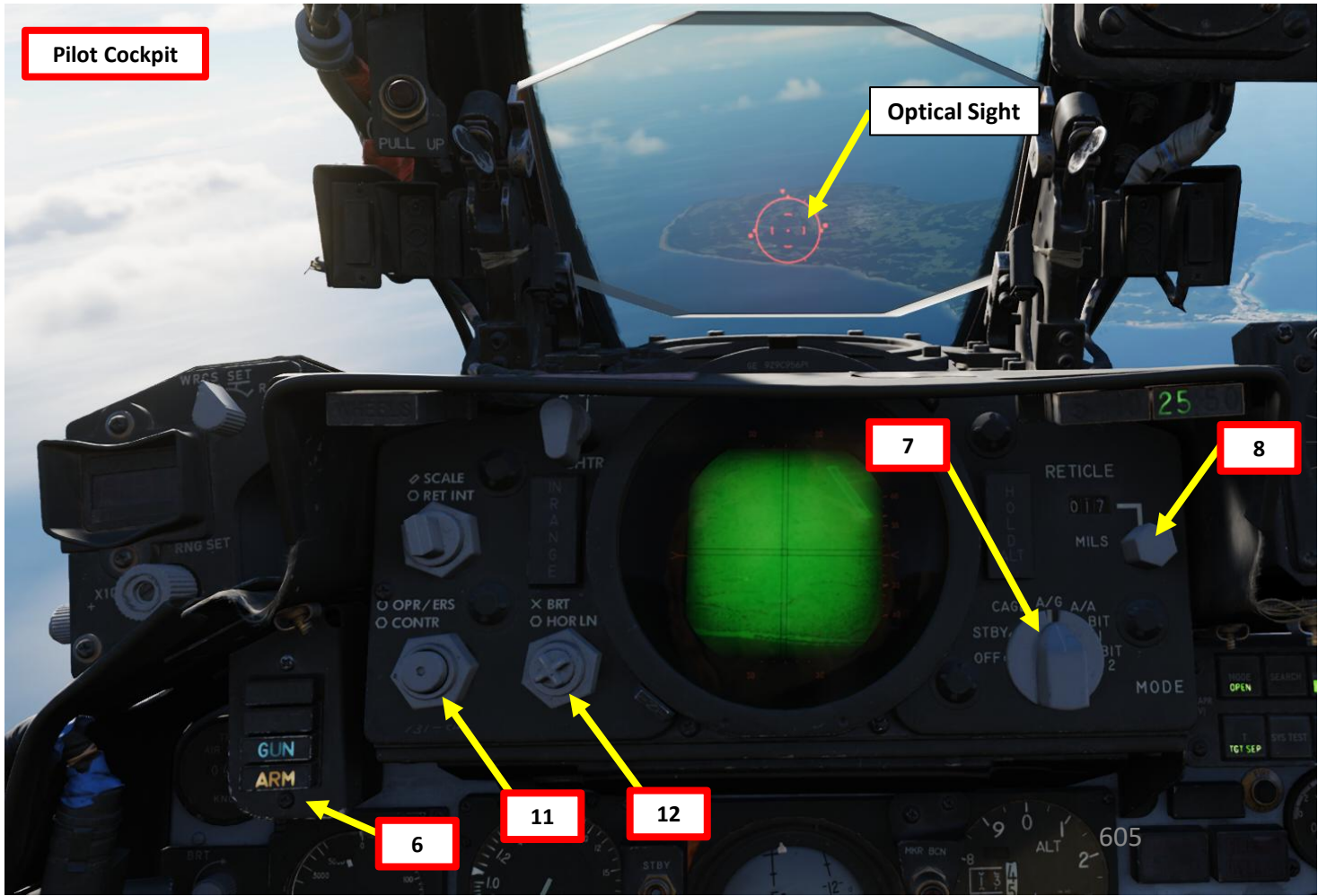
2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

A – Weapon Setup

6. *[P]* Confirm ARM light is illuminated
7. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
8. *[P]* Set Reticle Depression Setting Knob to 17 Mils. This will make the optical sight roughly match the line-of-sight of the seeker head.
9. *[WSO]* Set Video Select Button – WEAPON.
10. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – TV (DOWN). This will display the TV feed from the HOBOS seeker.
11. *[P]* Adjust Screen Contrast – As desired (Outer knob)
12. *[P]* Adjust Screen Brightness – As desired (Inner knob)



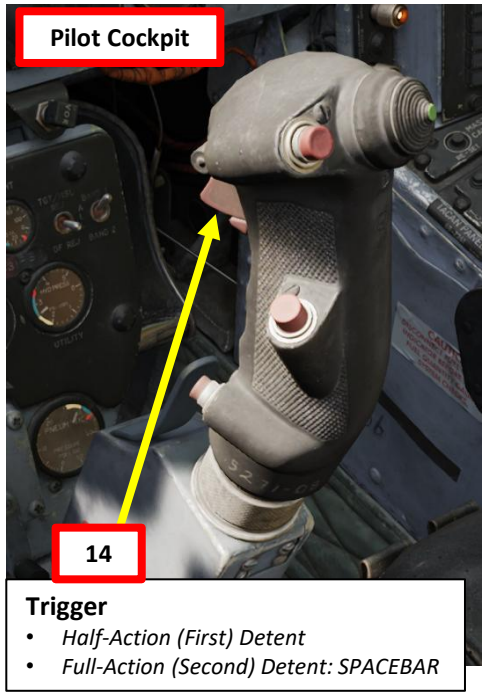




2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

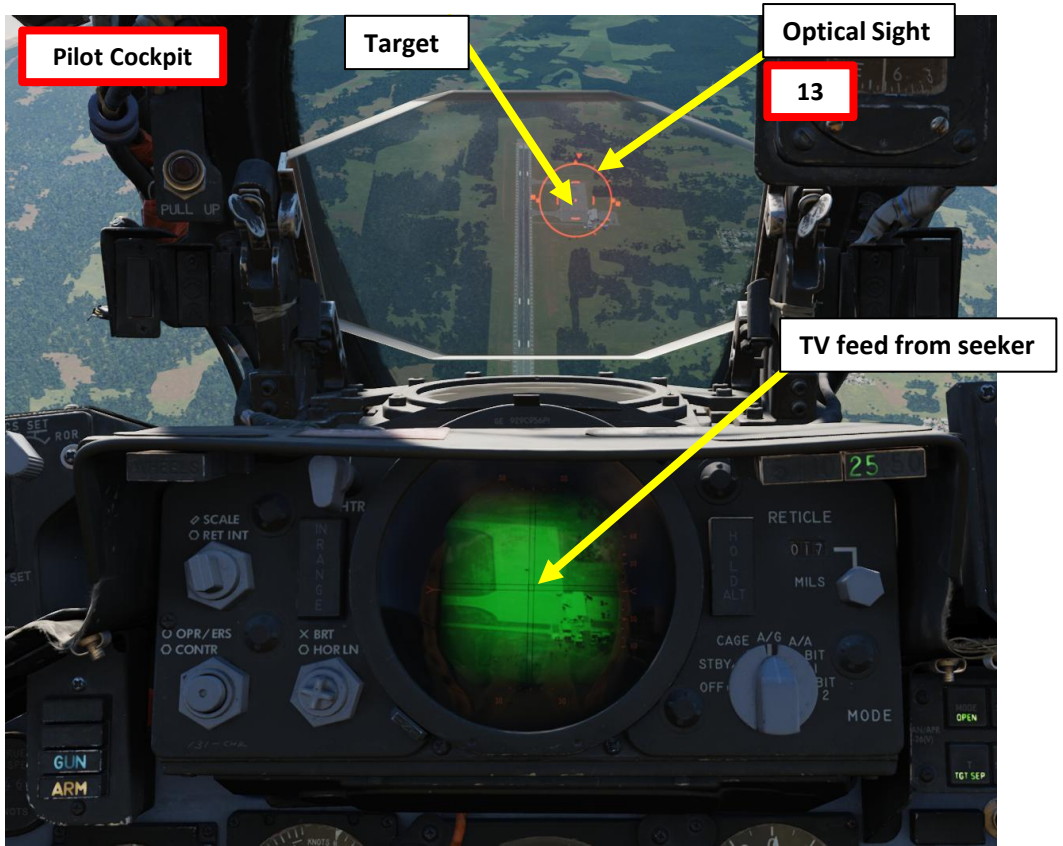
B – Perform Attack

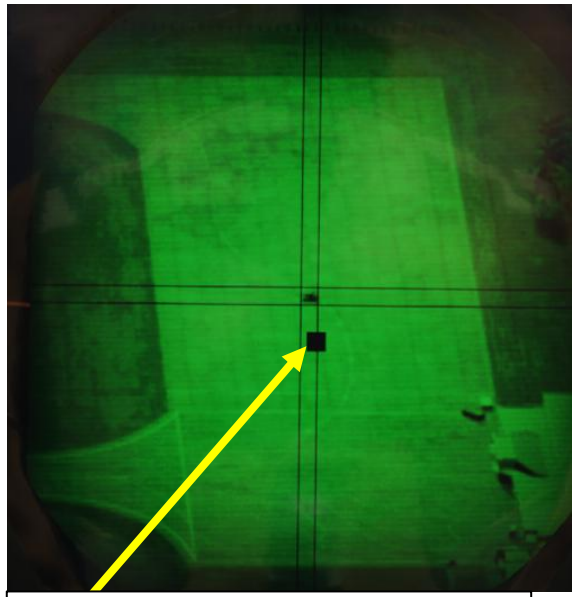
13. *[P]* Perform a steep dive on the target (at least 50 deg) and steer aircraft to set the optical sight's reticle on the target. The camera sensor can not be slewed, the pilot has to fly the aircraft to place the crosshair on the TV display directly over the target.
14. *[P]* Once target is on the TV crosshair, **press and hold** the flight stick trigger's second detent (Full Action) (SPACEBAR) to command a lock.
15. *[P]* The seeker attempts to lock via contrast. If it fails to lock, the target likely does not stand out enough to its background.
16. *[P]* Once locked, a black square is added to the symbology, indicating the seeker head position. If the black square drifts too much away from the center of the crosshair, you will likely miss the target.



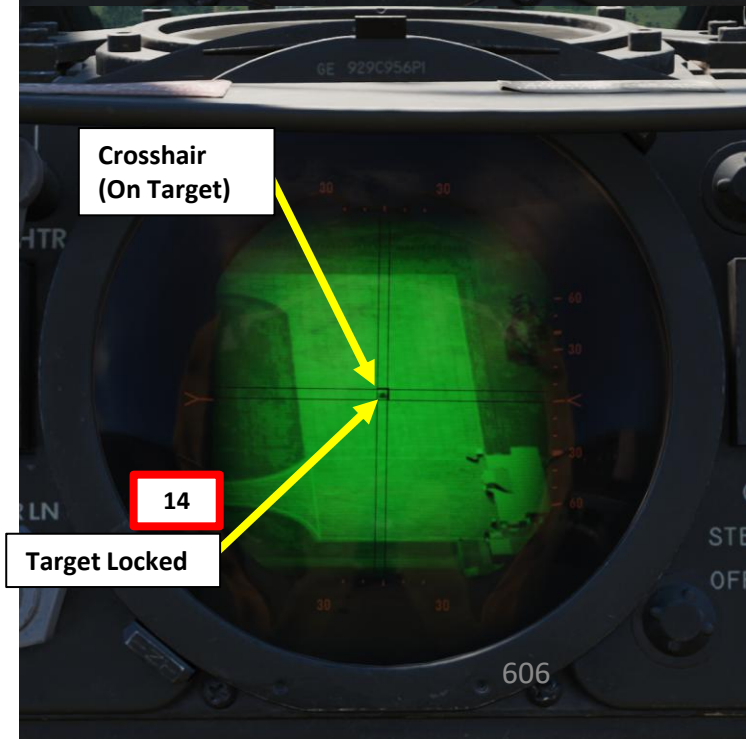
Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*







Seeker Head Position: fly aircraft to keep black square centered on crosshair

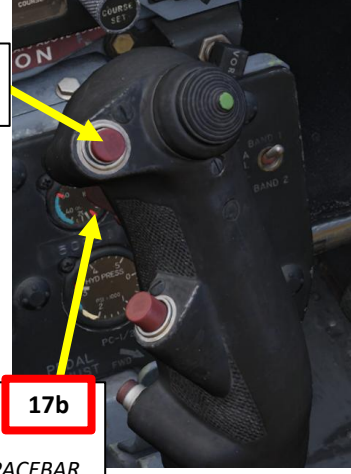


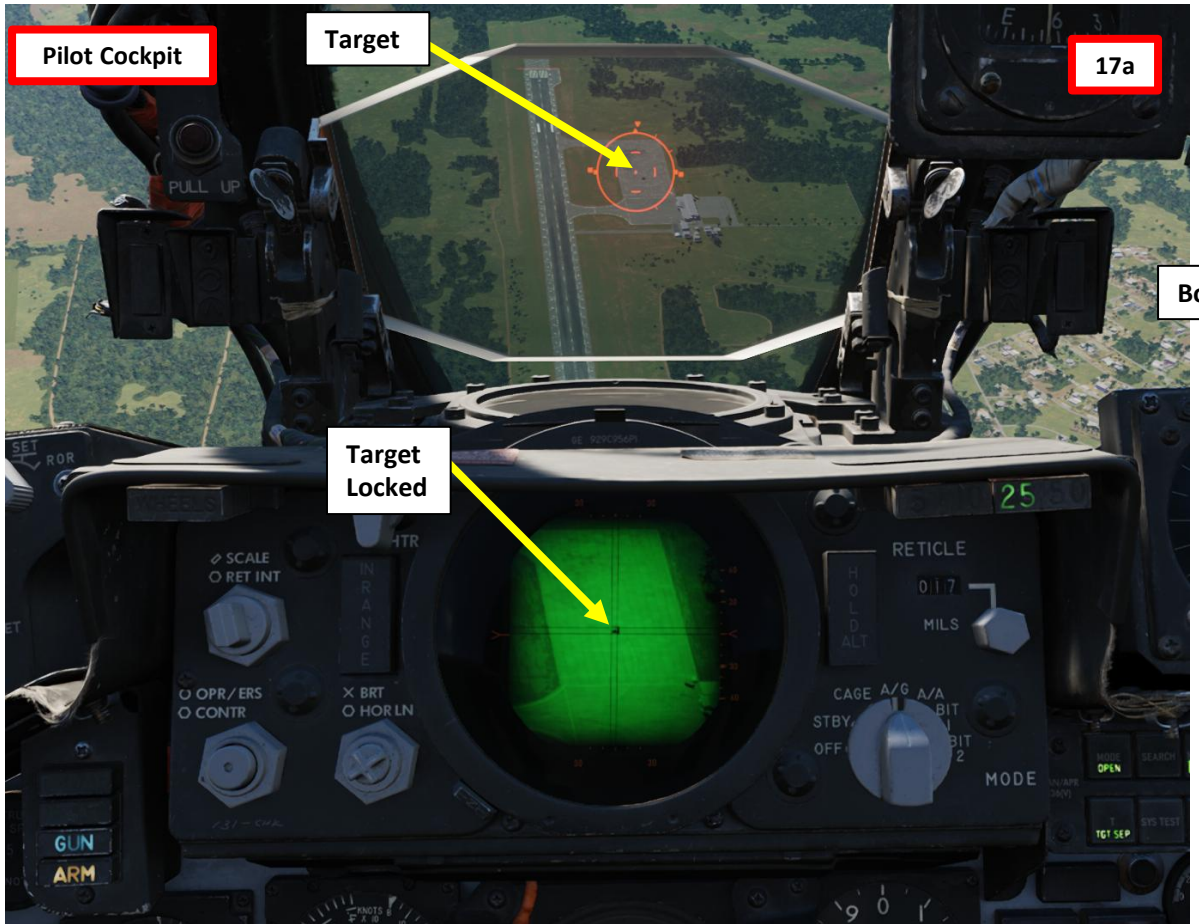
2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

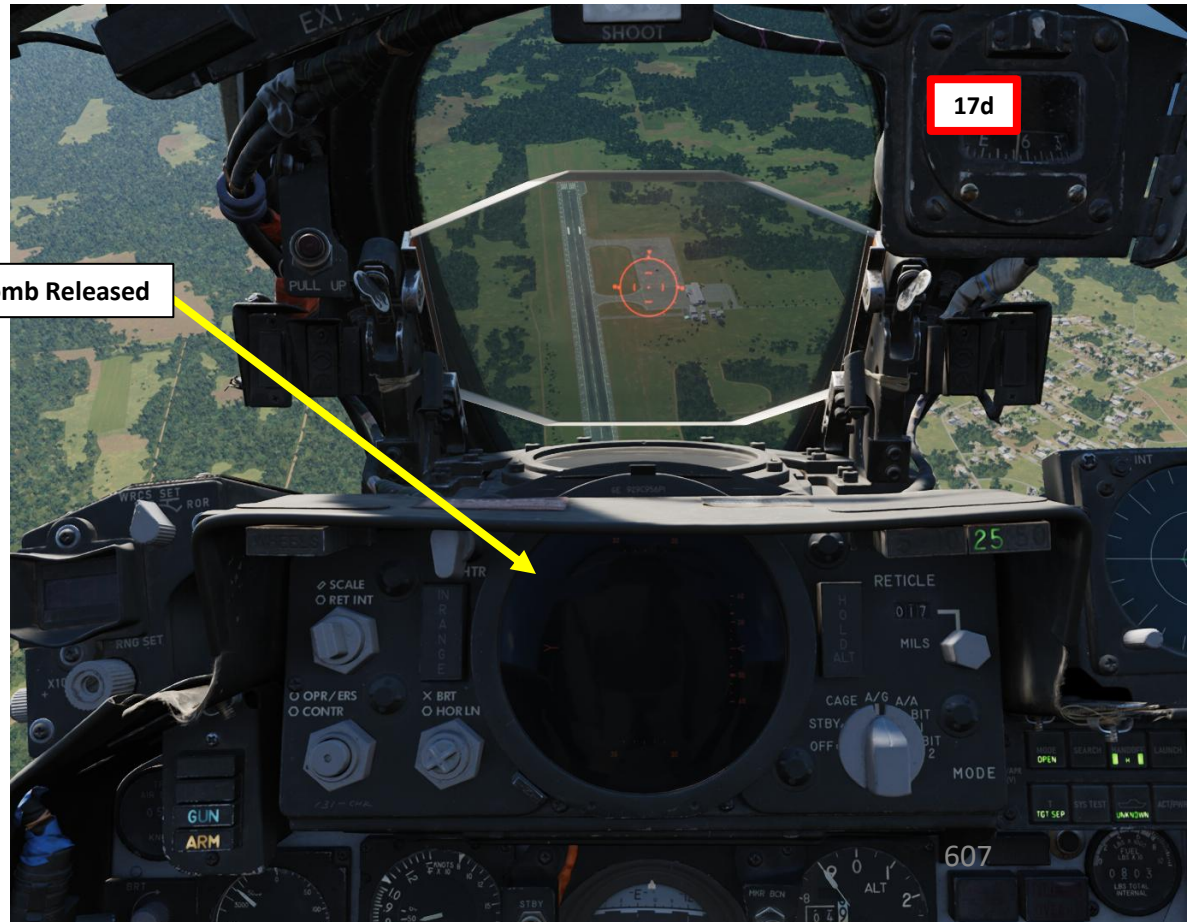
B – Perform Attack

17. [P] To release bomb:

a) Steer the aircraft to ensure the seeker head position (black box) remains centered on the TV crosshair.
b) Ensure the target lock is maintained by keeping the flight stick trigger's second detent (Full Action) (SPACEBAR) pressed and held.
c) Press and hold the Bomb Release Button (RALT+SPACEBAR) until bomb automatically releases.
d) When bomb releases, egress away from the target.







2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.1 – GBU-8 HOBOS (Homing Bomb System)

B – Perform Attack

18. The bomb will guide itself towards the target until impact. Effective range varies a lot with release altitude and speed. The release mechanism does not check if the ordnance is within parameters. To reduce the risk of the weapon missing its target, prefer launching it from increased altitude and speed.







2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.2 – AGM-62 Walleye



2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.2 – AGM-62 Walleye

A – Weapon Setup

1. *[P]* Select desired Station Select Buttons. We will use LI.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Weapon Selector Knob – TV.
3. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
4. *[P]* Set Master Arm Switch – ARMED (UP)
5. *[P]* Once station is selected, Direct mode is set and TV weapon is selected, a three-minute warm-up period is required before the AGM-62 Walleye can be employed. When warm-up sequence is complete, the ARM light should illuminate on the selected station.





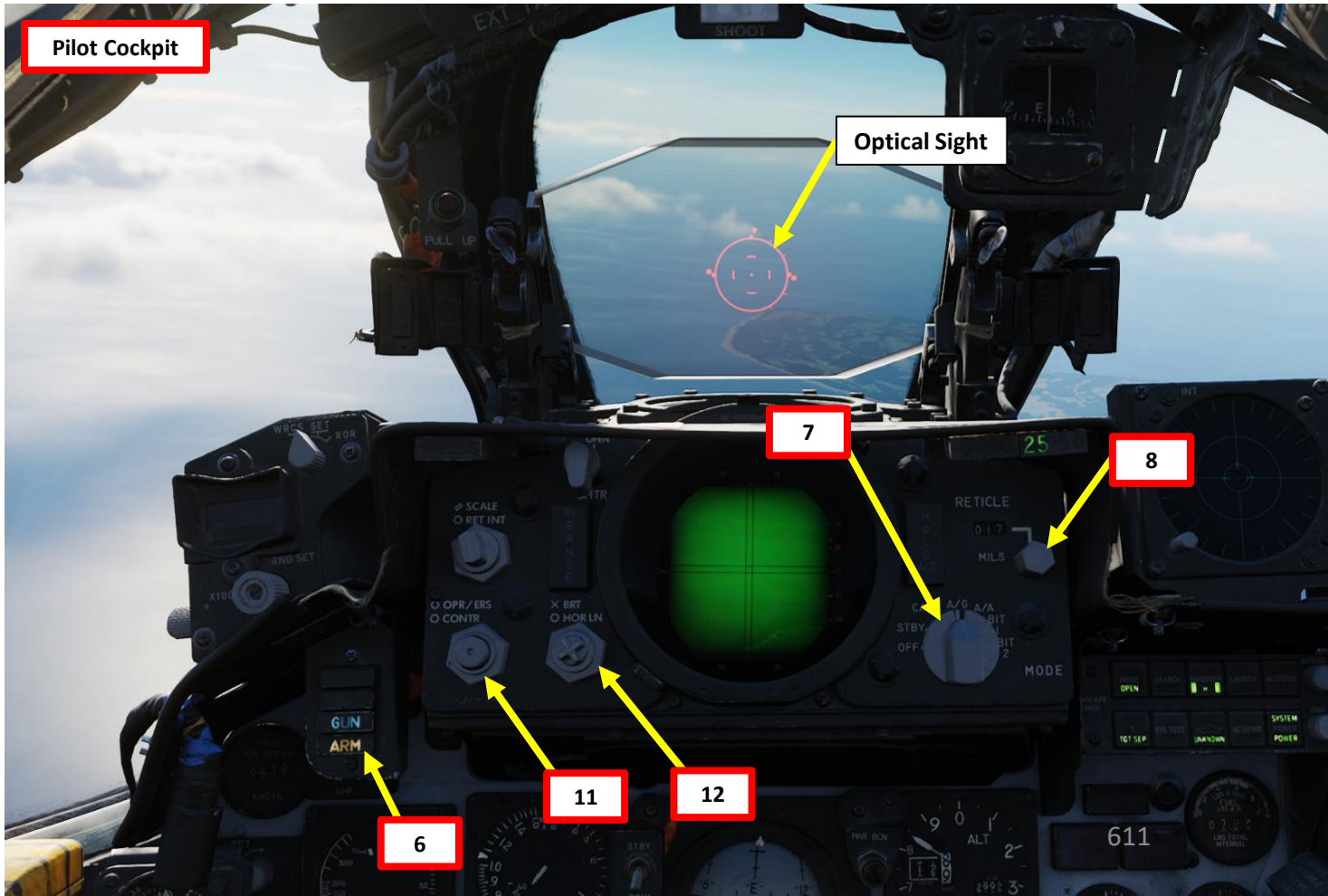
2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.2 – AGM-62 Walleye

A – Weapon Setup

6. *[P]* Confirm ARM light is illuminated
7. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
8. *[P]* Set Reticle Depression Setting Knob to 17 Mils. This will make the optical sight roughly match the line-of-sight of the seeker head.
9. *[WSO]* Set Video Select Button – WEAPON.
10. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – TV (DOWN). This will display the TV feed from the Walleye seeker.
11. *[P]* Adjust Screen Contrast – As desired (Outer knob)
12. *[P]* Adjust Screen Brightness – As desired (Inner knob)



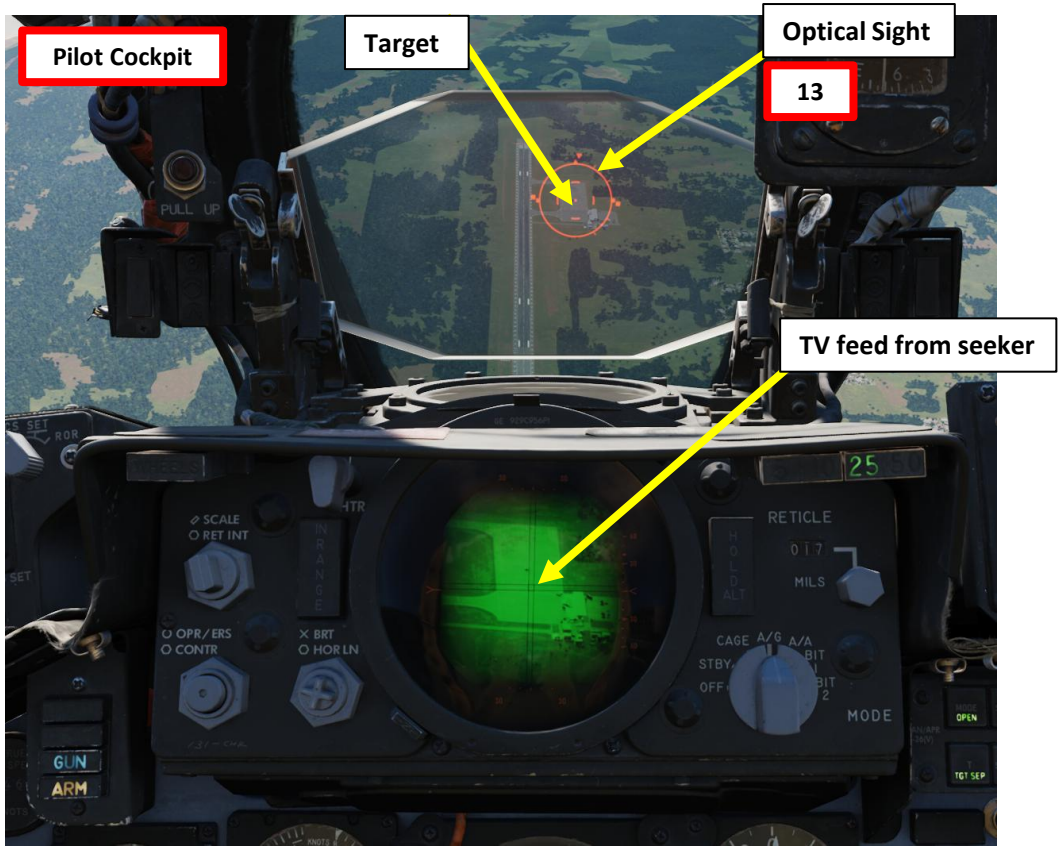




2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.2 – AGM-62 Walleye

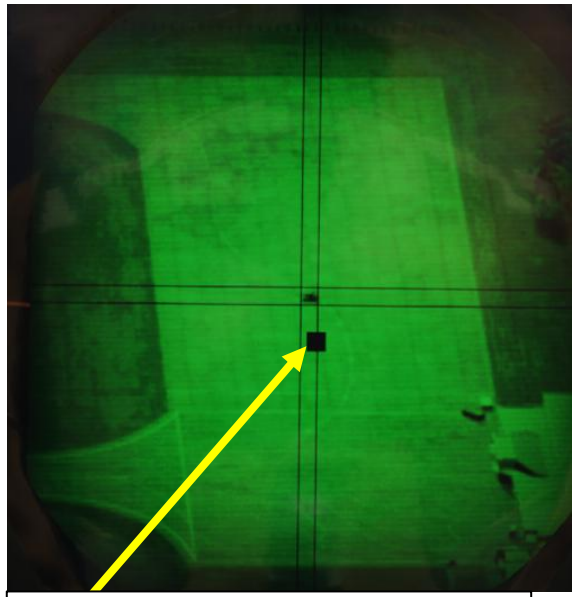
B – Perform Attack

13. *[P]* Perform a steep dive on the target (at least 50 deg) and steer aircraft to set the optical sight's reticle on the target. The camera sensor can not be slewed, the pilot has to fly the aircraft to place the crosshair on the TV display directly over the target.
14. *[P]* Once target is on the TV crosshair, **press and hold** the flight stick trigger's second detent (Full Action) (SPACEBAR) to command a lock.
15. *[P]* The seeker attempts to lock via contrast. If it fails to lock, the target likely does not stand out enough to its background.
16. *[P]* Once locked, a black square is added to the symbology, indicating the seeker head position. If the black square drifts too much away from the center of the crosshair, you will likely miss the target.



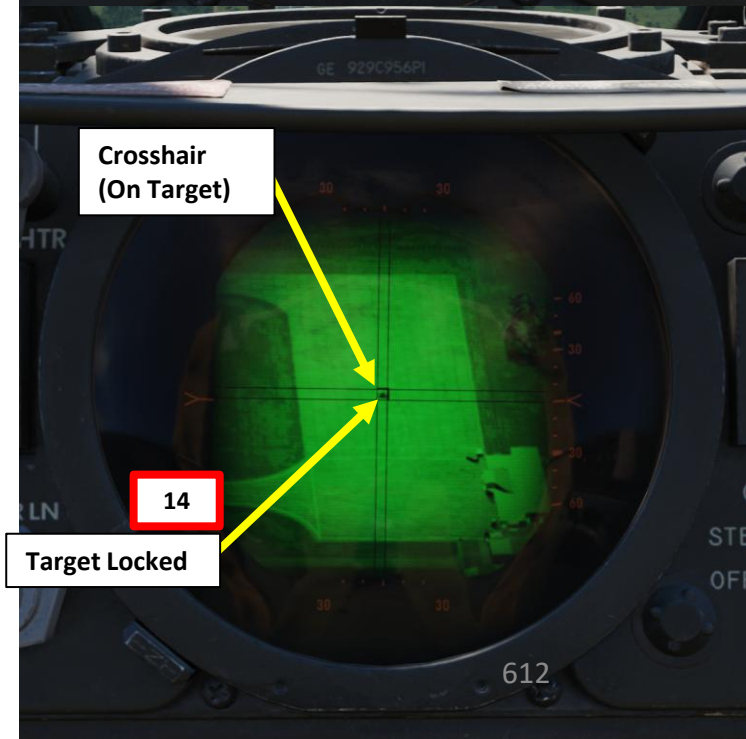


Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*



Seeker Head Position: fly aircraft to keep black square centered on crosshair



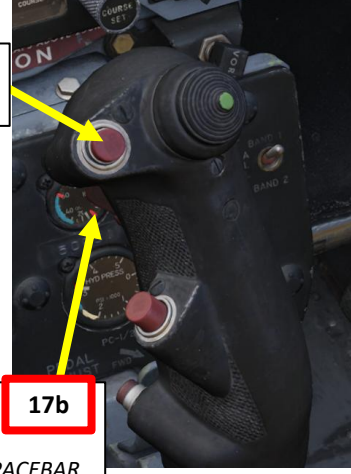


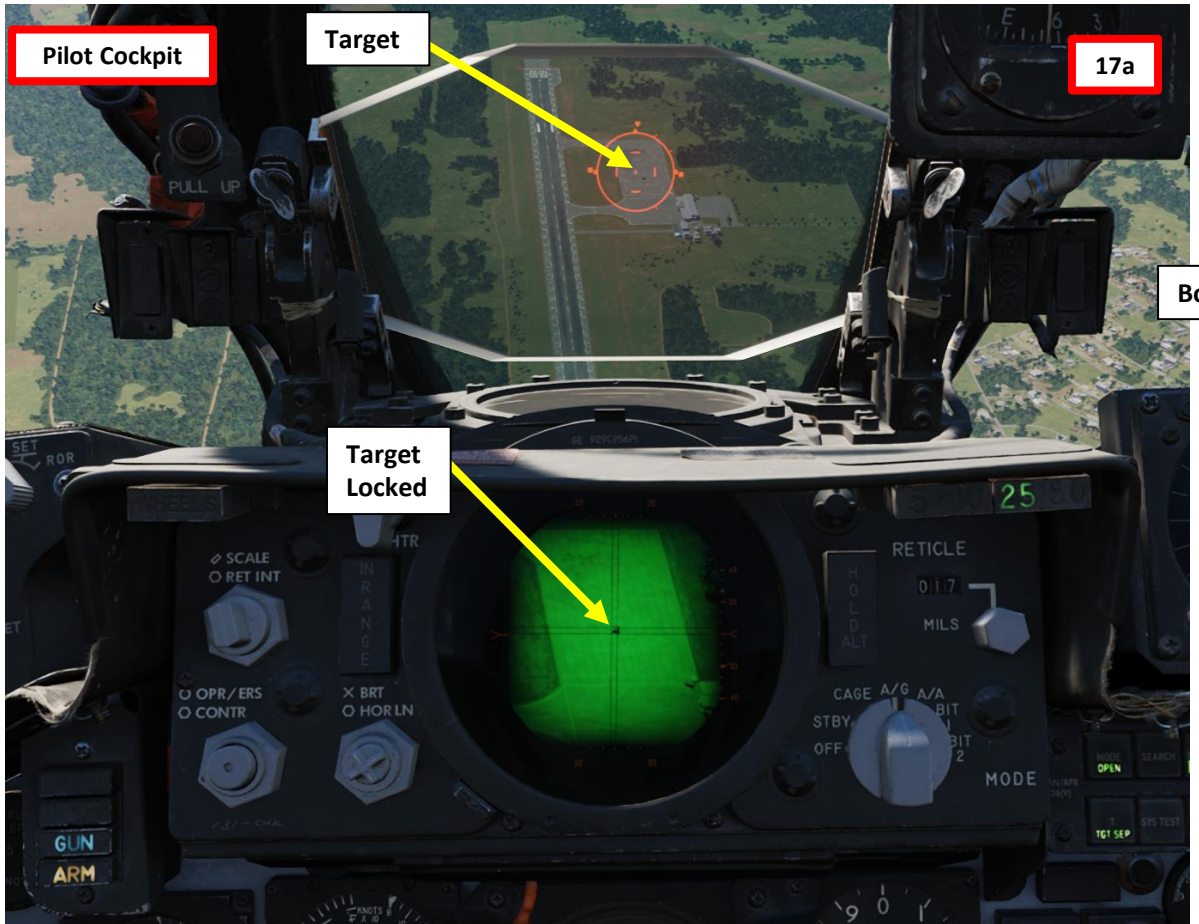
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2.8 – Electro-Optical TV Guided Bombs
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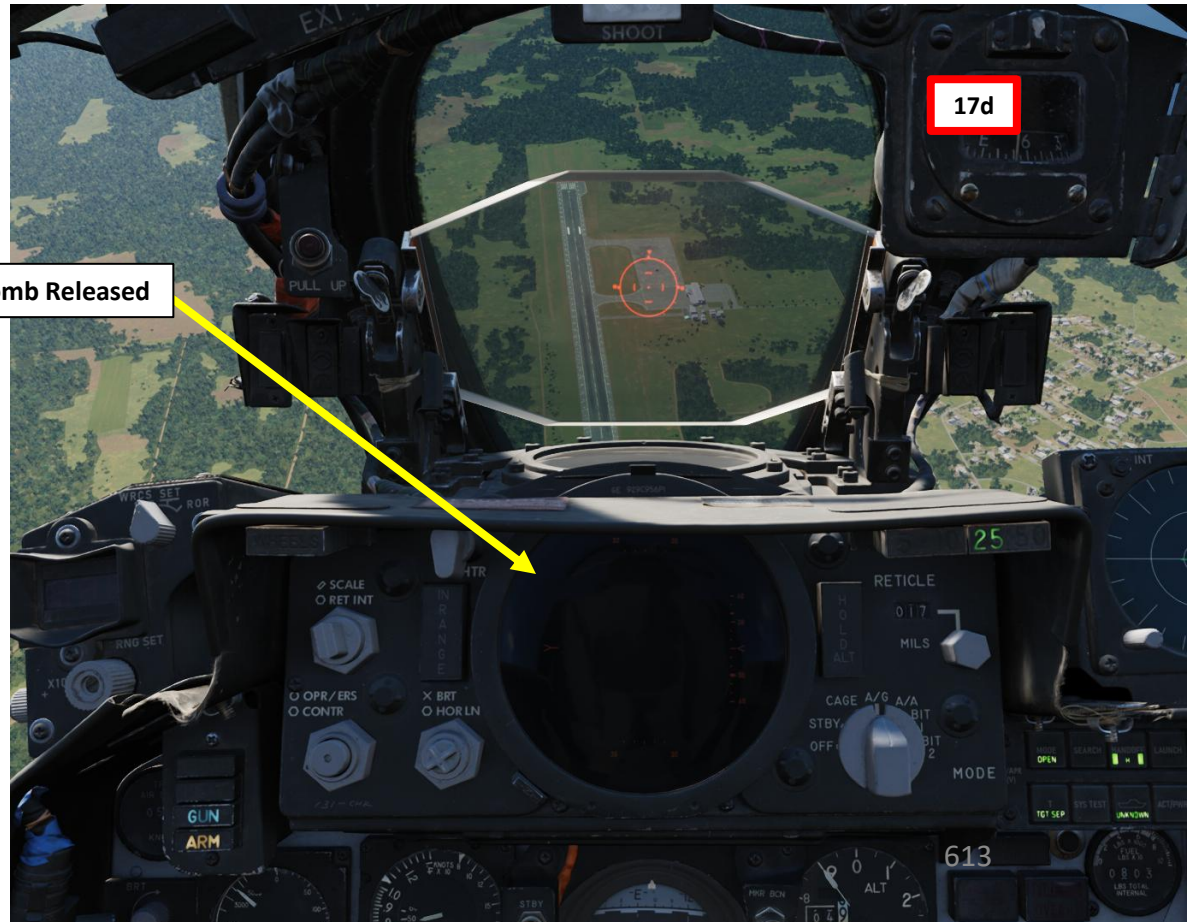
B – Perform Attack

17. [P] To release bomb:

a) Steer the aircraft to ensure the seeker head position (black box) remains centered on the TV crosshair.
b) Ensure the target lock is maintained by keeping the flight stick trigger's second detent (Full Action) (SPACEBAR) pressed and held.
c) Press and hold the Bomb Release Button (RALT+SPACEBAR) until bomb automatically releases.
d) When bomb releases, egress away from the target.







2 – AIR-TO-GROUND WEAPONS
2.8 – Electro-Optical TV Guided Bombs
2.8.2 – AGM-62 Walleye

B – Perform Attack

18. The bomb will guide itself towards the target until impact. Effective range varies a lot with release altitude and speed. The release mechanism does not check if the ordnance is within parameters. To reduce the risk of the weapon missing its target, prefer launching it from increased altitude and speed.







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1 – AGM-45 Shrike



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

SEAD: Suppression of Enemy Air Defenses

Suppression of Enemy Air Defenses (SEAD, also known in the United States as "Wild Weasel" and (initially) "Iron Hand" operations) are military actions to suppress enemy surface-based air defenses, including not only surface-to-air missiles (SAMs) and anti-aircraft artillery (AAA) but also interrelated systems such as early-warning radar and command, control and communication (C3) functions, while also marking other targets to be destroyed by an air strike. Suppression can be accomplished both by physically destroying the systems or by disrupting and deceiving them through electronic warfare.

The F-4E Phantom can use the AGM-45 Shrike missile to suppress radar emitters (or at least force them to shut down their radar) in conjunction with the AN/ALR-45 RWR (Radar Warning Receiver), which displays which radar emitters are “painting” the aircraft.







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

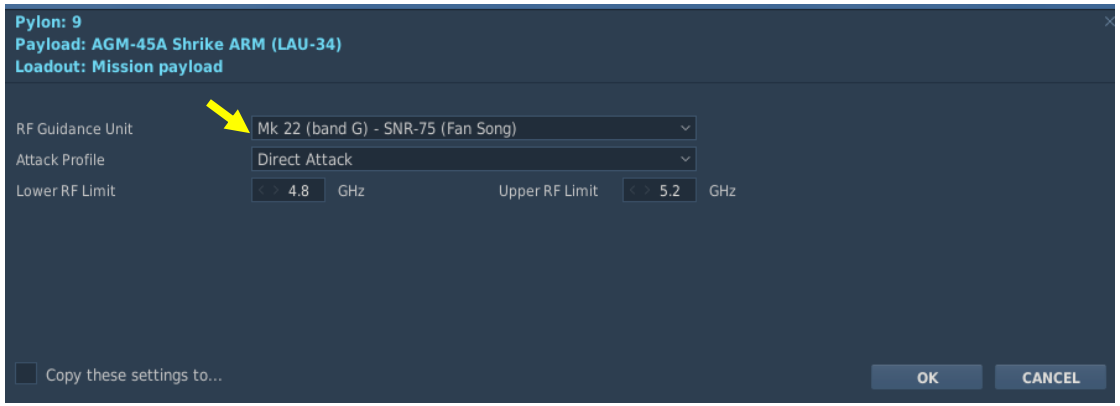
The AGM-45 Shrike Missile

The Sparrow-derived **AGM-45 Shrike** is an early attempt at an anti-radiation missile for the suppression of enemy air defense (SEAD) role. Mating a frequency-tuned seeker with the rocket body of an AIM-7, the Shrike provided the United States Navy, and later the United States Air Force, with a standoff option for the engagement of enemy SAM radars. While nominally effective, in practice the Shrike was a difficult weapon to employ properly, given its limited range, low speed, and primary engagement mode that left the launching aircraft within lethal envelopes of most opposing air defense systems. Further reducing its potency was a small warhead, meaning that in most instances only the emitting antenna itself was damaged, rather than the vehicle it was mounted to.

While limited in most respects, the Shrike received a number of upgrades over its lifetime, lasting in service from the mid-60s in Vietnam, until just after the Gulf War, through better engines and additional seeker updates for later SAM systems.

The AGM-45 has 10 available seeker heads, which each target a specific emitter radio frequency, to select from. These seeker heads are selected from the ground crew or via the Mission Editor. Some careful planning is required prior to flight in order to be properly prepared to engage the threats effectively.

See the table in the next page to see which seeker head to use for what target.







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

The AGM-45 Shrike Missile

Missile RF (Radio Frequency) Guidance Unit – What to use against what?
Soviet Land-Based Threats

Seeker	Band	SA-2	SA-3	SA-5	SA-6	SA-8	SA-10	SA-11	SA-13	SA-15	SA-19	EWR (Early Warning Radar)
Mk 22	G	TR/RF							TR	TR		DE
Mk 23	Complete E-F	RF		TS			TS/BB/CS	SR	TR	SR	SR	
Mk 24 Mod 5	Narrow E-F	RF		TS			TS		TR		SR	
Mk 24 Mod 34	Broad E-F	RF		TS			TS/BB/CS		TR		SR	
Mk 25	G	TR/RF							TR	TR		DE
Mk 36	I	RF	TR		TR		TR	TR	TR			
Mk 37	C	FF/RF	FF	FF	SR	SR			TR			
Mk 49 Mod 0	H-I	RF	TR	TR	TR		TR	TR	TR			
Mk 49 Mod 1	H-I	RF	TR	TR	TR		TR	TR	TR			
Mk 50	E-H	TR/RF		TS			TS/BB/CS	SR	TR	SR/TR	SR	DE

Legend:
- SR: Search Radar
- TR: Tracking Radar
- STR: Search and Tracking Radar
- RF: Rangefinder

****

- BB: Big Bird (SA-10 Search Radar)
- CS: Clam Shell (SA-10 Search Radar)
- DE: Dog Ear
- FF: Flat Face (SA-2/3/5 Search Radar)
- TS: Tin Shield (SA-5/10 Search Radar)

Additional Note: The SA-2/3/5 all can use the same Flat Face search radar with the SA-5 having the option of using the Tin Shield as a search radar as well.

2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

The AGM-45 Shrike Missile

Missile RF (Radio Frequency) Guidance Unit – What to use against what? NATO Threats						
Seeker	**Band**	**Hawk**	**Patriot**	**Rapier**	**Roland**	**NASAMs**
Mk 22	G	TR	STR	SR		
Mk 23	Complete E-F	TR		SR		
Mk 24 Mod 5	Narrow E-F	TR		SR		
Mk 24 Mod 34	Broad E-F	TR		SR		
Mk 25	G	TR	STR	SR		
Mk 36	I	TR		SR	TR	SR
Mk 37	C	SR/TR		SR		
Mk 49 Mod 0	H-I	TR		SR		
Mk 49 Mod 1	H-I	TR		SR		
Mk 50	E-H	TR	STR	SR		

Legend:
- SR: Search Radar
- TR: Tracking Radar
- STR: Search and Tracking Radar
- RF: Rangefinder

Missile RF (Radio Frequency) Guidance Unit – What to use against what? Combined NATO & Soviet AAA (Anti-Air Artillery) Threats				
Seeker	**Band**	**Shilka**	**Firecan**	**Gepard**
Mk 22	G		TR	
Mk 23	Complete E-F		TR	SR
Mk 24 Mod 5	Narrow E-F		TR	SR
Mk 24 Mod 34	Broad E-F		TR	
Mk 25	G		TR	
Mk 36	I		TR	
Mk 37	C		TR	
Mk 49 Mod 0	H-I		TR	
Mk 49 Mod 1	H-I		TR	
Mk 50	E-H		TR	SR

Legend:
- SR: Search Radar
- TR: Tracking Radar
- STR: Search and Tracking Radar
- RF: Rangefinder

2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

The AGM-45 Shrike Missile

Missile RF (Radio Frequency) Guidance Unit – What to use against what? Soviet Naval Threats									
Seeker	**Band**	**Kirov**	**Slava**	**Kuznetsov**	**Molniya**	**Grisha**	**Krivak**	**Neustrashimy**	**Ropucha**
Mk 22	G	TR	TR	TR		TR	TR	TR	
Mk 23	Complete E-F	SR/TR	SR/TR	SR/TR	SR/TR	TR	TR	SR/TR	
Mk 24 Mod 5	Narrow E-F	SR/TR	TR	SR/TR	SR/TR	TR	TR	SR/TR	
Mk 24 Mod 34	Broad E-F	TR	TR	TR		TR	TR	TR	
Mk 25	G	TR	TR	TR		TR	TR	TR	
Mk 36	I	SR/TR	SR/TR	SR/TR	SR/TR	TR	TR	SR/TR	
Mk 37	C	TR	TR	TR		TR	TR	TR	
Mk 49 Mod 0	H-I	TR	TR	TR		SR/TR	SR/TR	TR	
Mk 49 Mod 1	H-I	TR	TR	TR		SR/TR	SR/TR	TR	
Mk 50	E-H	SR/TR	SR/TR	SR/TR	SR/TR	TR	TR	SR/TR	

Legend:
- SR: Search Radar
- TR: Tracking Radar
- STR: Search and Tracking Radar
- RF: Rangefinder

2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

Bang-Bang

The Shrike missile's fins only actuate with bang-bang control inputs. In control theory, a "bang-bang" controller (hysteresis, 2 step or on–off controller) is a feedback controller that switches abruptly between two states. Why is this relevant, though?

Once the missile guidance is enabled, the AGM-45 will be corkscrewing (naturally roll at approximately 55-60 degrees per second) and its fins will be bang-banging constantly, which results in a very high potential energy loss once guidance begins. Simply put, the Shrike decelerates very quickly the more it needs to manoeuver to home on a target, which severely reduces the missile's practical range and effectiveness. This highlights the need for using the Shrike in an energy-efficient manner by either using a lofting profile (increasing its range and conserving potential energy) or by firing it close to the target. These risks need to be taken into account when performing these kinds of missions.



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

Sources:

AGM-45 Shrike Quick Guide by Klarsnow
https://forum.dcs.world/topic/349673-agm-45-shrike-quick-guide-by-klarsnow-updated-june-5th-2024/

Heatblur Simulations Wiki
https://f4.manuals.heatblur.se/stores/air_to_ground/missiles/shrike.html

Employment Modes

There are three primary employment methods for the Shrike:

A – AGM-45 Mode (WRCS)

Used only with the AGM-45 in conjunction with the WRCS (Weapon Release Computer Set), this mode is the primary means of employment of the Shrike. The mode is based around a high altitude attack profile, and depends on the pre-programmed weapon engagement envelope of the AGM-45 stored within the WRCS. This profile, in conjunction with current aircraft state information from the INS (Inertial Navigation System) and a signal provided by the receiver in the missile - having detecting an emitter of the type its attuned to, define a flight path and release envelope for optimum probability of the missile reaching the target. Look angle and estimated range available, the WRCS will provide guidance instruction using the needles on the ADI. Once oriented in the dive angle, the horizontal range to target will be provided on the HSI (Horizontal Situation Indicator) and BDHI (Bearing Distance Heading Indicator), so long as the INS position is selected for navigation mode. As the aircraft aligns with the calculated trajectory, one of the indexer lights should illuminate, each light corresponding to a specific release maneuver.

- TLDR: AGM-45 mode provides you ranging indications for the Shrike and lets you know if you are in range to loft, perform a level release, or perform a diving release of the missile.

B – Loft Mode (LABS)

The Loft attack profile of the Shrike is like a loft bombing attack, utilizing the weapon lookup tables to define a suitable IP (Ingress Point) to release distance, the necessary release angle, and the time from IP to pull-up is determined by the lookup table speed versus the IP to release distance. The attack is performed like a loft bombing profile; the Phantom is flown over the IP at the intended altitude and airspeed, with the bomb release button being held from the point of flyover. The countdown timer initiates, the horizontal ADI bar appears to maintain level flight, and the pull-up lamp illuminates. When the pull-up timer runs out, the pull-up lamp will turn off, the sight reticle will turn off, and the horizontal ADI bar will move to display G load as normal for the pull-up maneuver; a correct profile will keep both ADI bars centered. When the aircraft achieves the programmed release angle, the missile will launch. Once launch has occurred, the pull-up lamp and sight reticle will illuminate again, and the horizontal ADI bar will stow. The Loft seeker of the AGM-45 Shrike needs to sense a differential pressure of 1 Bar and needs to sense a barometric height of over 18,000 ft to arm itself and start searching. When missile is lofted, the fins remaining locked and the missile flying ballistic until guidance enable it to retain much of its energy and usually results in a fairly steep (30-45 degree) descent angle when it enables guidance.

- TLDR: Loft mode can provide a great range if lofted accurately, however the missile will not start guiding until much later which is not the best for short range engagements.
- **Note: Since no loft attack profiles are currently available for the Shrike, we will not demonstrate that mode since the majority of missions in DCS can be done with other employment modes.**

C – Direct Mode (WRCS)

Direct mode employment of the AGM-45 is dependent on the crew knowing the precise location of the target SAM emitter; while it can be utilized as a fallback method in event of a WRCS system failure, the need for at least 10 degrees of dive angle against the target for successful delivery places a premium on being able to plan the attack against a specific point on the ground. To employ the weapon in Direct mode, the crew confirms receipt of emitter audio, and initiates a dive to center the ADI needles at the target. The crew should then check the dive chart for angle and altitude above ground level, and the pilot should maneuver into that orientation, maintaining a centered vertical ADI needle. From that point, the bomb release button is pressed and held until the Shrike is fired.

- TLDR: Direct mode is your “shoot it straight down the throat” guidance control selection, however the missile will have a very short range.

2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.1 – AGM-45 Shrike: Introduction

Missile Guidance Control Settings

When equipping a missile, the ground crew must select one of two guidance control settings: **Loft** or **Direct**. Consider these guidance control settings as missile "autopilot" modes that give the commands from the seeker to the fins to steer the missile (and that cannot be selected from the cockpit). Missile guidance control is not enabled until after launch and certain conditions are met. You can choose the conditions that will enable the guidance control by selecting LOFT ATTACK or DIRECT ATTACK on the rearm fuze selection menu, or in the mission editor.

Loft Guidance Setting

This is the most complex set of conditions to enable the guidance control section. The conditions are:

- **Condition 1**: Missile barometric altimeter detects a pressure increase of 1 psi (about 3000 feet depending on altitude and temperature)
- **Condition 2**: Missile barometric altimeter senses that the missile is below 18,000 ft MSL (Mean Sea Level)

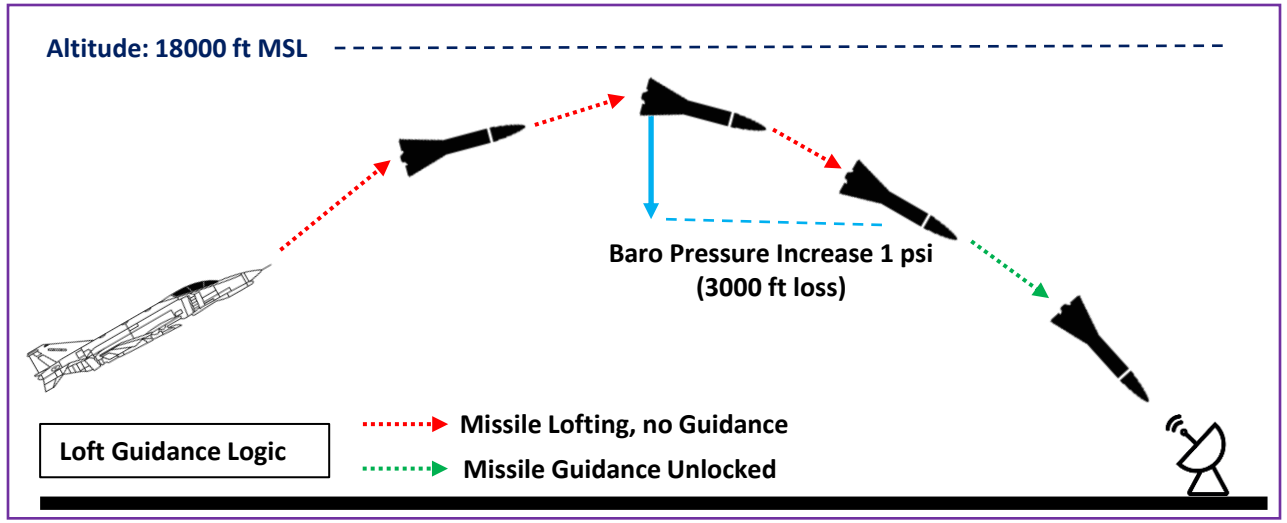
Once both of these conditions are met, the guidance control section will unlock and the signals from the seeker will be sent to the control section and the fins. Until these conditions are met the missile will be flying completely ballistic and unguided, even though the seeker may see and be tracking the emitter the entire time.

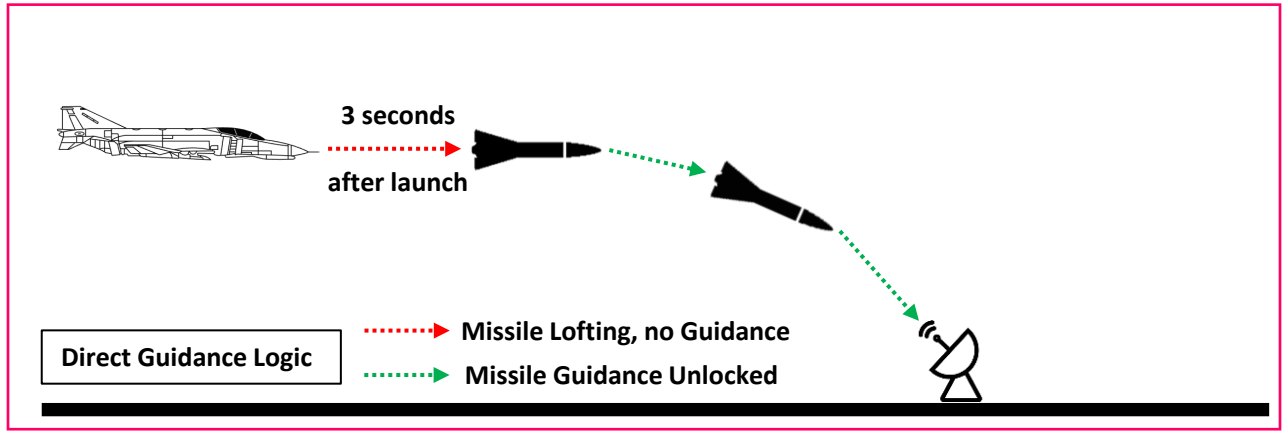
Direct Guidance Setting

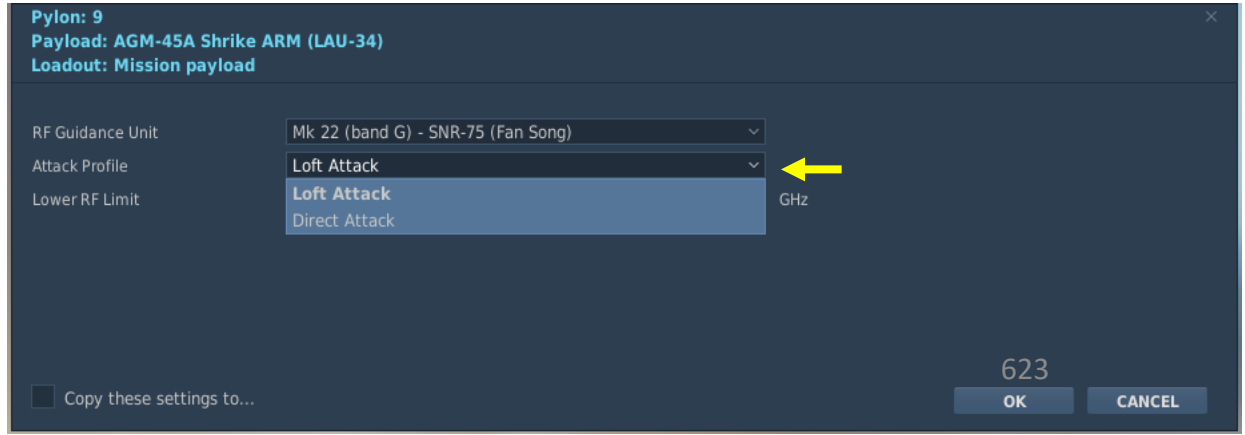
With this selected the altitude sensor for the loft attack is bypassed and the guidance control unlocks approximately 3 seconds after launch. The AGM-45 will naturally roll at approximately 55-60 degrees per second, and the guidance control system does not attempt to stop this once it enables. Additionally, the fins only actuate with bang-bang control inputs, which results in a very high potential energy loss once guidance begins.

****

Important Note: *the direct/loft missile guidance control settings are independent from the AGM-45/direct/loft employment modes, which means it is your job to check that the right guidance setting is selected for the right employment mode. As an example, you could select a Direct Guidance seeker with a Loft Employment Mode… and the missile will likely fall short of the target because of it.*







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)



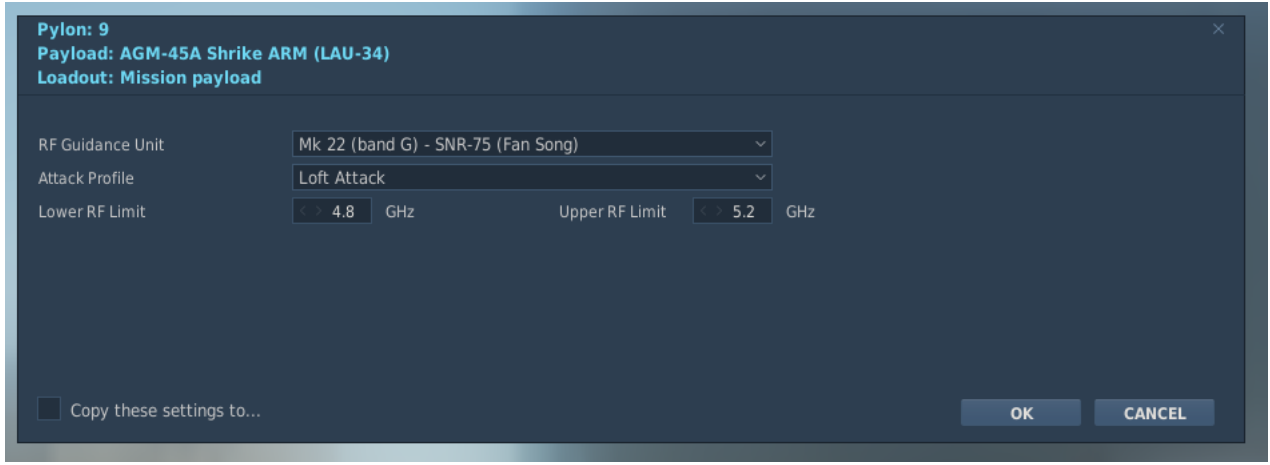
2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

A – Equipment Check

Our target is a SA-2 Fan Song Tracking Radar.

Check with the ground crew that the AGM-45 Shrike missile equipped has a **Mk 22 RF (Radio Frequency) Guidance Unit** and a **Loft Attack Guidance Attack Profile**.

Note: The WRCS (Weapon Release Control Set) has no way of knowing which type of seeker guidance you have selected and will always be calculating assuming the LOFT ATTACK logic is set.

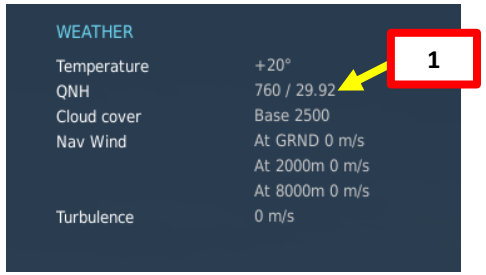




2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

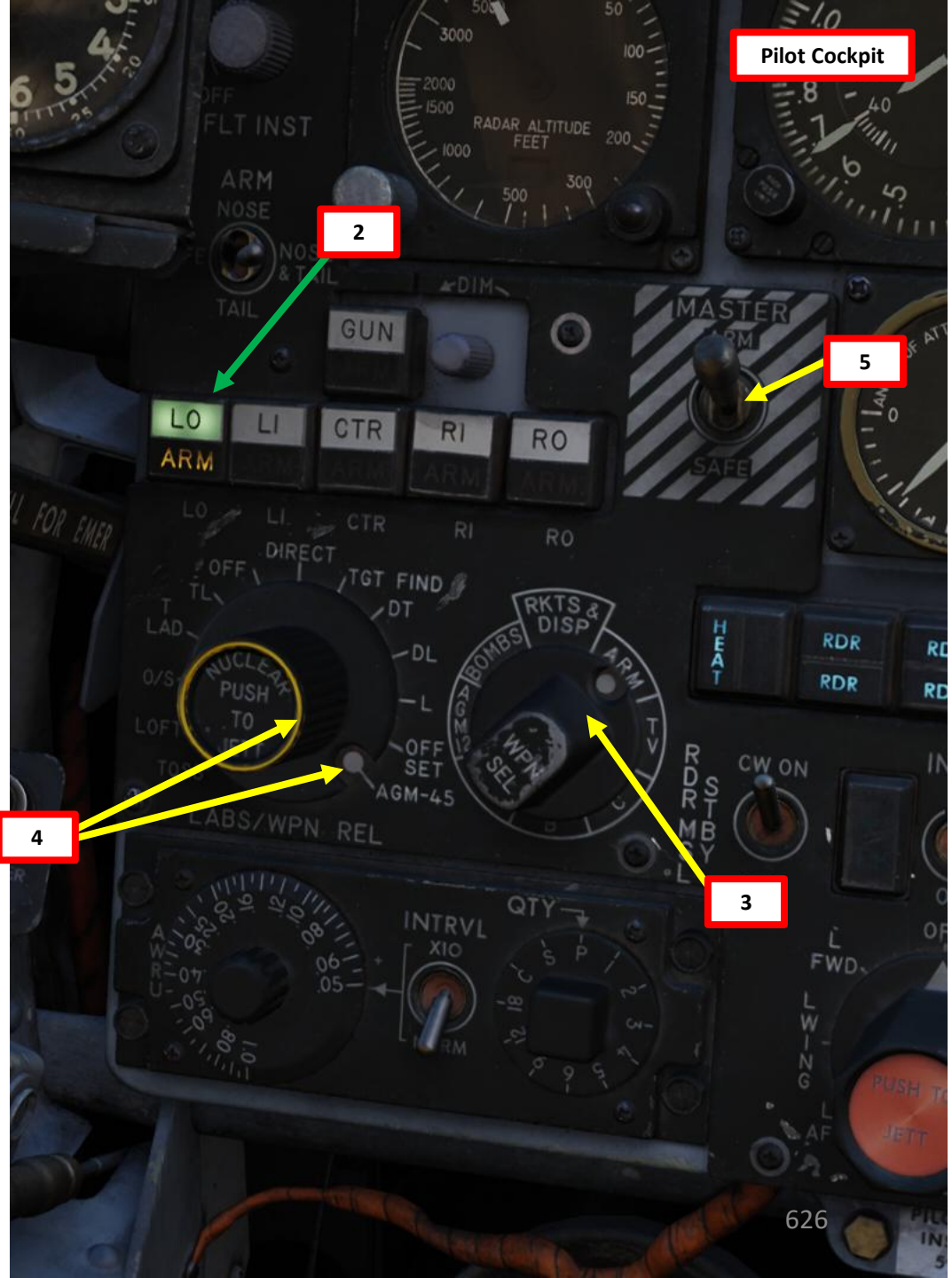
B – Weapon Setup

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.
2. *[P]* Select desired Station Select Button. We will use LO.
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – ARM (Anti-Radiation Missile).
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – AGM-45
5. *[P]* Set Master Arm Switch – ARMED (UP)
6. *[P]* Set the Target/Missile Reject Switch in the DF REJ (DOWN) position
   - For Shrikes, TGT/MSL REJ turns off the weapon seeker entirely until released. The DF REJ position selects the WRCS mode for receiving a solution, while the center position uses the weapons own, less accurate seeker system instead.





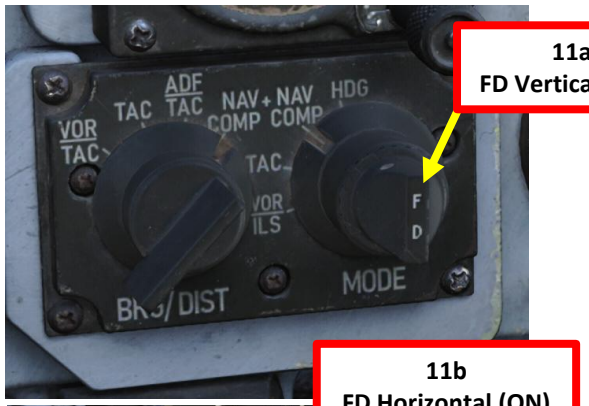


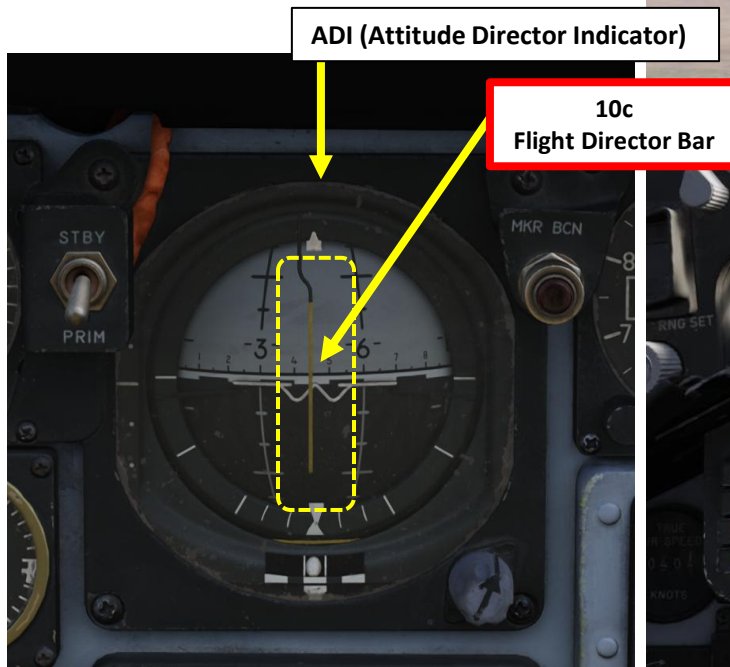


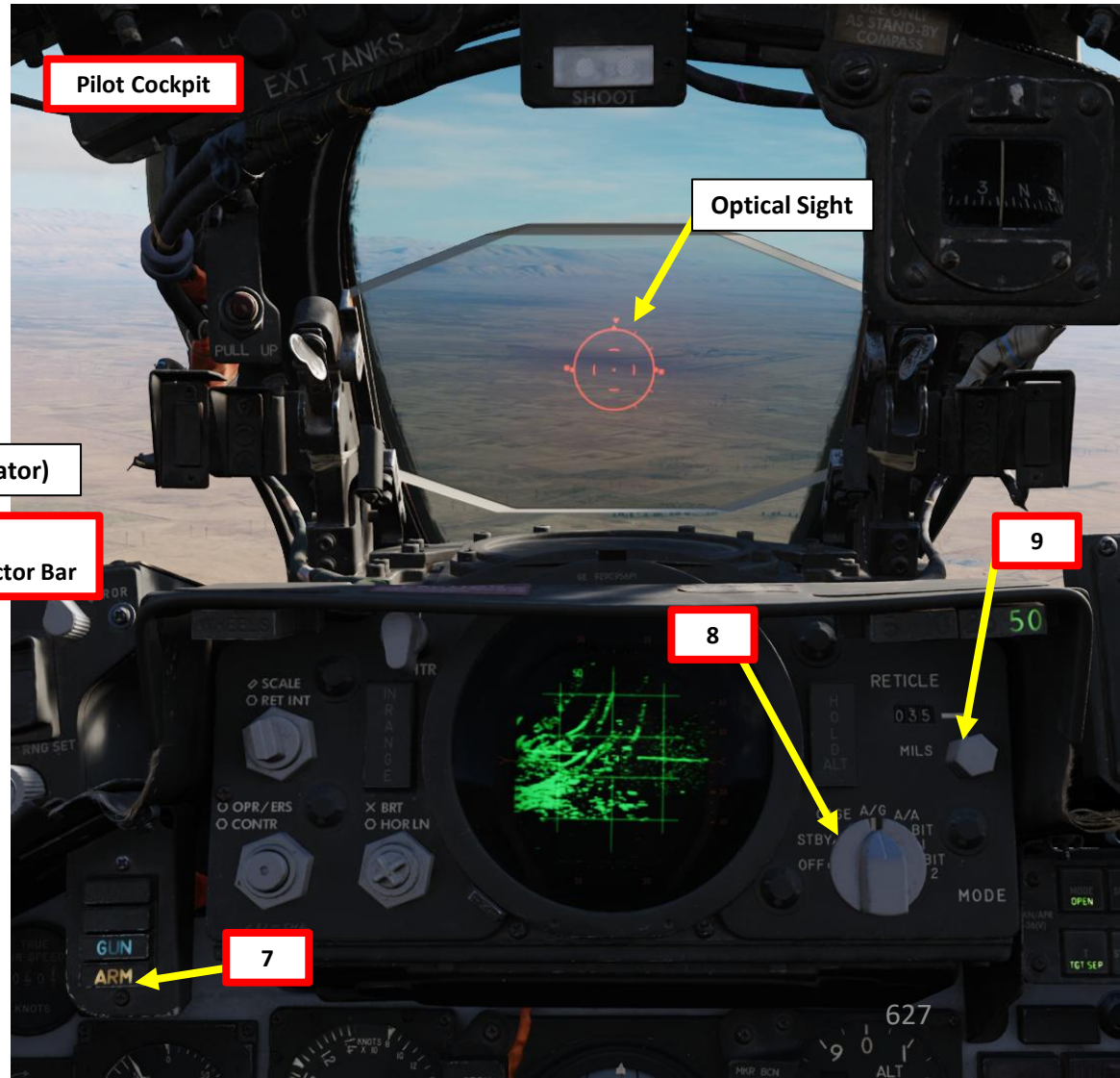
2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

B – Weapon Setup

7. *[P]* Confirm ARM light is illuminated
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Set Reticle Depression Setting Knob to 35 Mils.
10. *[P]* Verify that Navigation Mode Selector (Outer Knob) and Navigation Input Selector are both set to NAV COMP (Navigation Computer).
11. *[P]* Set Flight Director – ON.
    - Turn the inner "FD" knob in the Horizontal position (ON), then confirm the flight director is ON by checking that the yellow flight director bar is visible on the ADI (Attitude Director Indicator)





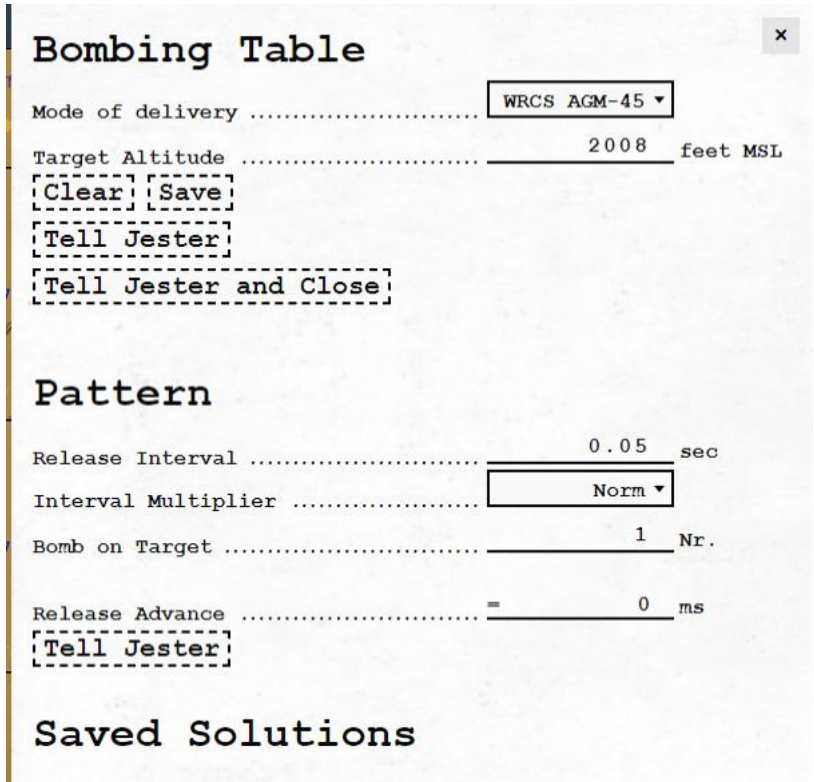


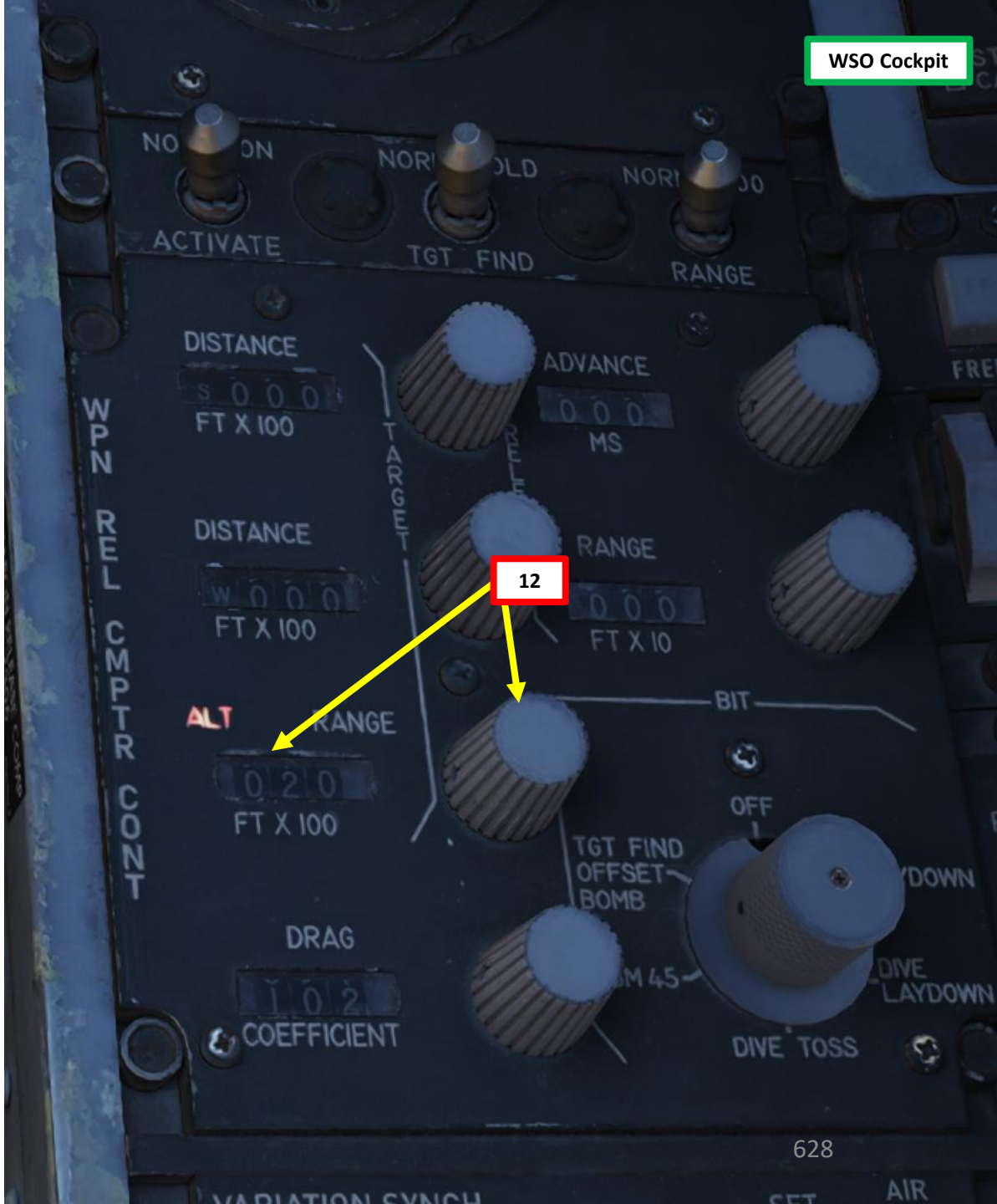
2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

B – Weapon Setup

12. *[WSO]* Set Target Altitude Setting: 2008 ft (value obtained from target elevation from F10 map). The WRCS (Weapon Release Control Set) in AGM-45 mode makes use of the "target altitude" setting to trigonometrically calculate a ground range to your INS (Inertial Navigation System) depression angle as displayed on your ADI (Attitude Director Indicator).

- Note: If using the JESTER AI as the WSO, you can alternatively:
    a) Select the « Bombing Table Utility » by pressing « RCTRL+B ».
    b) On Bombing Table Utility, select WRCS AGM-45 Mode of delivery
    c) Select Target Altitude: 2008 ft MSL (Mean Sea Level) – Obtained from F10 map
    d) Click SAVE.
    e) Click TELL JESTER to set the Target Altitude in the rear cockpit.





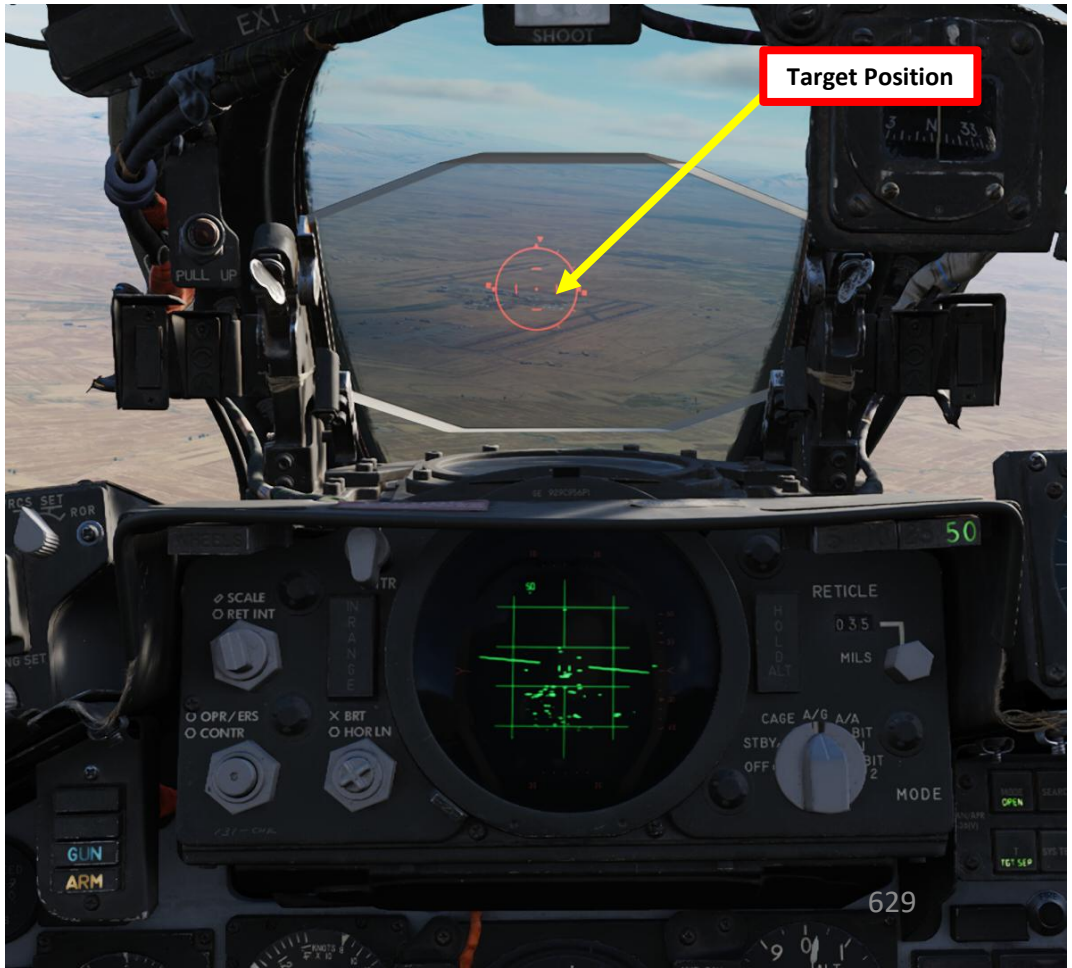
2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

C – Perform Attack

13. *[P]* Once the missile is armed, the missile seeker's receiver is activated and upon emitter acquisition will begin scanning for emitters that match its pre-programmed parameters.
14. *[P]* Once the radar emitter is detected by the missile seeker, a sharp tone should be audible. The WRCS (Weapon Release Control Set) begins calculating the optimal flight path and release envelope. This process relies on real-time data from the missile's receiver and the aircraft's INS (Inertial Navigation System), ensuring precise guidance.
15. *[P]* Confirm that emitter lock has been achieved by checking the relevant cockpit indicators before proceeding with the attack.
    a) ADI (Attitude Director Indicator) needles are visible to help you adjust your orientation for optimal firing solution
    b) HSI (Horizontal Situation Indicator) provides horizontal range to the target

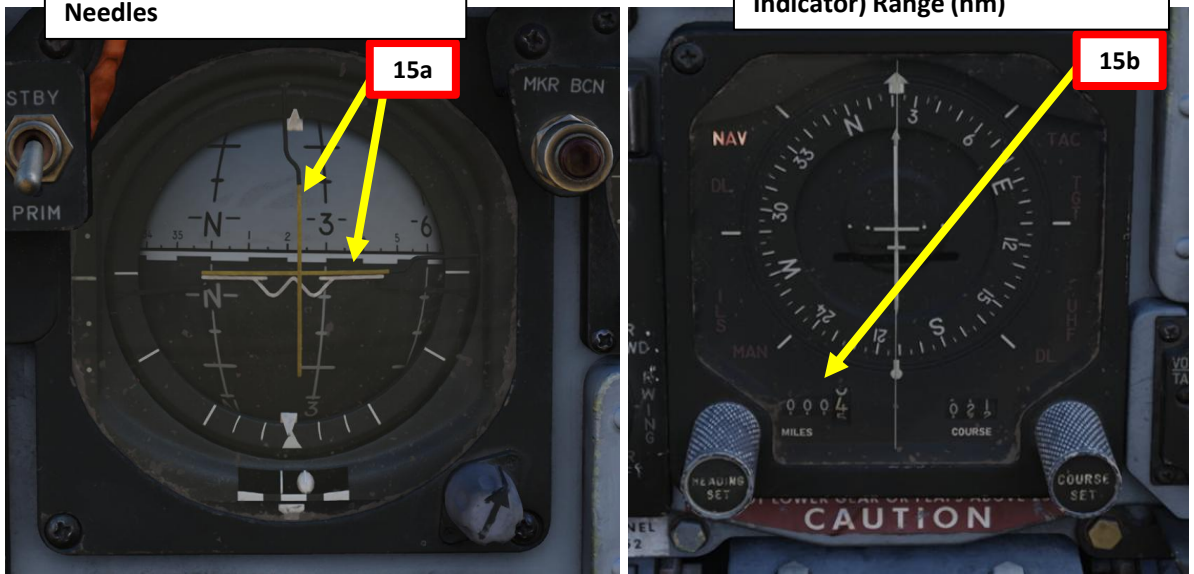
AN/ALR-46 RWR (Radar Warning Receiver) Indicator





ADI (Attitude Director Indicator) Needles

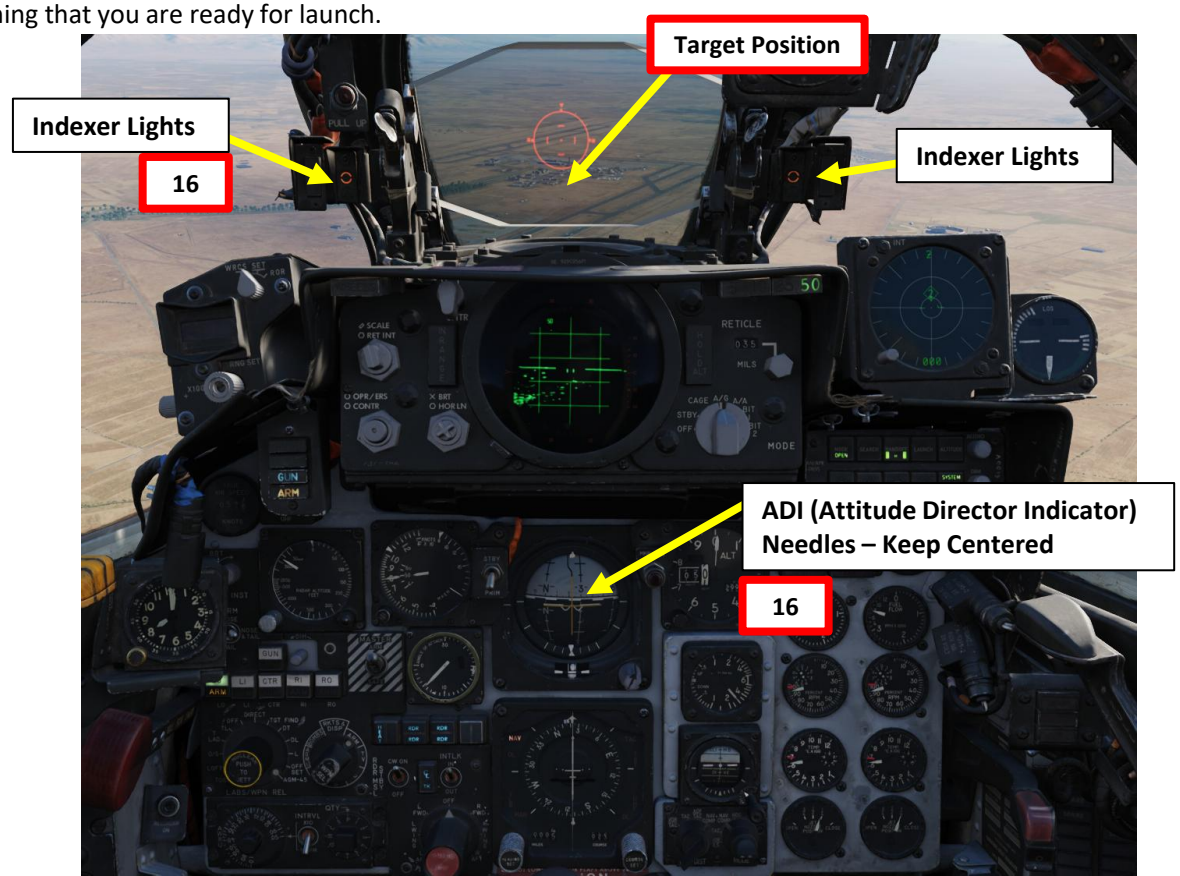
HSI (Horizontal Situation Indicator) Range (nm)



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

C – Perform Attack

16. *[P]* Fly the aircraft to center the ADI (Attitude Director Indicator) needles. Once the aircraft is within missile range, one of the indexer lights will illuminate based on the detected range to target to instruct the pilot as to the required release maneuver: dive, level, or pull-up. These indications are based on your current nose depression angle, and will be calculated and displayed regardless of whether your shrike sees anything, or even if you have a shrike on the aircraft.
    - If the **Pull-up Light** illuminates, begin a steady pull-up maneuver to meet the release parameters. Rotate the aircraft smoothly back toward the horizon and, if necessary, continue into a shallow climb profile.
    - If the **Dive Light** illuminates, initiate a controlled dive toward the target. This typically occurs when the attack is initiated close to the target, so ensure you are prepared to commit quickly, as proximity to the emitter increases the risk of enemy retaliation.
    - The **Level Light** indicates that the aircraft is in the correct orientation for missile release. In some cases, this light may illuminate immediately or shortly after another maneuver, confirming that you are ready for launch.



Special note must be made of the importance of maintaining the ADI needles centered, especially the vertical azimuth relationship. Because the orientation of the missile itself when installed on the wing can cause offset of its receiver to occur when the aircraft is banked, preparation of the attack may require repeated adjustments with wings brought to level every few seconds to make certain the aircraft is pointing at the emitter.







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

C – Perform Attack

17. *[P]* When the conditions are correct and the indexer light confirms the appropriate release profile, press and hold the Bomb Release Button (RALT+SPACEBAR) to initiate the missile launch sequence. Maintain the aircraft's orientation as instructed by the ADI needles and Indexer Lights until the Shrike is released from the hardpoint.
    - Note: The callout for firing a Shrike anti-radiation missile is "Shotgun".



17 **Bomb Release Button**
- *Binding: RALT+SPACEBAR*



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.2 – AGM-45 Shrike: AGM-45 Mode (WRCS)

C – Perform Attack

18. *[P]* The missile fins remain locked and the missile flying ballistic until guidance enable. This allows the Shrike to retain much of its energy and usually results in a fairly steep (30-45 deg) descent angle when it enables guidance. The seeker only has a 45 deg field of view, and the target must be inside that field of view when the guidance section activates (below 18,000 feet and missile's altimeter detects a 1 psi pressure increase (3000 ft altitude decrease)). This means you have to actually get that missile quite accurately to a window above the target when the seeker activates where it can detect it and guide.
19. Keep in mind that suppression of enemy air defenses does not necessarily imply the destruction of the radar emitter; forcing a radar emitter to shut down and hide may be a victory in itself.







2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

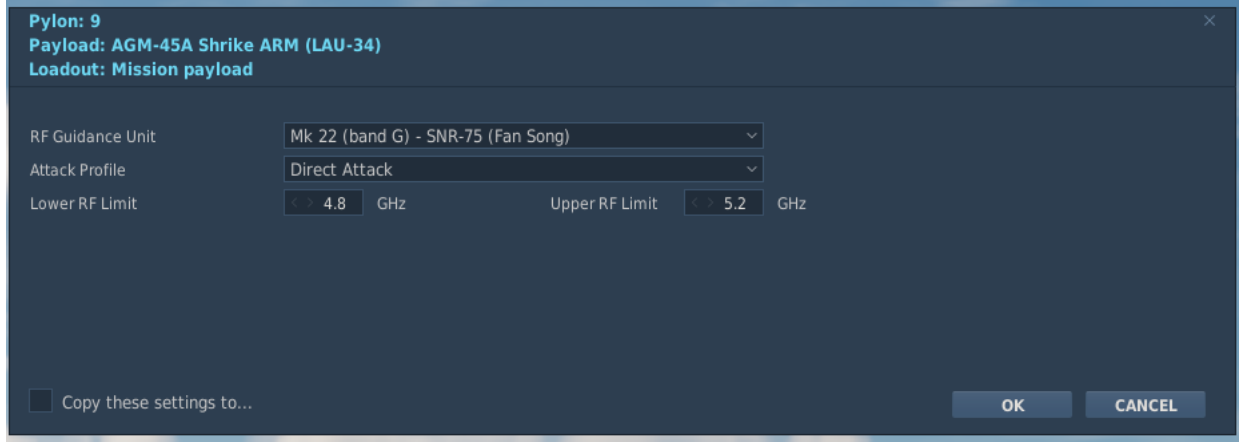


2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

A – Equipment Check

Our target is a SA-2 Fan Song Tracking Radar.

Check with the ground crew that the AGM-45 Shrike missile equipped has a **Mk 22 RF (Radio Frequency) Guidance Unit** and a **Direct Attack Guidance Attack Profile**.

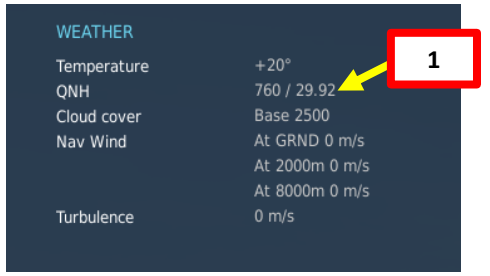




2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

B – Weapon Setup

1. *[P+WSO]* Consult the mission briefing and verify that barometric pressure is set up to the correct value at the target area. In this example, we have a standard QNH value of 29.92 in Hg.
2. *[P]* Select desired Station Select Button. We will use LO.
    - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
3. *[P]* Set Weapon Selector Knob – ARM (Anti-Radiation Missile).
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – Direct
5. *[P]* Set Master Arm Switch – ARMED (UP)
6. *[P]* Set the Target/Missile Reject Switch in the DF REJ (DOWN) position
    - For Shrikes, TGT/MSL REJ turns off the weapon seeker entirely until released. The DF REJ position selects the WRCS mode for receiving a solution, while the center position uses the weapons own, less accurate seeker system instead.







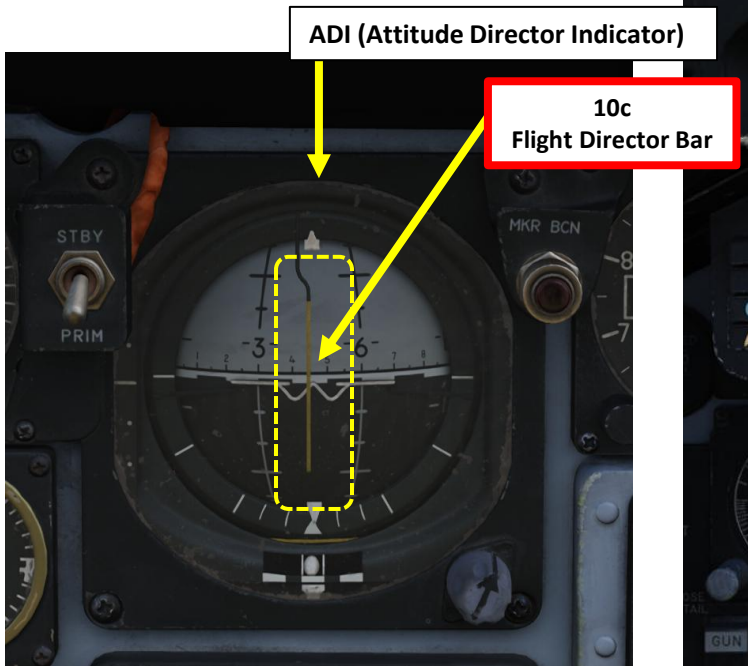


2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

B – Weapon Setup

7. *[P]* Confirm ARM light is illuminated
8. *[P]* Set Sight Mode Selector – A/G (Air-to-Ground)
9. *[P]* Set Reticle Depression Setting Knob to 35 Mils.
10. *[P]* Verify that Navigation Mode Selector (Outer Knob) and Navigation Input Selector are both set to NAV COMP (Navigation Computer).
11. *[P]* Set Flight Director – ON.
    - Turn the inner "FD" knob in the Horizontal position (ON), then confirm the flight director is ON by checking that the yellow flight director bar is visible on the ADI (Attitude Director Indicator)





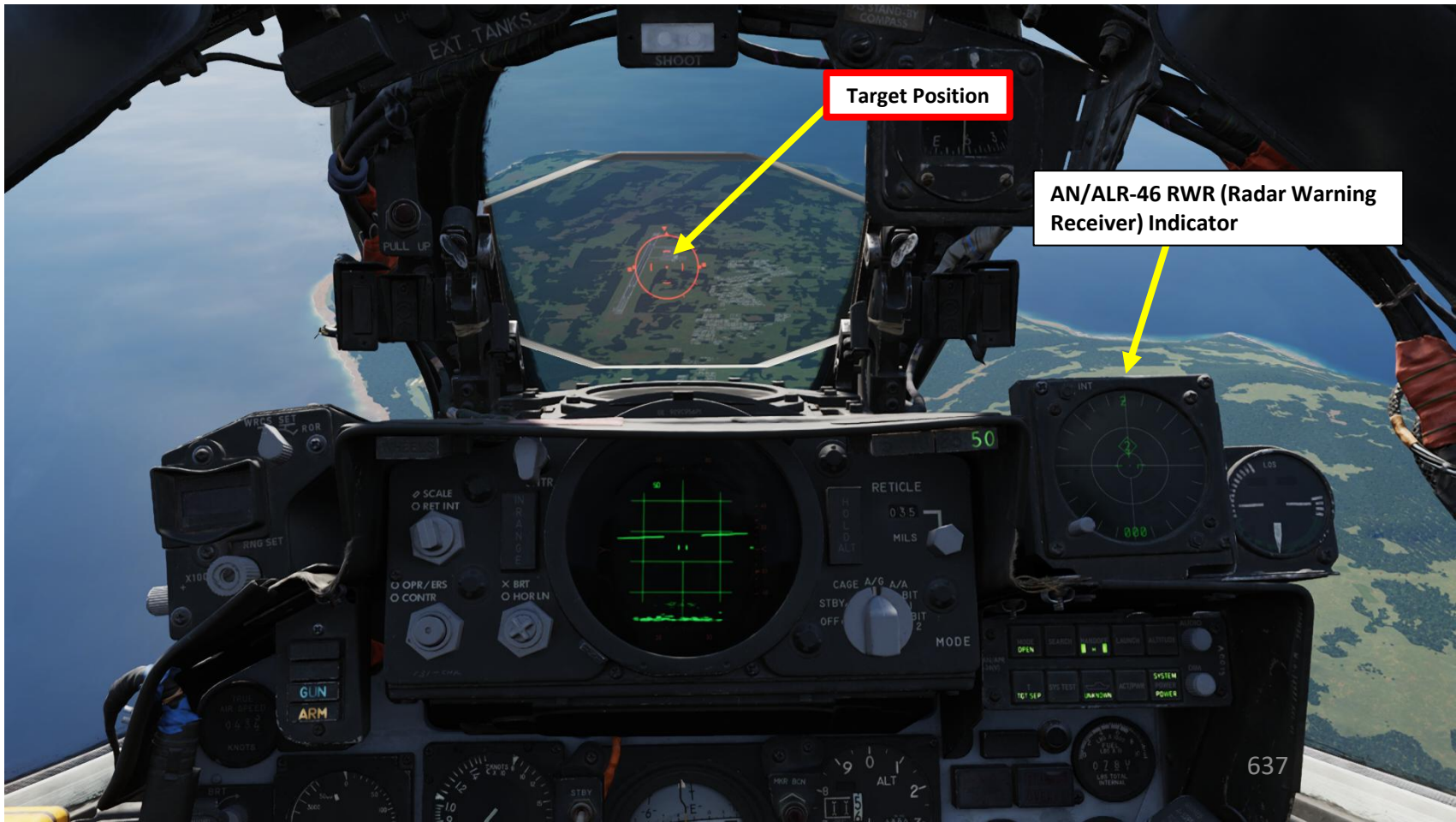


2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

C – Perform Attack

12. *[P]* Once the missile is armed, the missile seeker's receiver is activated and upon emitter acquisition will begin scanning for emitters that match its pre-programmed parameters.
13. *[P]* Once the radar emitter is detected by the missile seeker, a sharp tone should be audible.
14. *[P]* Before proceeding with the attack, confirm that emitter lock has been achieved by checking that the ADI (Attitude Director Indicator) needles are visible to help you adjust your orientation for optimal firing solution.





2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

C – Perform Attack

15. *[P]* Fly the aircraft to center the ADI (Attitude Director Indicator) needles while performing a 20 deg dive.
You should try to pick up the target visually and set the optical sight on it.



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

C – Perform Attack

16. *[P]* While maintaining a 10-20 deg dive angle, press and hold the Bomb Release Button (RALT+SPACEBAR) to initiate the missile launch sequence. There is no indication that you are in range or out of range.
    - Note: The callout for firing a Shrike anti-radiation missile is “Shotgun”.



17 **Bomb Release Button**
- *Binding: RALT+SPACEBAR*



2 – AIR-TO-GROUND WEAPONS
2.9 – Anti-Radiation Missiles
2.9.1.3 – AGM-45 Shrike: Direct Mode (WRCS)

C – Perform Attack

17. *[P]* The missile fins unlock 3 seconds after launch, bypassing the missile's altitude sensor for a loft attack. The missile will naturally roll at approx. 55-60 deg per second, and the guidance control system does not attempt to stop this once it enables. The fins actuate with bang-bang control inputs, resulting in a corkscrewing trajectory and a very high potential energy loss once guidance begins. This is why direct attack guidance missiles have very short range and that the depression angle is very important since the more the missile has to glide to the target, the more likely it will run out of energy and fall short of the target.
18. Keep in mind that suppression of enemy air defenses does not necessarily imply the destruction of the radar emitter; forcing a radar emitter to shut down and hide may be a victory in itself.







3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air



3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.1 – Introduction

The F-4 Phantom has an interesting story when it comes to its gun. After the Korean War, there was a major shift in air combat philosophy. With the new age of missiles, dogfighting was deemed an obsolete concept since most air-to-air engagements were expected to occur beyond visual range. The early variants of the F-4 Phantom were therefore not equipped with any guns, expecting missiles and radars to provide enough standoff range to keep the skies clear without bandits getting anywhere close to the fighters. Once the Vietnam War started, a combination of restrictive rules of engagement (ROE) and the unreliability of early Sparrow and Sidewinder missiles forced the US Air Force to acknowledge that dogfighting was still very much a necessity, especially against Vietnamese MiG-17s or MiG-19s.

In order to fill this new requirement, the General Electric M61 Vulcan cannon finally went to war as an integral part of the Phantom with the advent of the F-4E variant, with the nose profile and APQ-120 radar modified to fit the weapon. Carrying 639 rounds in the internal drum, the six-barreled Gatling style rotary cannon provides a user-selectable rate of fire from 4000 to 6000 rounds per minute with armor piercing incendiary and high explosive incendiary round options available. Useful in both air-to-air and air to ground roles, the Vulcan was used for four confirmed kills by the USAF over Vietnam with the F-4E.



M61A1 Vulcan Cannon (20 mm)
- *639 rounds capacity*

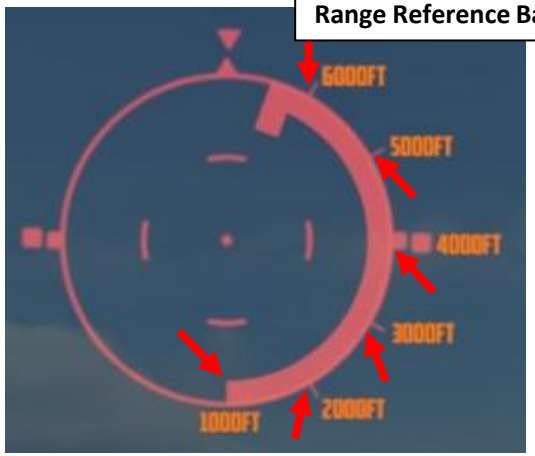


Ammunition Types (20 mm)
- ***HEI: High Explosive Incendiary***
- ***API: Armor Piercing Incendiary***
- ***AP&HE: Armor Piercing & High Explosive***
- ***TP: Training Practice, inert rounds***

3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.1 – Introduction

The **LCOSS (Lead Computing Optical Sight System)** is used to establish a visual sight reference to either air-to-air or air-to-ground weapons delivery. A red reticle is projected on a combining glass. The LCOSS features different modes that can be selected via the Sight Mode Selector.

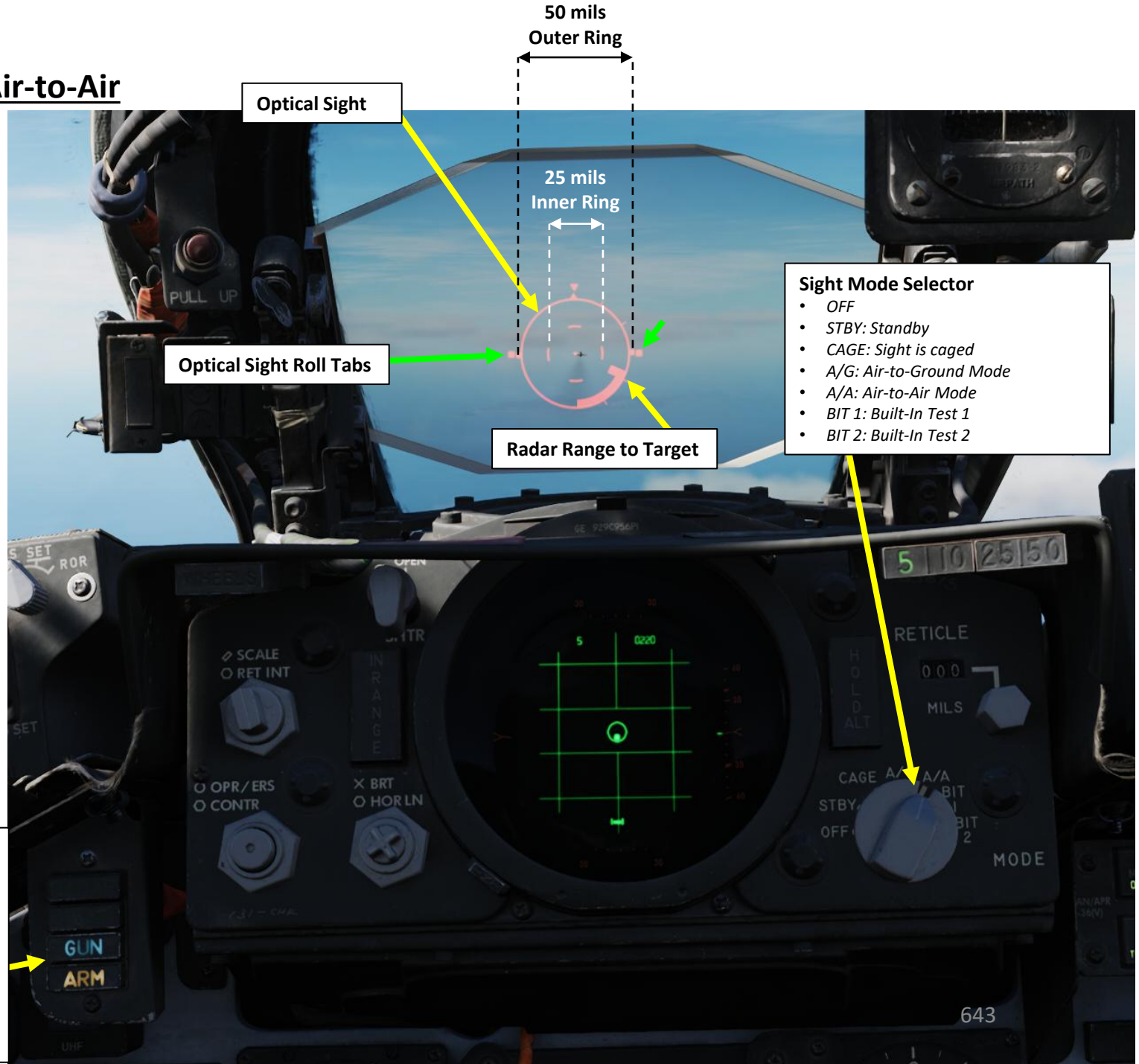
The reticle image that is projected onto the combining glass is composed of a fixed reticle, roll reference tabs, and a range bar. The fixed reticle consists of 2-mil diameter pipper located in the center of a 25-mil diameter segmented circle, and a 50-mil diameter completed circle. The range bar is semicircular and appears on the inside of the 50-mil circle only when a target has been acquired by radar lockon. The range scale changes depending on whether GUN mode is selected or not.



Head-Up Display (HUD) Indicator Lights

This panel provides weapon status for the Master Arm control as well as the current selected air-to-air weapon based on the position of the gun/missile pinky switch on the left throttle handle

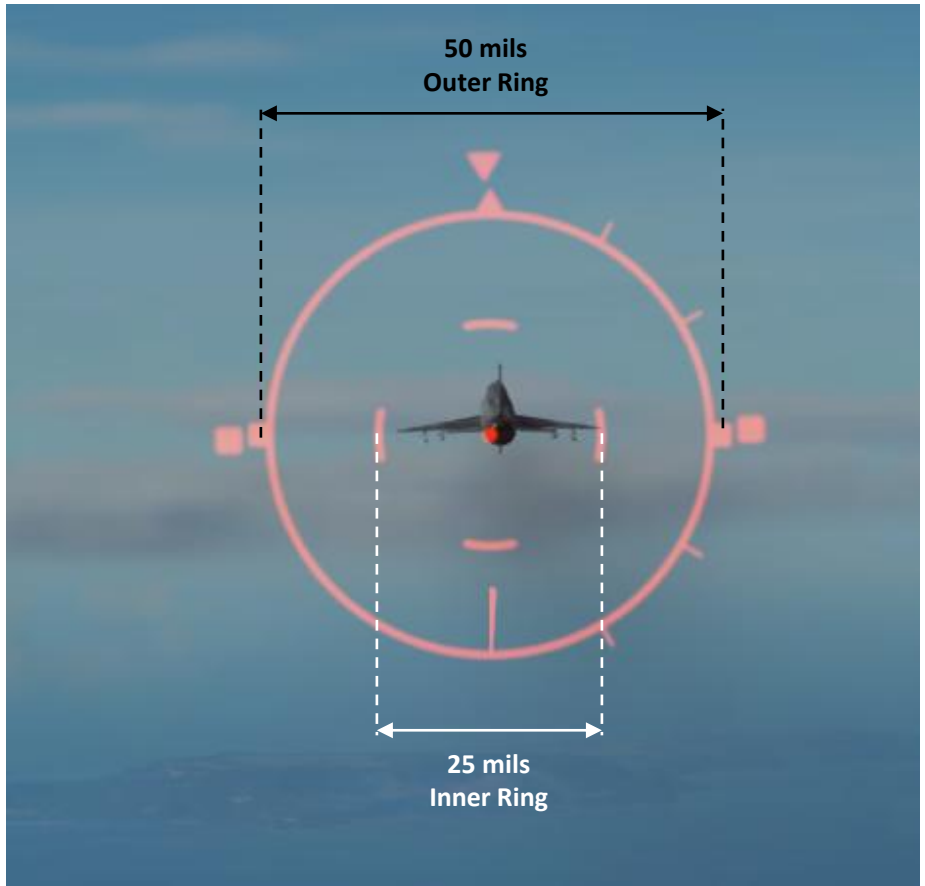
- ***RADAR**: Illuminates when a radar-guided air-to-air missile is selected (AIM-7 Sparrow).*
- ***HEAT**: Illuminates when an infrared-guided air-to-air missile is selected (AIM-9 Sidewinder).*
- ***GUN**: Illuminates when the nose gun/cannon is selected.*
- ***ARM**: Illuminates when the Master Arm switch is selected to ARM.*



3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.1 – Introduction

In air-to-air mode, the optical sight functions as a lead computing optical sighting system (LCOSS), thus maneuvering in both elevation and azimuth relative to a radar locked target, or a default 1000 ft range setting in the event of no lock. With a radar lock, the range bar presentation is relative to 6700 ft just to the left of the tick at the 1 o'clock position, down to 1000 ft at the 6 o'clock position.

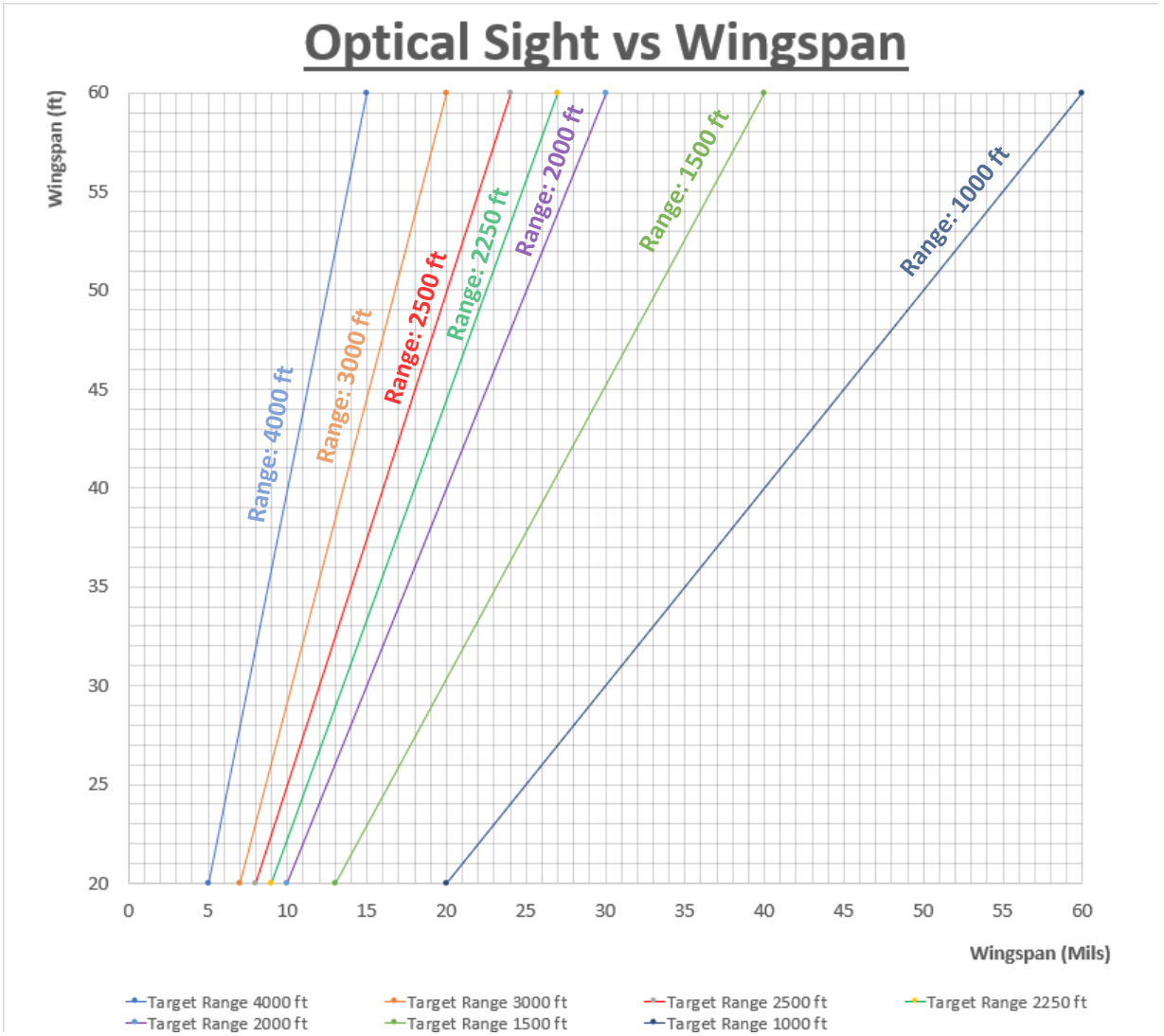
For a target like a MiG-21 with a wingspan of 23 ft, its wingspan should fit within 23 mils. As a rule of thumb, you should be at a 1000 ft firing range when the target's wings fit within the inner reticle ring (25 mils).



Rule of Thumb to estimate target range
- 1000 x wingspan (ft) / Range (ft) = mils in diameter

Example for a wingspan of 39 ft for a 1500 ft range:
1000 x 39 ft wingspan / 1500 ft range = 26 mils

Useful Wingspan Values:
- Mig-21: 23 ft
- Mig-23: 45 ft unswept, 25 ft swept
- Mig-29: 39 ft
- Su-27: 48 ft



3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.1 – Introduction

Now… how do we know when the target is in range to fire? Typically, you choose a firing range/distance first (as an example, 1000 ft or 305 meters), then place the sight on the target and approach until it fits reference marks in "mils" (milliradians, which is an angle) for the desired firing distance.

As an example, let's take the MiG-21, which has a wingspan (length) of about 23 ft (7 meters).

There is a rule in trigonometry that states that "in a right triangle, the tangent (tan) of an angle is the length of the opposite side divided by the length of the adjacent side". For very small angles, simplifications can be made. I'll spare you the math, but the bottom line is:

$$\frac{\theta}{2} = \arctan\left(\frac{L/2}{D}\right)$$

$$\text{For small angles, } \arctan\left(\frac{L/2}{D}\right) \textit{ can be approximated to } \frac{L/2}{D}$$

$$\text{Therefore: } \theta = \frac{L}{D}$$

We know the reticle outer ring's diameter represents an angle of 50 milliradians (50 thousandths of a radian, or 2° 51' in degrees) and the inner ring 25 milliradians. From the equation above, we can determine what distance D_1 the target is from us when its wingspan (L_1) fits within the outer reticle diameter.

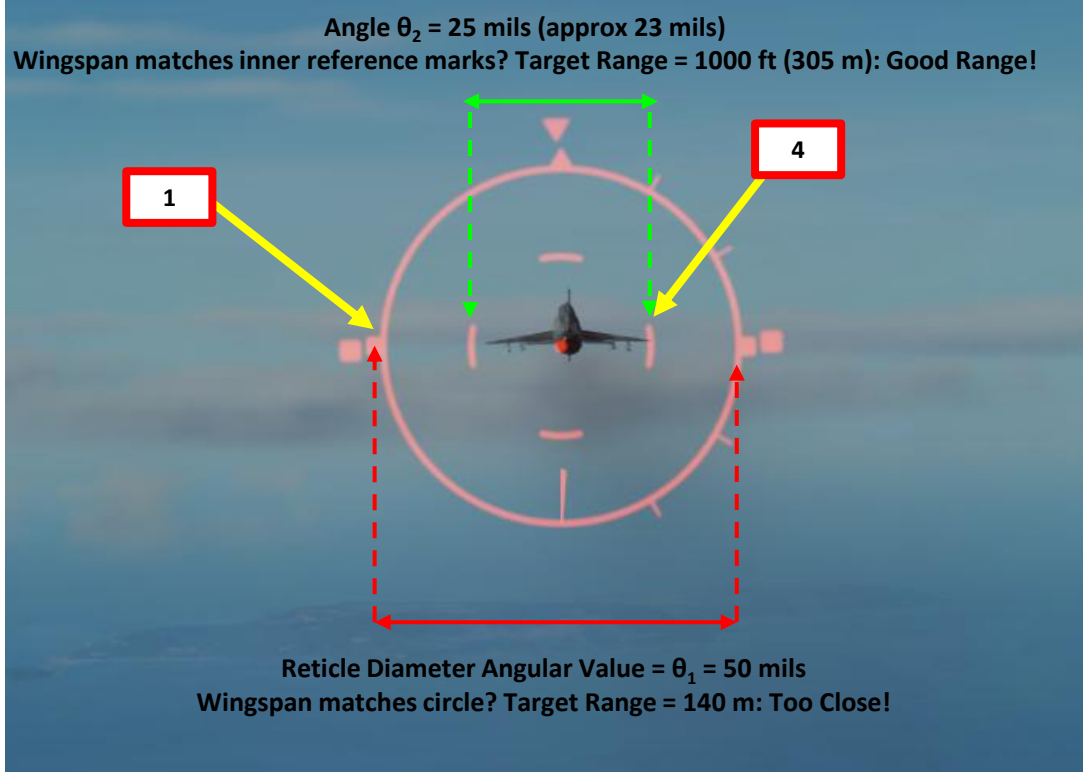
For a target with a length L_1 = 7 m that fits within the outer reticle angle θ_1 of 50 milliradians:

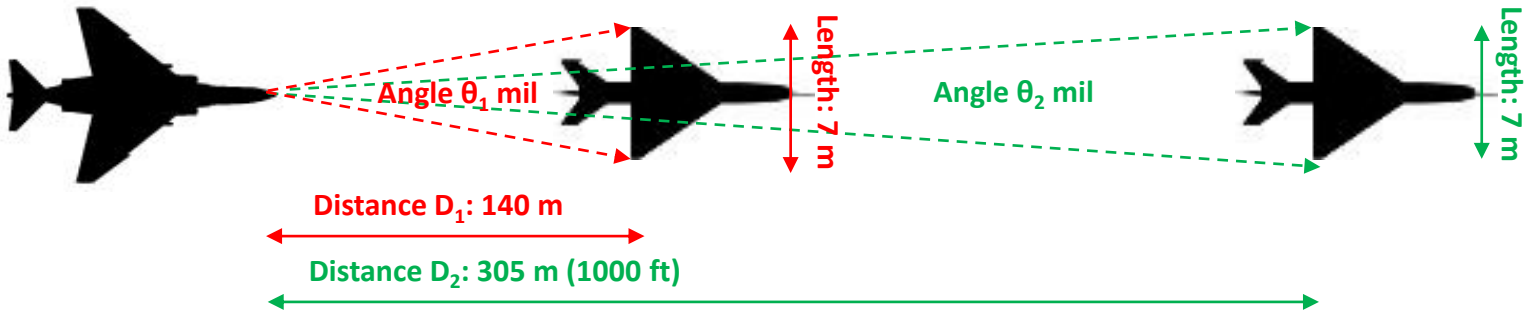
$$\theta_1 = 50\ mils = \frac{L_1}{D_1}$$

$$D_1 = \frac{L_1}{\theta_1} = \frac{7\ m}{0{,}050\ rad} = 140\ meters$$

For a target with a length L_2 = 7 m at a distance D_2 of 305 m or 1000 ft (the range we actually want to fire at):

$$\theta_2 = \frac{L_2}{D_2} = \frac{7\ m}{305\ m} = 0.023\ rad \approx 23\ mils\ (milliradians)$$



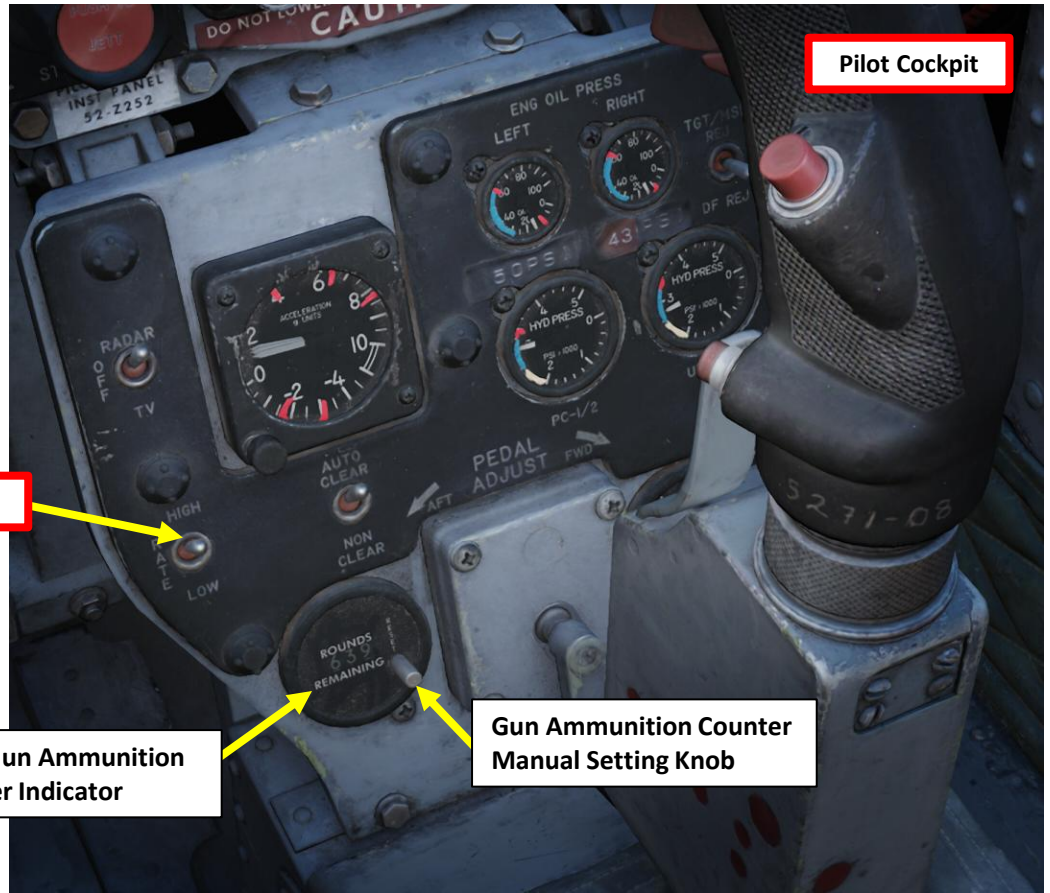


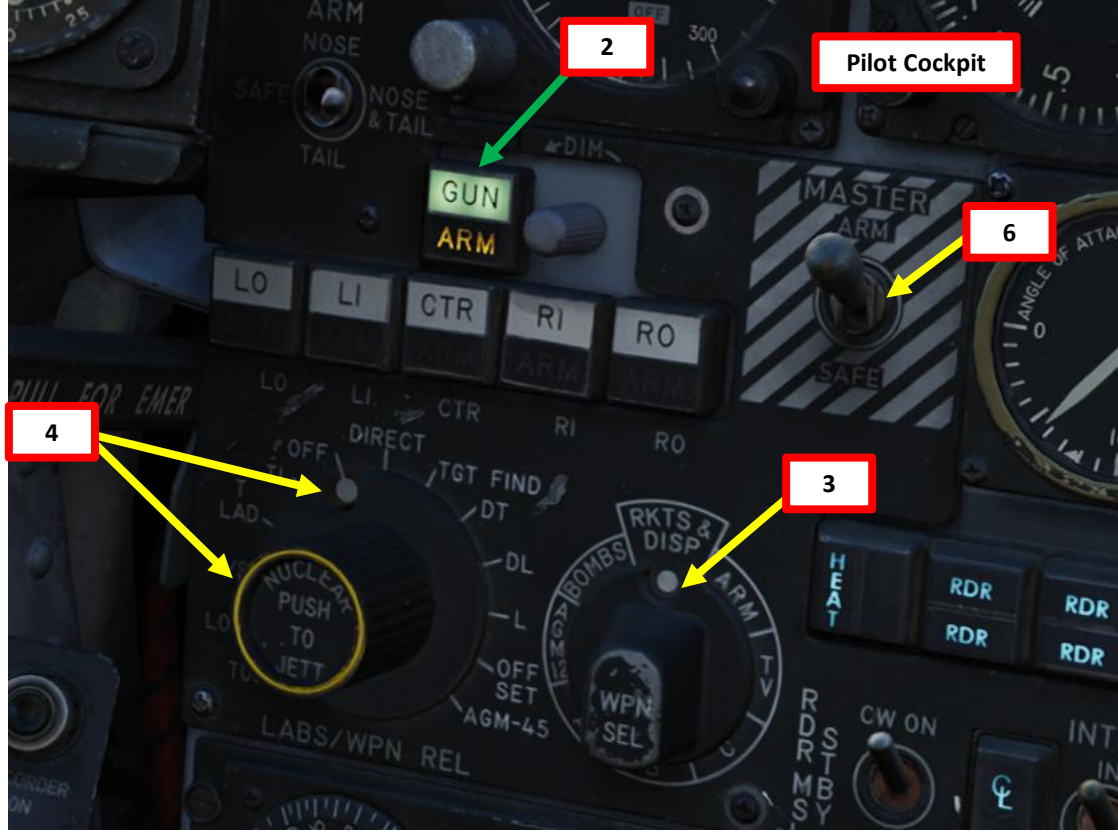
Now… how do we interpret the gunsight to estimate the range of a target?

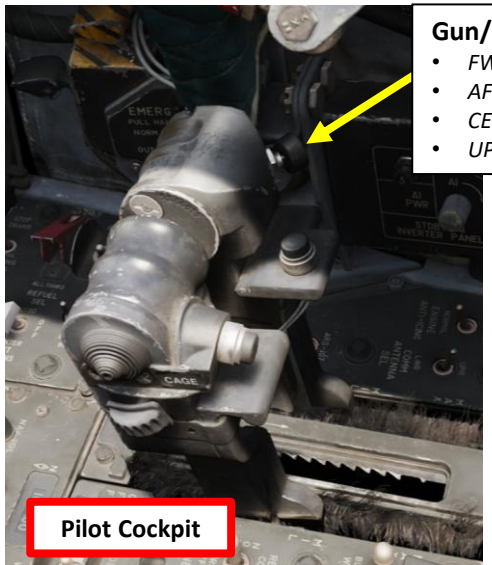
1. We know the outer **reticle diameter** is 50 mils (50 thousandths of a radian, or 2° 51' in degrees).
2. We calculated that when the wingspan of a target fits within the diameter of the reticle, we are at a range of approx. 140 meters, which is way too close.
3. We use the **inner ring marks** of the gunsight to a distance of 1000 ft / 305 m (optimal firing range) for a wingspan of 7 m (23 ft).
4. When target wings fit within the **inner ring marks**, we know we are at the optimal firing range of 1000 ft (305 m). You may fire.

3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.2 – Employment without Radar

1. *[P]* Set Gun/Missile Pinky Switch – GUN (AFT).
2. *[P]* Select GUN Button.
3. *[P]* Set Weapon Selector Knob – Any position except TV or ARM.
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – OFF
5. *[P]* Set Gun Fire Rate Switch – As desired
    - UP: High Rate of Fire (6000 rounds/min)
    - DOWN: Low Rate of Fire (4000 rounds/min)
6. *[P]* Set Master Arm Switch – ARMED (UP)



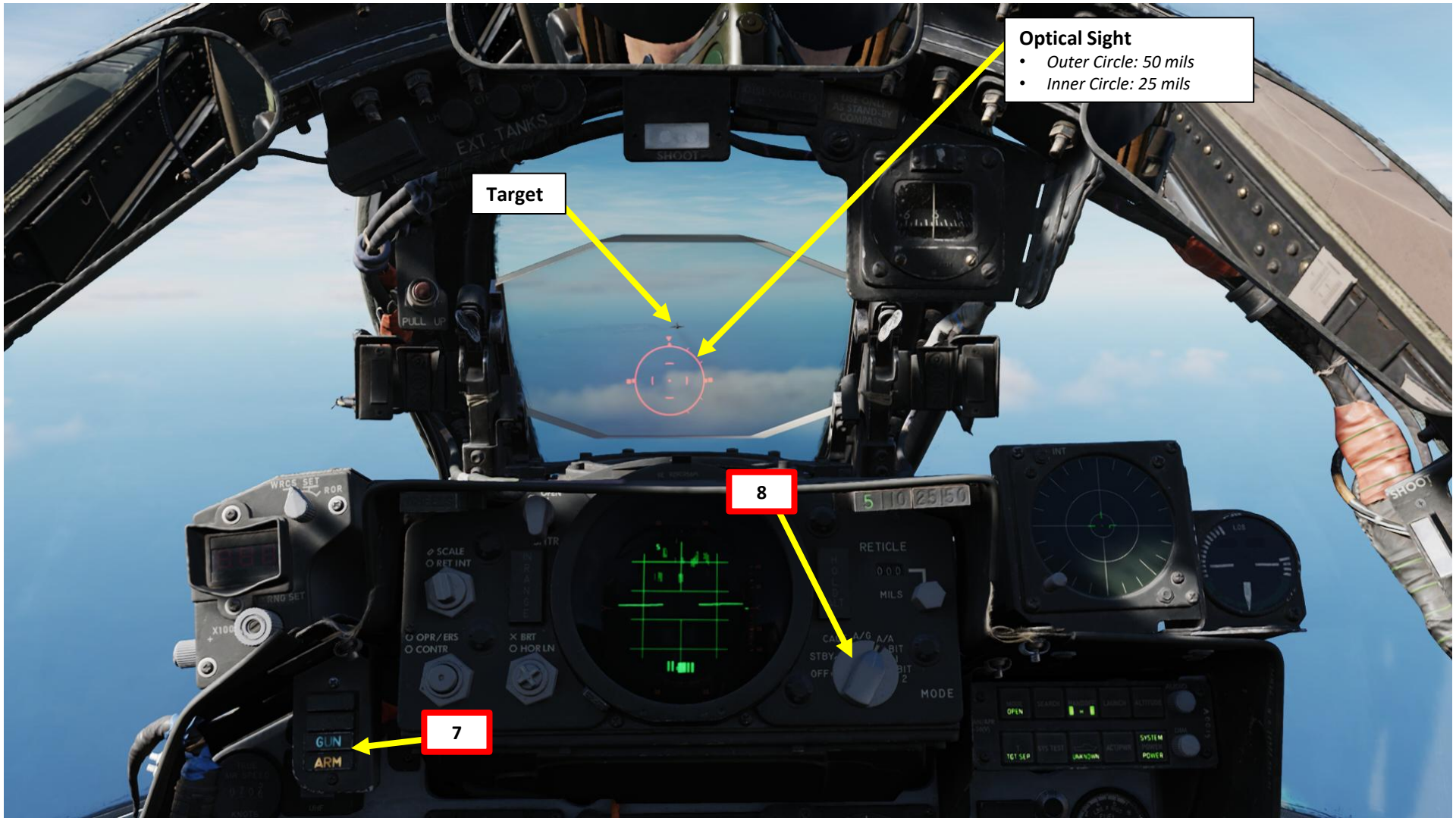




Gun/Missile Pinky Switch — 1
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

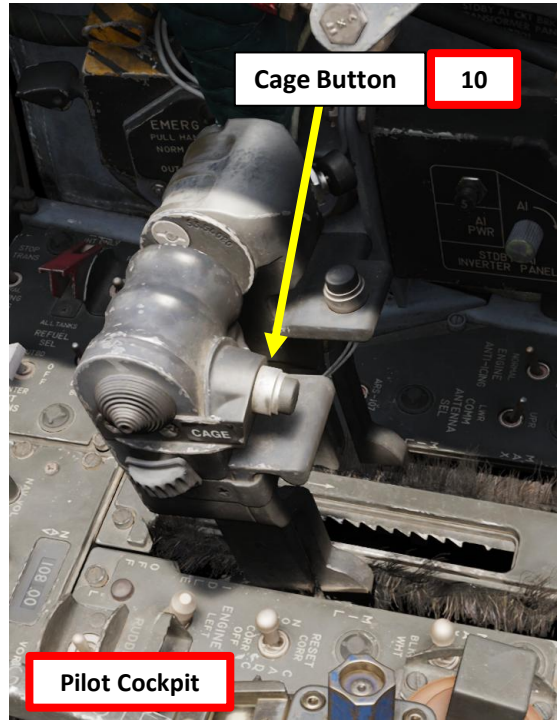
3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.2 – Employment without Radar

7. *[P]* Confirm ARM light and GUN light are both illuminated
8. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
9. *[P]* In air-to-air mode, the optical sight functions as a lead computing optical sighting (LCOS), thus maneuvering in both elevation and azimuth relative to a default 1000 ft range setting if no radar lock is performed.

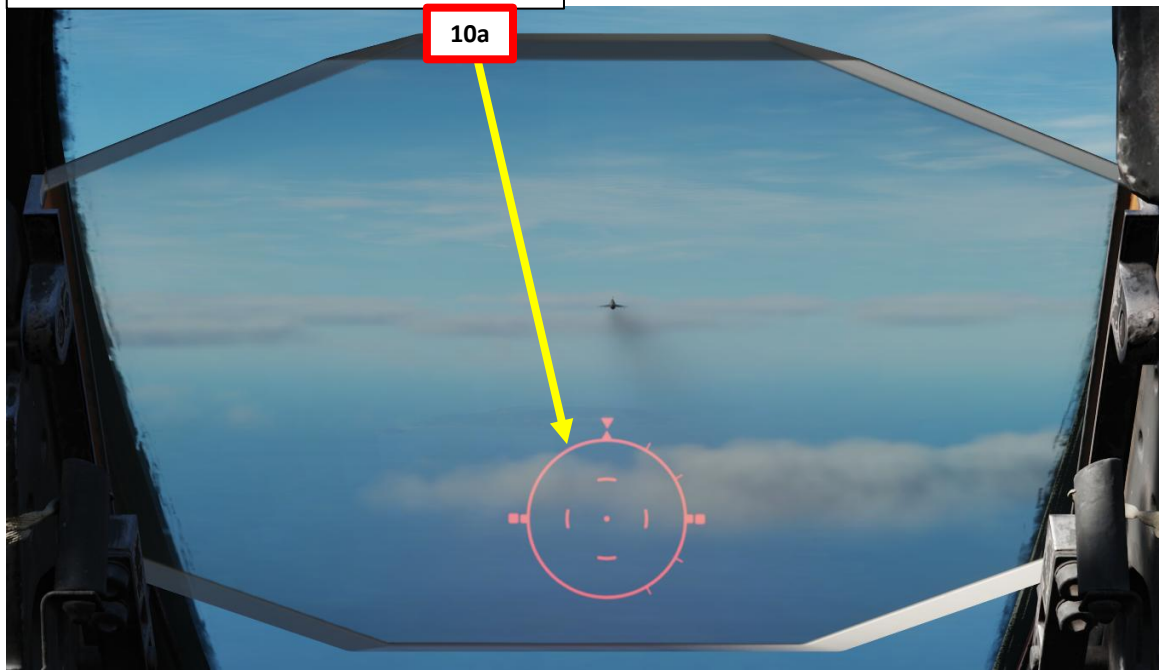


3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.2 – Employment without Radar

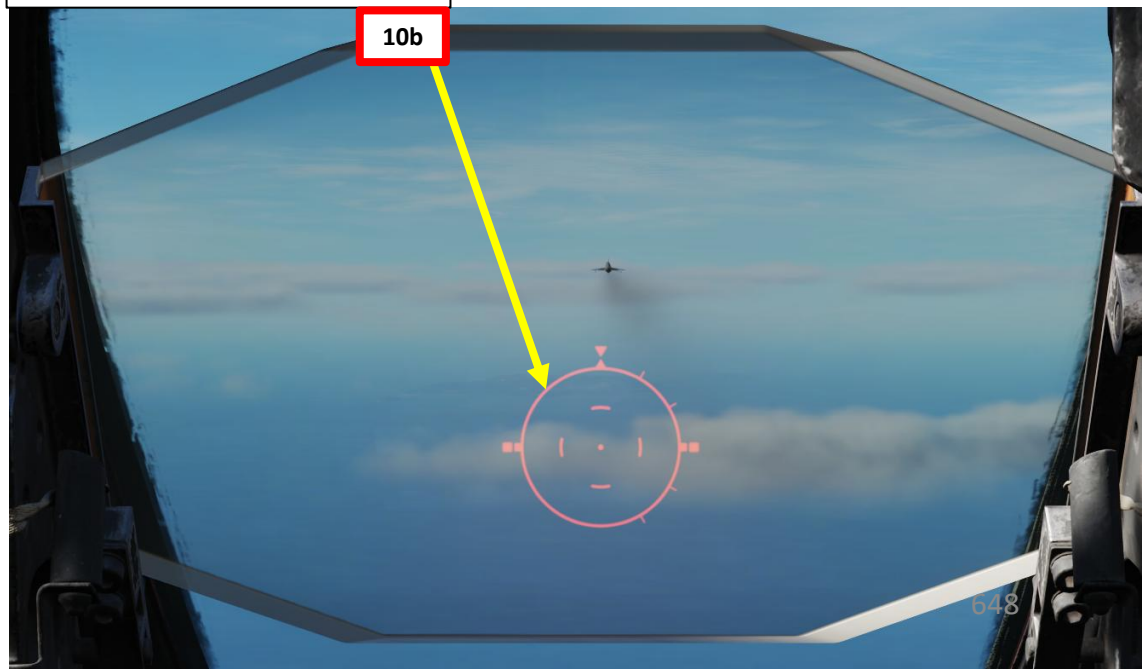
10. [P] While the gun is selected in A/A Mode and no radar lock is performed, depressing the Cage button on the pilot's throttle will "cage" (fix) the reticle.
- a) When Cage Button is released (uncaged), the reticle moves in azimuth and elevation to display the lead required for a 1000 ft range.
- b) When Cage Button is depressed (caged), the reticle is caged at radar boresight line (RBL). It will not move in azimuth or elevation. This can be used if you are pulling significant Gs and the pipper/reticle is buried at the bottom of the gunsight; caging the sight will provide a fixed reference for a high aspect snap shot.



Optical Sight – Moves in Azimuth/Elevation (Uncaged, Cage Button Released)

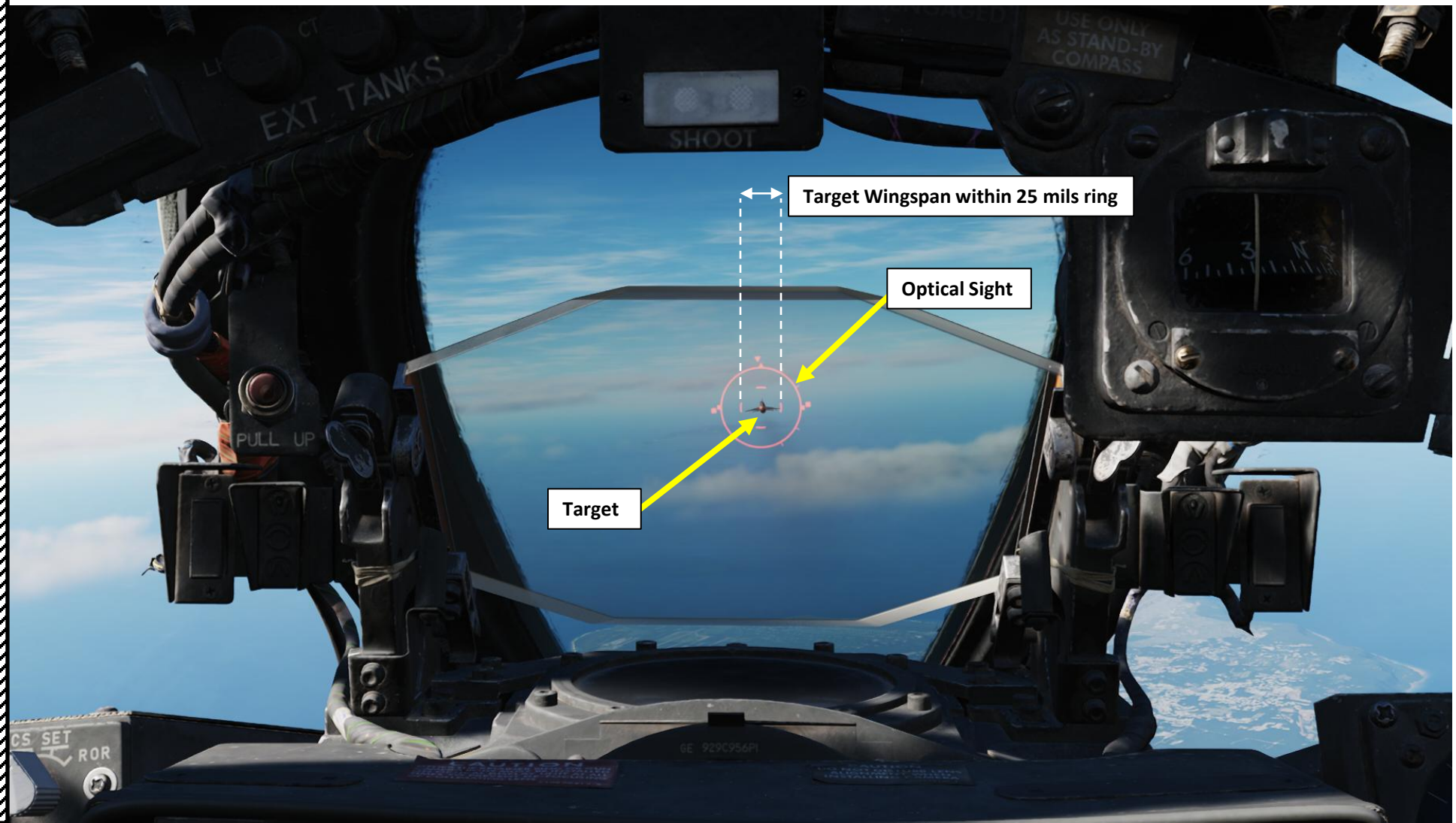


Optical Sight – Caged/Fixed to RBL (Caged, Cage Button Pressed)



3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.2 – Employment without Radar

11. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target.
12. *[P]* When in range, squeeze the Trigger's second detent (Full Action) (SPACEBAR) to fire the internal gun. For a target like a MiG-21 with a wingspan of 23 ft, its wingspan should fit within 23 mils. As a rule of thumb, you should be at a 1000 ft firing range when the target's wings fit within the inner reticle ring (25 mils).





Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.2 – Employment without Radar

13. Accumulated gas is vented by ram air entering the Gun Purge Door on the nose of the aircraft. The door is held closed by hydraulic pressure and will automatically open to release the gas from firing the gun. It closes after the gas pressure has reduced below a threshold or the gun is de-energized, for example when switching Master Arm or all rounds have been fired. The venting process takes between 10 seconds to 1 minute, depending on the burst duration.



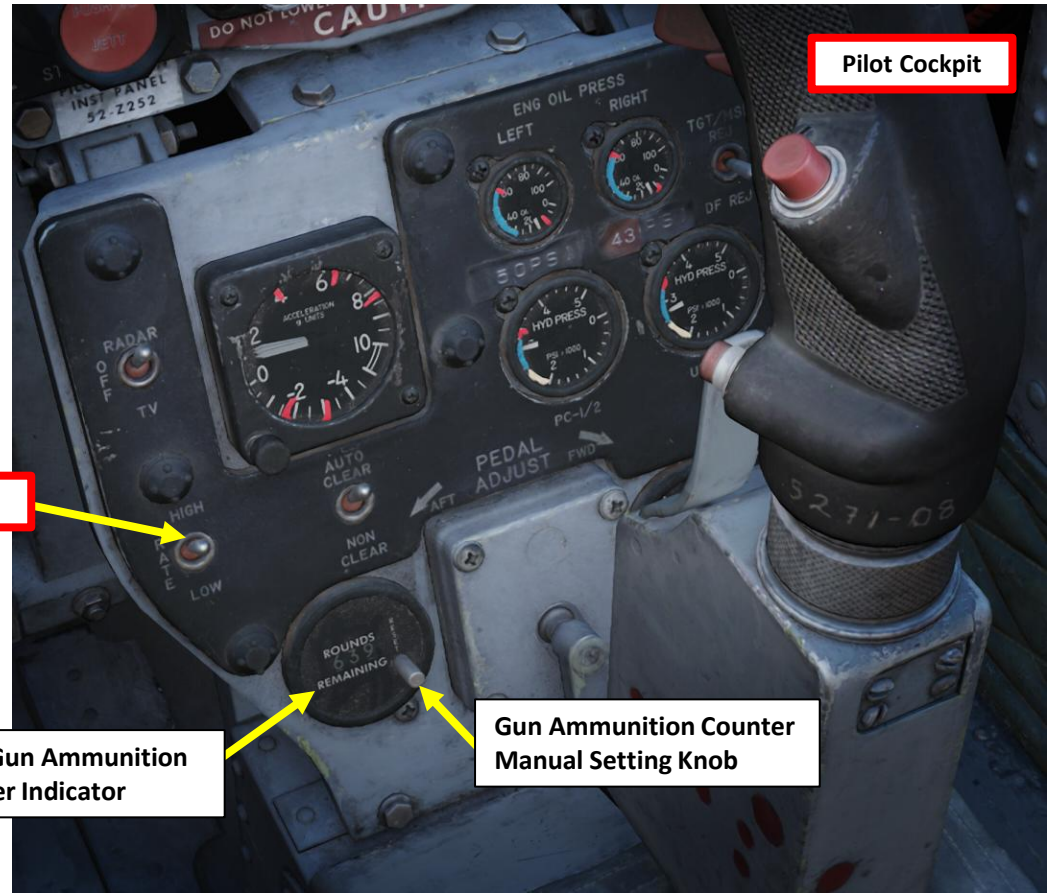


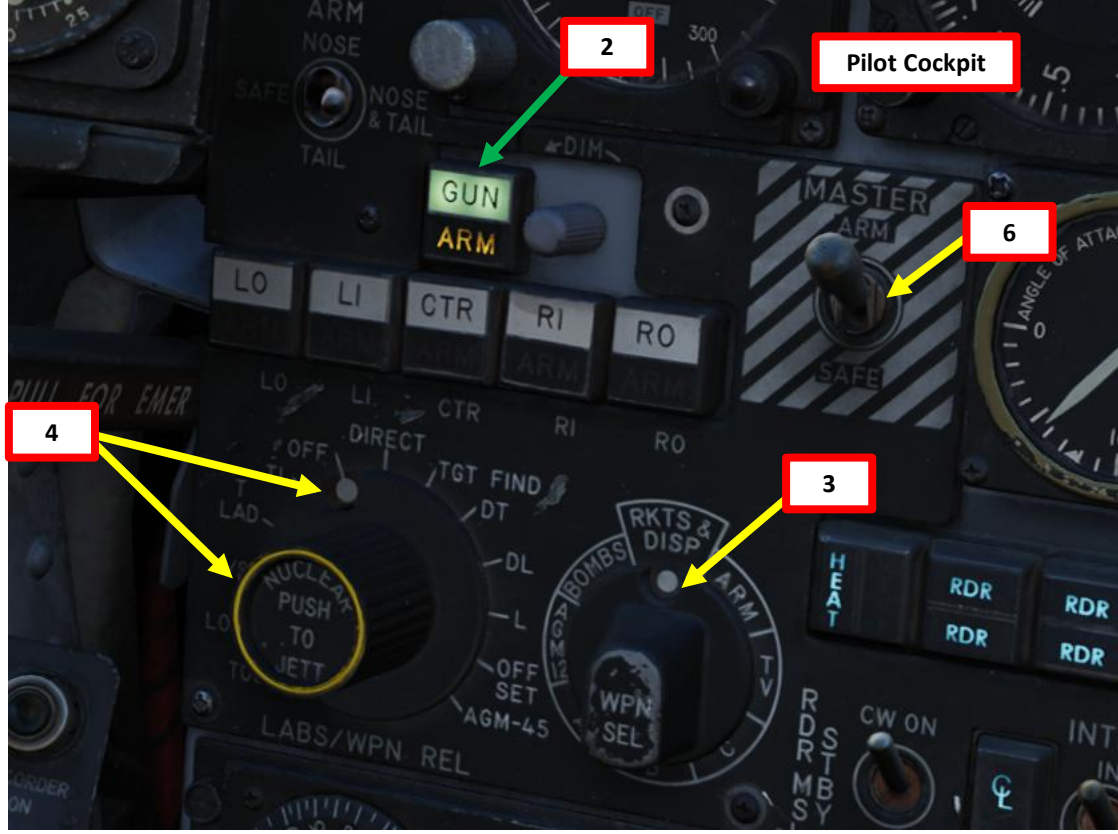


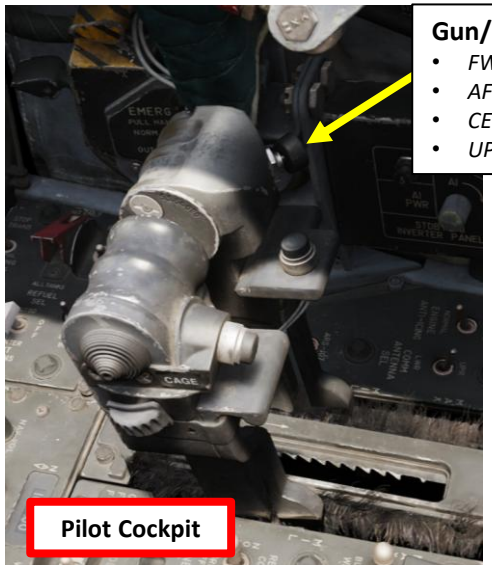
3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

A – Weapon Setup

1. *[P]* Set Gun/Missile Pinky Switch – GUN (AFT).
2. *[P]* Select GUN Button.
3. *[P]* Set Weapon Selector Knob – Any position except TV or ARM.
4. *[P]* Set Air-to-Ground Weapon Delivery Mode – OFF
5. *[P]* Set Gun Fire Rate Switch – As desired
   - UP: High Rate of Fire (6000 rounds/min)
   - DOWN: Low Rate of Fire (4000 rounds/min)
6. *[P]* Set Master Arm Switch – ARMED (UP)





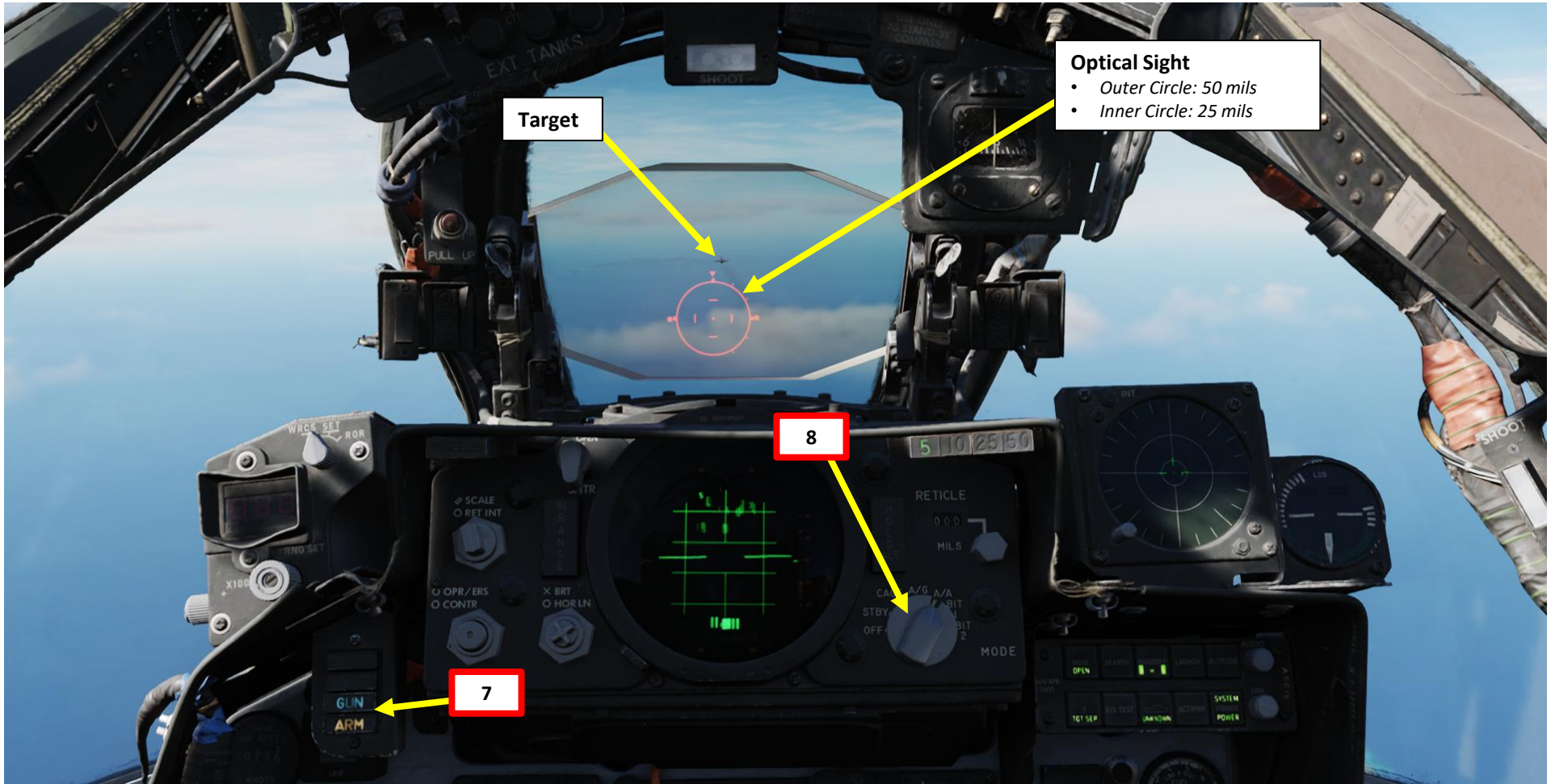


Gun/Missile Pinky Switch — 1
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

A – Weapon Setup

7. *[P]* Confirm ARM light and GUN light are both illuminated
8. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
9. *[P]* In air-to-air mode, the optical sight functions as a lead computing optical sighting (LCOS), thus maneuvering in both elevation and azimuth relative to a radar locked target, or a default 1000 ft range setting in the event of no lock. With a radar lock, the range bar presentation is relative to 6700 ft just to the left of the tick at the 1 o'clock position, down to 1000 ft at the 6 o'clock position.

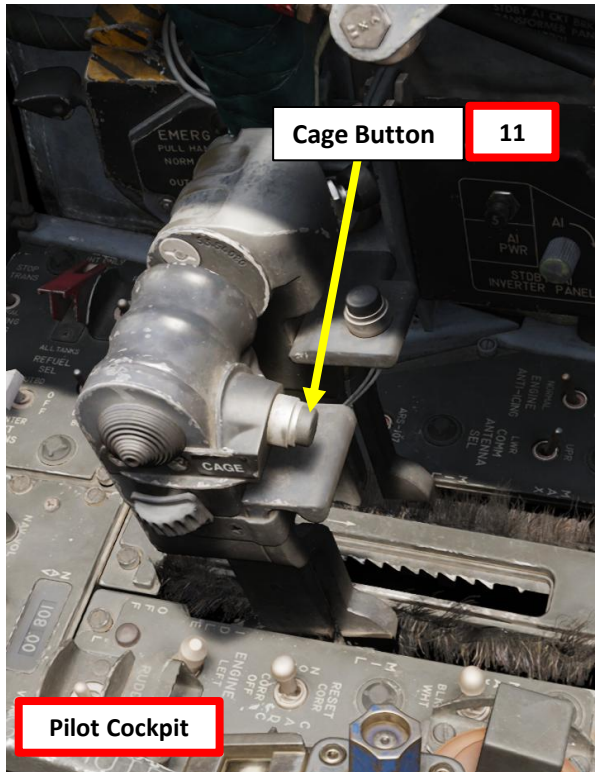


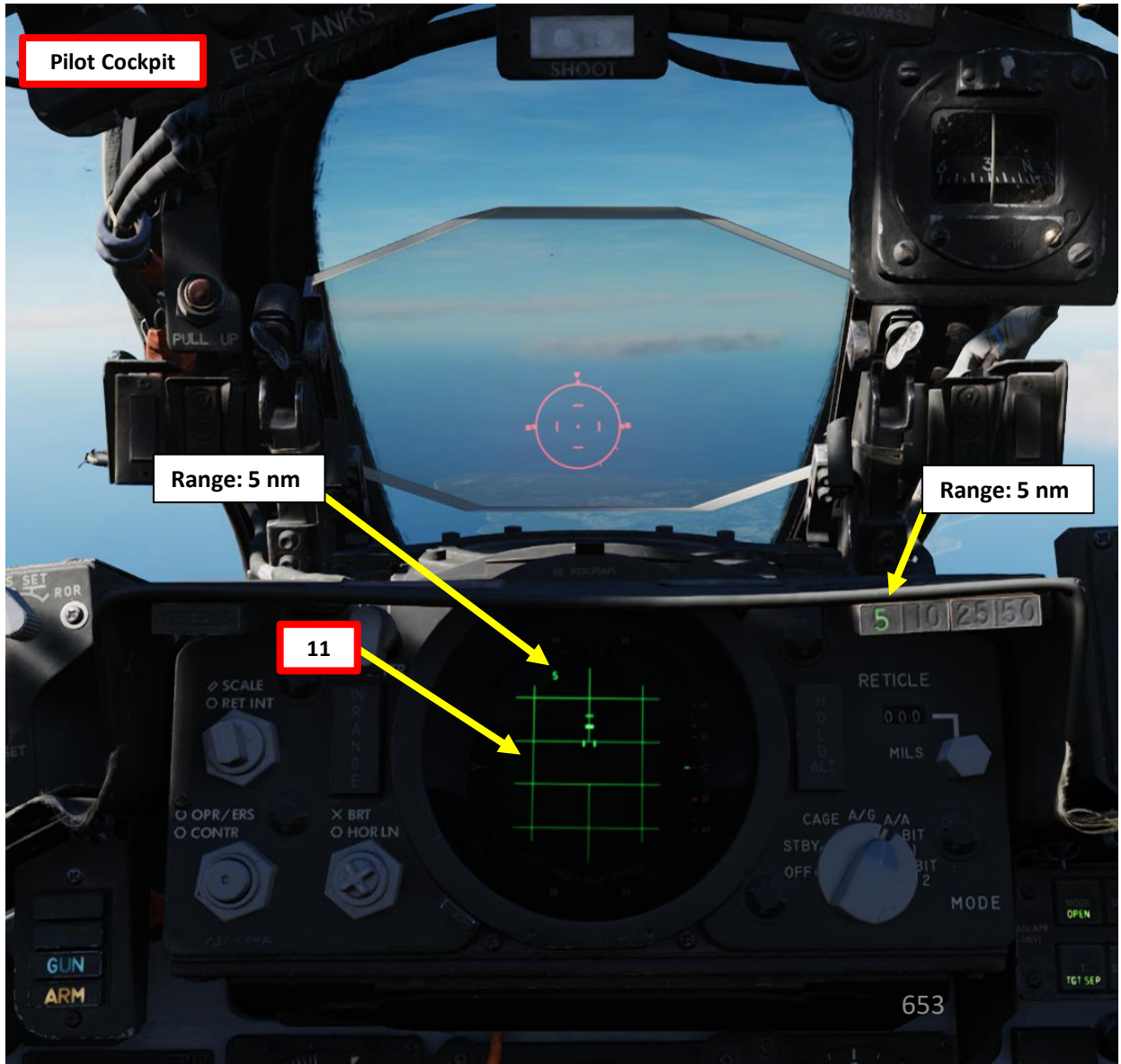
3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

B – Perform Radar Lock

10. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
11. *[P]* Select **Cage Mode** by depressing the Cage button on the pilot's throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.



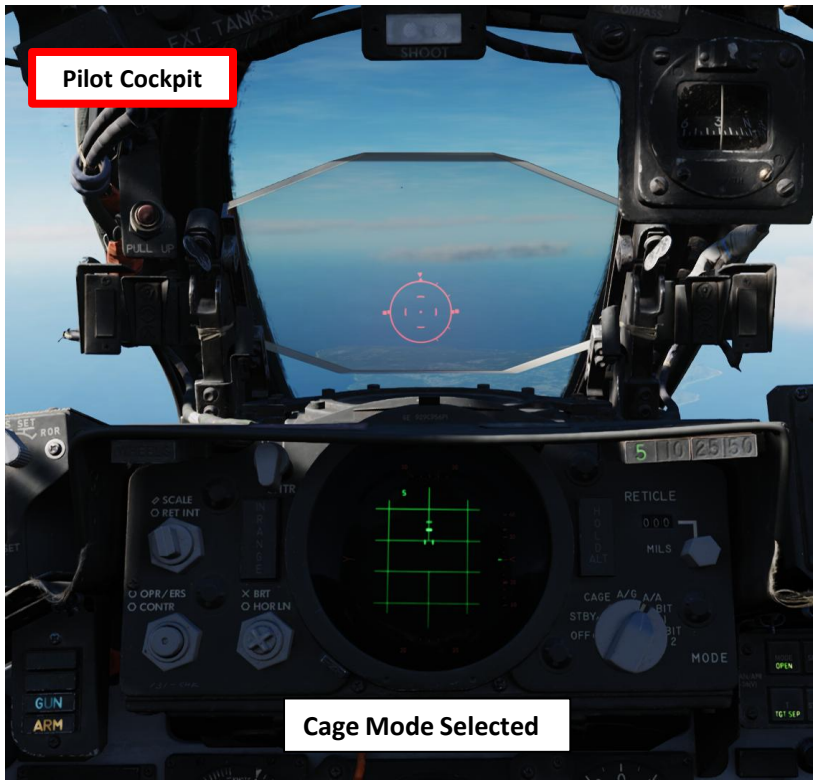




3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

B – Perform Radar Lock

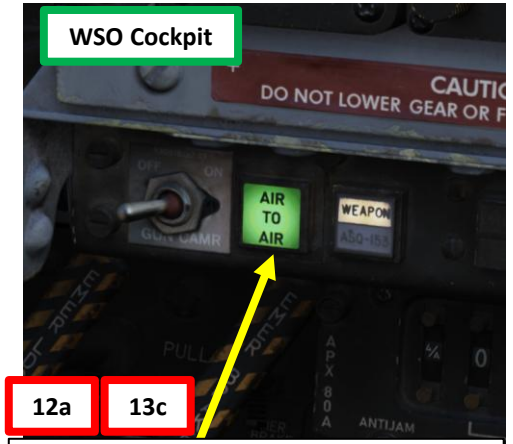
12. *[P]* When Cage mode is selected:
    a) The Air-To-Air light in the rear pit illuminates
    b) Trigger control is transferred to the air-to-air weapons (including when ARM and TV are selected)
    c) The Optical sight switches into A/A mode
    d) CAA (Computer Automatic Acquisition) mode becomes available for selection.
13. Additional Notes about Cage Mode:
    a) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch on the throttle is in RADAR or HEAT, the radar breaks track and returns to boresight.
    b) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch is in GUNS, the lock is not broken.
    c) Cage Mode can be exited with the pilot's Weapon Select Knob (set into or out of the B position) or with the WSO pressing the Air-to-Air Button.





Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*





Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

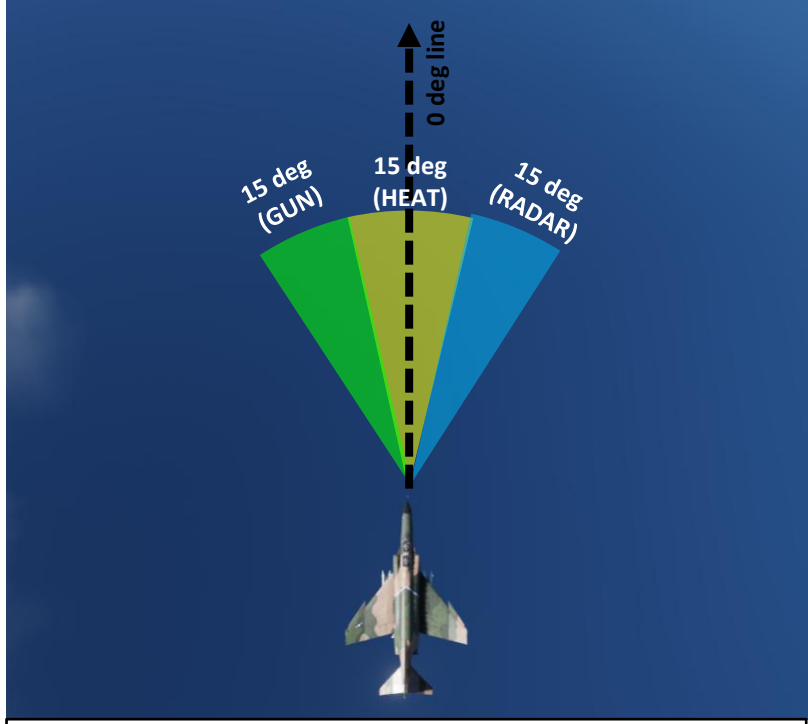
Weapon Selector Knob
- *B: Cancels air-to-air missile CAGE requirement.*



3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

B – Perform Radar Lock

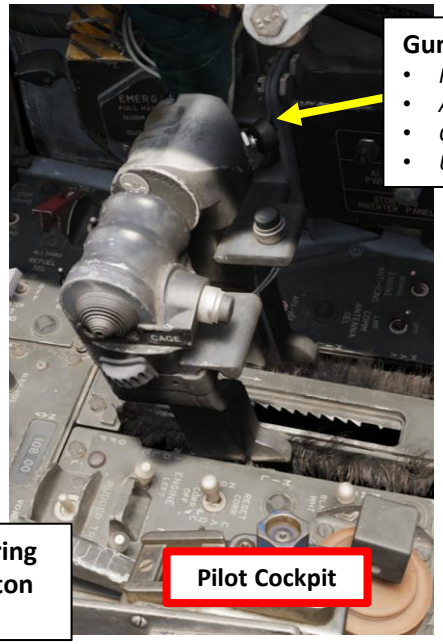
14. *[P]* Select **CAA (Computer Automatic Acquisition) Mode** by pressing the Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button on either the Pilot (or WSO stick).
15. *[P]* When CAA Mode is selected:
    a) The radar enters a vertical-oriented scan pattern 78 degrees in height by 15 degrees wide, the scan is 3 vertical bars wide.
    b) Actual radar lock capability within this scan pattern is from +45 degrees above the horizon line to -9 degrees below the horizon line due to radar's software limitation.
    c) In the event that the radar finds a suitable target within the scan volume, the target will be automatically locked.
    d) Should the flight crew find the locked target not be the one intended, the Nose Gear Steering button can be pressed on either stick grip to return the radar back to the search pattern.
16. *[P]* In CAA mode, the radar's search pattern can be shifted left and right utilizing the pinky switch on the throttle.
    - Pinky Switch – AFT (GUNS): Scan Center is 15 deg Left
    - Pinky Switch – CENTER (HEAT): Scan Center is centered (0 deg)
    - Pinky Switch – FWD (RADAR): Scan Center is 15 deg Right



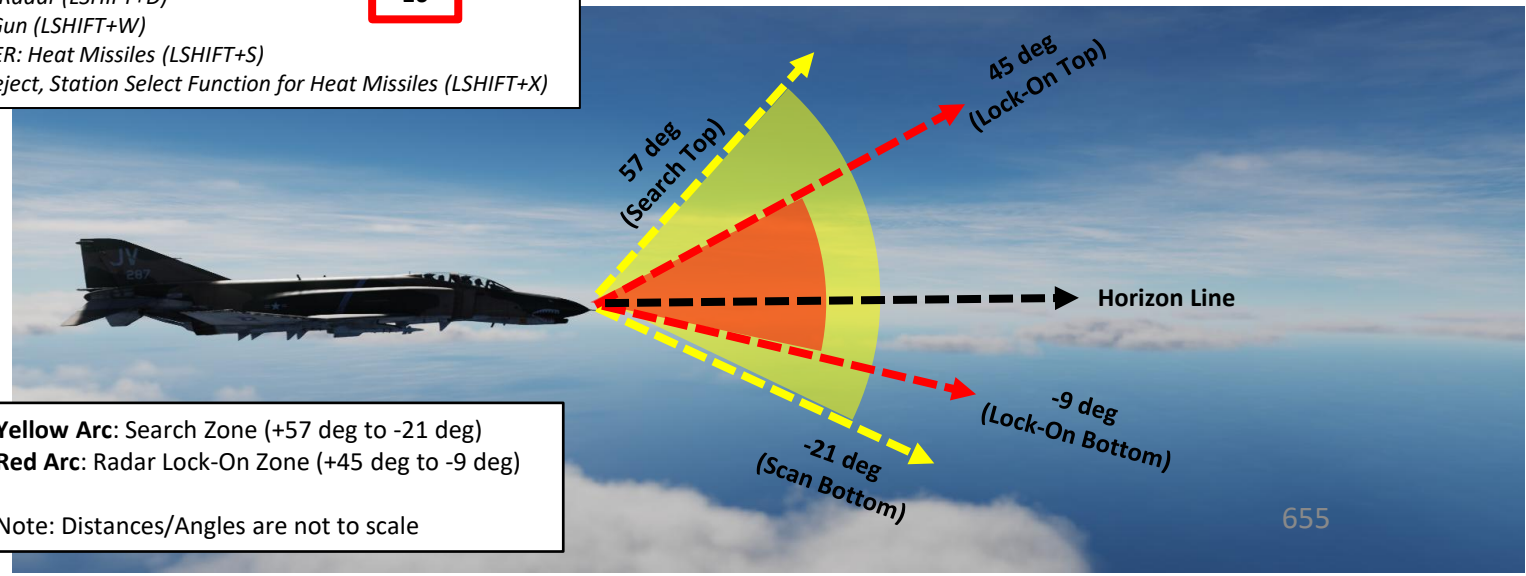
Green Arc: Left Corridor (Gun/Missile Pinky Switch AFT (GUN))
Yellow Arc: Center Corridor (Gun/Missile Pinky Switch CENTER (HEAT))
Blue Arc: Right Corridor (Gun/Missile Pinky Switch FWD (RADAR))



Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Gun/Missile Pinky Switch 16
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



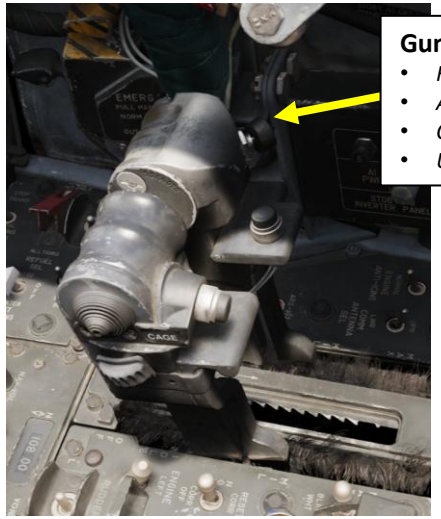
Yellow Arc: Search Zone (+57 deg to -21 deg)
Red Arc: Radar Lock-On Zone (+45 deg to -9 deg)

Note: Distances/Angles are not to scale

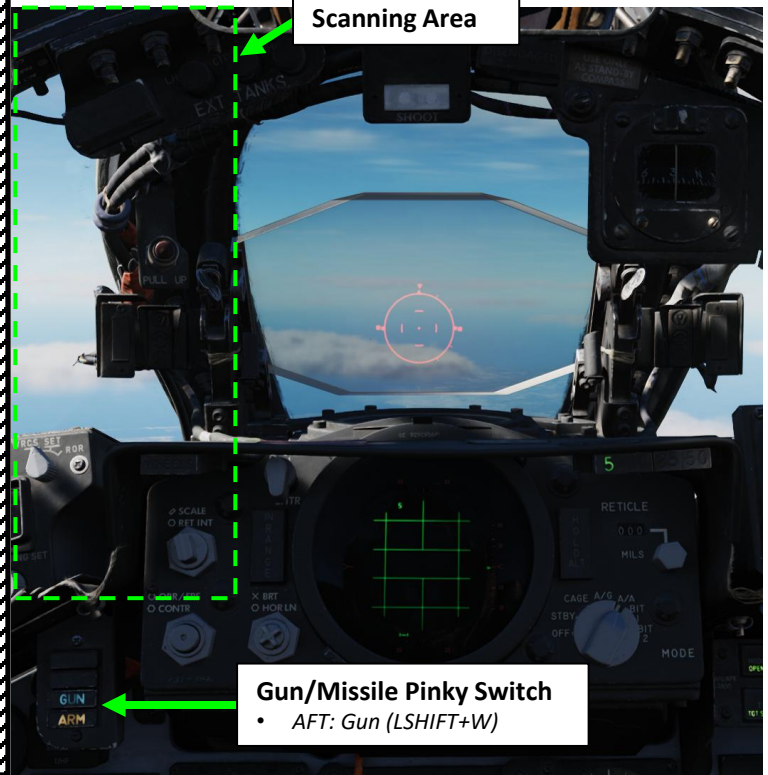
3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

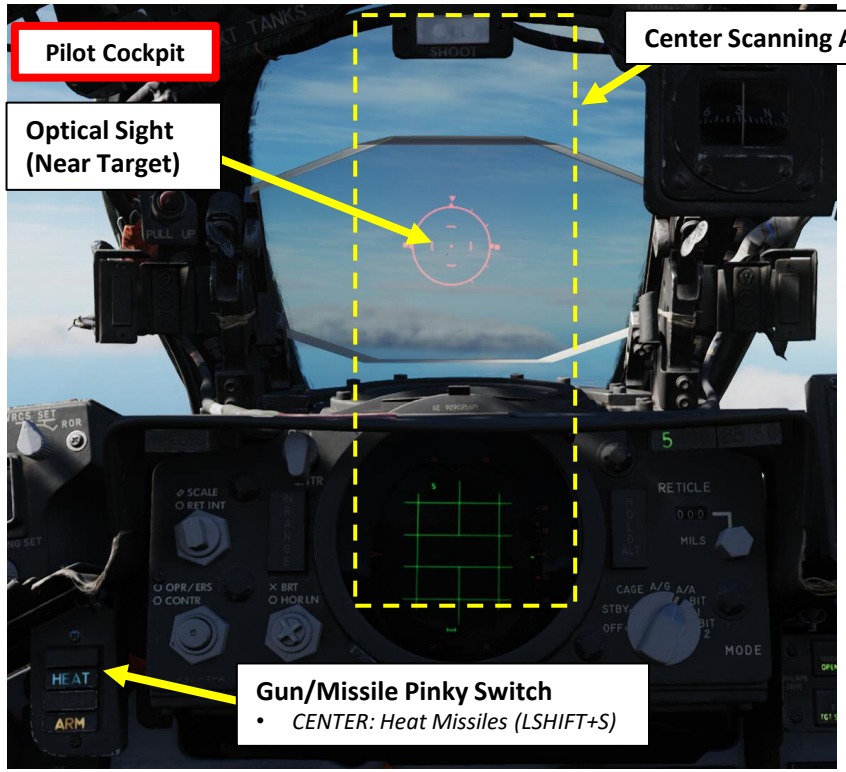
B – Perform Radar Lock

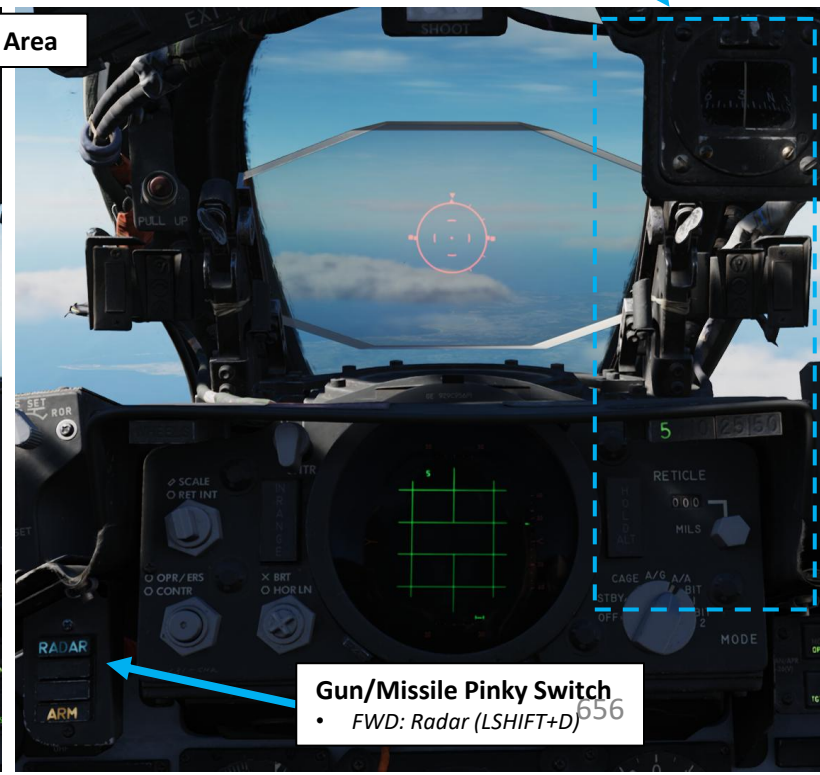
17. *[P]* I suggest leaving the Gun/Missile Pinky Switch in the CENTER (HEAT) position, which makes it easier to find a target and just line up the optical sight on it.
    - While in CAA mode, the GUN, HEAT and RADAR lights on the HUD (Heads-Up Display) are representative of the position of the Gun/Missile Pinky Switch, not which weapon is selected.
    - As mentioned previously, the position of the Gun/Missile Pinky switch in CAA mode defines where the radar is scanning.
18. *[P]* The pilot should visually line up the optical sight near the target. When the radar finds a suitable target within the scan volume and a 5 nm range, the target will be locked.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



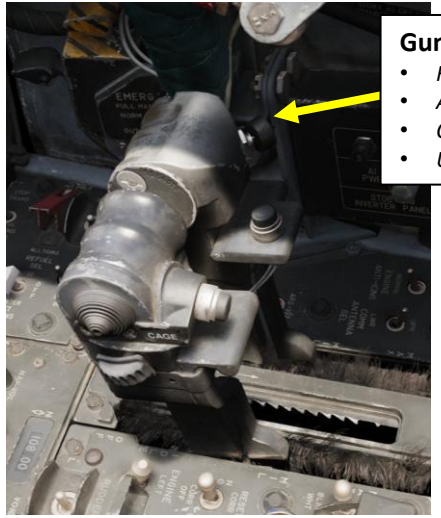




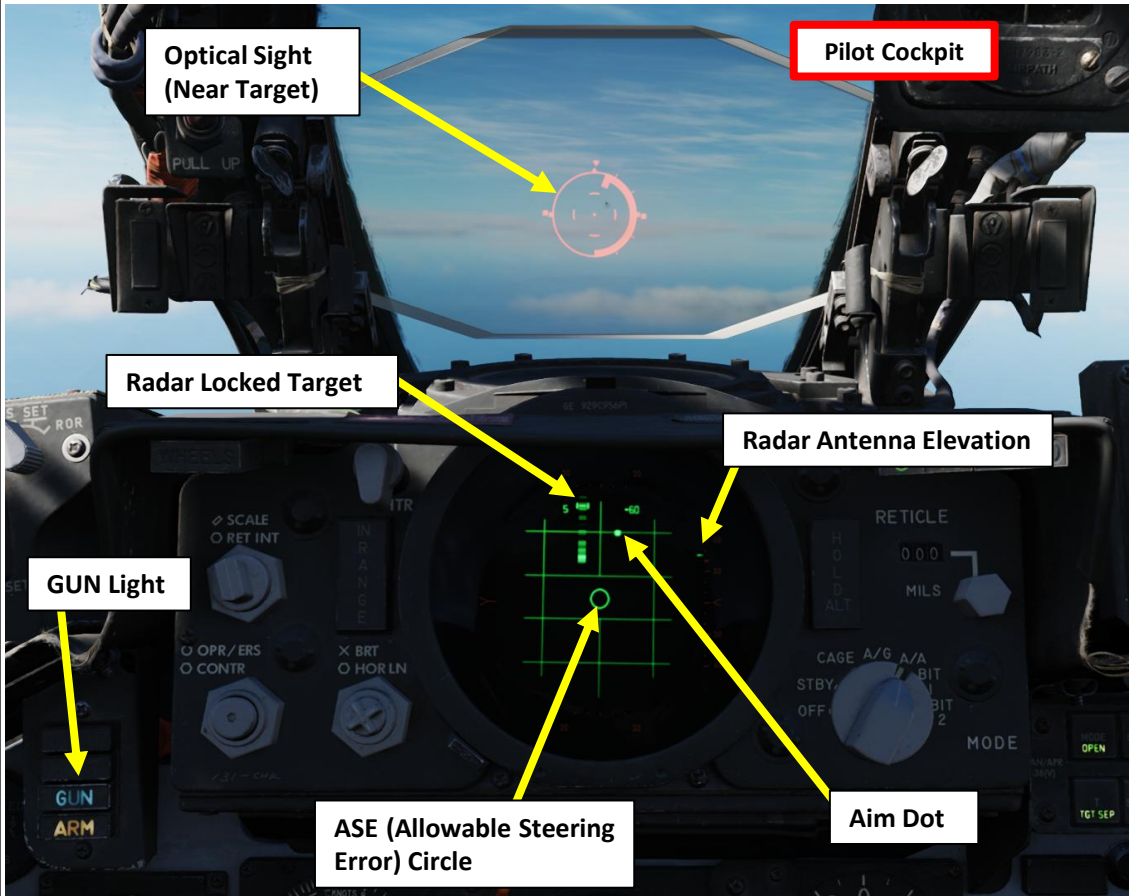
3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

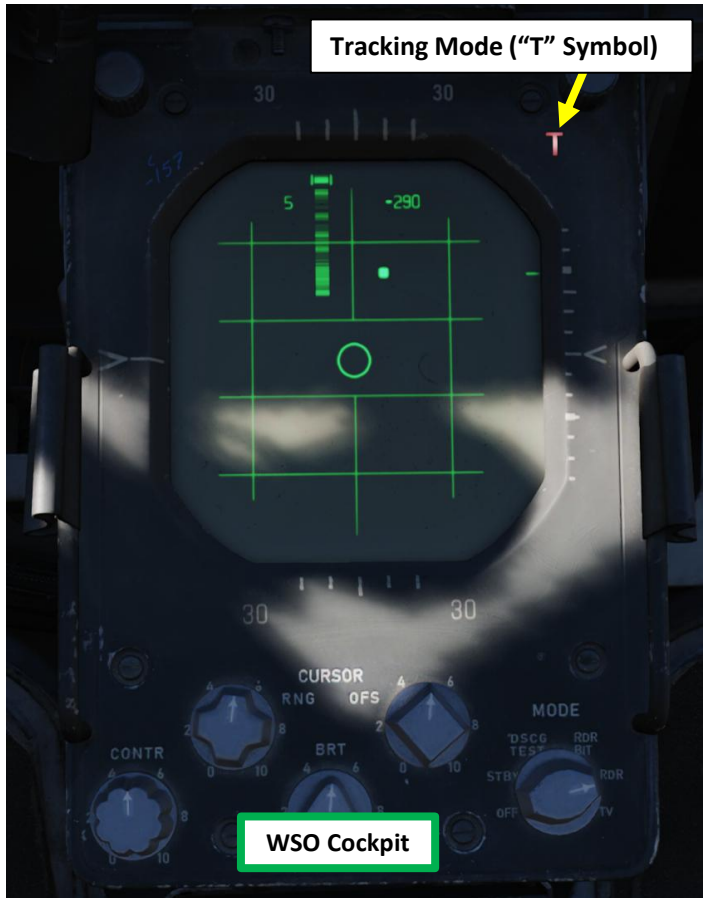
B – Perform Radar Lock

19. Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears
    - The Aim Dot appears
20. *[P]* Set the Gun/Missile Pinky Switch in the AFT (GUN) position to display gun-related ranging information on the optical sight. Confirm that the GUN light illuminates.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*





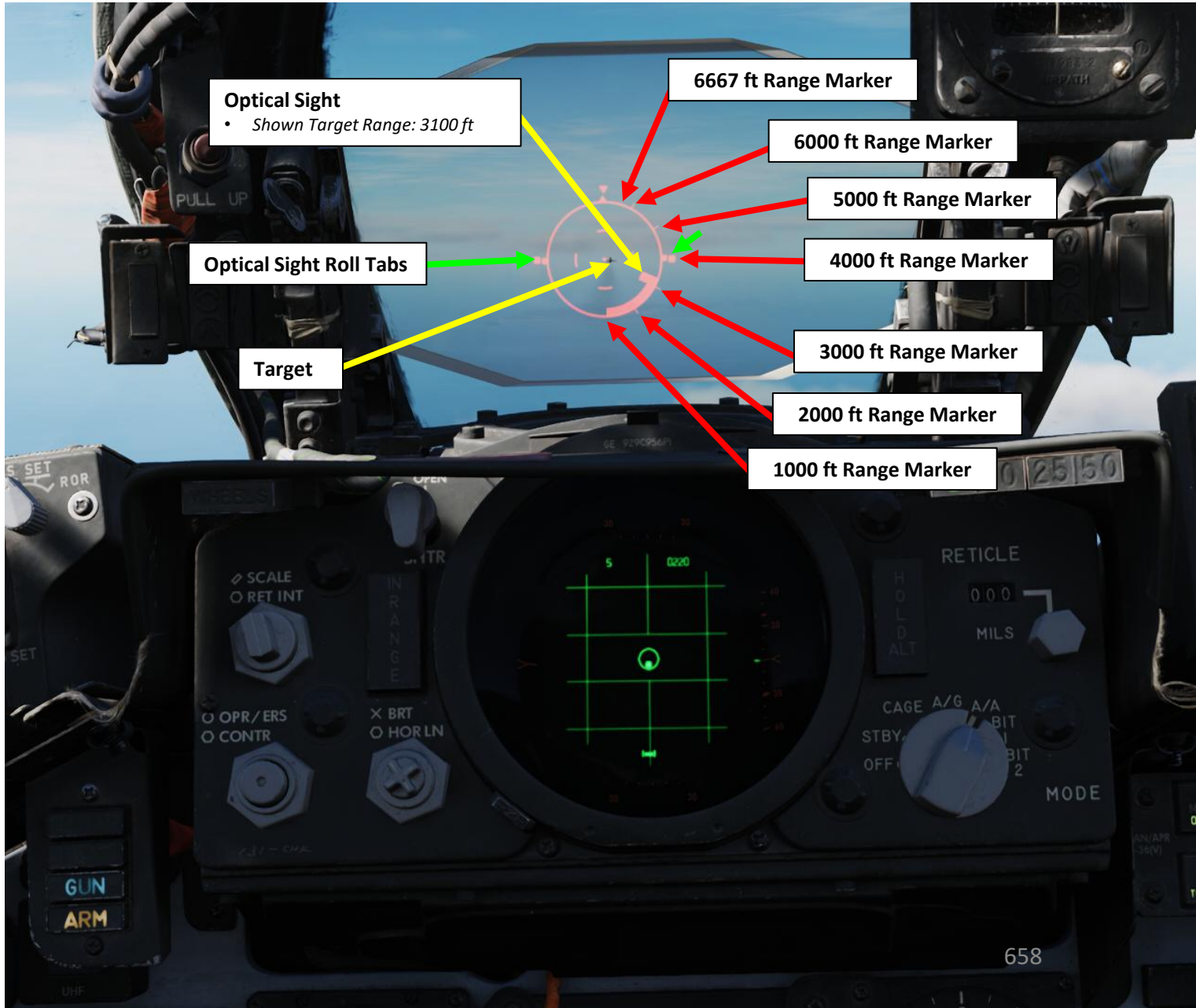


3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

C – Engage Target

21. *[P]* With the Sight Mode Selector set to A/A (Air-to-Air) and gun selected, the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target. The inside tab of the range bar at 6 o'clock shows an actual radar range of 1000 ft. At the 5 o'clock position, the range bar is 2000 ft, continuing with 1000 ft increments per tab. The maximum range that can be shown is 6667 ft. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time). The sight **will NOT follow the target**.

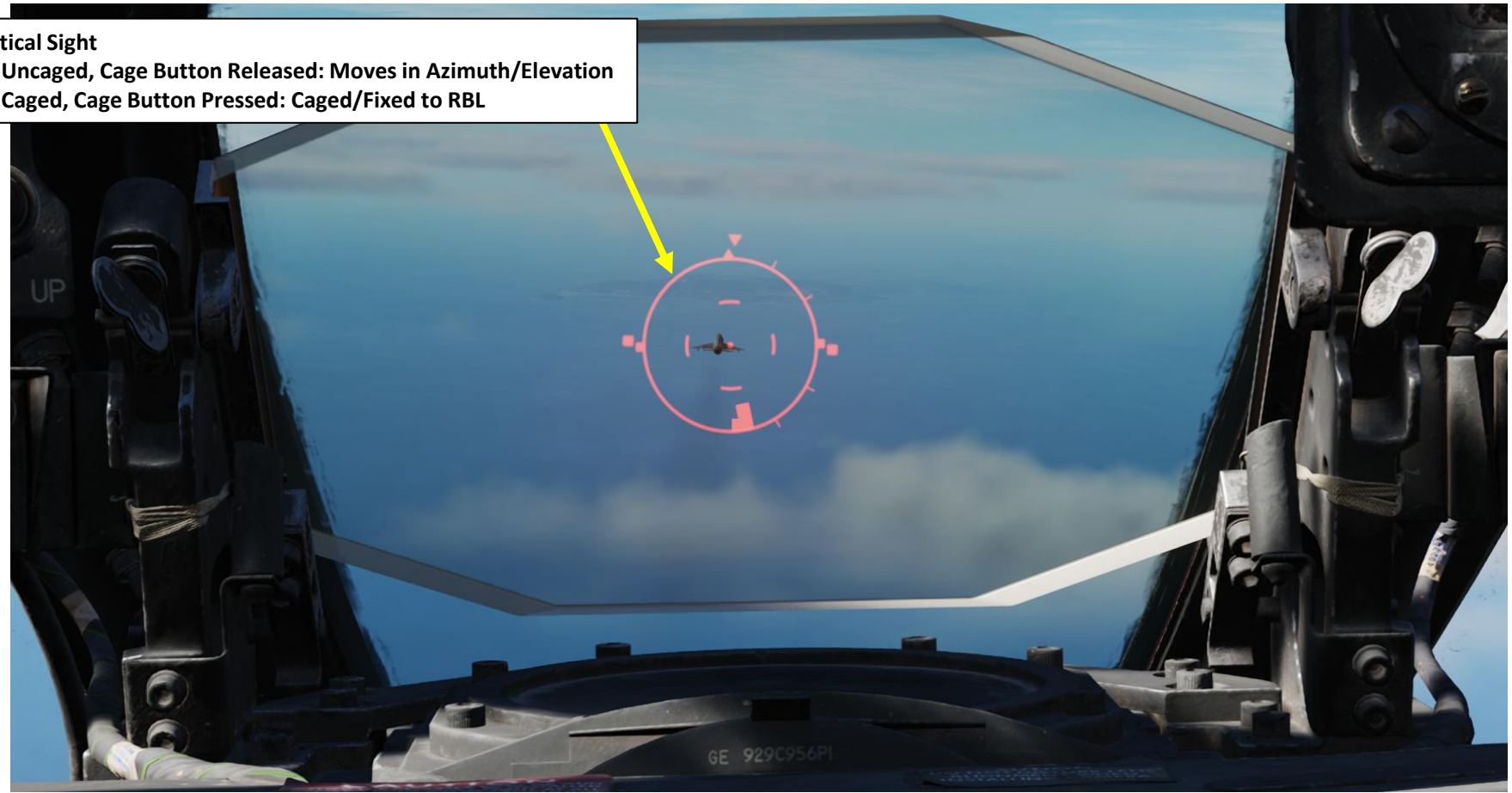


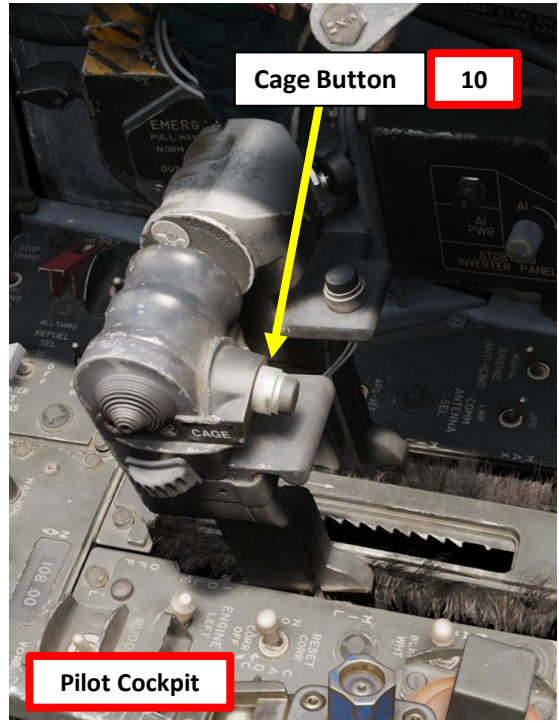


3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

C – Engage Target

22. *[P]* While the gun is selected in A/A Mode and no radar lock is performed, depressing the Cage button on the pilot's throttle will "cage" (fix) the reticle.
    a) When Cage Button is released (uncaged), the reticle moves in azimuth and elevation to display the lead required for up to a maximum range of 4000 ft.
    b) When Cage Button is depressed (caged), the reticle stiffening function (sight fixed to radar boresight line, RBL) is applied as long as Cage Button is pressed. The range bar continues to indicate the actual radar range or the maximum displayable range. This can be used if you are pulling significant Gs and the pipper/reticle is buried at the bottom of the gunsight; caging the sight will provide a fixed reference for a high aspect snap shot.

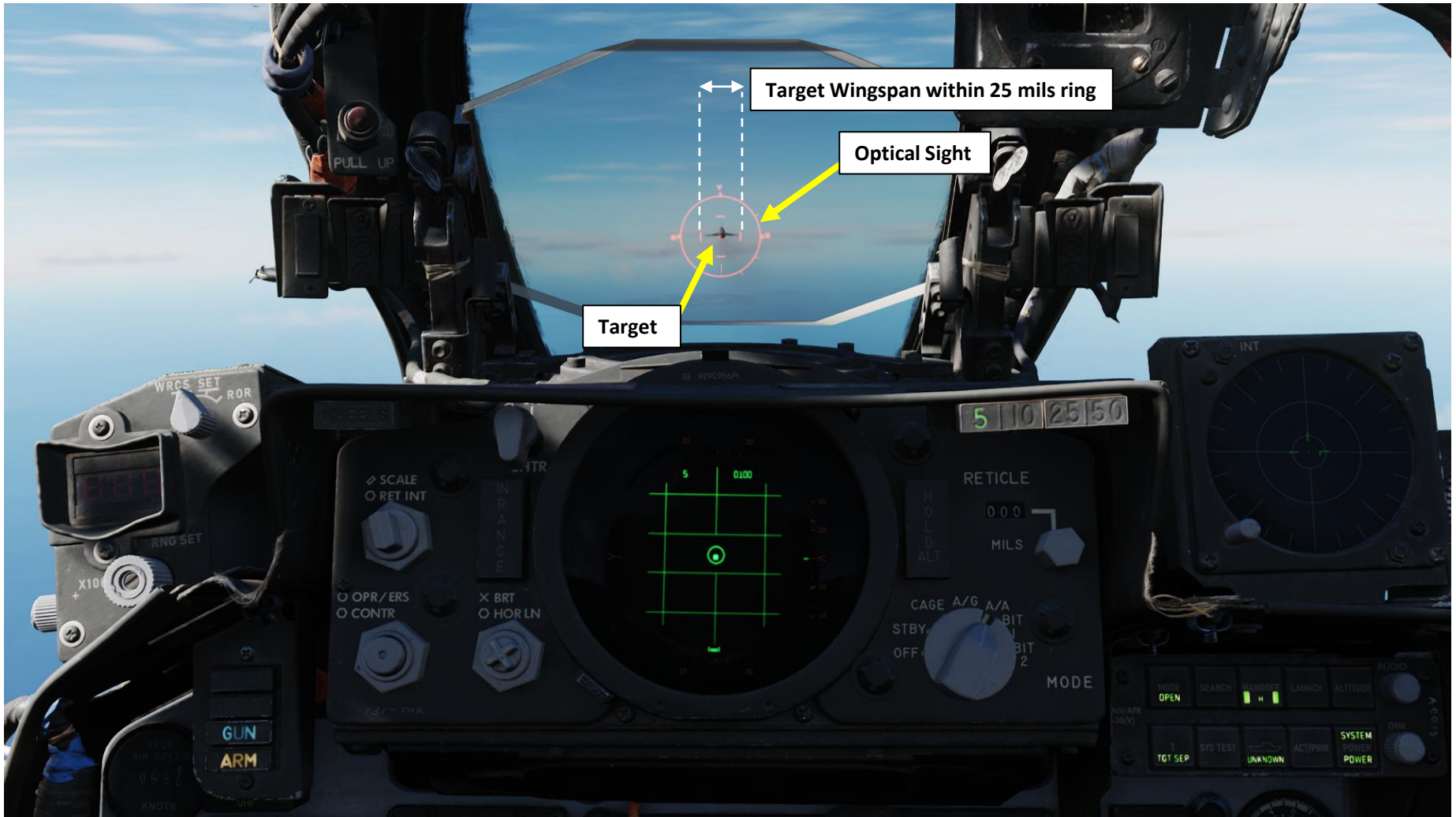




3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

C – Engage Target

23. *[P]* Maneuver the aircraft to place the pipper/reticle over the intended target.
24. *[P]* When in range, squeeze the Trigger's second detent (Full Action) (SPACEBAR) to fire the internal gun. For a target like a MiG-21 with a wingspan of 23 ft, its wingspan should fit within 23 mils. As a rule of thumb, you should be at a 1000 ft firing range when the target's wings fit within the inner reticle ring (25 mils).





Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

C – Engage Target

25. Accumulated gas is vented by ram air entering the Gun Purge Door on the nose of the aircraft. The door is held closed by hydraulic pressure and will automatically open to release the gas from firing the gun. It closes after the gas pressure has reduced below a threshold or the gun is de-energized, for example when switching Master Arm or all rounds have been fired. The venting process takes between 10 seconds to 1 minute, depending on the burst duration.





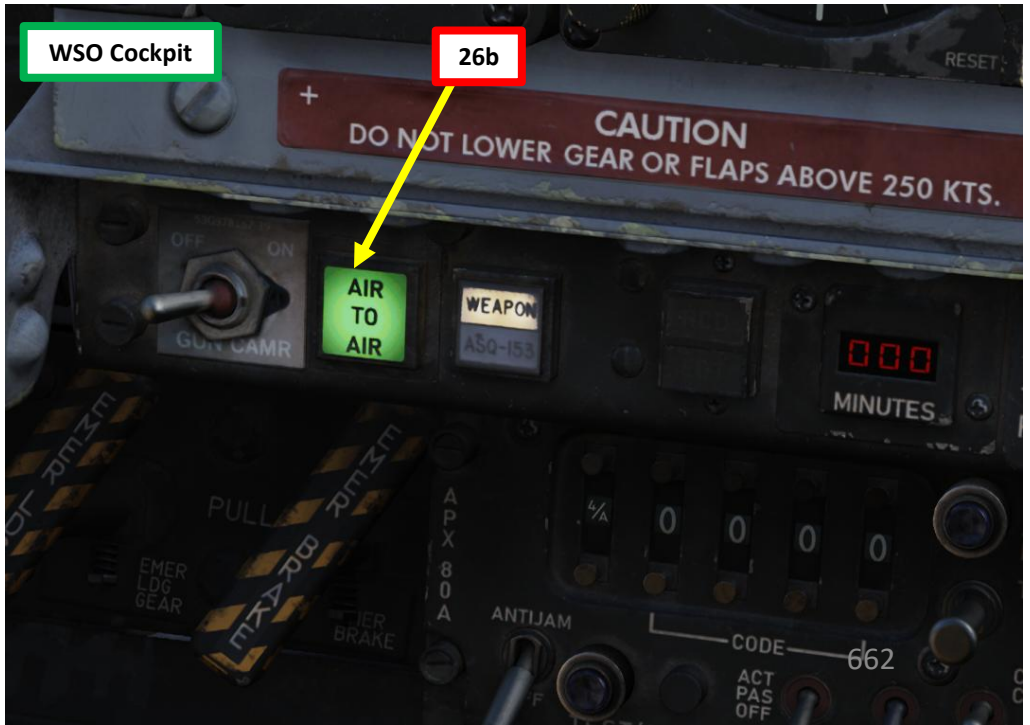


3 – AIR-TO-AIR WEAPONS
3.1 – M61A1 Vulcan Cannon (20 mm) – Air-to-Air
3.1.3 – Employment with Radar

C – Engage Target

26. If you want to exit CAA mode, you can either:
    - *a) [P]* Select position B on the Weapon Select Knob, or
    - *b) [WSO]* Push the Air-To-Air button.
    - Note: Should a radar lock be in place at the time of CAA mode exit, it will be retained.





3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile



3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.1 – Introduction

Entering service with the United States Navy in 1956, and finally accepted by the United States Air Force in 1964, the short range, infrared seeking AIM-9 Sidewinder is considered by most to be the world's first truly effective air to air guided missile. Beginning with the AIM-9B and maintaining compatibility to the AIM-9M in US service, the Sidewinder provided the Phantom II with a capable close-in weapon system against rapidly maneuvering opponents. Employment of the AIM-9 can be performed with or without a radar lock, but radar lock will not guide the missile in any way; radar will only provide steering cues and ranging information.

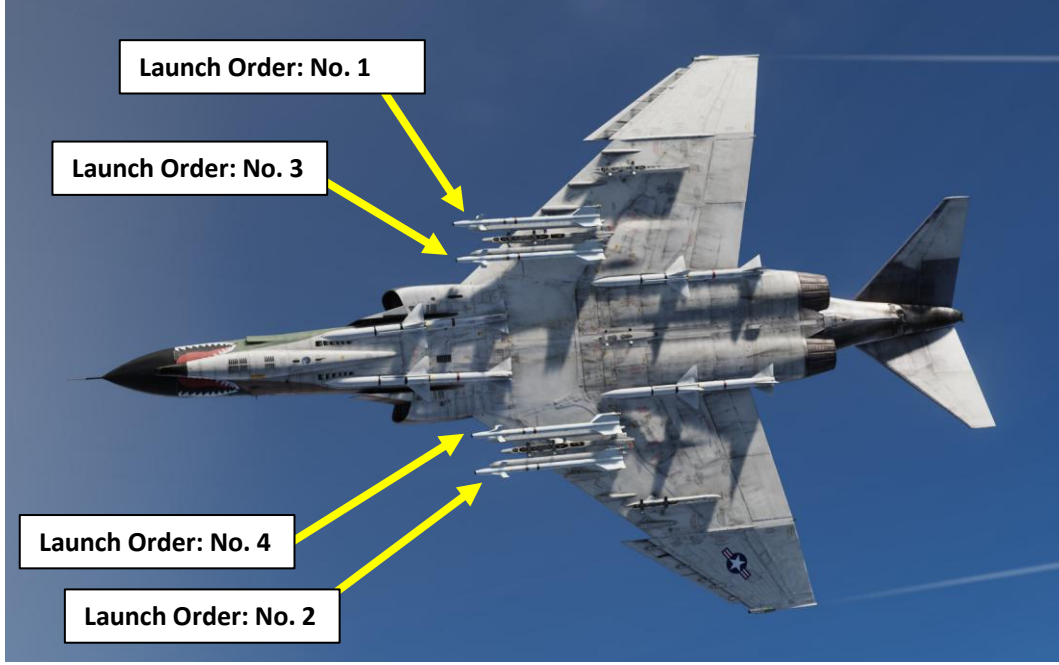
AIM-9 Sidewinder Missile Types

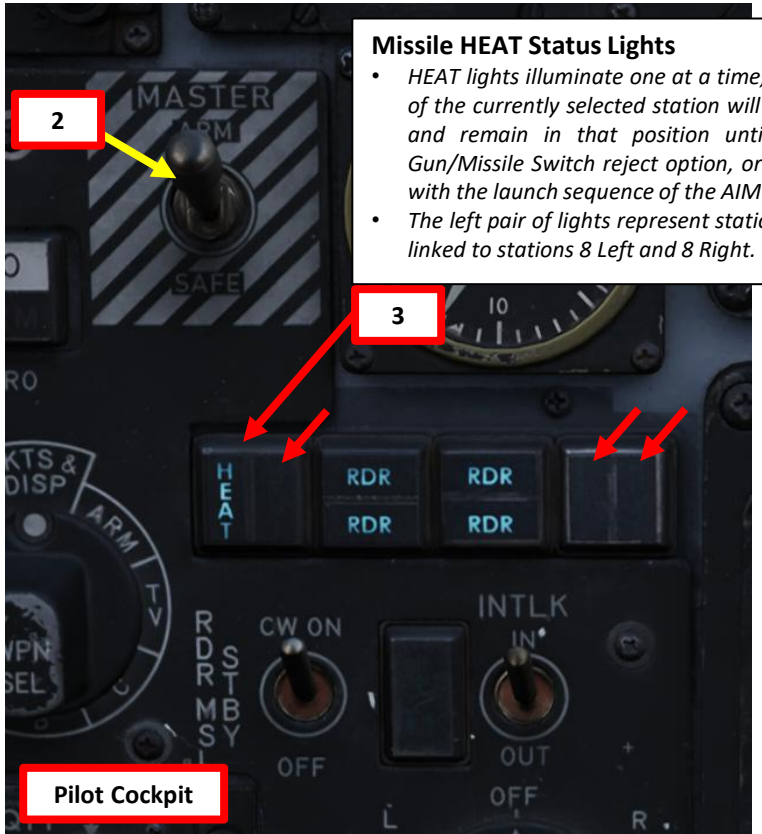
Type	Description	Lock Tone	Uncage Capability	Aspect	Maneuverability	Countermeasure Resistance	Motor Performance
AIM-9B	First operational version of the Sidewinder family, entering service in the 1950s. It utilized an infrared homing seeker for target acquisition and tracking, making it a heat-seeking missile.	No	No	Rear	Poor	Poor	Poor
AIM-9J	Featuring enhanced guidance and performance characteristics. It retained the infrared homing seeker but had improved sensitivity and better resistance to countermeasures.	No	Yes	Rear	Fair	Fair	Poor
AIM-9JULI	Variant of the AIM-9J developed by Germany. It featured modifications to meet specific operational requirements.	Yes	Yes	All	Fair	Good	Fair
AIM-9L	Significant upgrade with improved infrared homing capabilities, allowing for better target discrimination. It introduced all-aspect targeting, meaning it could engage targets from any angle, not just from behind.	Yes	Yes	All	Good	Good	Good
AIM-9M	Improved guidance and counter-countermeasures capabilities. It had enhanced maneuverability and improved target-tracking algorithms, making it more effective in combat situations.	Yes	Yes	All	Good	Good	Good
AIM-9P	Developed for export and used by various nations. It featured improvements over earlier models in terms of reliability and seeker performance.	No	Yes	Rear	Fair	Fair	Poor
AIM-9P-3	Improves the P version by using a reduced-smoke motor and improving the guidance system. Base of the swedish RB-24J missile.	No	Yes	Rear	Fair	Fair	Fair
AIM-9P-5	Further improves counter-countermeasures capabilities, as seen in the M version. Base of the swedish RB-24L missile.	Yes	Yes	All	Fair	Good	Fair

3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.2 – Weapon Setup

A – Missile Selection

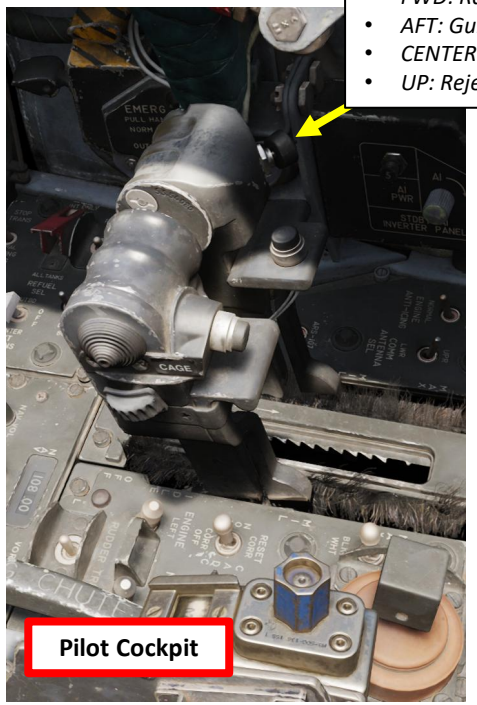
1. *[P]* Set Gun/Missile Pinky Switch – HEAT (CENTER).
2. *[P]* Set Master Arm Switch – ARMED (UP)
3. *[P]* Confirm that Missile HEAT Status light of desired station is illuminated.
4. *[P]* The launch sequence for AIM-9 missile stations is Left Outboard, Right Outboard, Left Inboard and Right Outboard.
    - Note: Pressing the Gun/Missile Pinky Switch in the HEAT/CENTER position will cycle between missiles.





Missile HEAT Status Lights

- *HEAT lights illuminate one at a time, rather than all up upon circuit configuration. The light of the currently selected station will illuminate beginning at the raising of the gear handle, and remain in that position until the weapon is either cycled using the throttle's Gun/Missile Switch reject option, or is launched. The HEAT light arrangement corresponds with the launch sequence of the AIM-9 Sidewinder.*
- *The left pair of lights represent station 2 Left and 2 Right respectively, while the right pair is linked to stations 8 Left and 8 Right.*



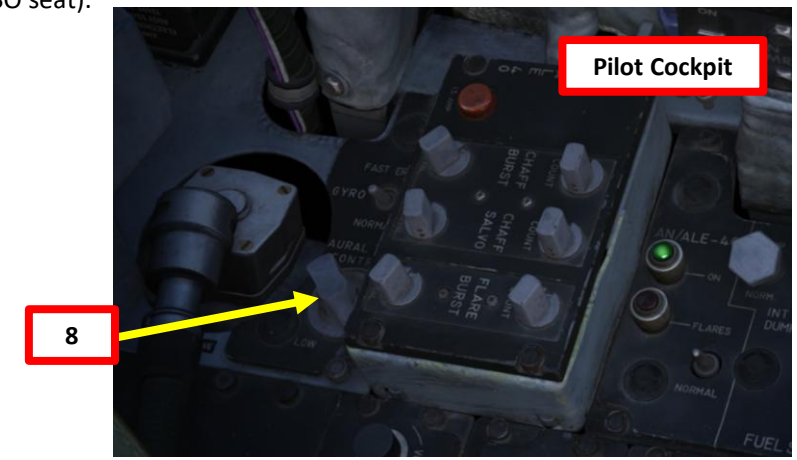
Gun/Missile Pinky Switch

- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

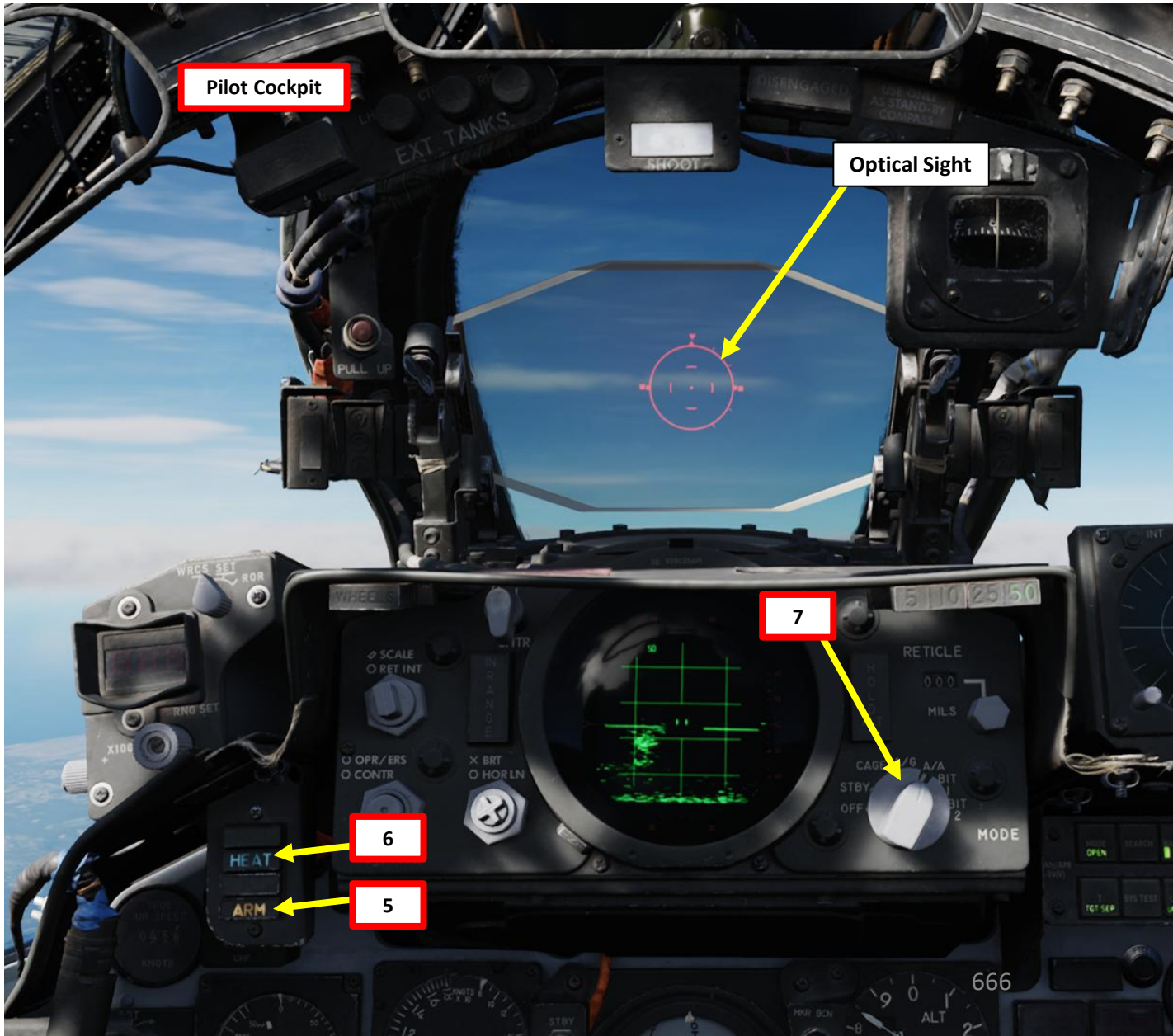
3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.2 – Weapon Setup

B – Missile Preparation

5. *[P]* Confirm ARM light is illuminated
6. *[P]* Confirm HEAT light is illuminated
7. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
8. *[P]* Adjust Aural Tone Volume Knob – As desired. This will control the volume of the Sidewinder tone.
9. *[P]* If using the radar for ranging information & steering cues, set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).



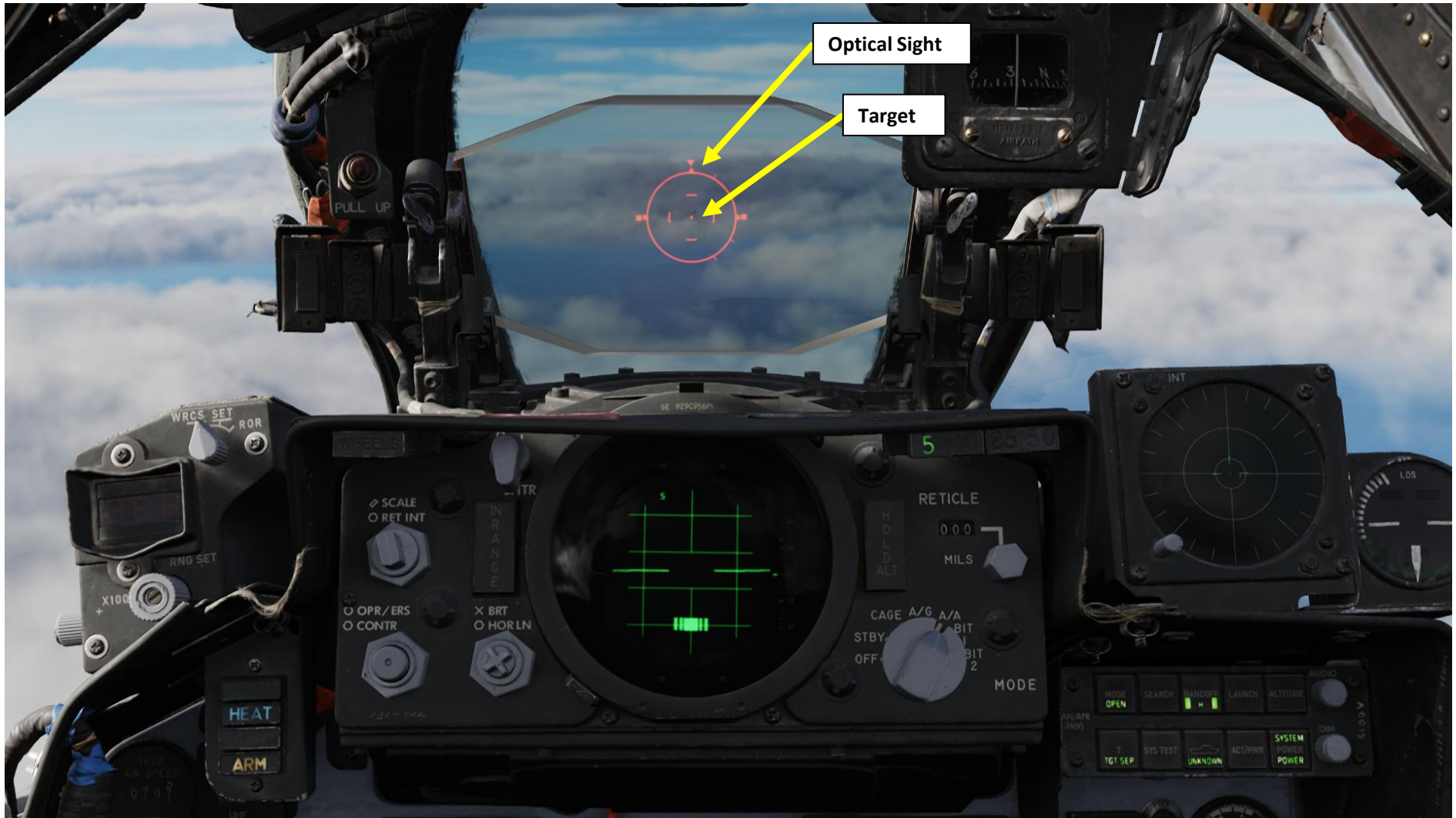




3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.3 – Employment without Radar

A – Engage Target

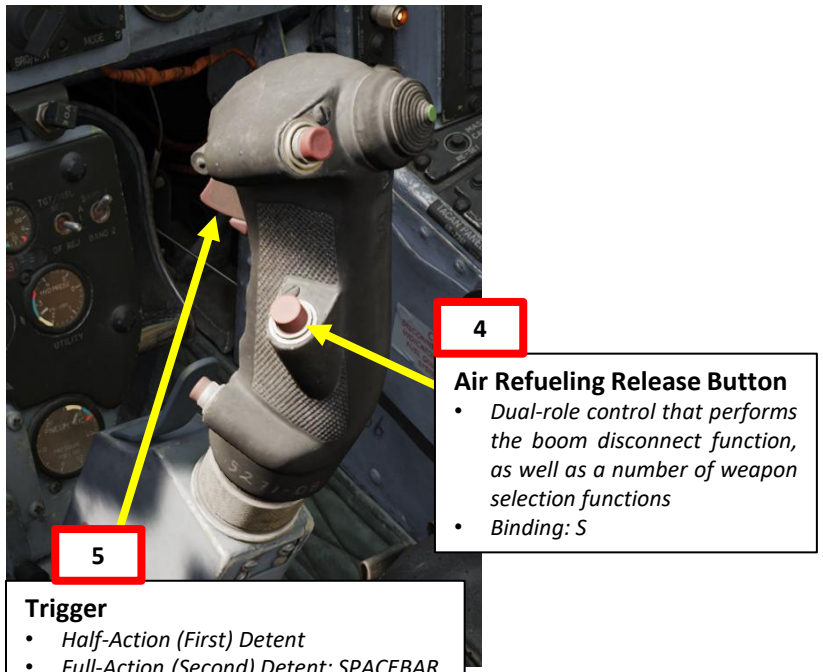
1. *[P]* Manoeuver the aircraft to center the optical sight roughly on the target. This should allow for rapid acquisition by the seeker of the selected AIM-9. The AIM-9 missile will track heat signatures by itself.

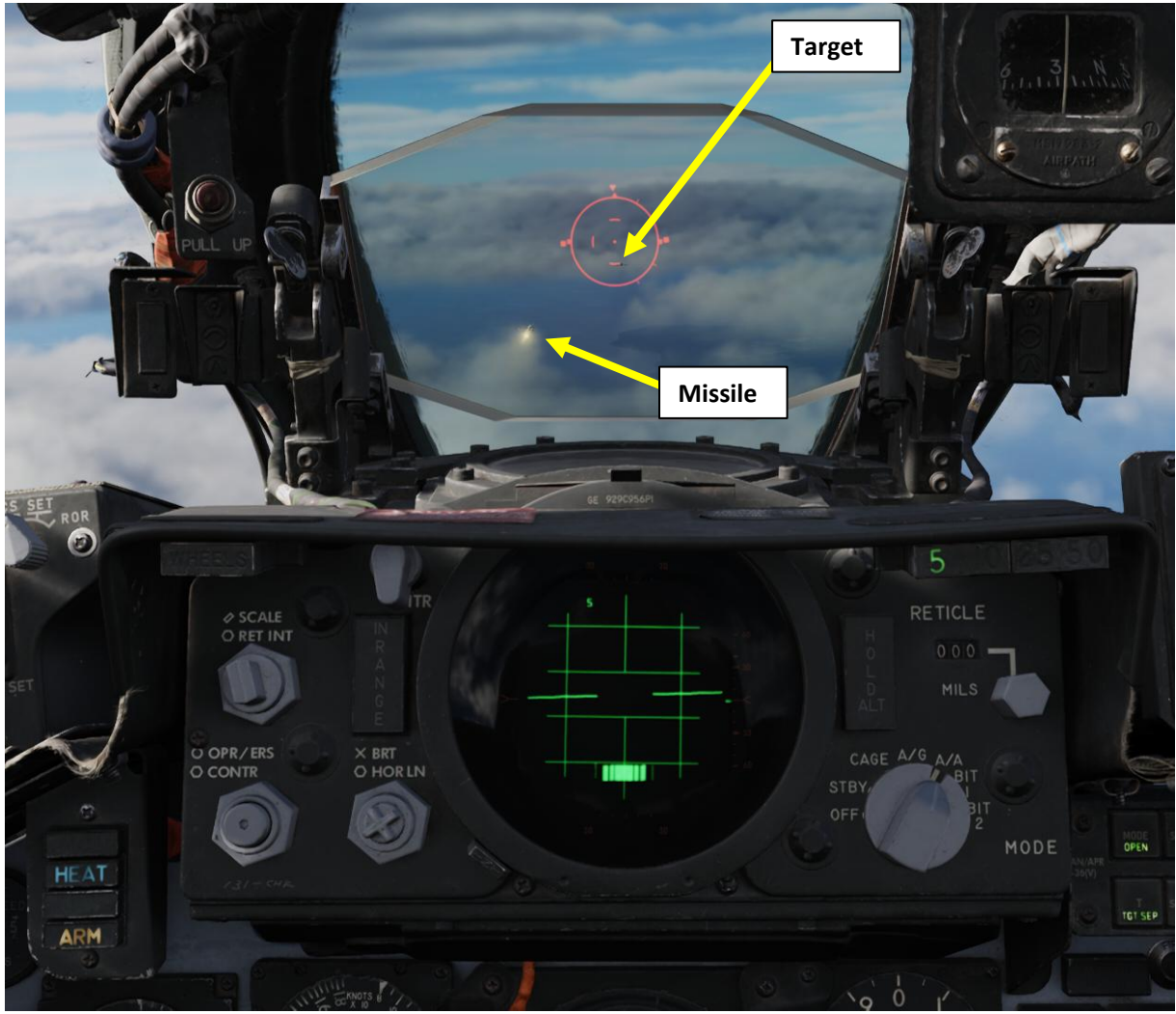


3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.3 – Employment without Radar

A – Engage Target

2. *[P]* When the AIM-9 is not detecting a heat signature, a low-pitch growl is audible. Once you have flown the aircraft to roughly place the optical sight over the target, the missile seeker head will attempt to detect a heat signature in this area.
3. *[P]* Once a heat signature from the target is detected, the low-pitch growl will transition into a high-pitch tone.
4. *[P]* The pilot may launch the missile immediately or attempt to achieve the seeker self-track (lockon) by uncaging the missile by holding down the Air Refueling Release Button.
    - Sidewinder self-track (seeker uncage) allows the seeker to maintain acquisition of the target (noted by the shifted audio tone), while permitting maneuver of the aircraft to a better aspect angle or range solution prior to launch if the situation allows. The amount of maneuver available to a given Sidewinder type is based on the variant, and should be considered before making the selection.
5. *[P]* Once you are within effective missile range and the missile is tracking (high-pitch tone is audible), squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired.





3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.3 – Employment without Radar

A – Engage Target

6. *[P]* Once launched, the missile seeker will track heat signatures on its own.







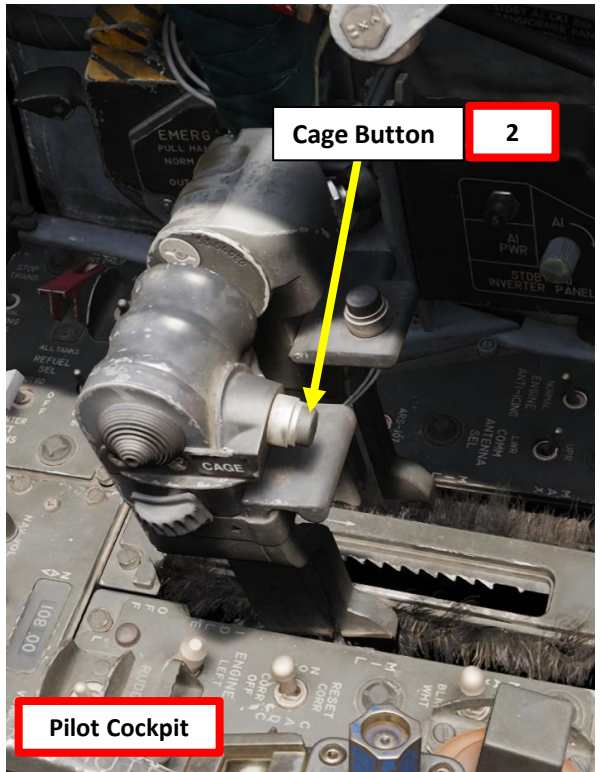
3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

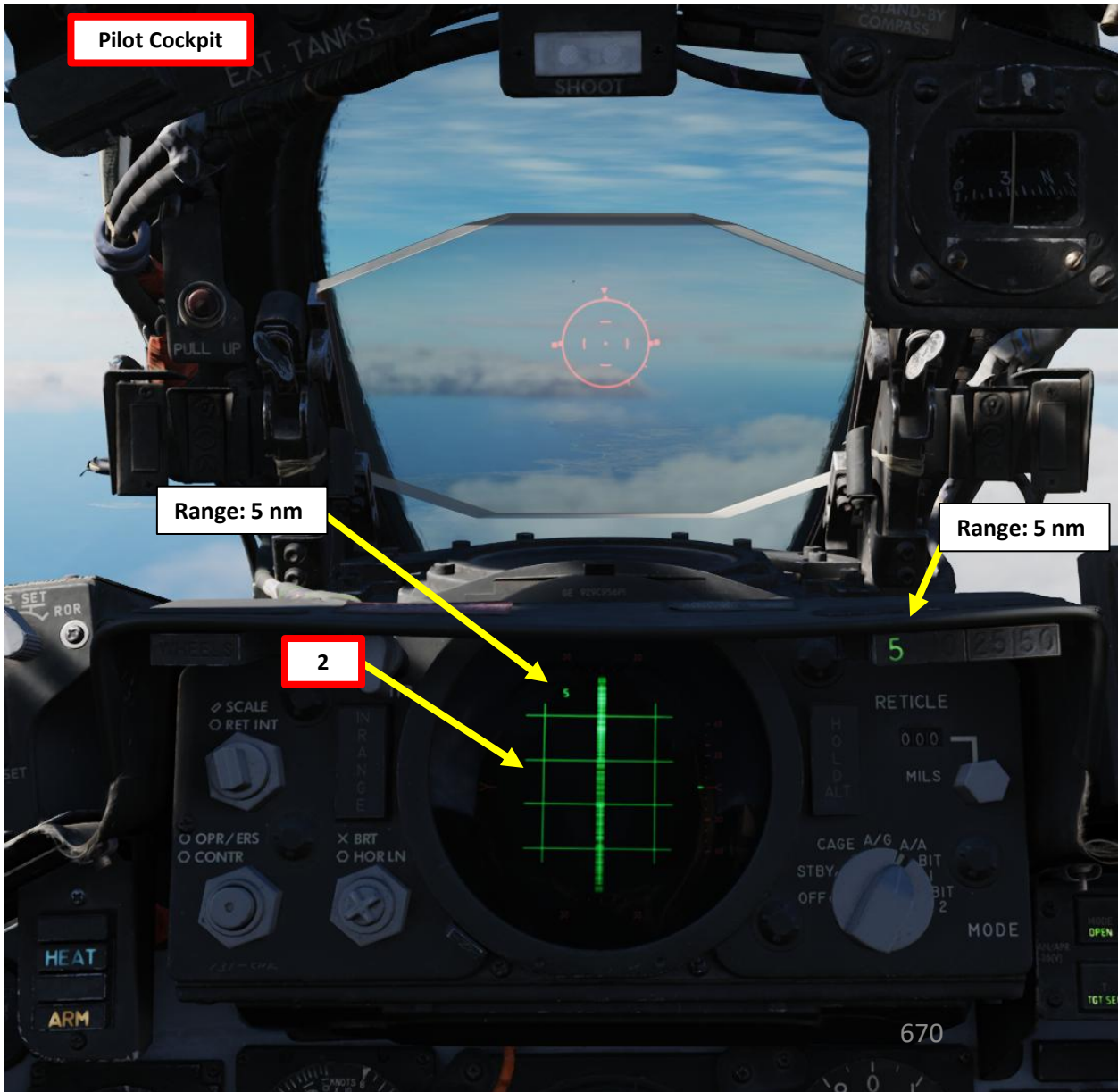
A – Perform Radar Lock

In order to perform search a track (lock) a target that is within visual/close range, the pilot is typically better positioned to perform the radar lock. Be aware not to confuse "Cage Mode" and "CAA (Computer Automatic Acquisition) Mode" since they are related but serve different functions. Keep in mind that the radar lock only helps the pilot to get a firing solution, it will not guide the Sidewinder missile itself.

1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[P]* Select **Cage Mode** by depressing the Cage button on the pilot's throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.



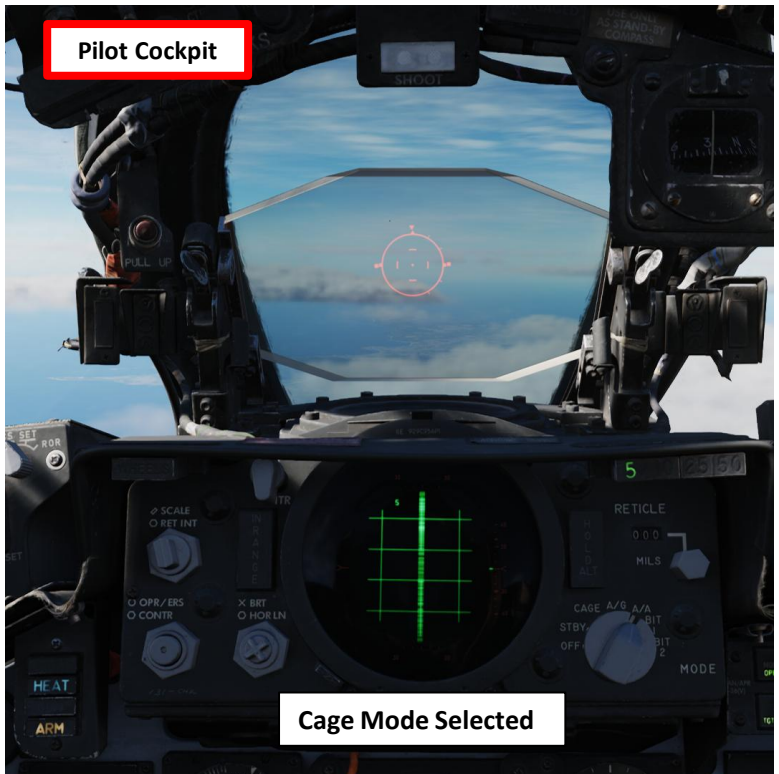




3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

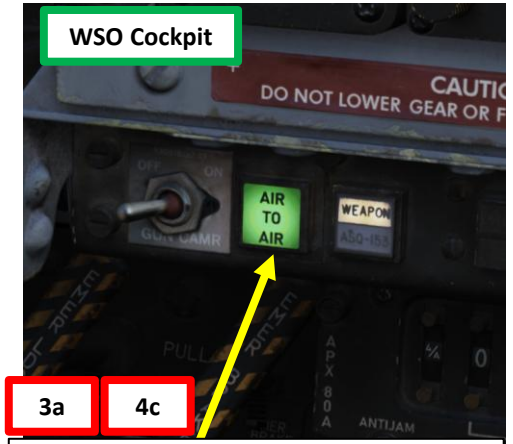
A – Perform Radar Lock

3. *[P]* When Cage mode is selected:
   a) The Air-To-Air light in the rear pit illuminates
   b) Trigger control is transferred to the air-to-air weapons (including when ARM and TV are selected)
   c) The Optical sight switches into A/A mode
   d) CAA (Computer Automatic Acquisition) mode becomes available for selection.
4. Additional Notes about Cage Mode:
   a) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch on the throttle is in RADAR or HEAT, the radar breaks track and returns to boresight.
   b) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch is in GUNS, the lock is not broken.
   c) Cage Mode can be exited with the pilot's Weapon Select Knob (set into or out of the B position) or with the WSO pressing the Air-to-Air Button.





Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*





Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

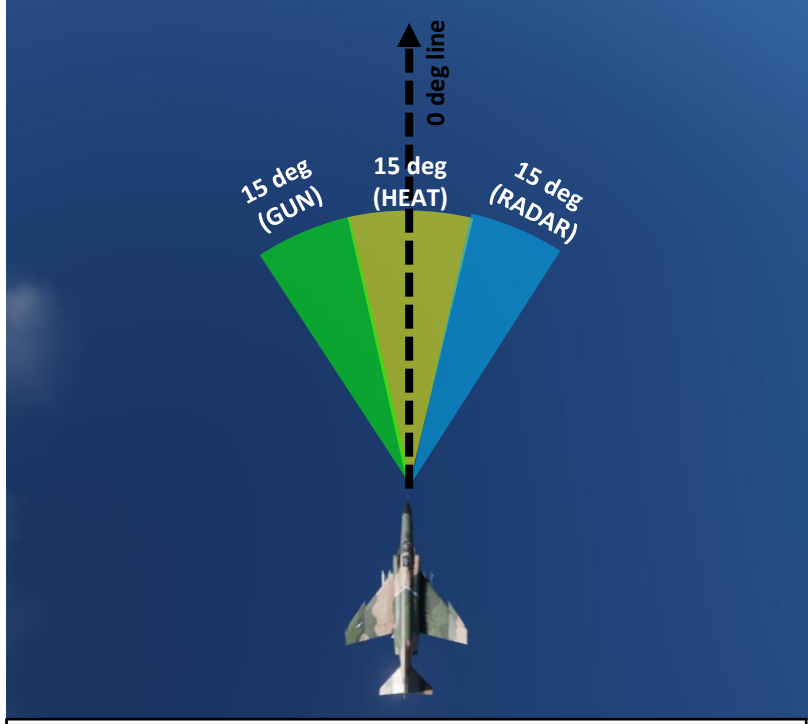
Weapon Selector Knob
- *B: Cancels air-to-air missile CAGE requirement.*



3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

A – Perform Radar Lock

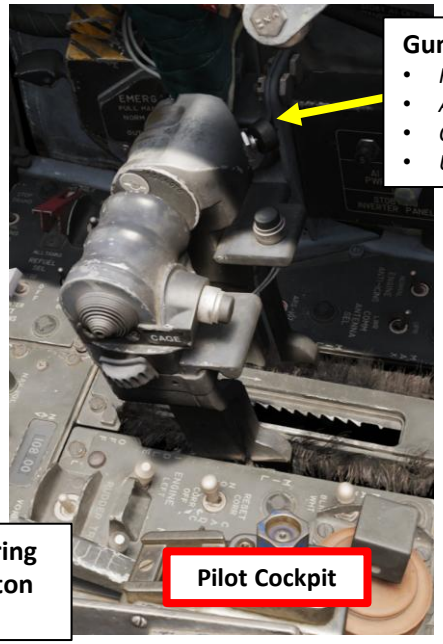
5. *[P]* Select **CAA (Computer Automatic Acquisition) Mode** by pressing the Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button on either the Pilot (or WSO stick).
6. *[P]* When CAA Mode is selected:
   a) The radar enters a vertical-oriented scan pattern 78 degrees in height by 15 degrees wide, the scan is 3 vertical bars wide.
   b) Actual radar lock capability within this scan pattern is from +45 degrees above the horizon line to -9 degrees below the horizon line due to radar's software limitation.
   c) In the event that the radar finds a suitable target within the scan volume, the target will be automatically locked.
   d) Should the flight crew find the locked target not be the one intended, the Nose Gear Steering button can be pressed on either stick grip to return the radar back to the search pattern.
7. *[P]* In CAA mode, the radar's search pattern can be shifted left and right utilizing the pinky switch on the throttle.
   - Pinky Switch – AFT (GUNS): Scan Center is 15 deg Left
   - Pinky Switch – CENTER (HEAT): Scan Center is centered (0 deg)
   - Pinky Switch – FWD (RADAR): Scan Center is 15 deg Right



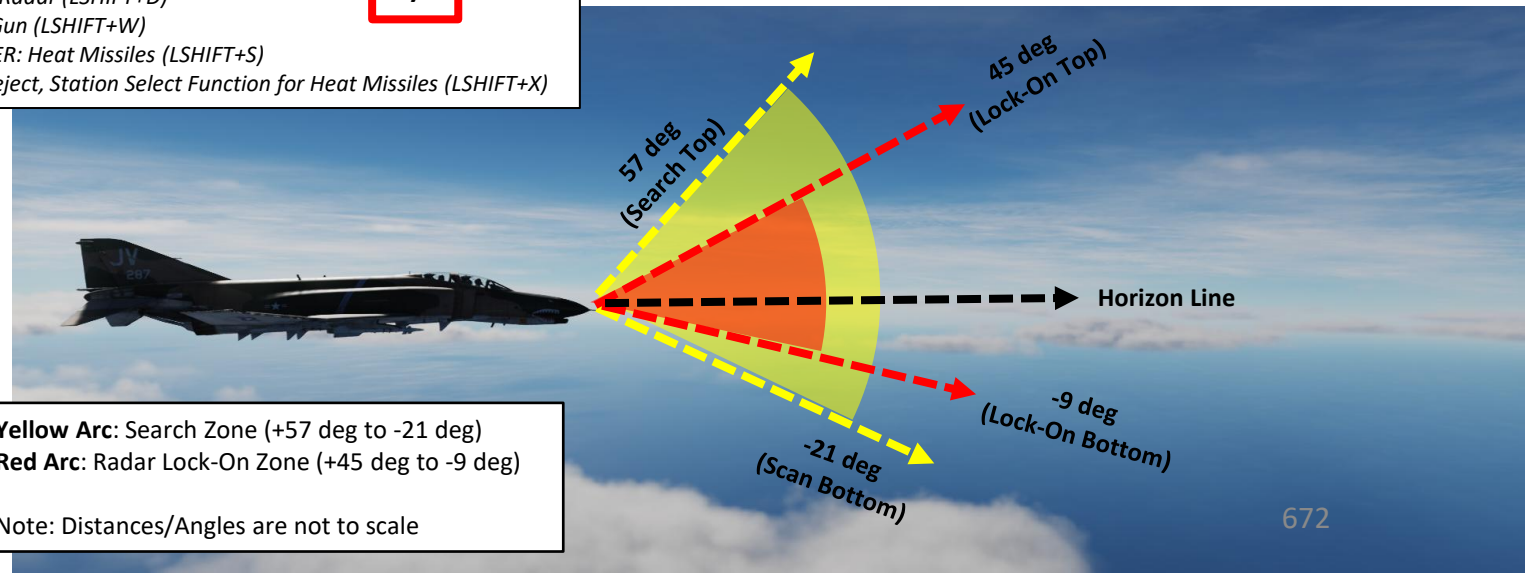
Green Arc: Left Corridor (Gun/Missile Pinky Switch AFT (GUN))
Yellow Arc: Center Corridor (Gun/Missile Pinky Switch CENTER (HEAT))
Blue Arc: Right Corridor (Gun/Missile Pinky Switch FWD (RADAR))



Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Gun/Missile Pinky Switch — 7
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



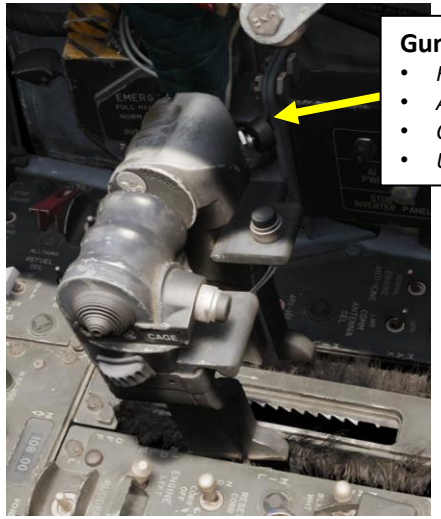
Yellow Arc: Search Zone (+57 deg to -21 deg)
Red Arc: Radar Lock-On Zone (+45 deg to -9 deg)

Note: Distances/Angles are not to scale

3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

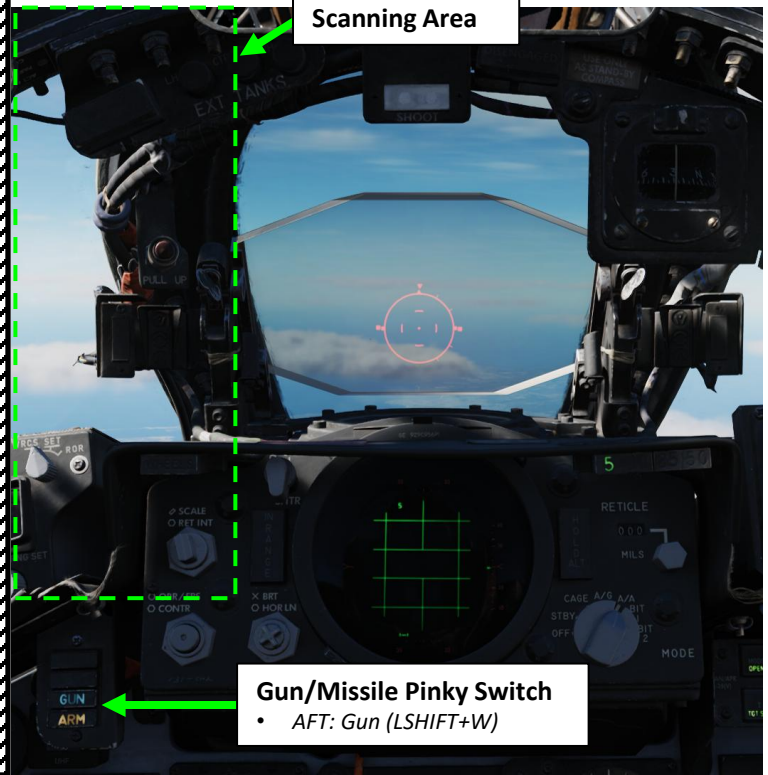
A – Perform Radar Lock

8. *[P]* I suggest leaving the Gun/Missile Pinky Switch in the CENTER (HEAT) position, which makes it easier to find a target and just line up the optical sight on it.
    - While in CAA mode, the GUN, HEAT and RADAR lights on the HUD (Heads-Up Display) are representative of the position of the Gun/Missile Pinky Switch, not which weapon is selected.
    - As mentioned previously, the position of the Gun/Missile Pinky switch in CAA mode defines where the radar is scanning.
9. *[P]* The pilot should visually line up the optical sight near the target. When the radar finds a suitable target within the scan volume and a 5 nm range, the target will be locked.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

Left 15 Deg Scanning Area

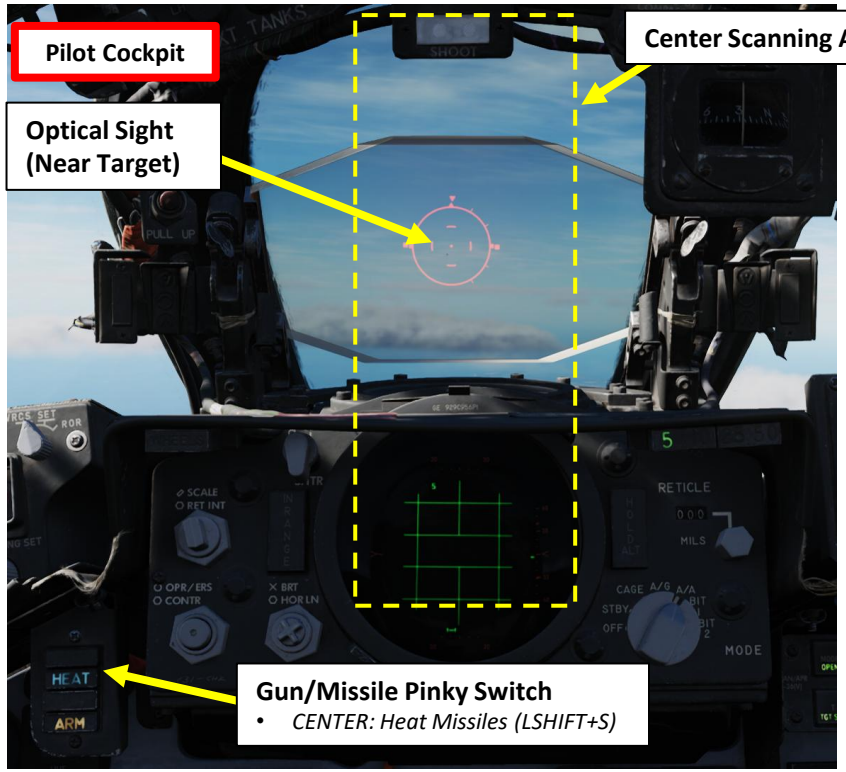


Gun/Missile Pinky Switch
- *AFT: Gun (LSHIFT+W)*

Pilot Cockpit

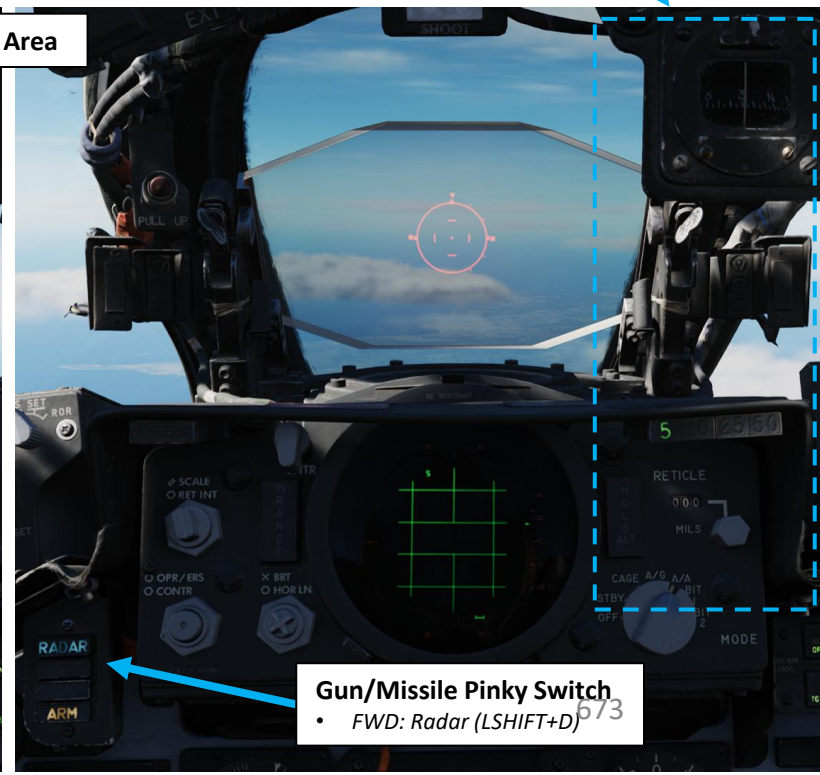
Optical Sight (Near Target)

Center Scanning Area



Gun/Missile Pinky Switch
- *CENTER: Heat Missiles (LSHIFT+S)*

Right 15 deg Scanning Area

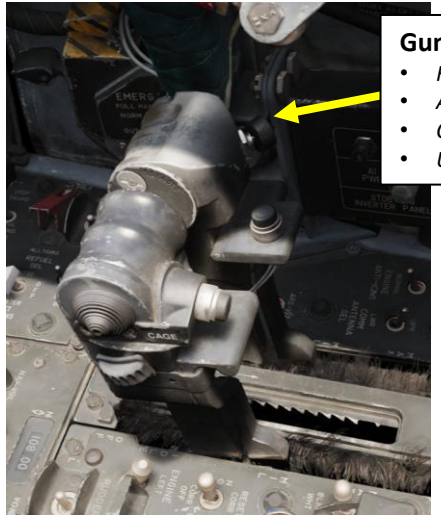


Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*

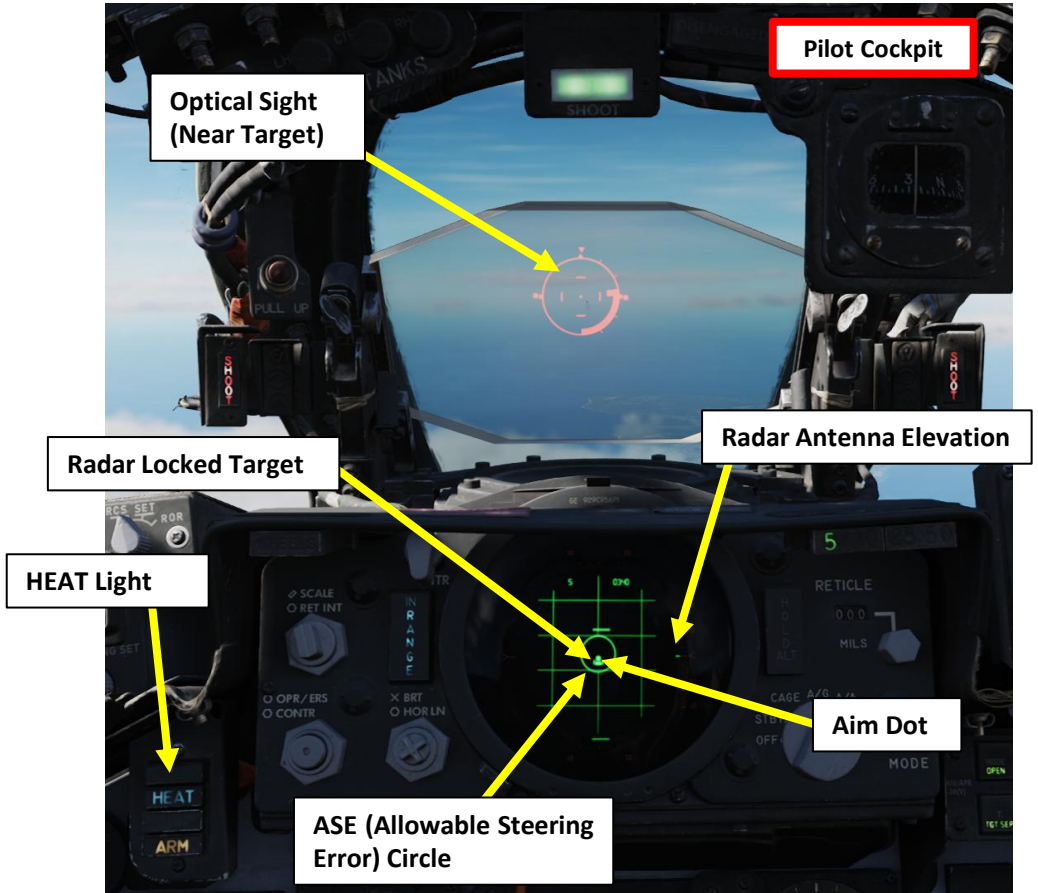
3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

A – Perform Radar Lock

10. Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears, which indicates the maximum lead or lag at which the missile can be launched and will still retain a high probability of hit
    - The Aim Dot appears, which provides steering commands to the pilot
11. *[P]* Set the Gun/Missile Pinky Switch in the CENTER (HEAT) position to display AIM-9 symbology. Confirm that the HEAT light illuminates.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



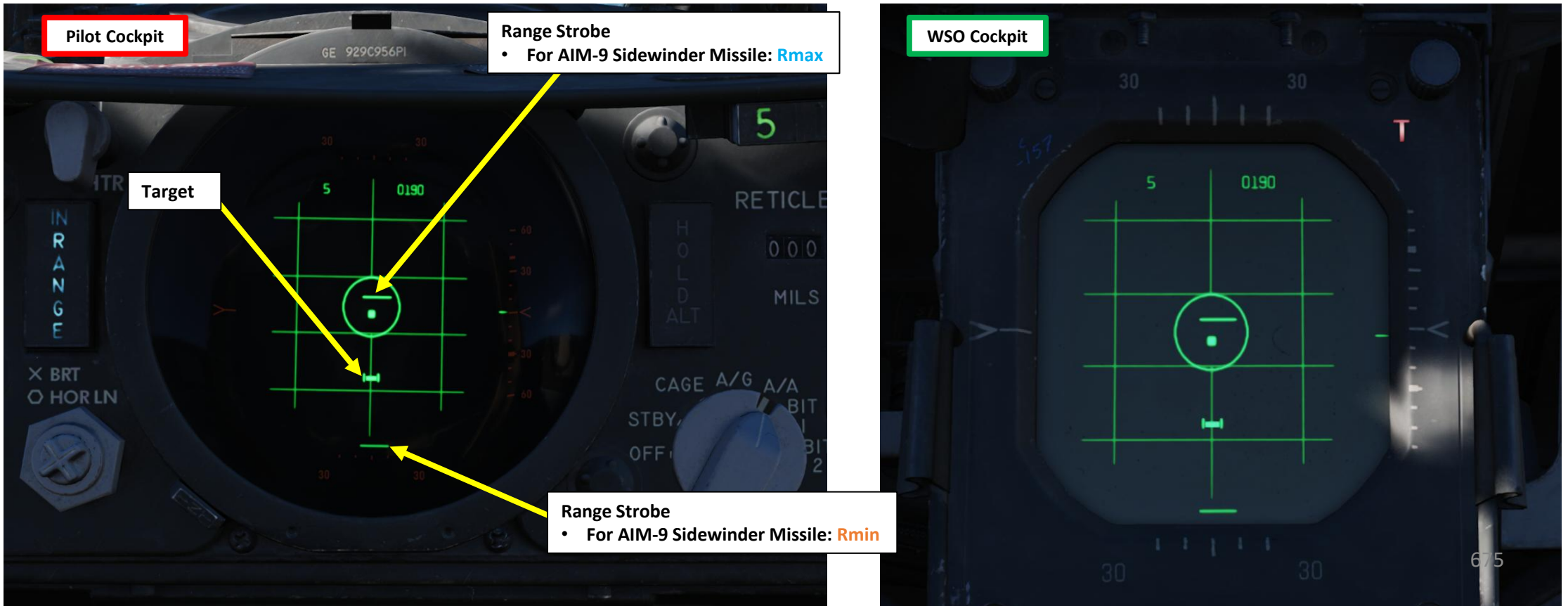




3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

A – Perform Radar Lock

12. *[P]* If an AIM-9 Sidewinder Missile is selected: range strobes display **Rmin** (Minimum range capability of the missile) and **Rmax** (Maximum range capability of the missile provided the target continues flying on current heading and course).

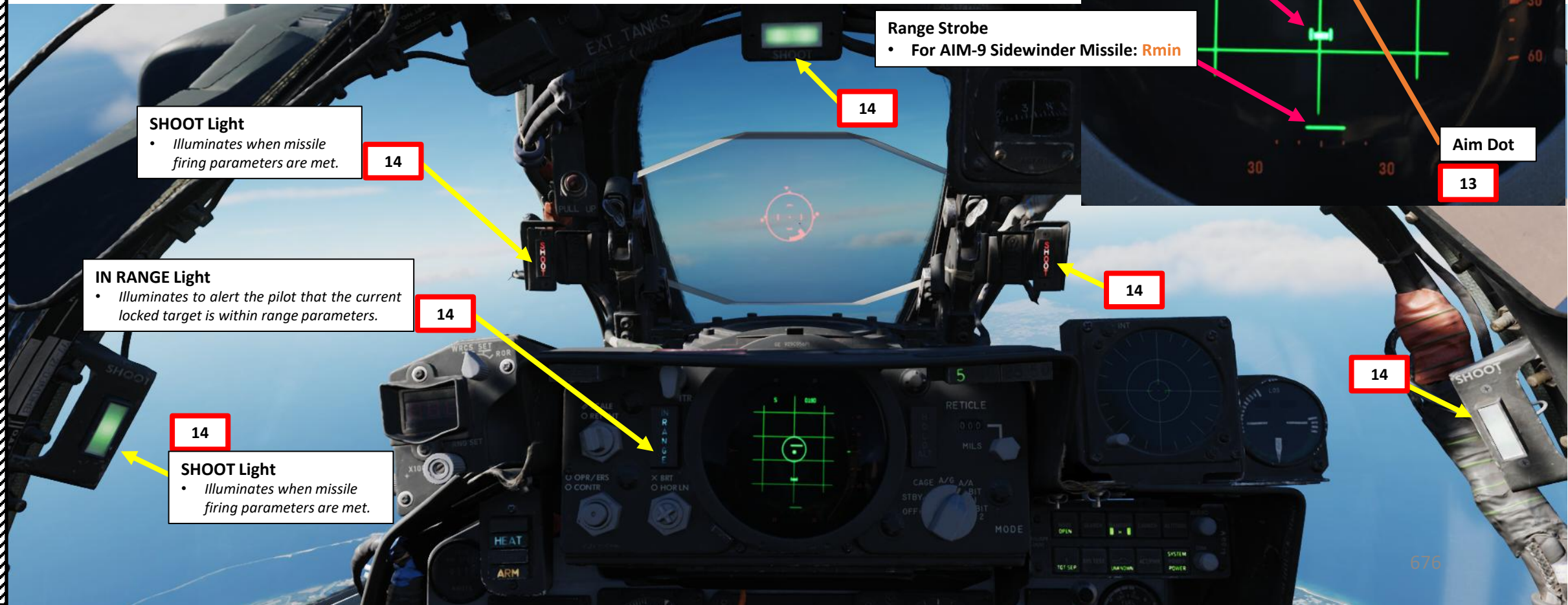


3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

B – Engage Target

13. *[P]* Manoeuver the aircraft to center the Aim Dot inside the ASE (Allowable Steering Error) Circle. Centering the aim dot in the ASE aligns the target to the RBL (Radar Boresight Line), allowing for rapid acquisition by the seeker of the selected AIM-9.
14. *[P]* When the IN RANGE and SHOOT lights illuminate, this means the Aim Dot is inside the ASE Circle and that the Target is within Rmax and Rmin (Minimum missile range). However, keep in mind that these indications are simply there to give you an idea that you should have a valid firing solution to uncage a Sidewinder seeker, then fire it at the target. The AIM-9 missile will not be guided by the radar; it tracks heat signatures by itself.

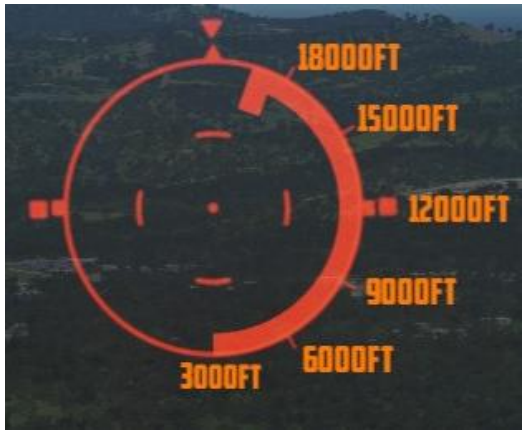


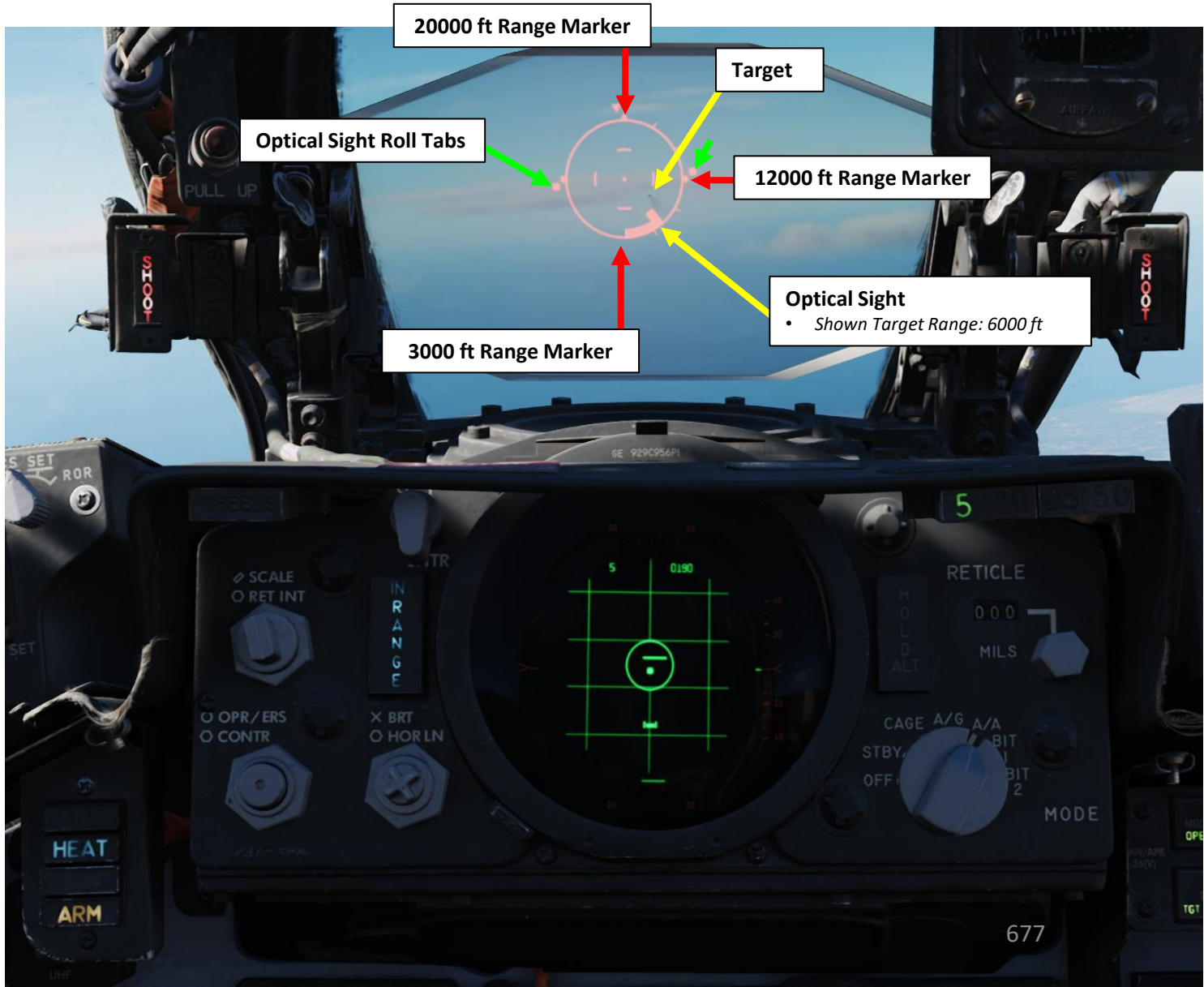


3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

B – Engage Target

15. *[P]* With the Sight Mode Selector set to A/A (Air-to-Air), the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target, displaying ranges up to 20,000 ft (top) to 3000 ft (bottom), with 12,000 ft signified at the 3 o-clock position. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time). The sight is stabilized at the Radar Boresight Line (RBL); **it will NOT follow the target**.

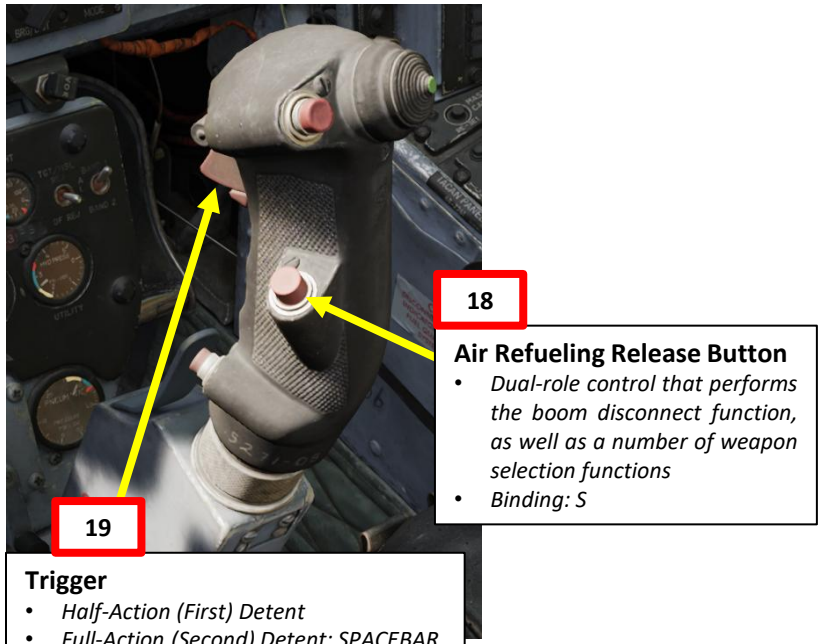


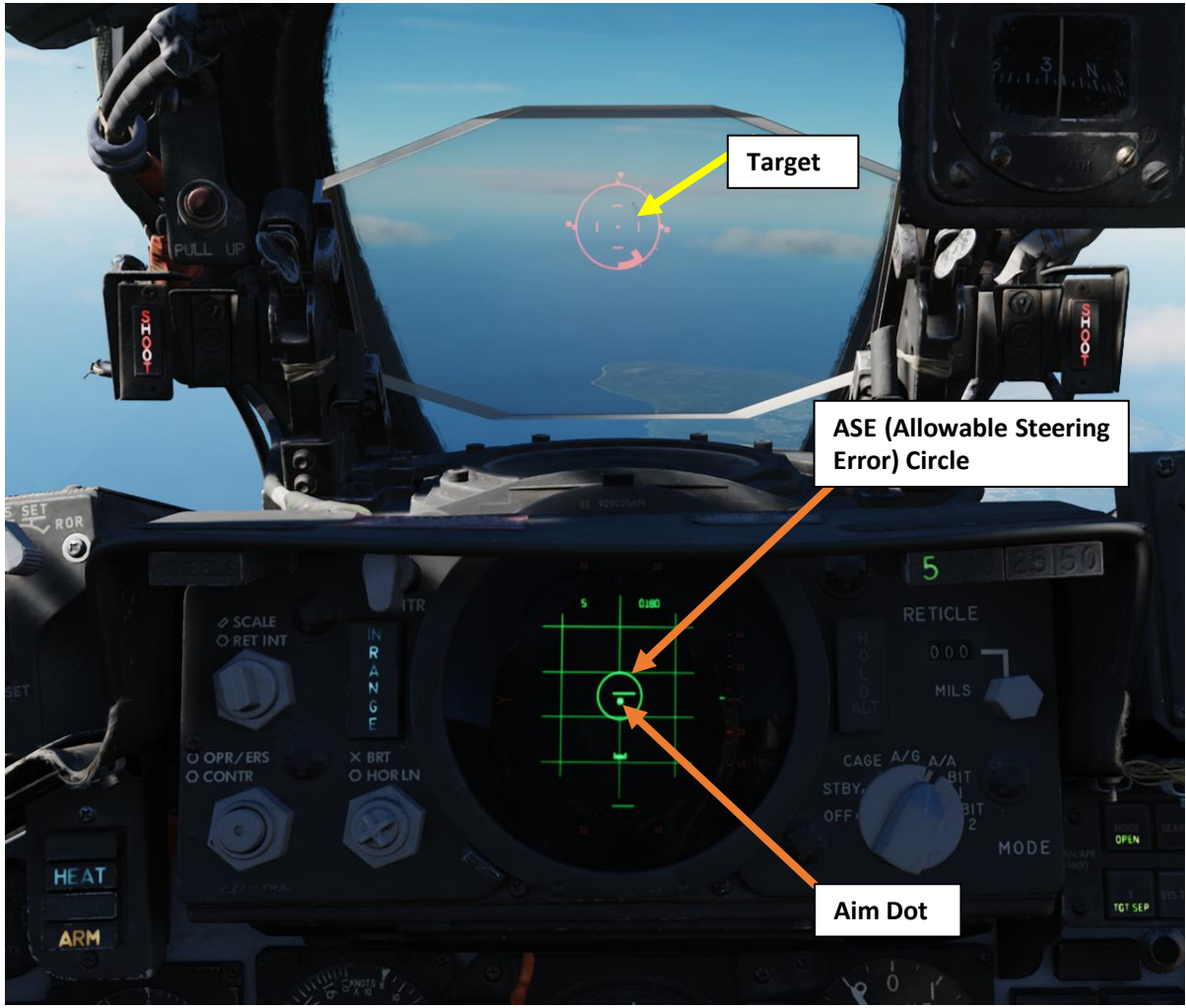


3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

B – Engage Target

16. *[P]* When the AIM-9 is not detecting a heat signature, a low-pitch growl is audible. Once you have flown the aircraft to roughly place the optical sight over the target, the missile seeker head will attempt to detect a heat signature in this area.
17. *[P]* Once a heat signature from the target is detected, the low-pitch growl will transition into a high-pitch tone.
18. *[P]* The pilot may launch the missile immediately or attempt to achieve the seeker self-track (lockon) by uncaging the missile by holding down the Air Refueling Release Button.
    - Sidewinder self-track (seeker uncage) allows the seeker to maintain acquisition of the target (noted by the shifted audio tone), while permitting maneuver of the aircraft to a better aspect angle or range solution prior to launch if the situation allows. The amount of maneuver available to a given Sidewinder type is based on the variant, and should be considered before making the selection.
19. *[P]* Once you are within effective missile range and the missile is tracking (high-pitch tone is audible), squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired.

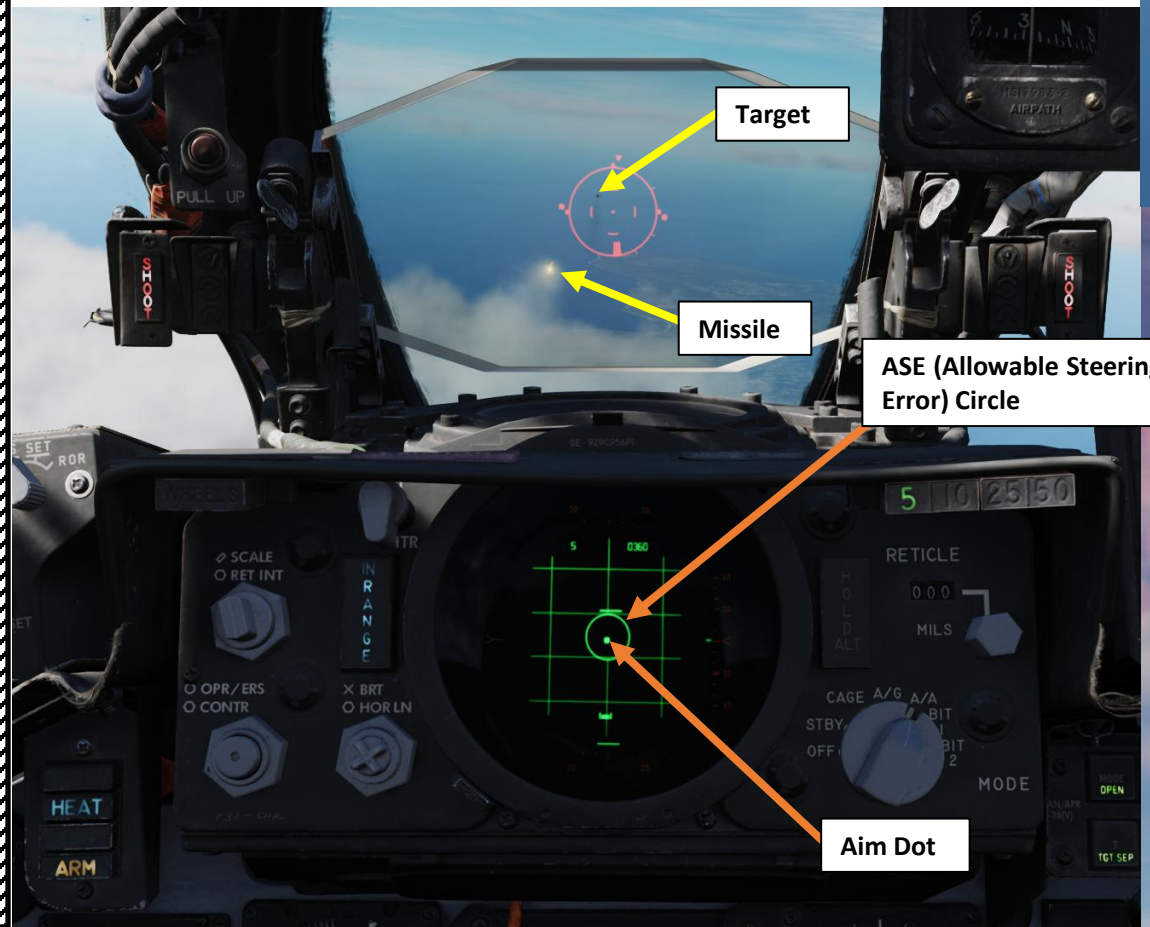




3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

B – Engage Target

20. *[P]* Once launched, the missile seeker will not require guidance by the radar since it will track heat signatures on its own; the radar is merely used to obtain an optimal firing solution.







3 – AIR-TO-AIR WEAPONS
3.2 – Infrared-Guided AIM-9 Sidewinder Missile
3.2.4 – Employment with Radar

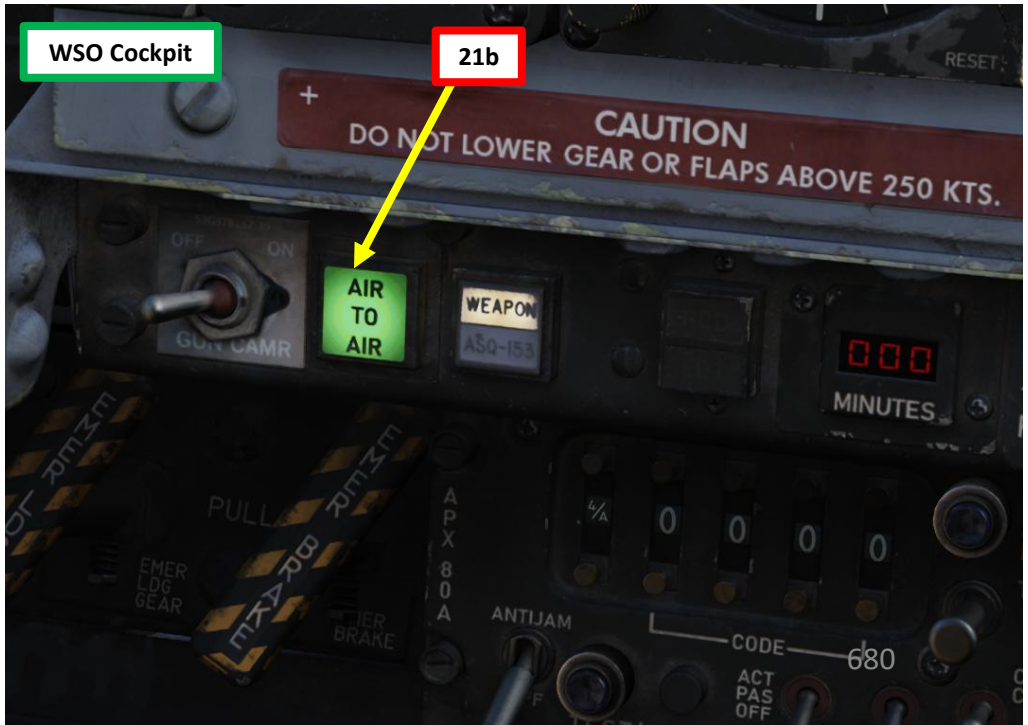
B – Engage Target

21. If you want to exit CAA mode, you can either:
    - *a) [P]* Select position B on the Weapon Select Knob, or
    - *b) [WSO]* Push the Air-To-Air button.
    - Note: Should a radar lock be in place at the time of CAA mode exit, it will be retained.

Pilot Cockpit



WSO Cockpit



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.1 – Introduction

The AIM-7 is a semi active radar missile with a maximum launch range of approximately 26 nautical miles. Originally designated the AAM-N-6 Sparrow III, the AIM-7 Sparrow saw initial service entry with the United States Navy in 1958. Unlike the beam-riding AIM-7A (AAM-N-2 Sparrow I), which required the launching aircraft to maintain boresight on the target for the flyout of the weapon, the semi-active radar homing AIM-7C could effectively engage a maneuvering target well off boresight, so long as the designating aircraft's radar could maintain a lock during the missile's intercept. The AIM-7C quickly gave way to the 7D, which saw a number of kills over Vietnam, and the 7E, which scored the majority of the type's kills in Southeast Asia. Additionally, the F-4E saw compatibility with the AIM-7F and AIM-7M.

AIM-7 Sparrow Missile Types

Type	Description	Seeker Performance	Range Performance	Dogfight Performance	Countermeasure Resistance & Clutter Rejection
AIM-7E	The E variant was an early version of the Sparrow missile, entering service in the 1960s, which uses proportional navigation and Semi Active Radar Homing to guide.	Poor	Fair	Poor	Poor
AIM-7E2	Changes were made to improve the performance in close range dogfight situations, at the expense of energy retention in longer ranged engagements. Fuzing time is also reduced allowing for proper fuzing in close engagements. Technically, the E2 has the same maximal range than the E. However, due to its maneuvering-behavior, that range lessens for anything but a dead straight shot.	Poor	Poor	Good	Poor
AIM-7F	The F Sparrow was upgraded to be solid state, have a higher performance two stage motor (boost and sustainer) and have improved electronics including the ability to coast targets through the main lobe clutter and altitude lines. These changes also make the seeker able to detect targets from further range and with increased countermeasure resistance and track using both continuous wave and pulse doppler guidance signals unlike the E, E2 and E3 which can only guide on continuous wave.	Fair	Good	Good	Fair
AIM-7M	The M was the first inverse mono-pulse Sparrow providing increased tracking precision, it also has improved motor performance and electronics, including improved clutter and countermeasure rejection. The M like all Sparrows can also guide using continuous wave, at a degraded tracking precision.	Good	Good	Good	Good

3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.2 – Weapon Setup

A – Missile Tuneup

1. *[P]* Set Missile Power Switch – CW ON (UP).
    - This powers up the klystron continuous wave (CW) emitter responsible for AIM-7 guidance signals and starts a missile tuning process.
2. *[P]* Wait until missile tuneup process is complete.
    a) AIM-7E Missile: Tuneup process takes 4 minutes.
        - *Note: If you do not wish to employ the AIM-7E missile at that time, set the Missile Power Switch to Standby (Middle), RDRs light will extinguish until you set the Missile Power Switch back to CW ON for employment.*

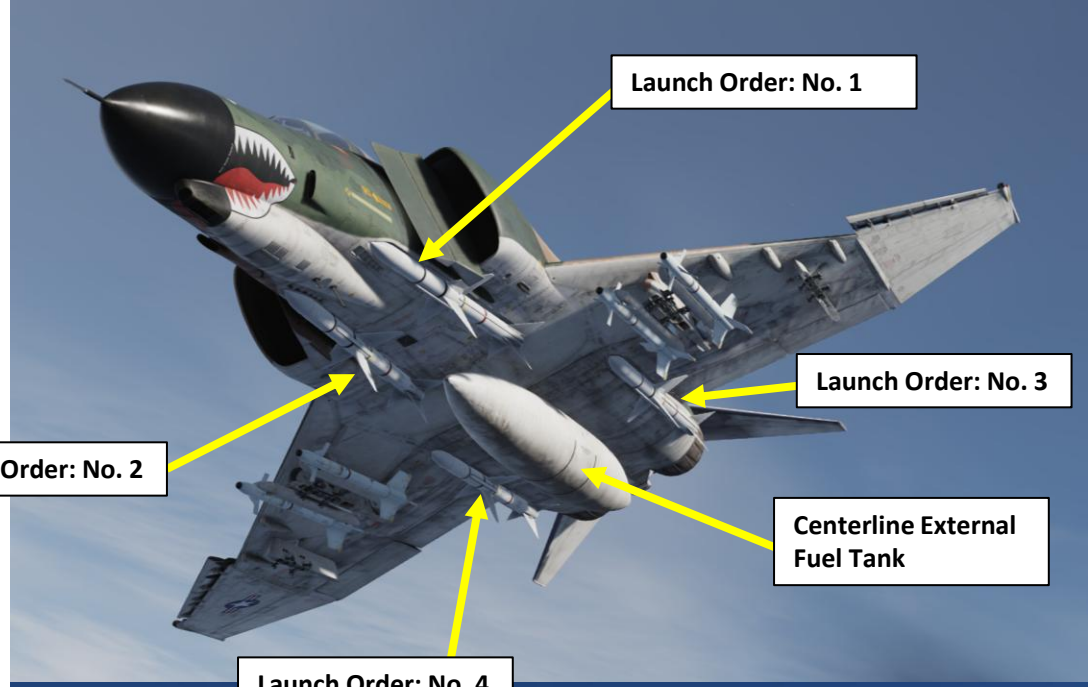
    b) AIM-7F Missile: Tuneup process takes 1 minute.
        - *Note: If you do not wish to employ the AIM-7E missile at that time, set the Missile Power Switch to Standby (Middle), RDR lights will remain illuminated until you set the Missile Power Switch back to CW ON for employment.*
3. *[P]* Once missile tuneup process is complete, confirm that Missile RDR Status lights are illuminated. Missile Power Switch should remain set to CW ON (UP)
4. *[P]* Set Interlock Switch – As desired. We will leave it to IN (UP).
    - Interlock IN: fire control system launch parameter interlocks are engaged. Range limits, ASE (Allowable Steering Error) limits, or radar not in visual intercept inhibits missile launch.
    - Interlock OUT: fire control system launch parameter interlocks override. AIM-7 will fire when trigger is pulled even when no launch condition is met.
5. *[P]* Set Master Arm Switch – ARMED (UP)



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.2 – Weapon Setup

B – Checking Missile Status

6. *[P]* The launch sequence for AIM-7 missile stations is Left Forward, Right Forward, Left Rear and Right Rear.
7. *[P]* If the CL TK (Centerline External Fuel Tank Aboard) Light is illuminated, a stores condition exists that precludes ejection or launch of an AIM-7 missile installed in one of the two forward positions. To use the Sparrows on these stations, the centerline store must be first jettisoned.
8. *[P]* If you need to jettison the centerline external fuel tank:
   a) Select CTR (Center) Station Select Button
   b) Set Selective Jettison Control Knob – STORES (FULLY DOWN)
   c) Push Selective Jettison Control Knob – IN.
   d) Centerline external fuel tank will jettison.
   e) Set Selective Jettison Control Knob – OFF (FULLY UP)
   f) De-select CTR (Center) Station Select Button.









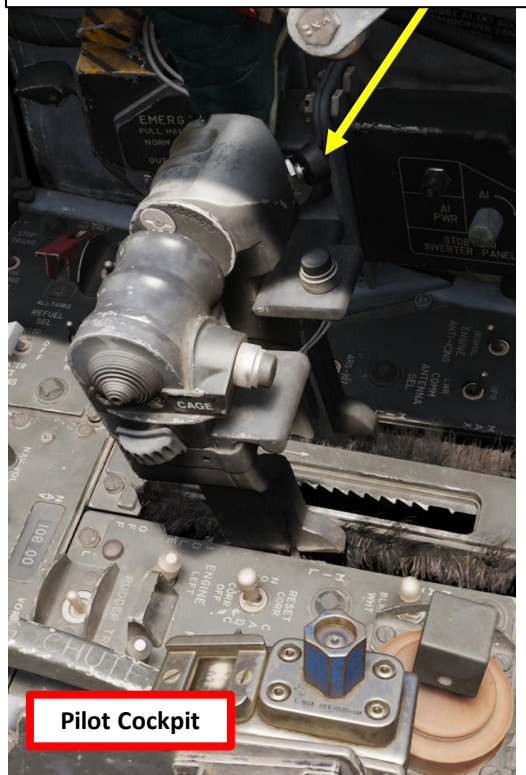
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.2 – Weapon Setup

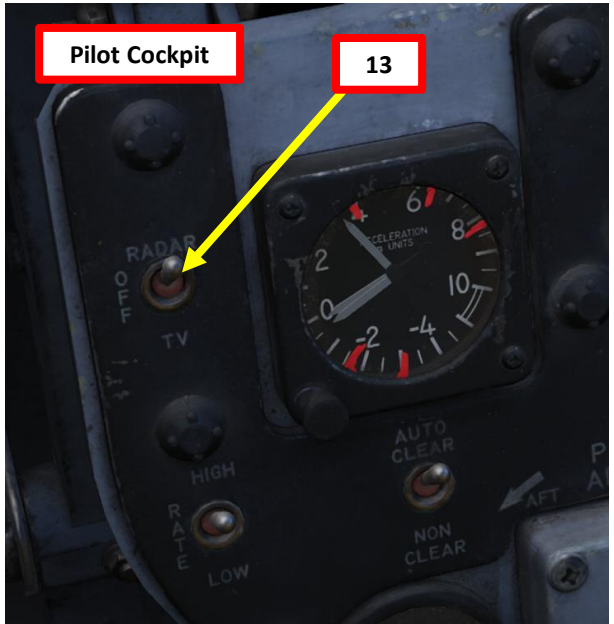
C – Missile Selection

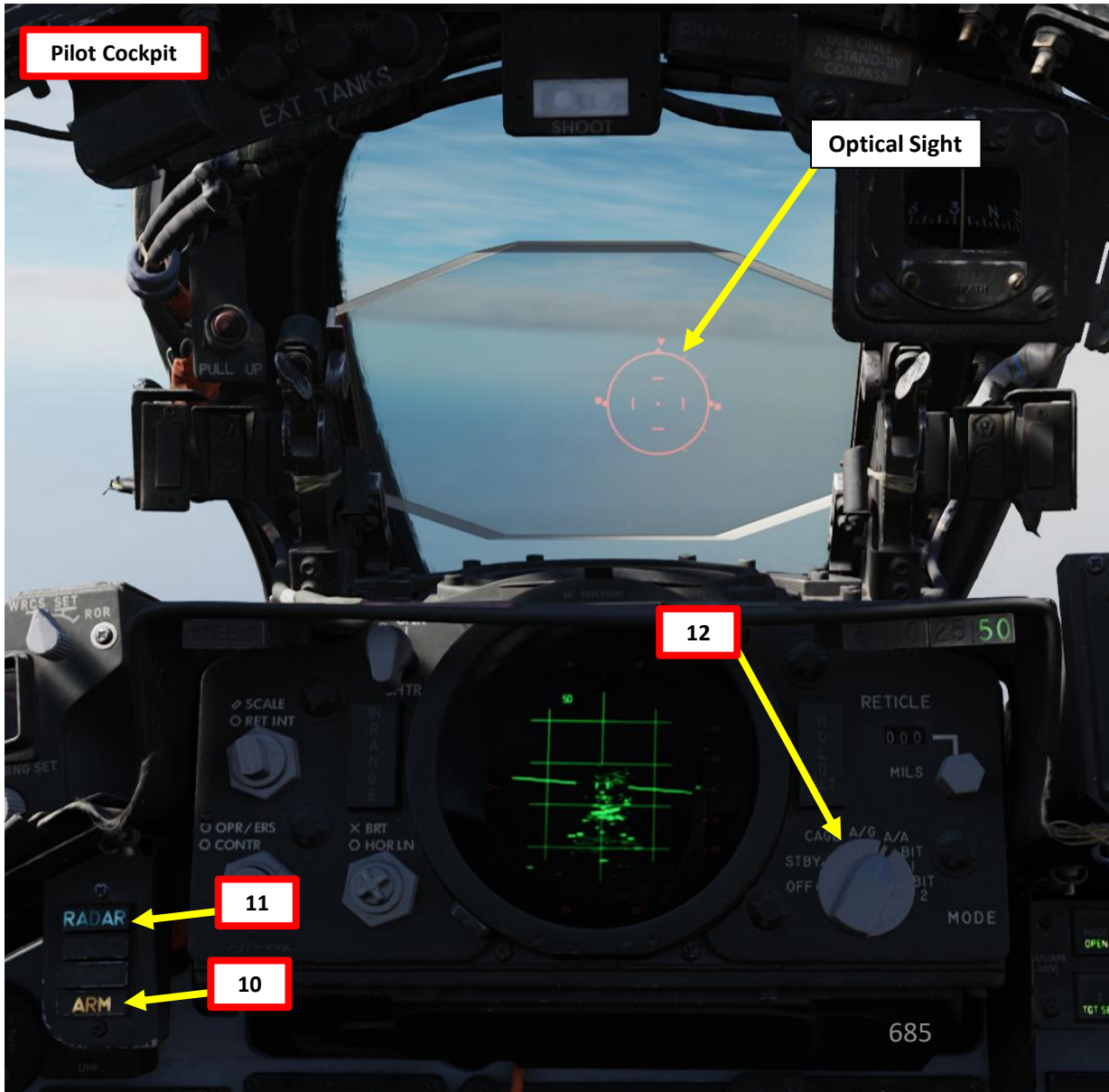
9. *[P]* Set Gun/Missile Pinky Switch – RADAR (FWD)
10. *[P]* Confirm ARM light is illuminated
11. *[P]* Confirm RADAR light is illuminated
12. *[P]* Set Sight Mode Selector – A/A (Air-to-Air)
13. *[P]* Set DSCG (Digital Scan Converter Group) Screen Mode Switch – RADAR (UP). This will display the radar display repeater (provided the radar is set up from the WSO seat).

Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*

9





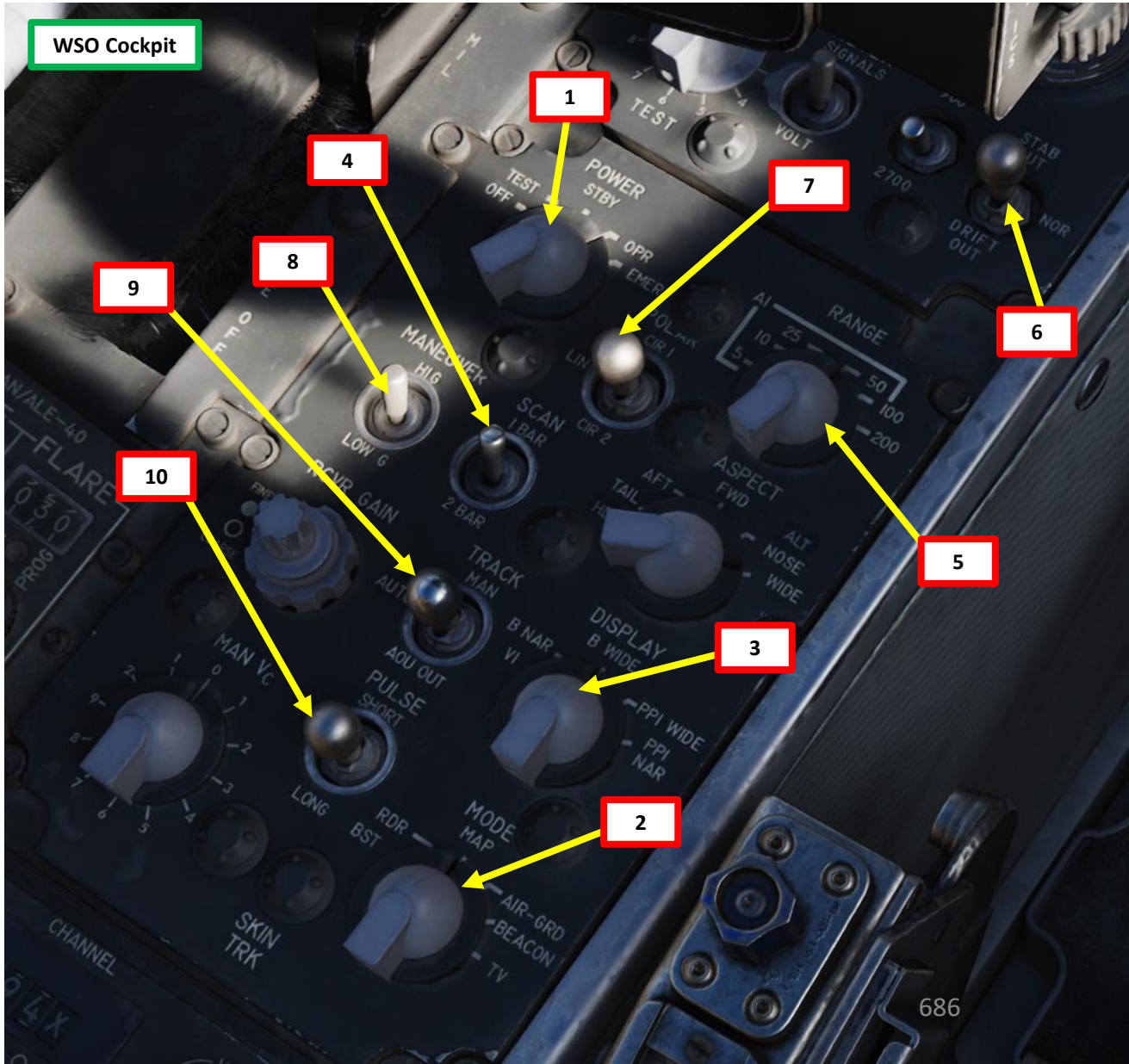


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

A – Perform Radar Lock

In order to perform search a track (lock) a target that is beyond visual range, you should have a general idea of where the target is at first since the Phantom's radar search capabilities are quite limited. This information would typically be provided by a ground controller via radio.

1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[WSO]* Set Radar Operation Mode – RDR (Radar) or MAP, as desired.
    - RDR provides feedhorn nutation, while MAP does not provide feedhorn nutation (narrower beam-width)
3. *[WSO]* Set Display Selector – B NAR (Narrow) or B WIDE, as desired.
4. *[WSO]* Set Radar Bar Scan Switch – As desired (1 Bar in this example).
5. *[WSO]* Set Radar Range Selector – As desired (50 nm or 25 nm settings are recommended).
6. *[WSO]* Set Stab (Antenna Stabilization Mode) Switch – NORMAL (MIDDLE)
7. *[WSO]* Set Polarization Switch – LINEAR (MIDDLE)
8. *[WSO]* Set Maneuver Switch – HI G (FWD)
9. *[WSO]* Set Track Switch – AUTO (MIDDLE).
    - Since we operate within the DCS environment, electronic warfare is quite simplified and Auto Tracking mode is good enough for our needs.
    - As a side note, Manual Tracking mode would allow you to manually set the range closure rate (Man Vc, in x100 kts). In theory, this could be useful in situations where the radar cannot get a reliable range to a target (likely due to jamming noise drowning your radar returns, making it close to impossible for the radar to get accurate ranging information).
10. *[WSO]* Set Pulse Switch – AUTO (MIDDLE)

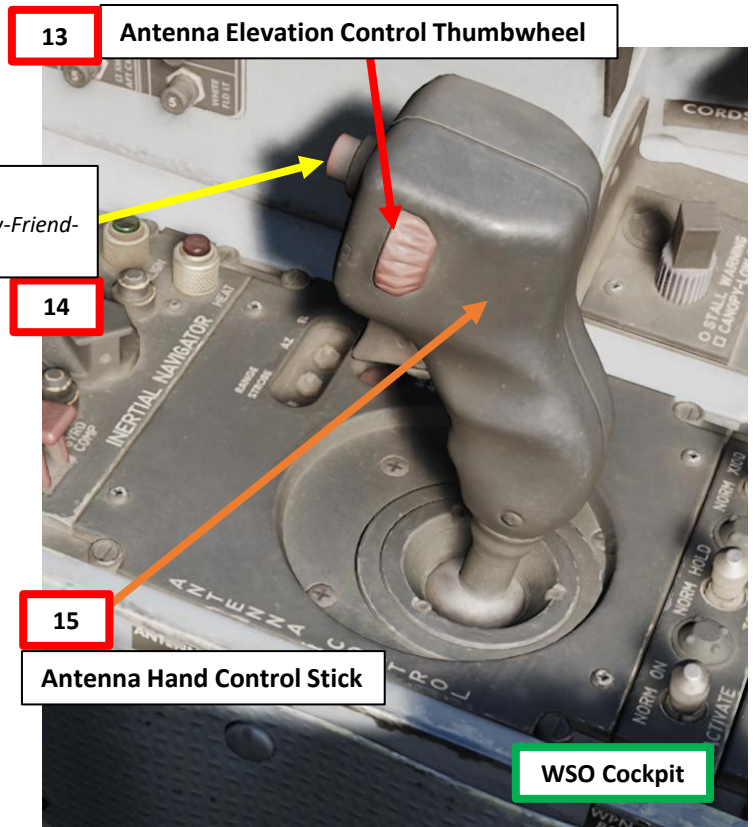


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

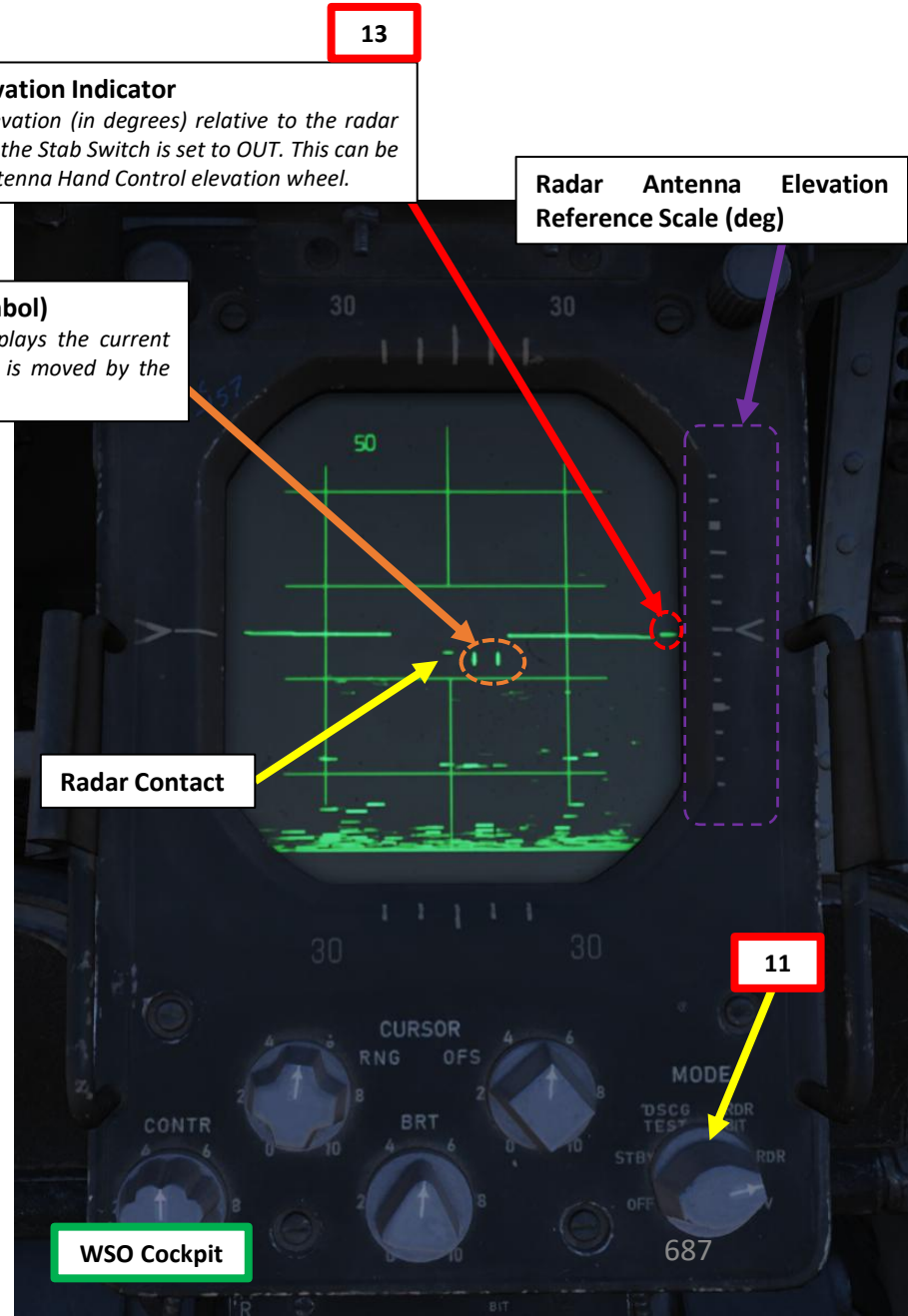
A – Perform Radar Lock

11. *[WSO]* Set DSCG (Digital Scan Converter Group) Mode Selector – RDR (Radar).
12. *[WSO]* Adjust Radar Gain using the Outer and Inner Receiver Gain Knobs to filter out radar clutter and discern radar contacts (air targets).
13. *[WSO]* Use the Antenna Elevation Control Thumbwheel to control the antenna elevation if required.
14. *[WSO]* Set up IFF as per Part 13, then initiate interrogation by pressing the Challenge Button on the Antenna Hand Control Stick. Confirm that no lines appear above or below the radar return; this indicates that the target is not responding to interrogation.
15. *[WSO]* Slew the Radar Cursor (Acquisition Symbol) with the Hand Control Stick over the target.





Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*

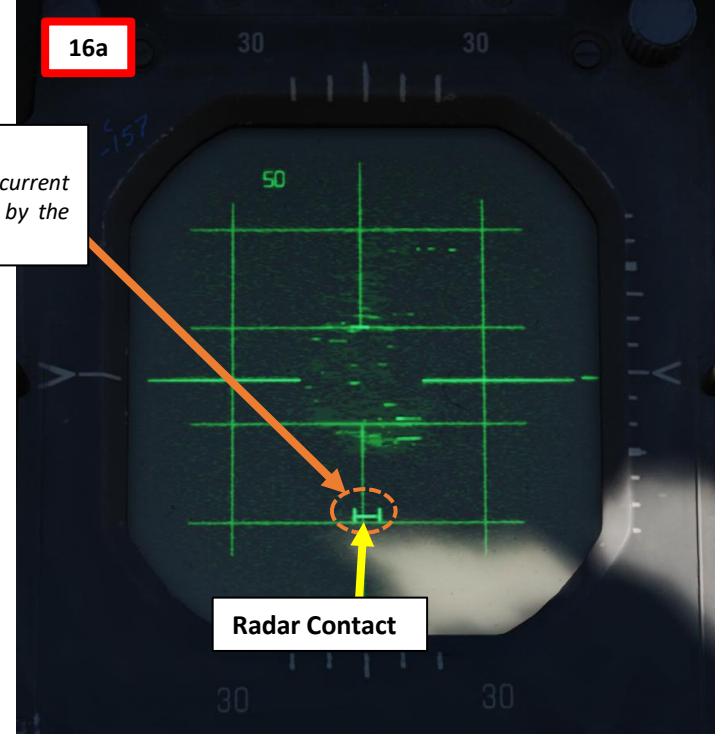


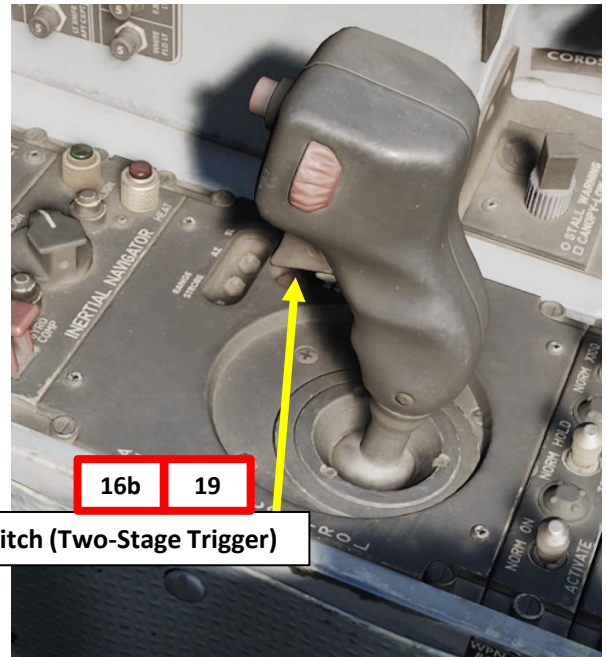
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

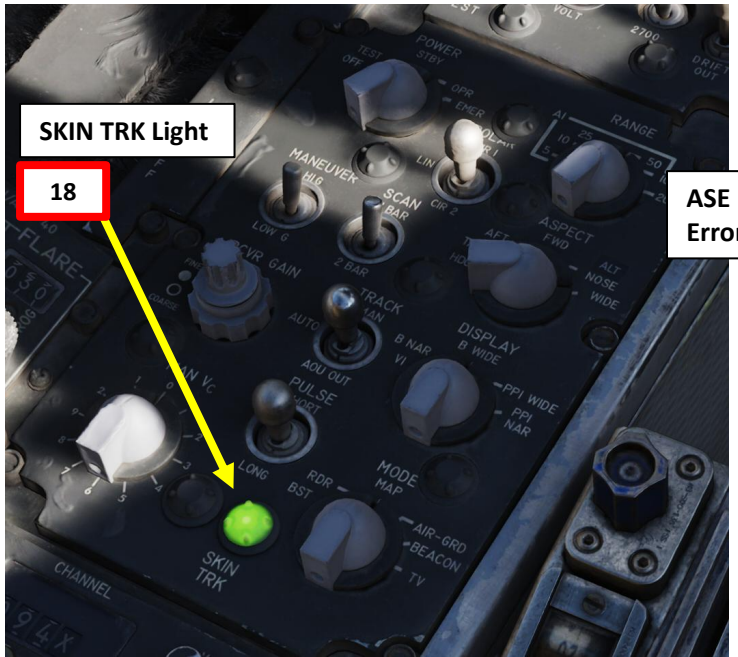
A – Perform Radar Lock

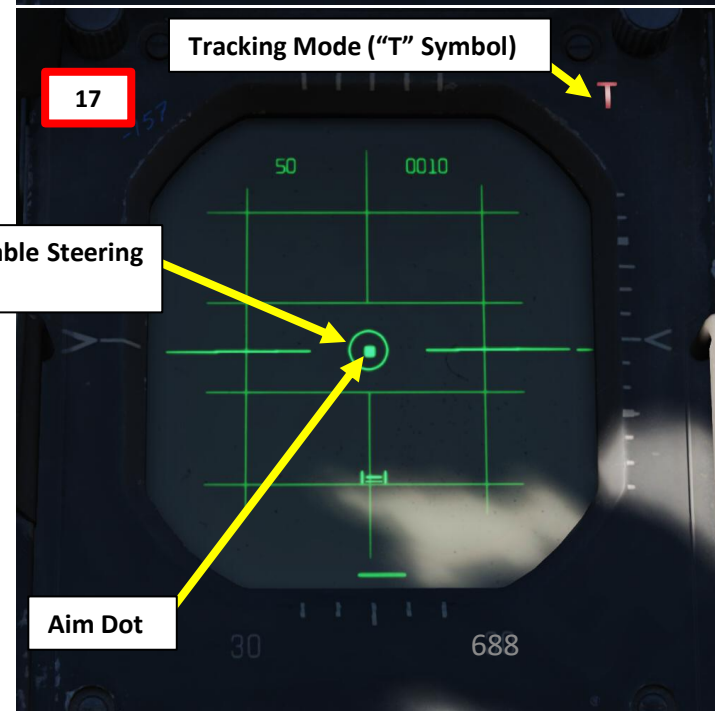
16. *[WSO]* Once the radar cursor is slewed over the target, press the Hand Control Stick Trigger's second detent (Full-Action).
    - Note: the first stage of the trigger (referred as "**half-action**") will initiate the visibility of the range strobe and allow positioning of the antenna in azimuth. The second stage of the trigger (referred as "**full-action**") will attempt an automatic lock-on if the range is set to 50 nm or less and the range strobe is positioned over the desired target.
17. *[WSO]* The radar will enter "acquisition mode" and automatically attempt to track (radar lock) the target.
18. *[WSO]* Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
        - If the target is manually tracked, or AOJ (Angle-On-Jam) or HOJ (Home-On-Jam) track conditions are effective, the SKIN TRK light will not illuminate
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears, which indicates the maximum lead or lag at which the missile can be launched and will still retain a high probability of hit
    - The Aim Dot appears, which provides steering commands to the pilot
19. *[WSO]* If you want to "unlock" the target, press the Hand Control Stick Trigger's second detent (Full-Action).

Radar Cursor (Acquisition Symbol)
- *Used to select targets and displays the current selected range and azimuth. It is moved by the Antenna Hand Control.*





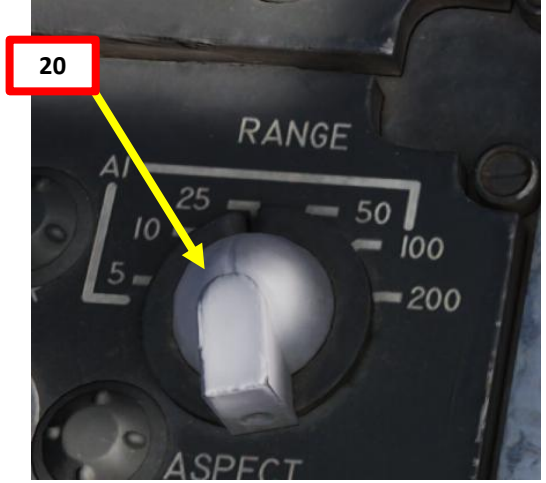




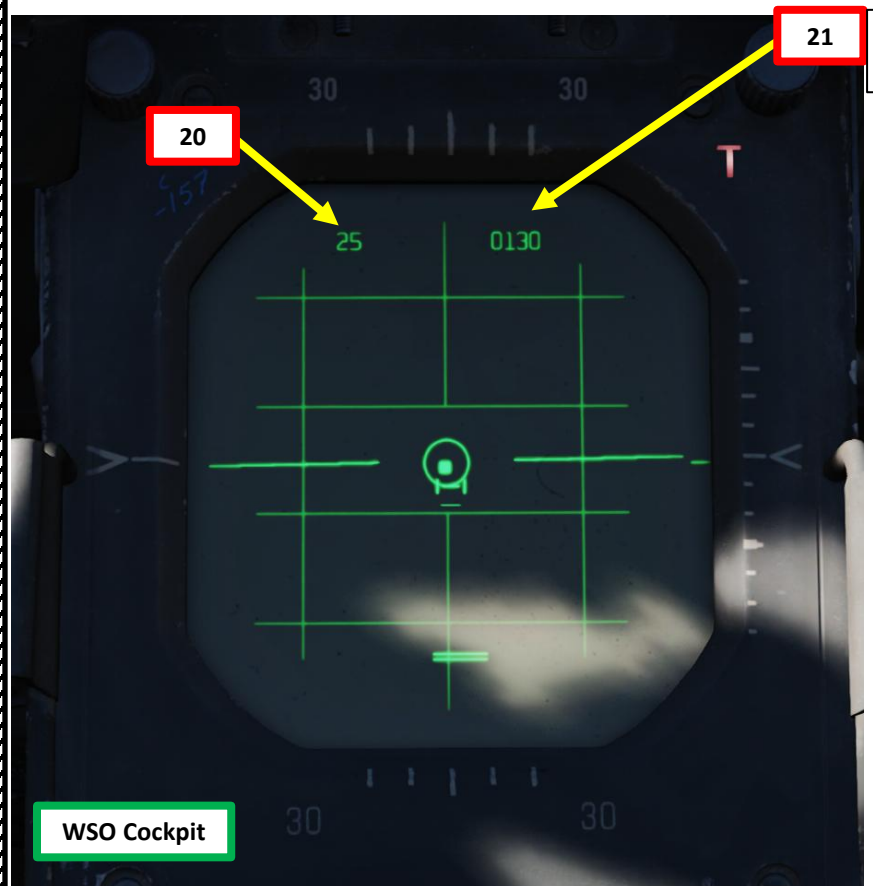
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

A – Perform Radar Lock

20. *[WSO]* Adjust gain and range accordingly to ensure good target visibility.
21. *[WSO]* If time allows for it, verify the validity of the target lock by using the Aspect Selector. I recommend leaving the Aspect Selector to AFT for faster and more accurate missile speedgate lockon.
    - WIDE Setting: Target Closure Velocity is displayed (kts)
    - NOSE Setting: Target Altitude is displayed (in hundreds of ft)
    - FWD Setting: Target Aspect Angle is displayed
    - AFT Setting: Target Closure Velocity is displayed (kts)
    - TAIL Setting: Target Heading is displayed







Aspect Selector – AFT Setting
- *Displays Closure Velocity (kts)*

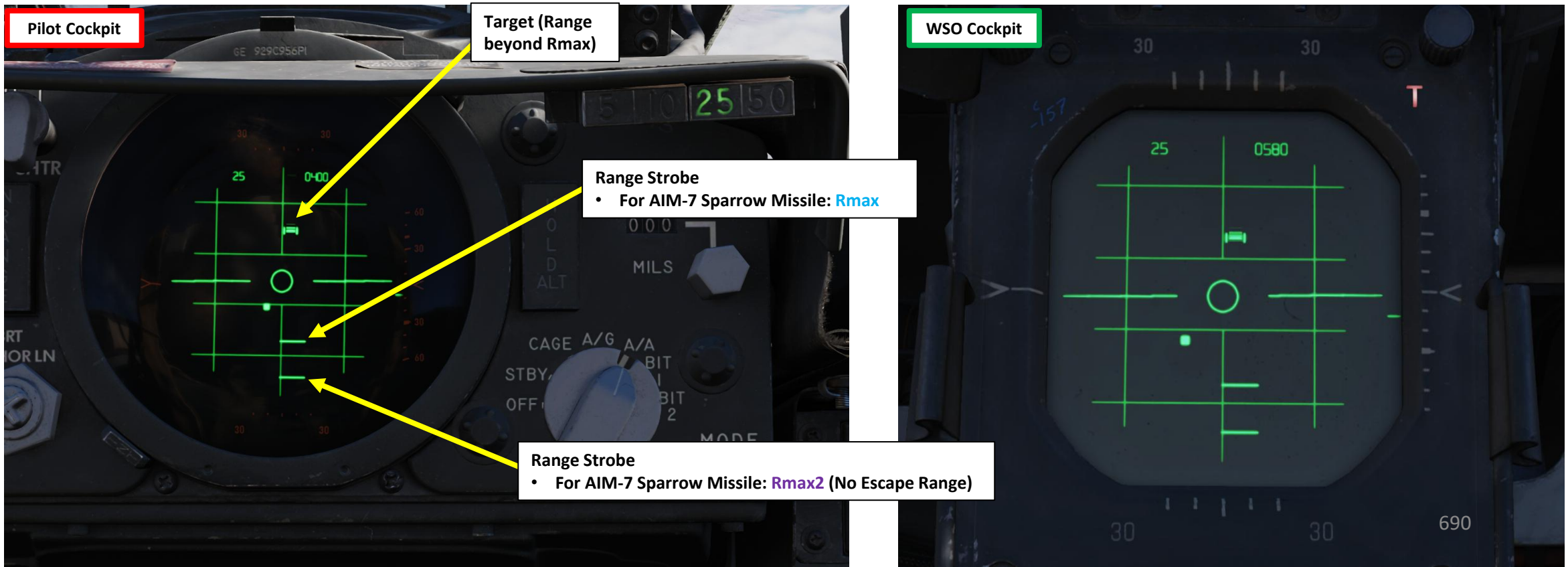
Selection	DSCG Display
WIDE	Closure Velocity
NOSE	Altitude
FWD	Aspect
AFT	Closure Velocity
TAIL	Heading



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

A – Perform Radar Lock

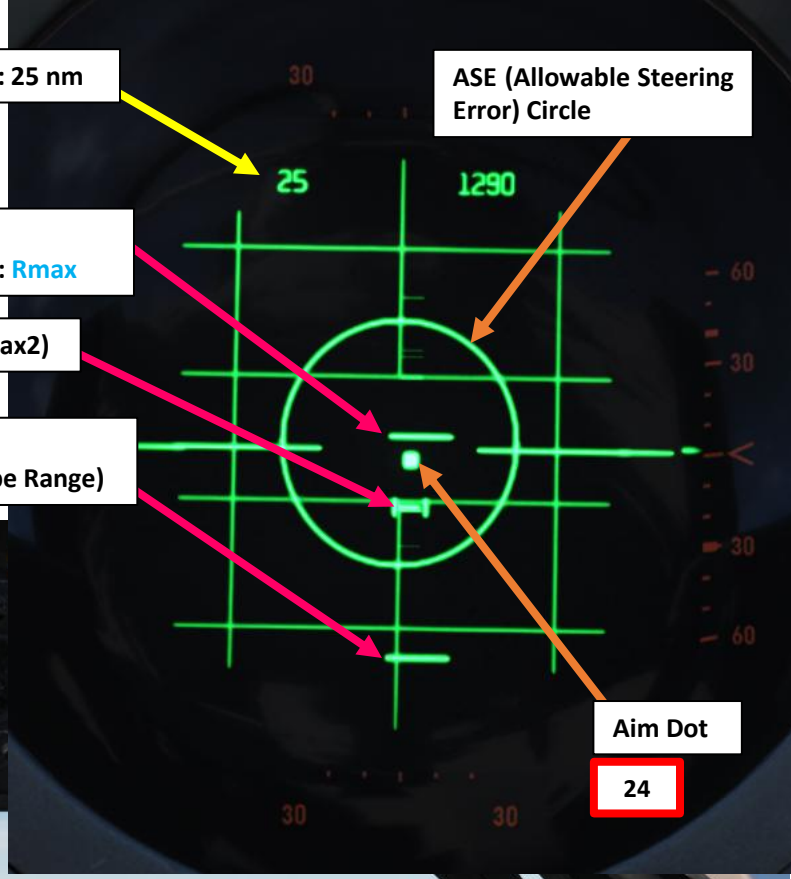
22. If Sparrows are selected and ready for employment, take note that the radar display will also show two range strobes. If an AIM-7 Sparrow Missile is selected: range strobes display **Rmax** (Maximum range capability of the missile provided the target continues flying on current heading and course) and **Rmax2** (Maximum range capability of the missile provided the target performs the shortest high-G turn to tail aspect, also referred as the "no escape range").
    - Note: **Rmax2** rate is based on altitude (8G up to 20000 ft, 6G to 35000 ft, and 4G above 35000 ft).
23. *[WSO]* Once radar lock is obtained, it is good practice for the WSO to count down 4 seconds out loud for the set-in period of the AIM-7E missile's speed-gate (or 2 seconds for the AIM-7F). This will let the pilot know when the missile is ready to be fired by calling out "1 Mississipi, 2 Mississipi, 3 Mississipi, 4 Mississipi, Shoot". Should this delay not be adhered to, the missile may fail to track because of improper target doppler injection.

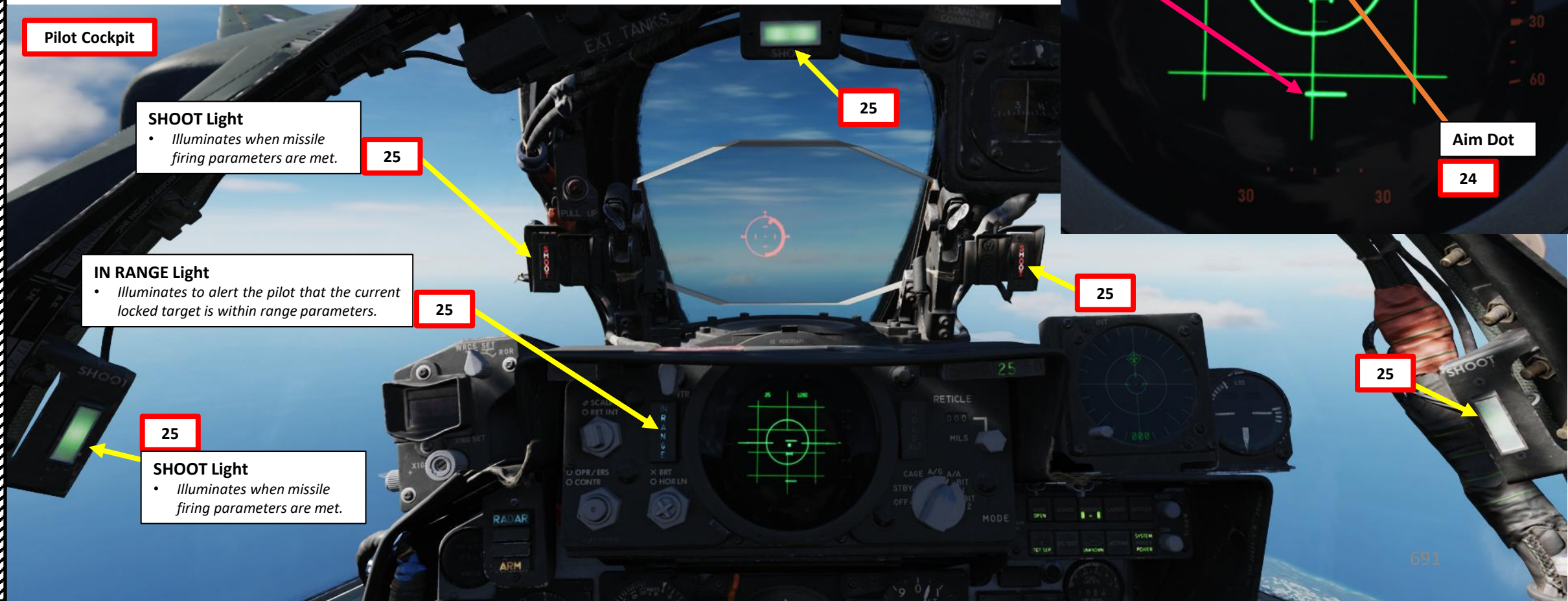


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

B – Engage Target

24. *[P]* Manoeuver the aircraft to center the Aim Dot inside the ASE (Allowable Steering Error) Circle.
25. *[P]* When the IN RANGE and SHOOT lights illuminate, this means the Aim Dot is inside the ASE Circle and that the Target is within Rmax and Rmin (Minimum missile range). This also means that the missile interlock requirements are met and the missile can be fired. Keep in mind that firing a Sparrow at long range will very likely yield a very low PK (probability of kill).





3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

A note about interlocks:
Depending on the position of the Interlock switch, the fire control system may inhibit missile launch if range limits, ASE (Allowable Steering Error) limits or radar restrictions inhibit missile launch (Interlock Switch IN).

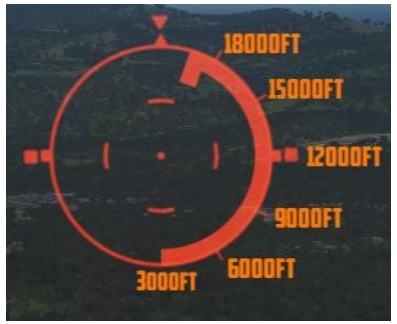
If Interlock switch is OUT, the AIM-7 will fire even if no launch conditions are met.

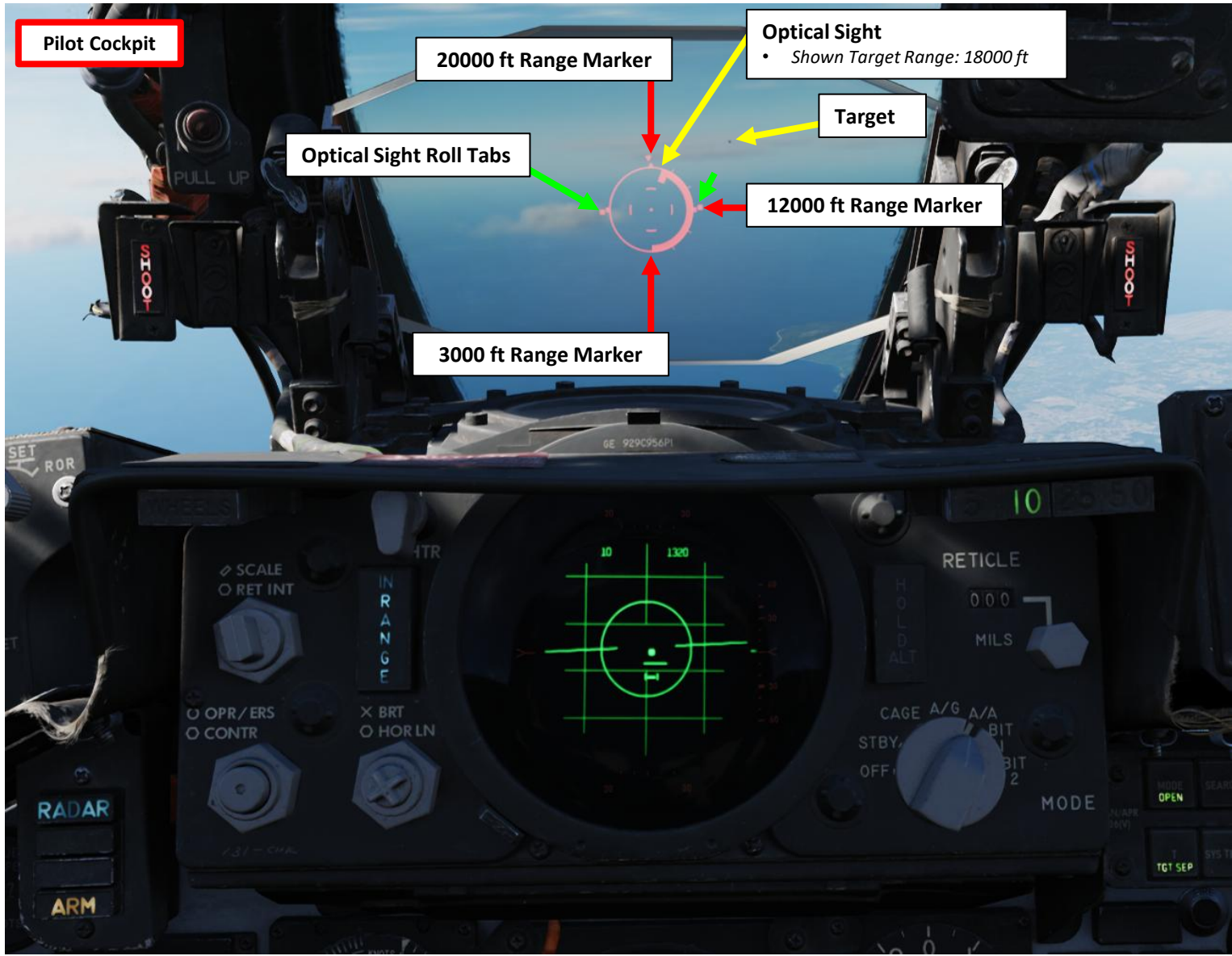
B – Engage Target

26. *[P]* With the Sight Mode Selector set to A/A (Air-to-Air), the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target, displaying ranges up to 20,000 ft (top) to 3000 ft (bottom), with 12,000 ft signified at the 3 o-clock position. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time). The sight is stabilized at the Radar Boresight Line (RBL); **it will NOT follow the target**.
27. *[P]* Squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired. While the missile's maximum range is 26 nm, try to launch within 10 nm (effective range).
    - Note: A second AIM-7 can be fired immediately at the same target, if desired, by releasing then squeezing the trigger a second time, holding it on the second actuation.



Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

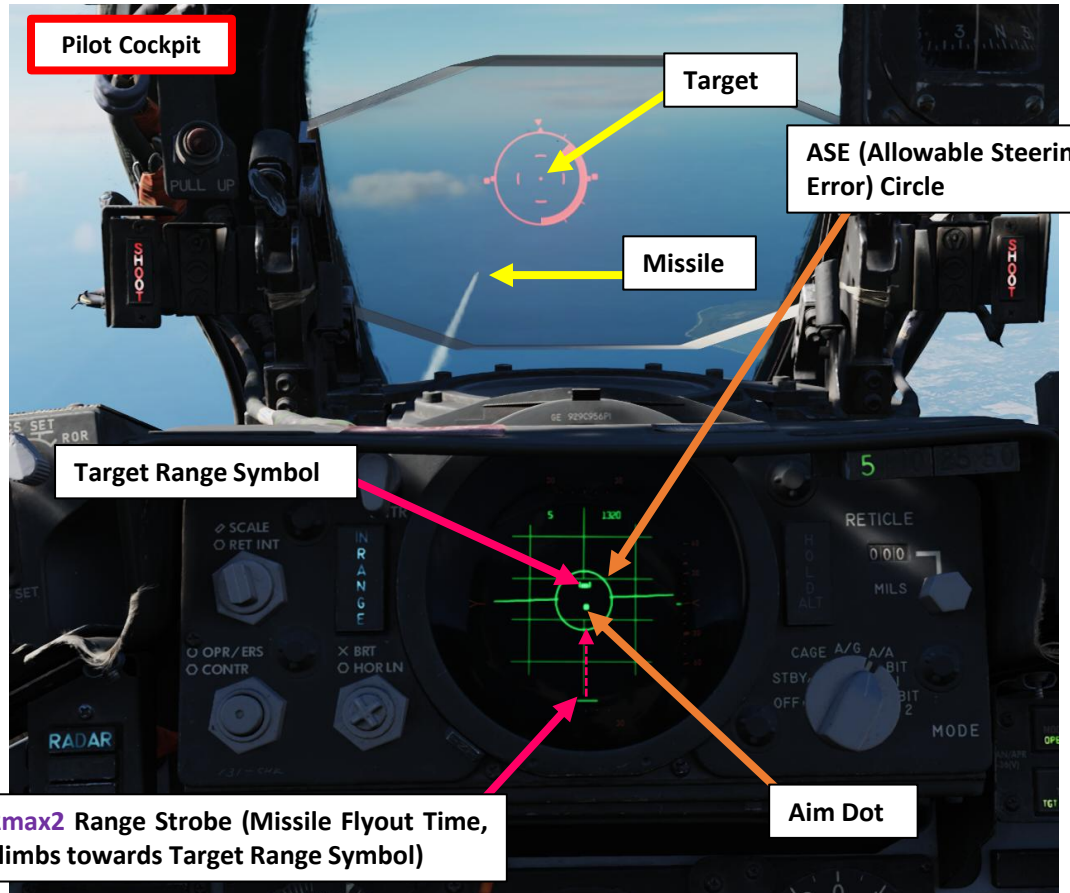




3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

B – Engage Target

28. *[P]* Once missile is fired, fly the aircraft to maintain radar lock since the missile is guided by the radar. Maintain aiming dot within the ASE (Allowable Steering Error) Circle.
29. *[P]* After missile launch, the Rmax2 strobe falls to the bottom of the display and begins driving upwards towards the target lock symbol; this functions as a missile flyout time. When the Rmax2 strobe (timer) reaches the locked target, it can be assumed that the missile has reached the target.







3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

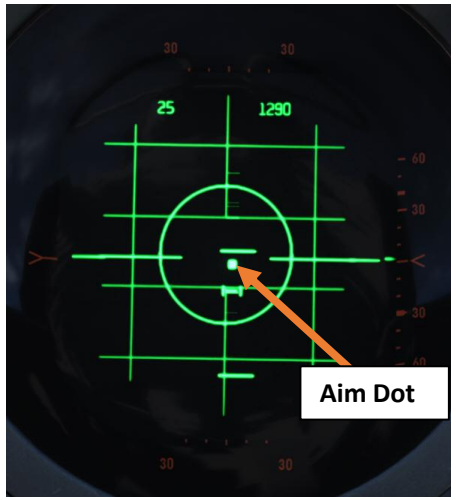
Aim Dot Interception Profiles

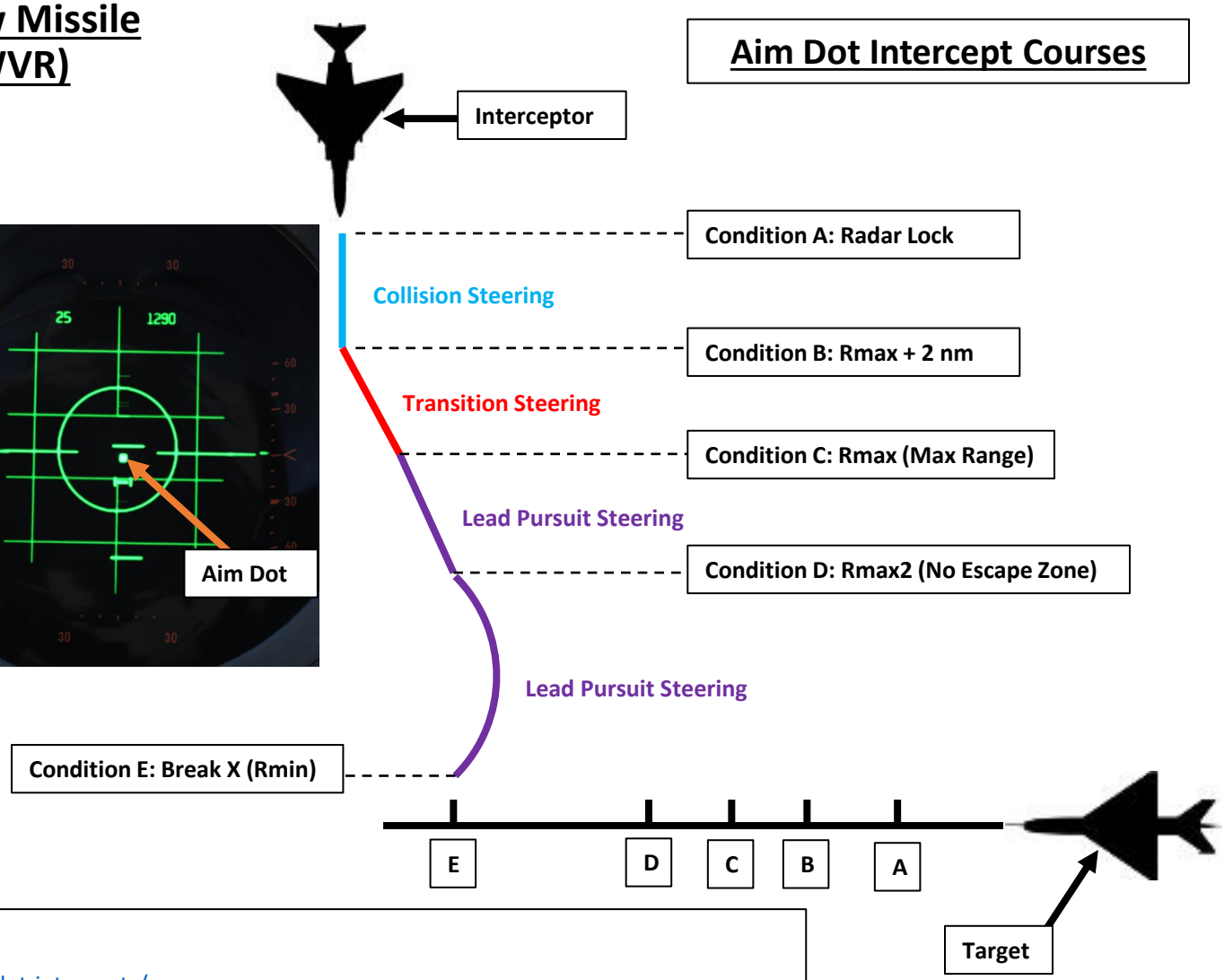
The aim dot provides steering commands to the pilot in order to intercept a radar locked target. These types vary depending on the range to target and other factors.

Three different aim dot intercept types are as follows:

- **Collision Steering**: minimizes time to intercept by putting the fighter on an intercept course.
- **Transition Steering**: begins 2 nm outside Rmax and steers the aircraft towards the next steering type.
- **Lead Pursuit Steering**: Begins inside Rmax, lead pursuit minimizes the missile's post-launch maneuvers.

These steering commands can be very useful in order to guide you towards a target. There are a number of great techniques which are explained in depth by FlyAndWire. See reference below.





F-4E Air-to-Air Tactics Series by FlyAndWire

- First Steps: https://flyandwire.com/2024/05/18/f-4e-air-to-air-i-first-steps/
- Aim Dot Intercepts: https://flyandwire.com/2024/05/22/f-4e-air-to-air-ii-aim-dot-intercepts/
- VISIDENT Mode: https://flyandwire.com/2024/05/24/f-4e-air-to-air-iii-visident/
- SYNC-Z-TURN Intercept Technique: https://flyandwire.com/2024/08/02/f-4e-air-to-air-v-sync-z-turn-essential/
- Assess CATA (Collision Antenna Train Angle) & Bandit Heading: https://flyandwire.com/2024/09/04/f-4e-air-to-air-vi-assess-cata-bandit-heading-essential/
- "40 deg Cold of CATA" Intercept Technique: https://flyandwire.com/2024/09/18/f-4e-air-to-air-vii-40-cold-of-cata-intercept-technique/

3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

Additional Notes

Missile SHOOT Restrictions

If AIM-7s are selected when the target aspect is 90 ±9 degrees (left or right) and the target is lower than 5 degrees above the horizon, the SHOOT lights are inhibited. This prevents shooting a Sparrow into the main lobe clutter.

The HOLD ALTITUDE Light

When the light is illuminated, the azimuth error in the aim dot should be corrected only when the light goes out. The fighter should snap up to center the aim dot. The Hold Altitude Light illuminates provided the following conditions are met:

- Range is greater than the computed snap-up range.
- Altitude is greater than 32,000 ft.
- The target is more than 8000 feet above the fighter.

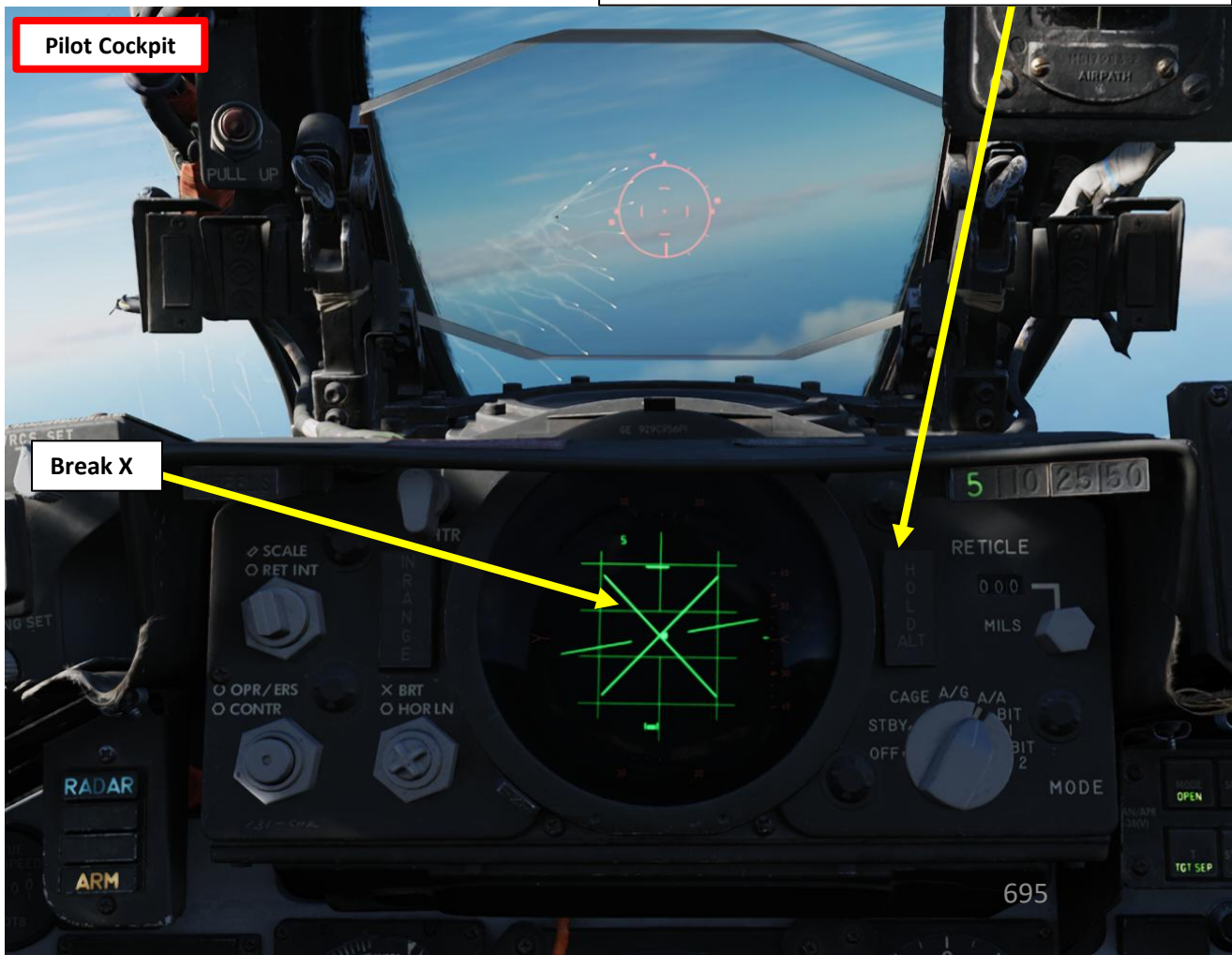
Break X (Rmin, Minimum Missile Range)

If Rmin (Minimum missile range) is attained for a Sparrow launch, the radar display reverts to a break X warning superimposed over the radar image.

In all modes (except VI) when the target is lower in range than the calculated Rmin the Break X symbol will be displayed to indicate minimum range condition. In Visual Intercept (VI), break X is displayed when range is less than 1000 ft. When break X is displayed, the ASE Circle is also removed.

HOLD ALT Light

- *Illuminates as an instruction to the pilot from the fire control system to maintain current altitude to assist in a snap-up intercept situation against a target above the fighter.*



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.3 – With Multicrew: Within Visual Range (WVR)

Useful Kneeboards from FlyAndWire

ANTENNA ELEVATION ANGLE

FLYANDWIRE.CO v0.1

ANTENNA ELEVATION [DEGREES] – Δ ALTITUDE vs RANGE

	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	150
1000	1.9	0.9	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
2000	3.8	1.9	1.3	0.9	0.8	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1
3000	5.6	2.8	1.9	1.4	1.1	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2
4000	7.5	3.8	2.5	1.9	1.5	1.3	1.1	0.9	0.8	0.8	0.6	0.5	0.5	0.4	0.4	0.3
5000	9.3	4.7	3.1	2.4	1.9	1.6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.3
6000	11.2	5.6	3.8	2.8	2.3	1.9	1.6	1.4	1.3	1.1	0.9	0.8	0.7	0.6	0.6	0.4
7000	13.0	6.6	4.4	3.3	2.6	2.2	1.9	1.6	1.5	1.3	1.1	0.9	0.8	0.7	0.7	0.4
8000	14.8	7.5	5.0	3.8	3.0	2.5	2.2	1.9	1.7	1.5	1.3	1.1	0.9	0.8	0.8	0.5
9000	16.5	8.4	5.6	4.2	3.4	2.8	2.4	2.1	1.9	1.7	1.4	1.2	1.1	0.9	0.8	0.6
10000	18.2	9.3	6.3	4.7	3.8	3.1	2.7	2.4	2.1	1.9	1.6	1.3	1.2	1.0	0.9	0.6
12500	22.4	11.6	7.8	5.9	4.7	3.9	3.4	2.9	2.6	2.4	2.0	1.7	1.5	1.3	1.2	0.8
15000	26.3	13.9	9.3	7.0	5.6	4.7	4.0	3.5	3.1	2.8	2.4	2.0	1.8	1.6	1.4	0.9
17500	29.9	16.1	10.9	8.2	6.6	5.5	4.7	4.1	3.7	3.3	2.7	2.4	2.1	1.8	1.6	1.1
20000	33.4	18.2	12.4	9.3	7.5	6.3	5.4	4.7	4.2	3.8	3.1	2.7	2.4	2.1	1.9	1.3
25000	39.5	22.4	15.3	11.6	9.3	7.8	6.7	5.9	5.2	4.7	3.9	3.4	2.9	2.6	2.4	1.6
30000	44.6	26.3	18.2	13.9	11.2	9.3	8.0	7.0	6.3	5.6	4.7	4.0	3.5	3.1	2.8	1.9
35000	49.0	29.9	21.0	16.1	13.0	10.9	9.3	8.2	7.3	6.6	5.5	4.7	4.1	3.7	3.3	2.2

MNEMONIC FORMULA: ANTENNA ELEVATION ANGLE (AEA)

AEA = Δ_{ALT} / (SR*100) *or* AEA = Δ_{ALT}[*h ft*]/ SR
SR = Δ_{ALT}[*h ft*] / AEA
Δ_{ALT}[*h ft*] = AEA * SR

EXAMPLE I
ALT_{F-4} = 30,000 ft
ALT_{TGT} = 15,000 ft
Δ_{ALT} = 15,000 ft → 150 [h ft]
SR = 15 nm
AEA = 150 / 15 = 10°

EXAMPLE II
SR = 5 nm
AEA = 15°
Δ_{ALT} = 15° * 5 = 75 [h ft] = 7500 ft

UP DN
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ALTITUDE DIFFERENCE

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Δ ALTITUDE [1000s OF FEET] – RANGE VS EL STROBE

	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	20°	25°	30°	35°	40°
1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.6	3.0	3.5	3.9
2	0.2	0.4	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	4.2	5	6	7	8
3	0.3	0.6	1.0	1.3	1.6	1.9	2.2	2.5	2.9	3.2	3.5	3.8	4.1	4.4	4.7	6	8	9	10	12
4	0.4	0.8	1.3	1.7	2.1	2.5	3.0	3.4	3.8	4.2	4.6	5	5	6	6	8	10	12	14	16
5	0.5	1.1	1.6	2.1	2.6	3.2	3.7	4.2	4.8	5	6	6	7	7	8	10	13	15	17	20
6	0.6	1.3	1.9	2.5	3.2	3.8	4.4	5	6	6	7	8	8	9	9	12	15	18	21	23
7	0.7	1.5	2.2	3.0	3.7	4.4	5	6	7	7	8	9	10	10	11	15	18	21	24	27
8	0.8	1.7	2.5	3.4	4.2	5	6	7	8	8	9	10	11	12	13	17	21	24	28	31
9	1.0	1.9	2.9	3.8	4.8	6	7	8	9	9	10	11	12	13	14	19	23	27	31	35
10	1.1	2.1	3.2	4.2	5	6	7	8	10	11	12	13	14	15	16	21	26	30	35	39
11	1.2	2.3	3.5	4.7	6	7	8	9	10	12	13	14	15	16	17	23	28	33	38	43
12	1.3	2.5	3.8	5	6	8	9	10	11	13	14	15	16	18	19	25	31	36	42	47
13	1.4	2.8	4.1	6	7	8	10	11	12	14	15	16	18	19	20	27	33	39	45	
14	1.5	3.0	4.5	6	7	9	10	12	13	15	16	18	19	21	22	29	36	43	49	
15	1.6	3.2	4.8	6	8	10	11	13	14	16	17	19	21	22	24	31	39	46		
20	2.1	4.2	6	8	11	13	15	17	19	21	23	25	27	29	31	42				
25	2.7	5	8	11	13	16	19	21	24	26	29	32	34	37	39					
30	3.2	6	10	13	16	19	22	25	29	32	35	38	41	44	47					
35	3.7	7	11	15	19	22	26	30	33	37	41	44	48							
40	4.2	8	13	17	21	25	30	34	38	42	46									
45	4.8	10	14	19	24	29	33	38	43	47										
50	5	11	16	21	26	32	37	42	48											
60	6	13	19	25	32	38	44													
70	7	15	22	30	37	44														
80	8	17	25	34	42															
90	10	19	29	38	48															
100	11	21	32	42																
150	16	32	48																	
200	21	42																		

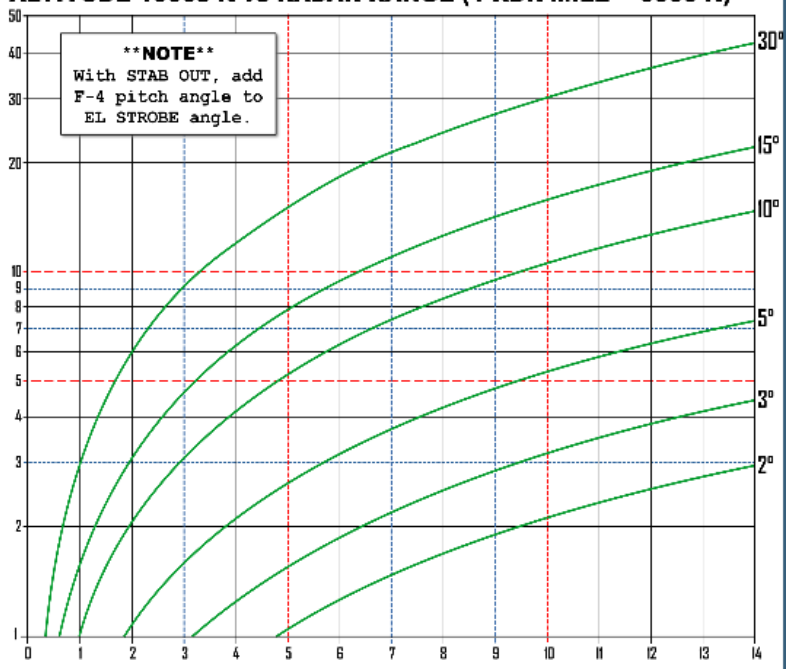
NOTE
With STAB OUT, add F-4 pitch angle to EL STROBE angle.

UP DN
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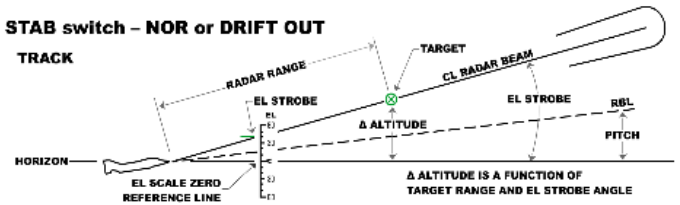
EL STROBE INTERPRETATION

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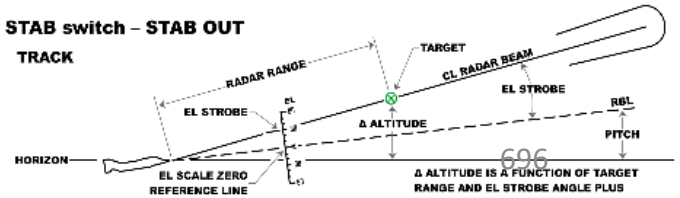
ALTITUDE 1000s ft vs RADAR RANGE (1 RDR MILE = 6000 ft)



STAB switch – NOR or DRIFT OUT



STAB switch – STAB OUT



UP DN
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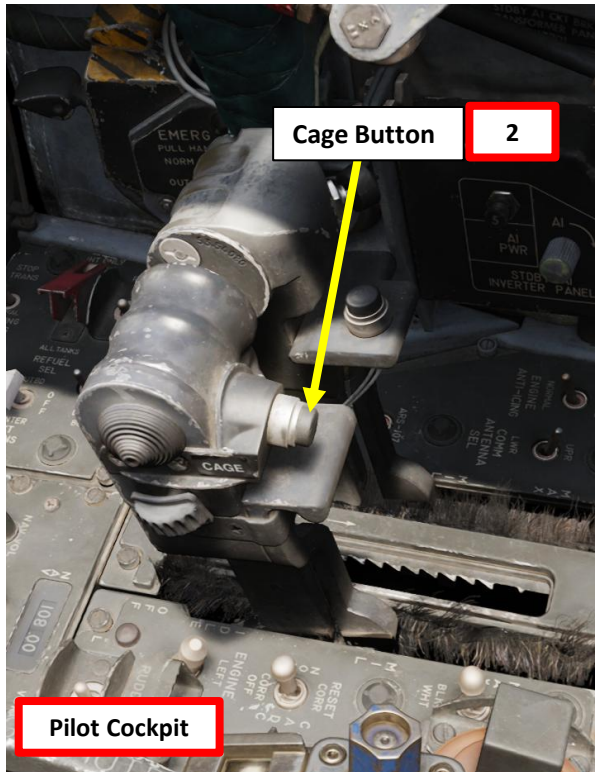
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

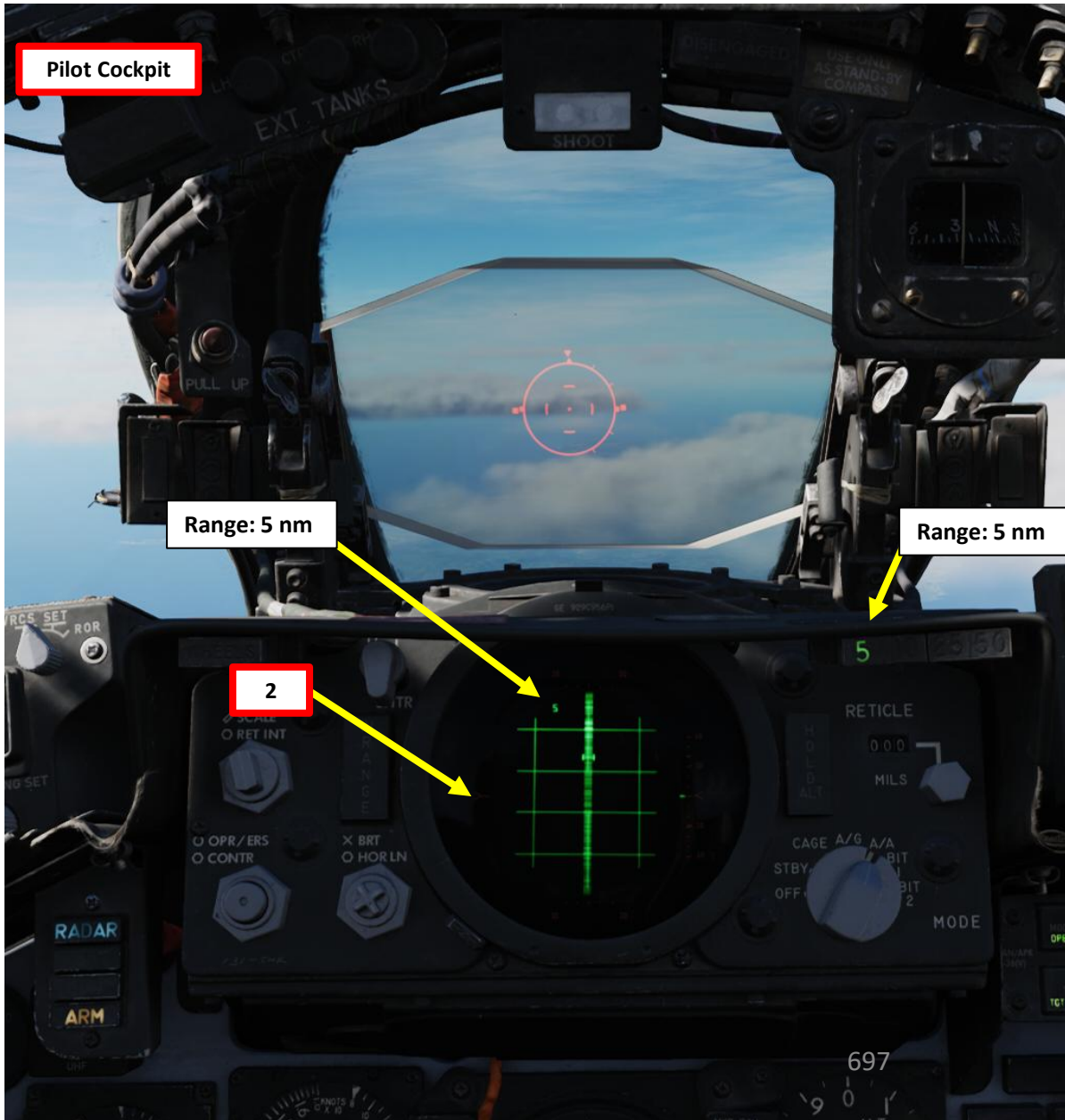
A – Perform Radar Lock

In order to perform search a track (lock) a target that is within visual/close range, the pilot is typically better positioned to perform the radar lock. Be aware not to confuse "Cage Mode" and "CAA (Computer Automatic Acquisition) Mode" since they are related but serve different functions.

1. *[WSO]* Set Radar Power Selector – OPR (Operate).
    - Ensure that the radar warm-up cycle (3 minutes) has been performed prior to this step.
2. *[P]* Select **Cage Mode** by depressing the Cage button on the pilot's throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.



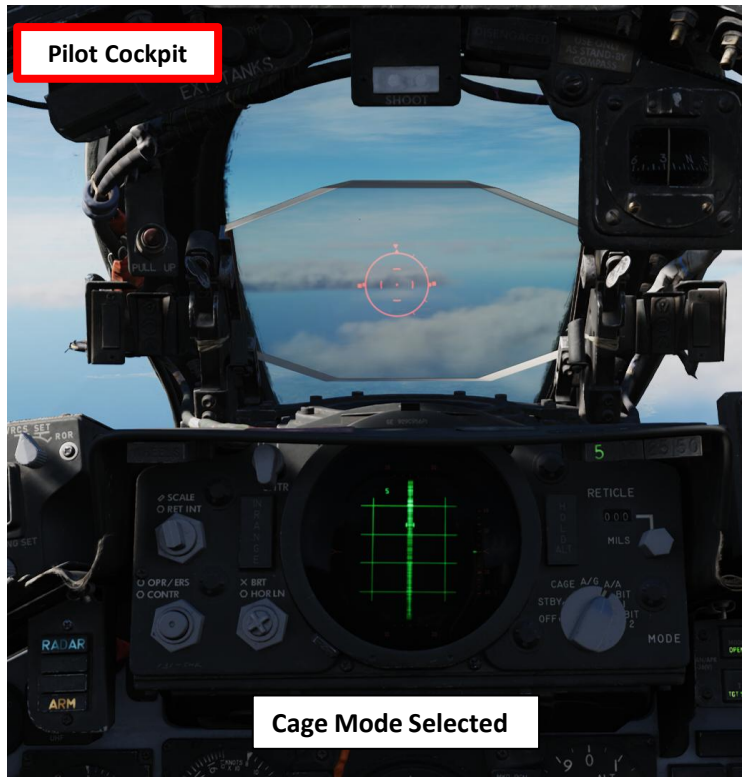




3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

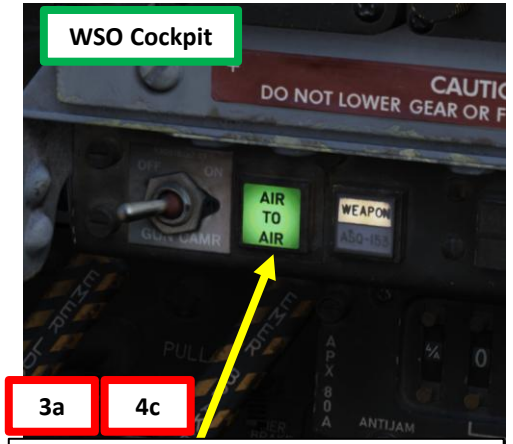
A – Perform Radar Lock

3. *[P]* When Cage mode is selected:
   a) The Air-To-Air light in the rear pit illuminates
   b) Trigger control is transferred to the air-to-air weapons (including when ARM and TV are selected)
   c) The Optical sight switches into A/A mode
   d) CAA (Computer Automatic Acquisition) mode becomes available for selection.
4. Additional Notes about Cage Mode:
   a) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch on the throttle is in RADAR or HEAT, the radar breaks track and returns to boresight.
   b) If a track condition exists before the Cage Button is pressed and the Gun/Missile Pinky switch is in GUNS, the lock is not broken.
   c) Cage Mode can be exited with the pilot's Weapon Select Knob (set into or out of the B position) or with the WSO pressing the Air-to-Air Button.





Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*





Air-to-Air Light
- *Illuminates when CAGE mode is activated.*
- *Pressing the light reverts the radar to the original operating condition prior to CAGE entry.*

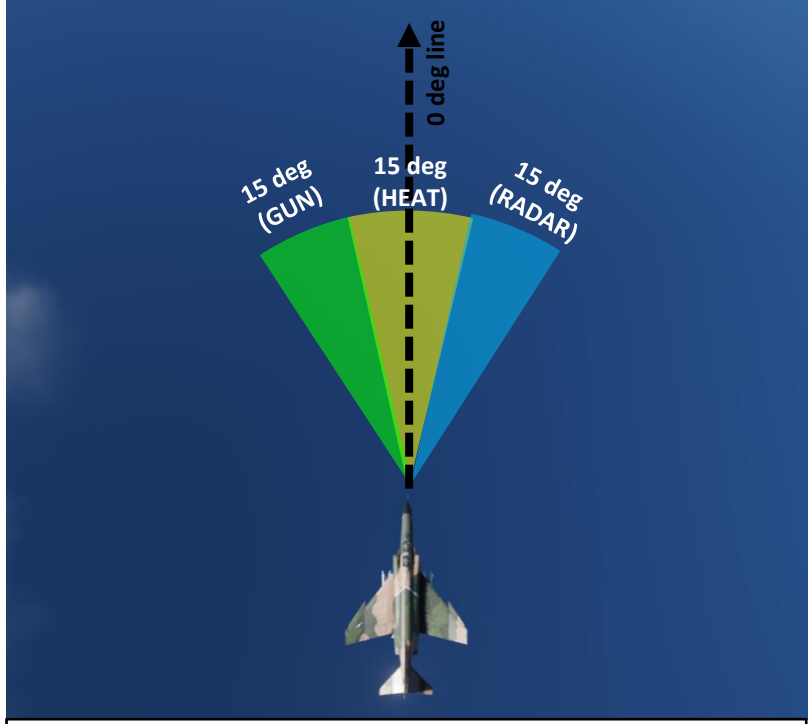
Weapon Selector Knob
- *B: Cancels air-to-air missile CAGE requirement.*



3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

A – Perform Radar Lock

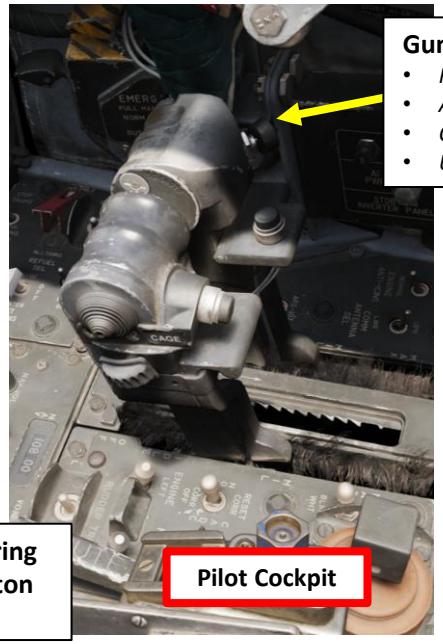
5. *[P]* Select **CAA (Computer Automatic Acquisition) Mode** by pressing the Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button on either the Pilot (or WSO stick).
6. *[P]* When CAA Mode is selected:
   a) The radar enters a vertical-oriented scan pattern 78 degrees in height by 15 degrees wide, the scan is 3 vertical bars wide.
   b) Actual radar lock capability within this scan pattern is from +45 degrees above the horizon line to -9 degrees below the horizon line due to radar's software limitation.
   c) In the event that the radar finds a suitable target within the scan volume, the target will be automatically locked.
   d) Should the flight crew find the locked target not be the one intended, the Nose Gear Steering button can be pressed on either stick grip to return the radar back to the search pattern.
7. *[P]* In CAA mode, the radar's search pattern can be shifted left and right utilizing the pinky switch on the throttle.
   - Pinky Switch – AFT (GUNS): Scan Center is 15 deg Left
   - Pinky Switch – CENTER (HEAT): Scan Center is centered (0 deg)
   - Pinky Switch – FWD (RADAR): Scan Center is 15 deg Right



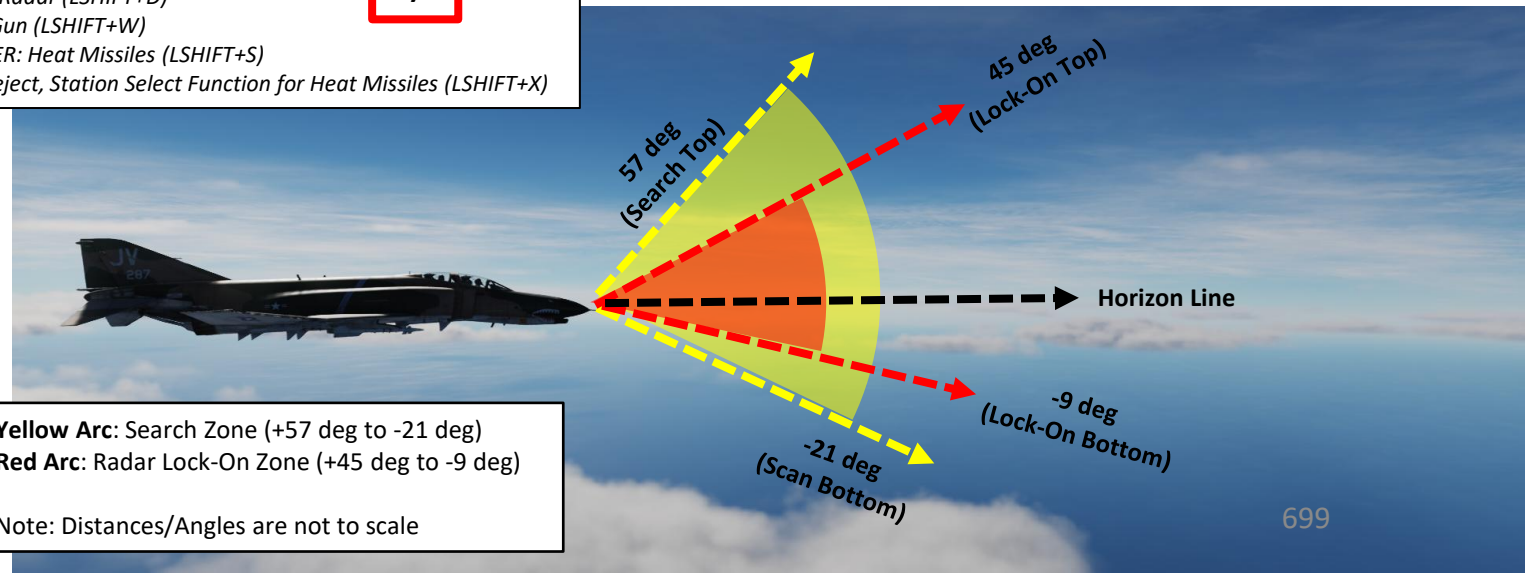
Green Arc: Left Corridor (Gun/Missile Pinky Switch AFT (GUN))
Yellow Arc: Center Corridor (Gun/Missile Pinky Switch CENTER (HEAT))
Blue Arc: Right Corridor (Gun/Missile Pinky Switch FWD (RADAR))



Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button
- *Binding: N*



Gun/Missile Pinky Switch 7
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
- *UP: Reject, Station Select Function for Heat Missiles (LSHIFT+X)*



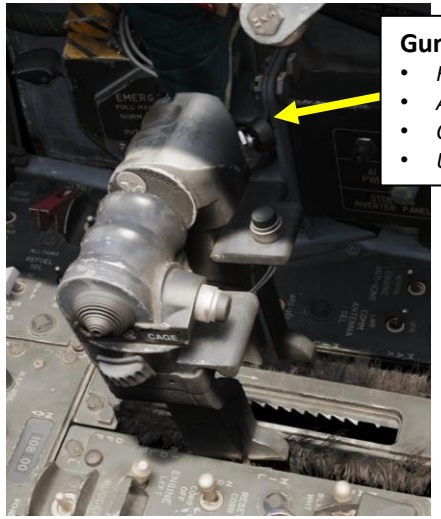
Yellow Arc: Search Zone (+57 deg to -21 deg)
Red Arc: Radar Lock-On Zone (+45 deg to -9 deg)

Note: Distances/Angles are not to scale

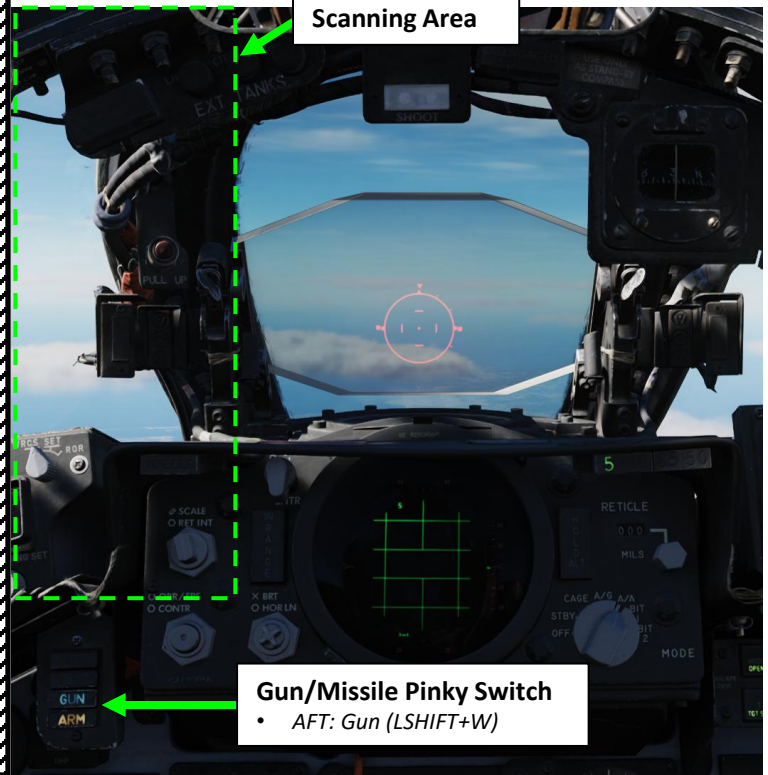
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

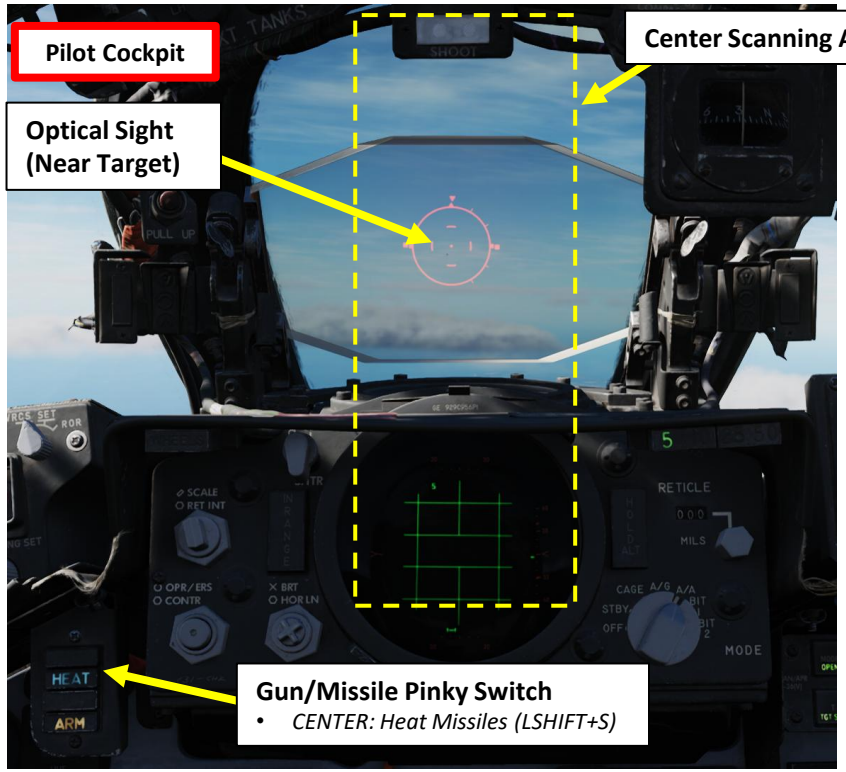
A – Perform Radar Lock

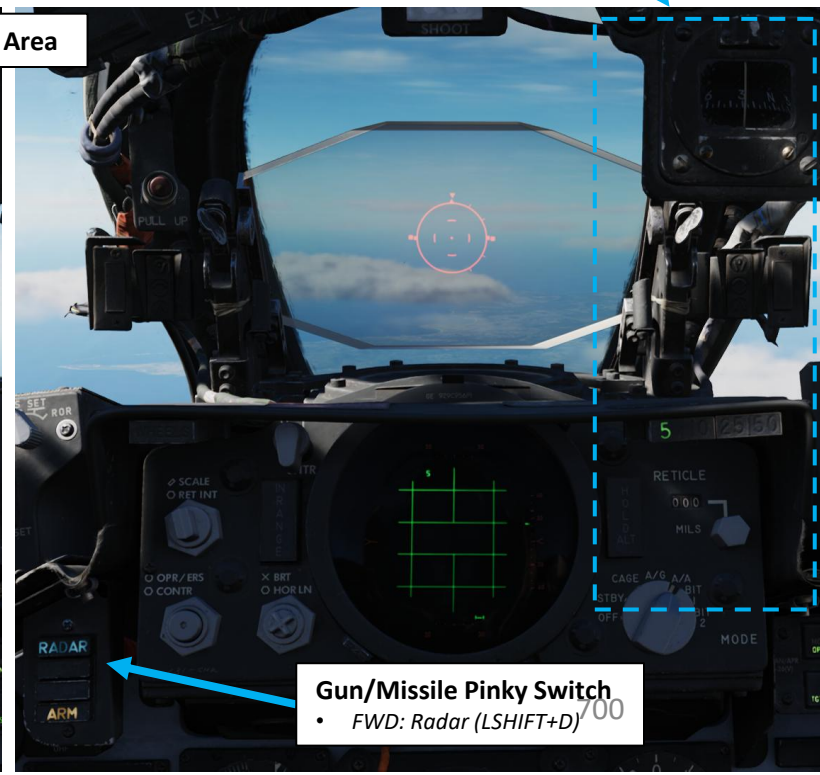
8. *[P]* I suggest leaving the Gun/Missile Pinky Switch in the CENTER (HEAT) position, which makes it easier to find a target and just line up the optical sight on it.
    - While in CAA mode, the GUN, HEAT and RADAR lights on the HUD (Heads-Up Display) are representative of the position of the Gun/Missile Pinky Switch, not which weapon is selected.
    - As mentioned previously, the position of the Gun/Missile Pinky switch in CAA mode defines where the radar is scanning.
9. *[P]* The pilot should visually line up the optical sight near the target. When the radar finds a suitable target within the scan volume and a 5 nm range, the target will be locked.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
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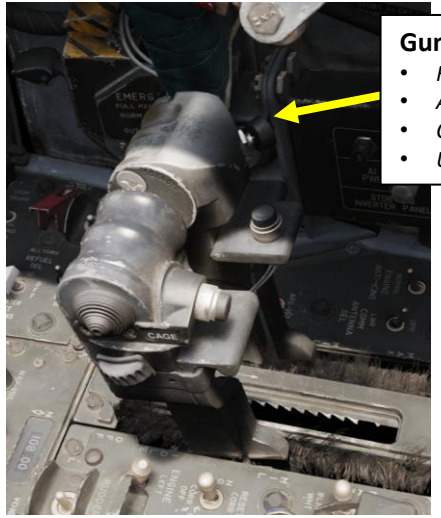




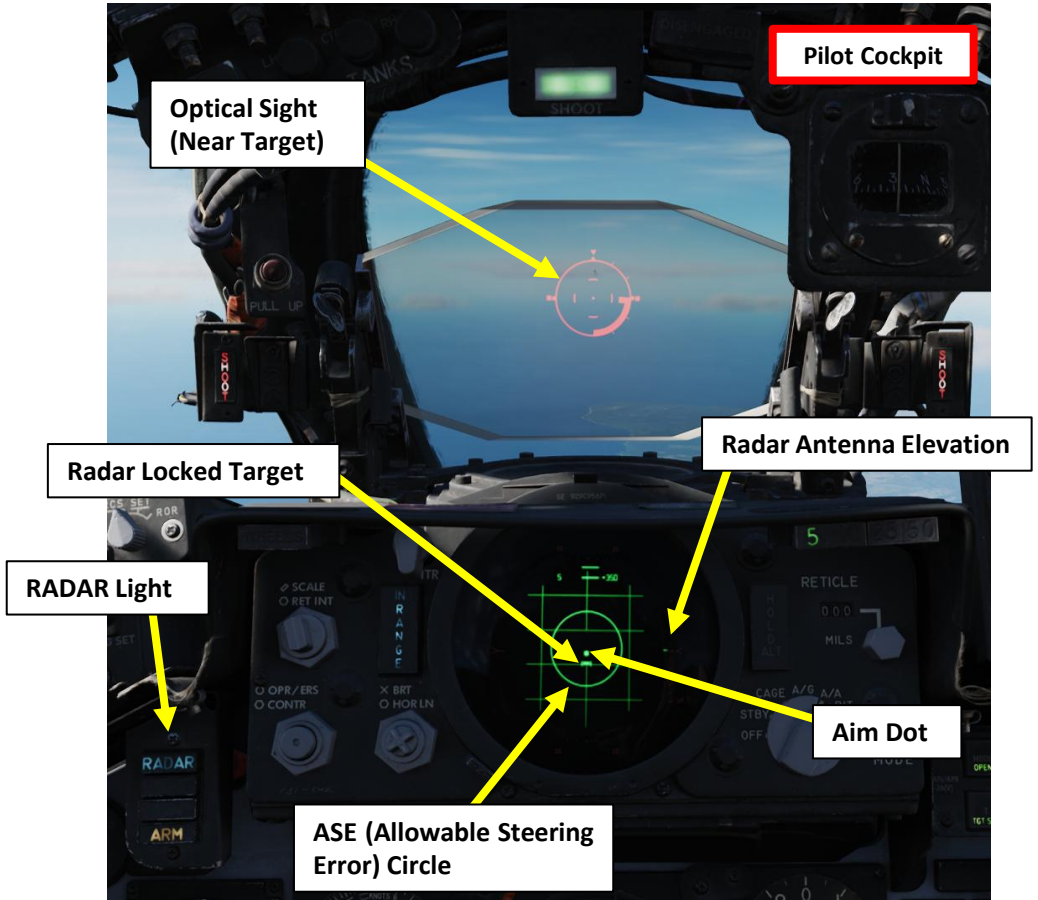
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

A – Perform Radar Lock

10. Once the target is tracked (radar locked):
    - The SKIN TRK (Skin Track) light illuminates
    - The "T" symbol illuminates if a range track condition is present
    - The ASE (Allowable Steering Error) Circle appears, which indicates the maximum lead or lag at which the missile can be launched and will still retain a high probability of hit
    - The Aim Dot appears, which provides steering commands to the pilot
11. *[P]* Set the Gun/Missile Pinky Switch in the FWD (RADAR) position to display AIM-7 symbology. Confirm that the RADAR light illuminates.



Gun/Missile Pinky Switch
- *FWD: Radar (LSHIFT+D)*
- *AFT: Gun (LSHIFT+W)*
- *CENTER: Heat Missiles (LSHIFT+S)*
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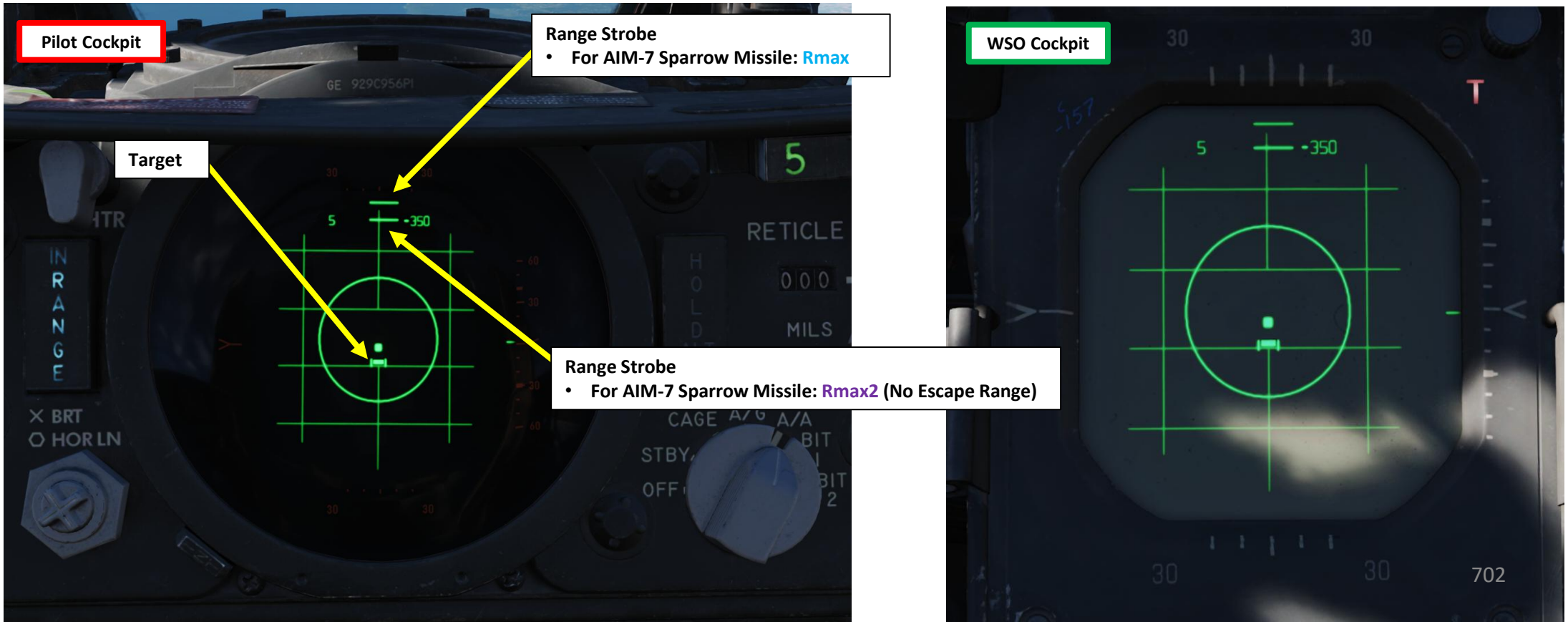




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3.3.4 – With Multicrew: Close Range (ACM)

A – Perform Radar Lock

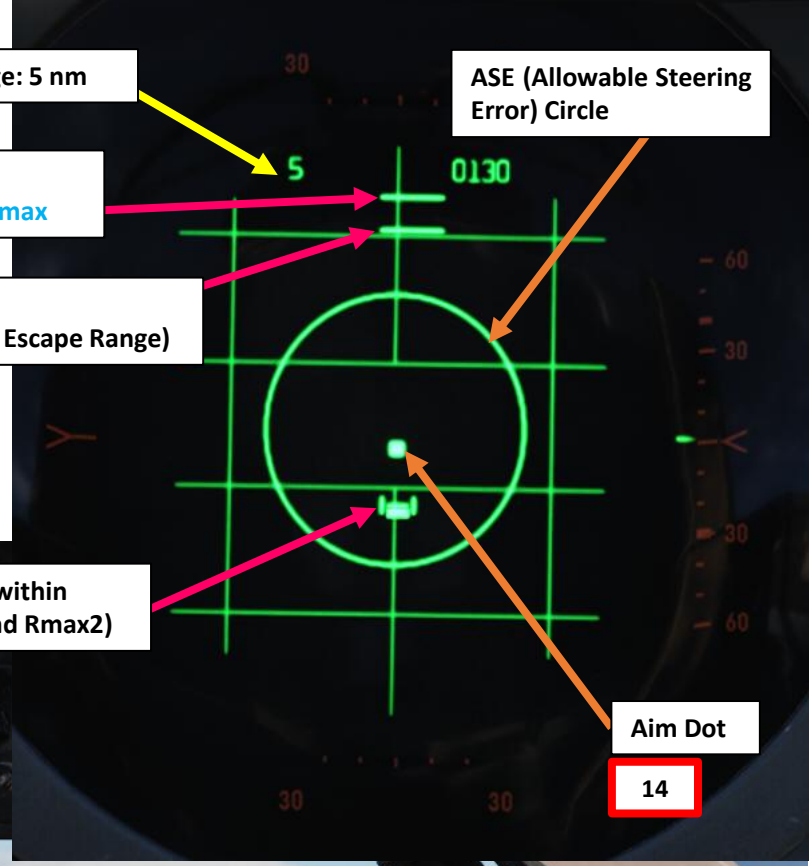
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    - Note: **Rmax2** rate is based on altitude (8G up to 20000 ft, 6G to 35000 ft, and 4G above 35000 ft).
13. *[P]* Once radar lock is obtained, it is good practice for the pilot to count down 4 seconds out loud for the set-in period of the AIM-7E missile's speed-gate (or 2 seconds for the AIM-7F). This will let the WSO know when the missile is ready to be fired by calling out "1 Mississipi, 2 Mississipi, 3 Mississipi, 4 Mississipi, Shoot". Should this delay not be adhered to, the missile may fail to track because of improper target doppler injection.

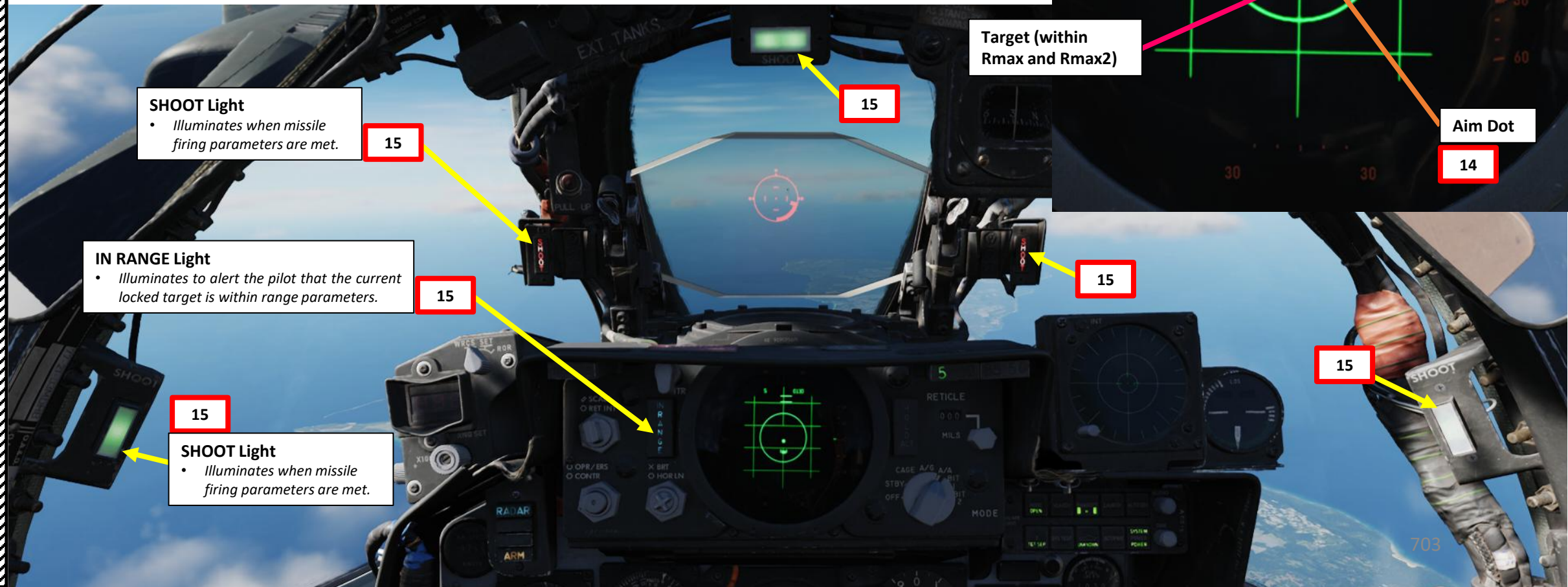


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

B – Engage Target

14. *[P]* Manoeuver the aircraft to center the Aim Dot inside the ASE (Allowable Steering Error) Circle.
15. *[P]* When the IN RANGE and SHOOT lights illuminate, this means the Aim Dot is inside the ASE Circle and that the Target is within Rmax and Rmin (Minimum missile range). This also means that the missile interlock requirements are met and the missile can be fired. Keep in mind that firing a Sparrow at long range will very likely yield a very low PK (probability of kill).





3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

A note about interlocks:
Depending on the position of the Interlock switch, the fire control system may inhibit missile launch if range limits, ASE (Allowable Steering Error) limits or radar restrictions inhibit missile launch (Interlock Switch IN).

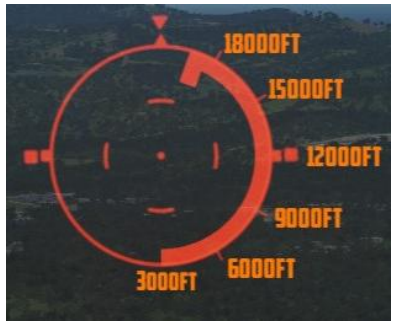
If Interlock switch is OUT, the AIM-7 will fire even if no launch conditions are met.

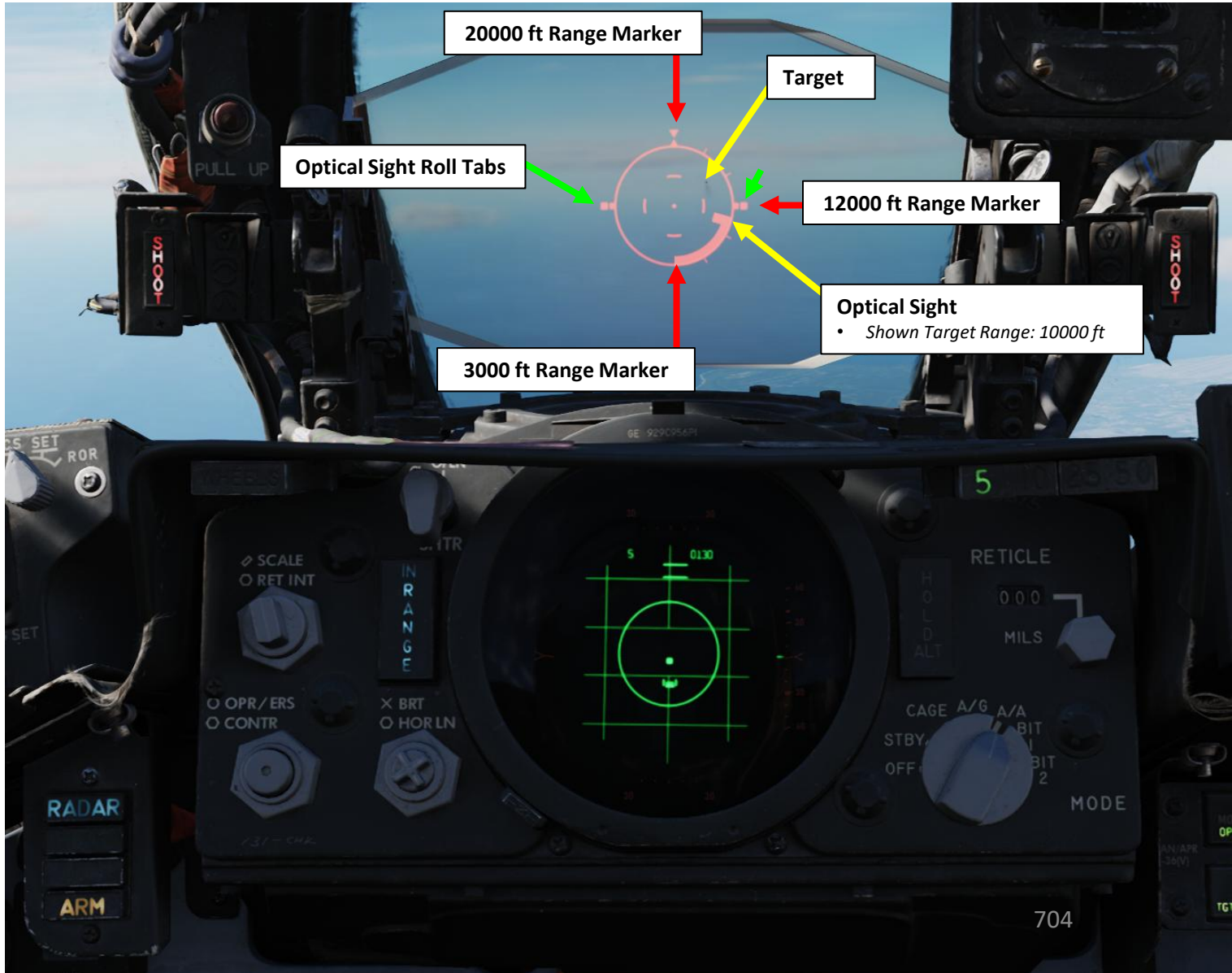
B – Engage Target

16. *[P]* With the Sight Mode Selector set to A/A (Air-to-Air), the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target, displaying ranges up to 20,000 ft (top) to 3000 ft (bottom), with 12,000 ft signified at the 3 o-clock position. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time). The sight is stabilized at the Radar Boresight Line (RBL); **it will NOT follow the target**.
17. *[P]* Squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired. While the missile's maximum range is 26 nm, try to launch within 10 nm (effective range).
    - Note: A second AIM-7 can be fired immediately at the same target, if desired, by releasing then squeezing the trigger a second time, holding it on the second actuation.



Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

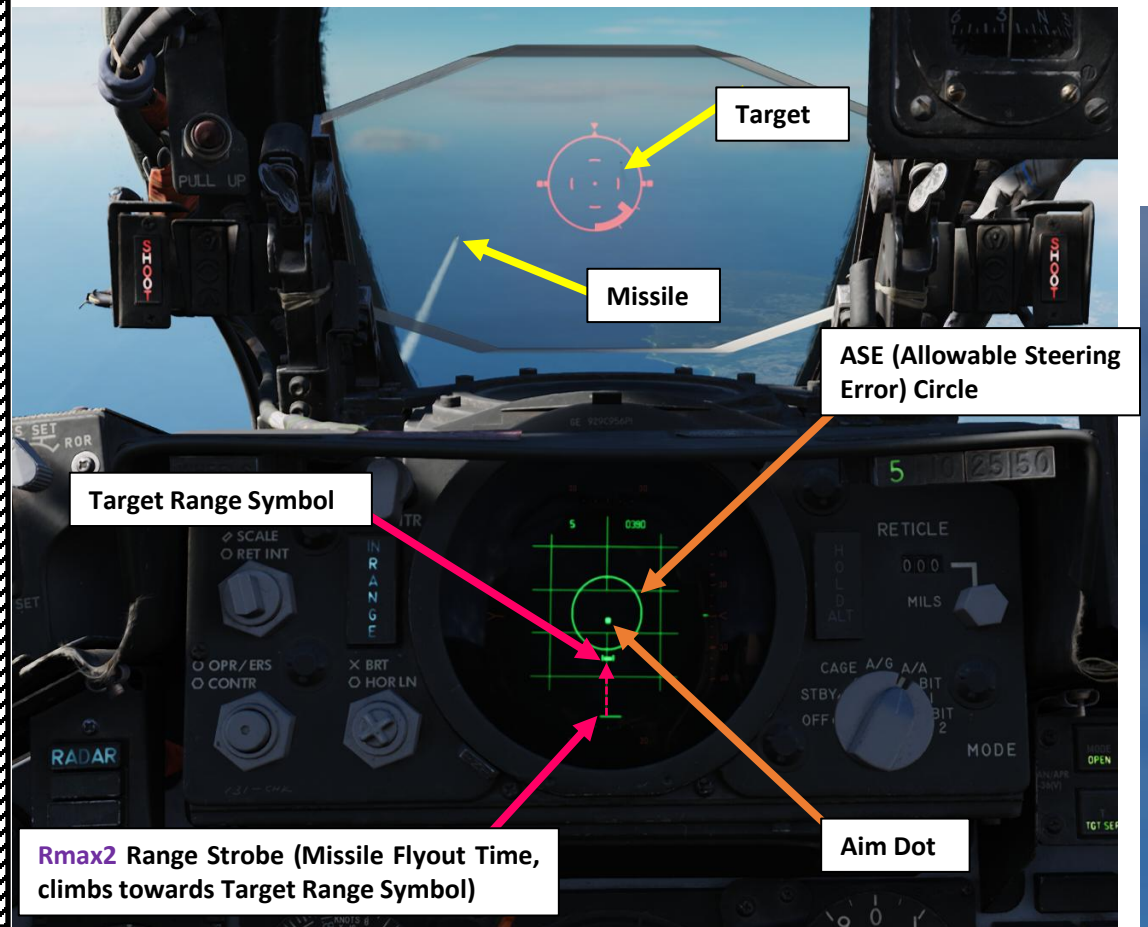




3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.4 – With Multicrew: Close Range (ACM)

B – Engage Target

18. *[P]* Once missile is fired, fly the aircraft to maintain radar lock since the missile is guided by the radar. Maintain aiming dot within the ASE (Allowable Steering Error) Circle.
19. *[P]* After missile launch, the Rmax2 strobe falls to the bottom of the display and begins driving upwards towards the target lock symbol; this functions as a missile flyout time. When the Rmax2 strobe (timer) reaches the locked target, it can be assumed that the missile has reached the target.





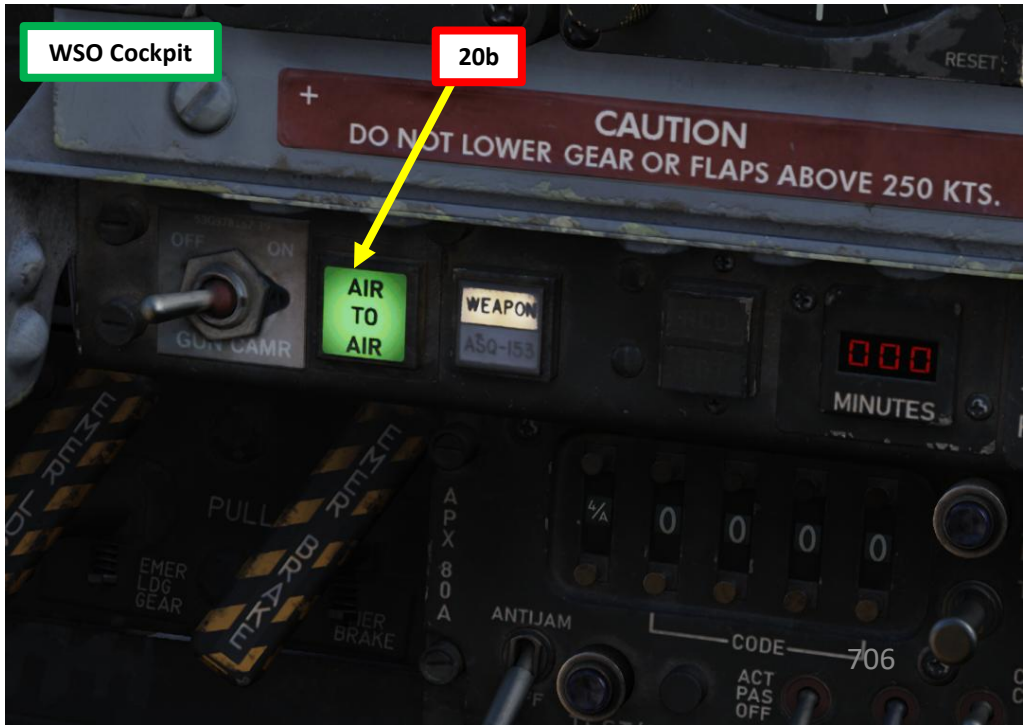


3 – AIR-TO-AIR WEAPONS
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3.3.4 – With Multicrew: Close Range (ACM)

B – Engage Target

20. If you want to exit CAA mode, you can either:
    - *a) [P]* Select position B on the Weapon Select Knob, or
    - *b) [WSO]* Push the Air-To-Air button.
    - Note: Should a radar lock be in place at the time of CAA mode exit, it will be retained.

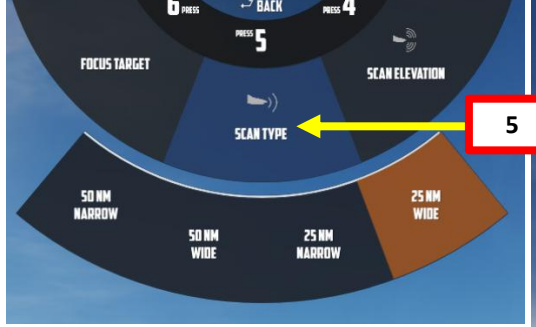


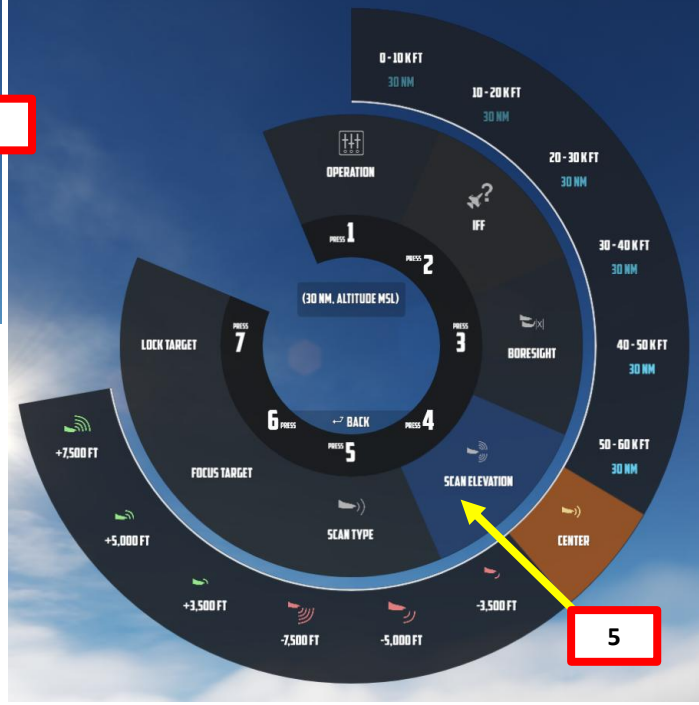


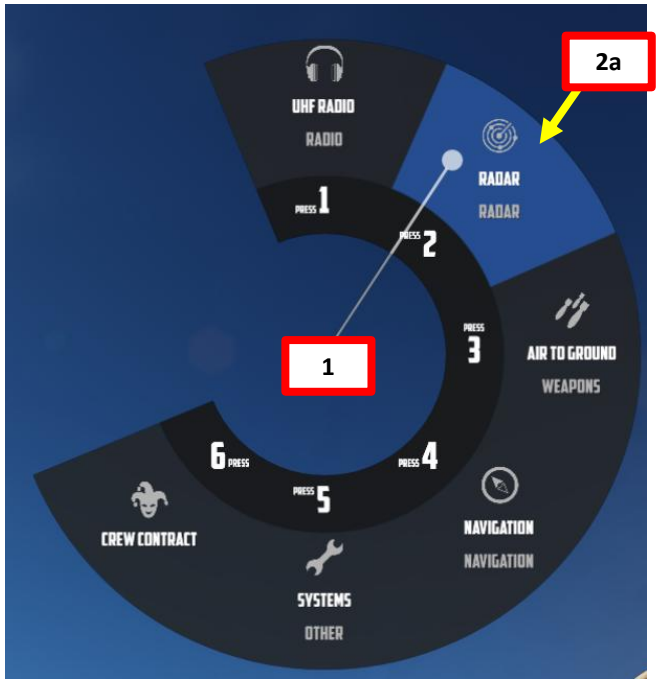
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.5 – With JESTER AI: Within Visual Range (WVR)

A – Perform Radar Lock

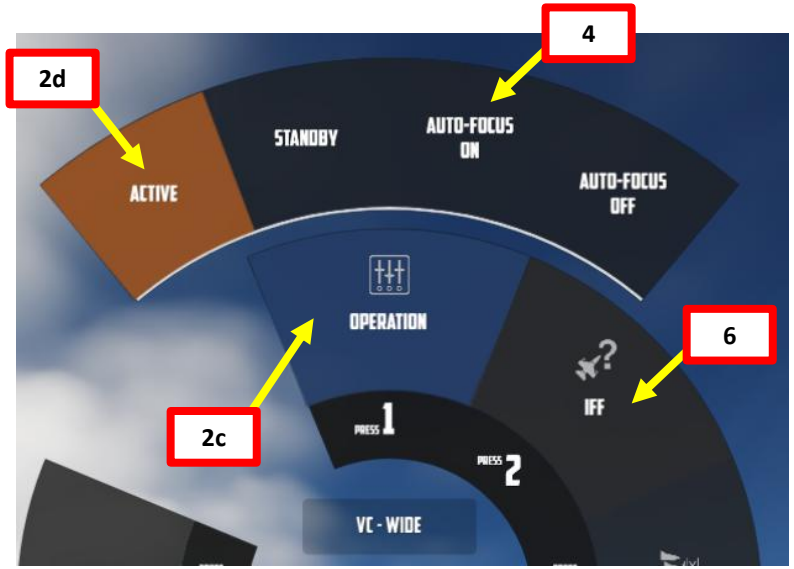
1. *[P]* To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).
2. *[P]* By default, JESTER should already have automatically set the radar to ACTIVE by himself once you are up in the air.
    - In certain situations, such as during landing, on the ground or when performing air-to-air refueling, the radar will be in Standby mode.
3. *[P]* JESTER will start scanning for targets automatically (SCAN/SEARCH Phase). This is the default phase Jester will be in. He will automatically point the antenna at different altitudes and ranges in order to scan the entire space ahead of the aircraft. Jester will automatically identify any new contact and call them out.
4. *[P]* Command Auto-Focus to ON from the OPERATION menu. JESTER will automatically focus on the highest priority target when spotted on the radar scope.
5. *[P]* If desired, use the **SCAN ELEVATION** menu to command specific antenna elevation settings and use the **SCAN TYPE** menu to command a specific display range (distance in nm) setting and Narrow/Wide azimuth coverage setting. JESTER typically manages that by himself.
6. *[P]* Selecting "**IFF**" commands JESTER to identify whether a selected radar contact is friendly or foe.









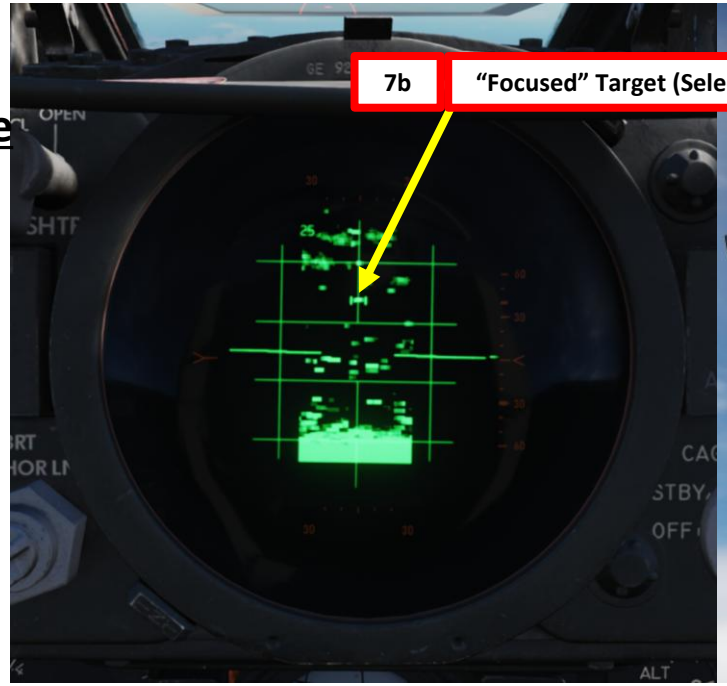


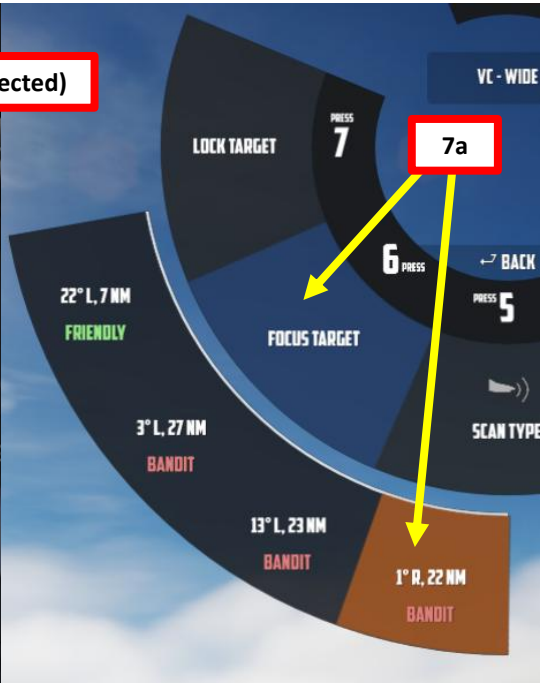
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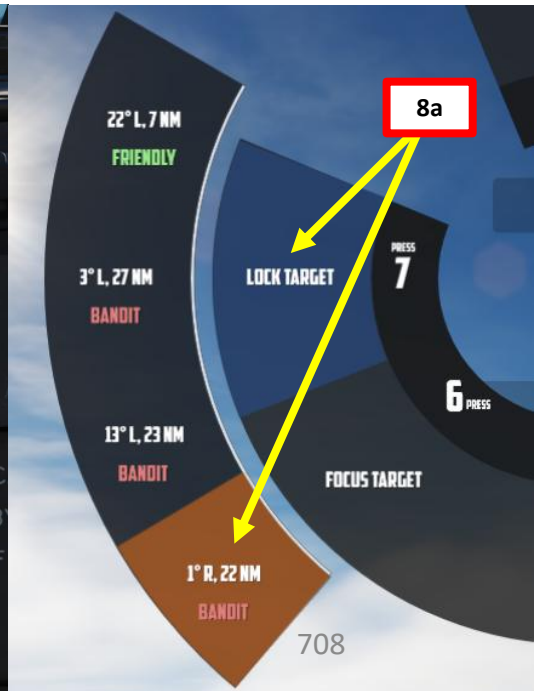
7. *[P]* When radar is in the Scan/Search phase, you can command JESTER to focus his attention on a specific target. In other words, "select but without performing a radar lock". You can either use the JESTER UI Menu (which is a bit more cumbersome) or use the quicker JESTER Context Action binding ("V").
    a) From the **JESTER UI ("A")**: Select FOCUS TARGET menu, then select desired target (includes bearing and distance information).
    Or;
    b) Using the **JESTER Context Action binding ("V"):**
        - **Short Press**: Commands JESTER to focus/select the next target visible on the radar scope.
        - **Double-Press**: Resets currently selected target and returns JESTER to his standard behavior of automatically selecting the highest priority threat.
8. *[P]* To command a radar lock/track, you can either use the JESTER UI Menu (which is a bit more cumbersome) or use the quicker JESTER Context Action binding ("V").
    a) From the **JESTER UI ("A")**: Select LOCK TARGET menu, then select desired target (includes bearing and distance information).
    Or;
    b) Using the **JESTER Context Action binding ("V"):**
        - **Long Press**: Commands a radar lock on the target currently selected by JESTER (or the target with the highest priority).
9. *[P]* If desired, you can issue additional commands to JESTER when radar is in the Lock/Track phase, including "radar unlock".
    - Using the **JESTER Context Action binding ("V"):**
        - **Short or Long Press**: Commands JESTER to drop the target's radar lock but keep the target in focus.
        - **Double-Press**: Commands JESTER to drop both the target's radar lock and focus (meaning JESTER will focus his attention on other targets).

[Link to JESTER Context Action Bindings]





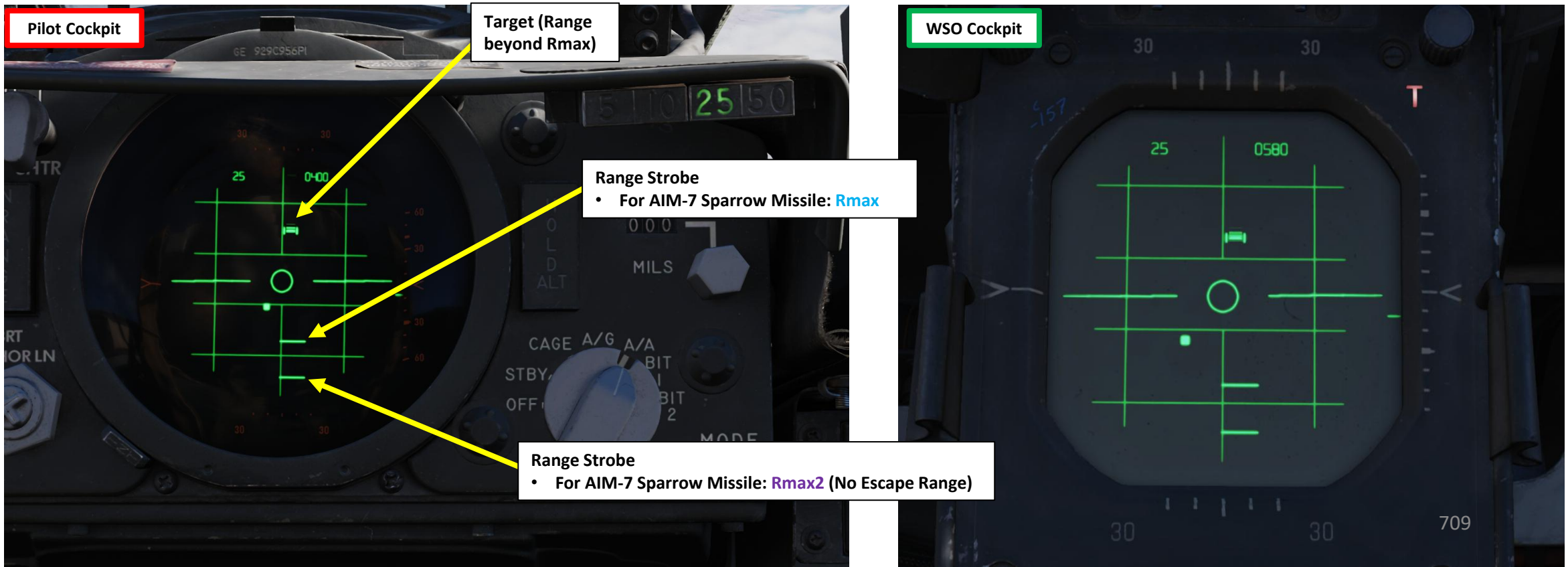




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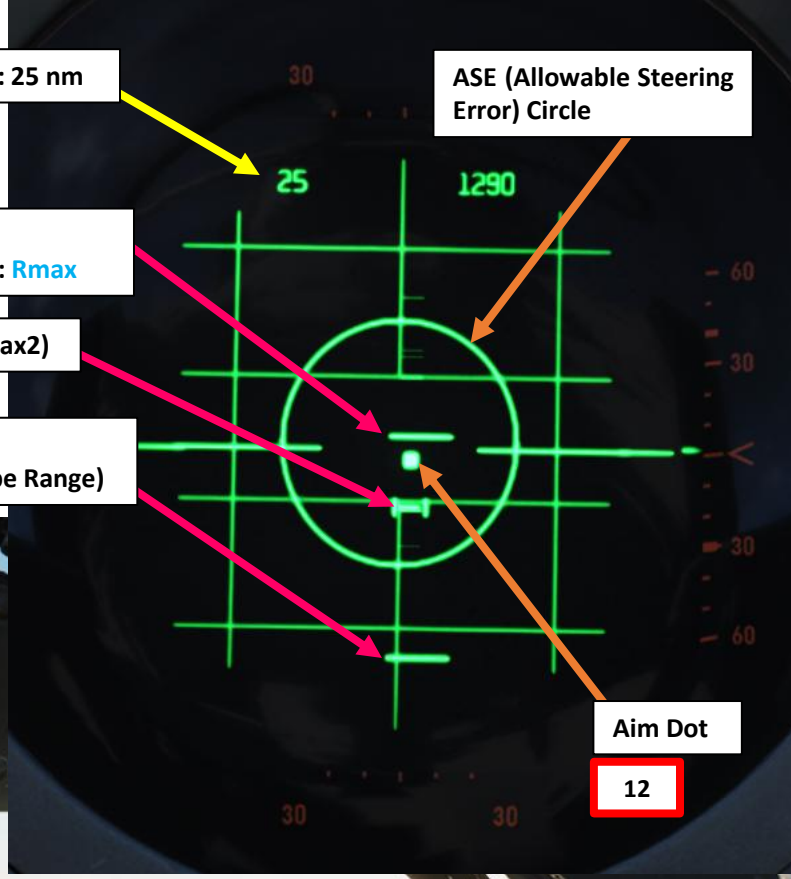
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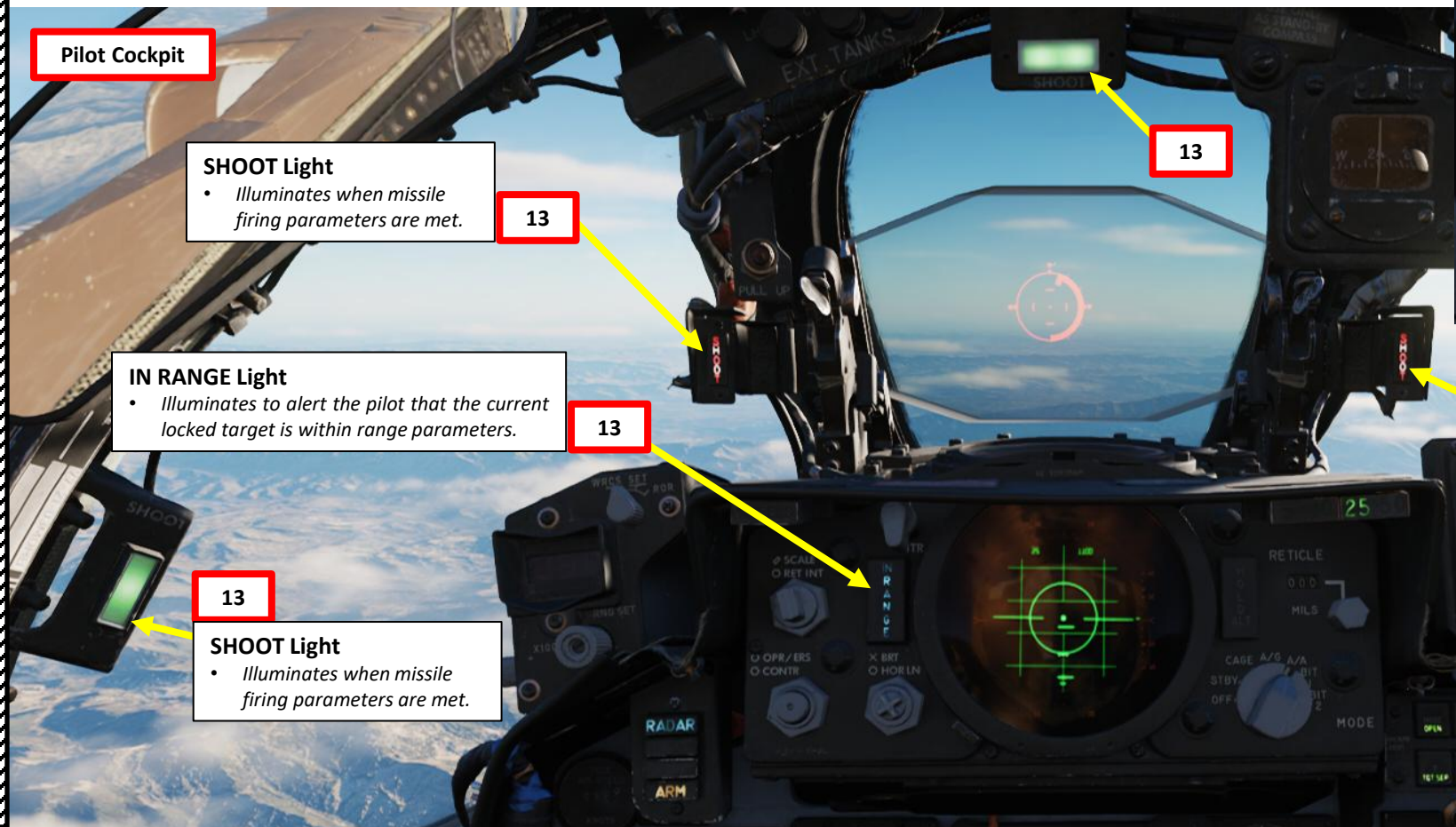


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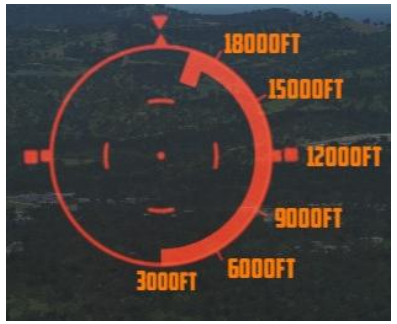
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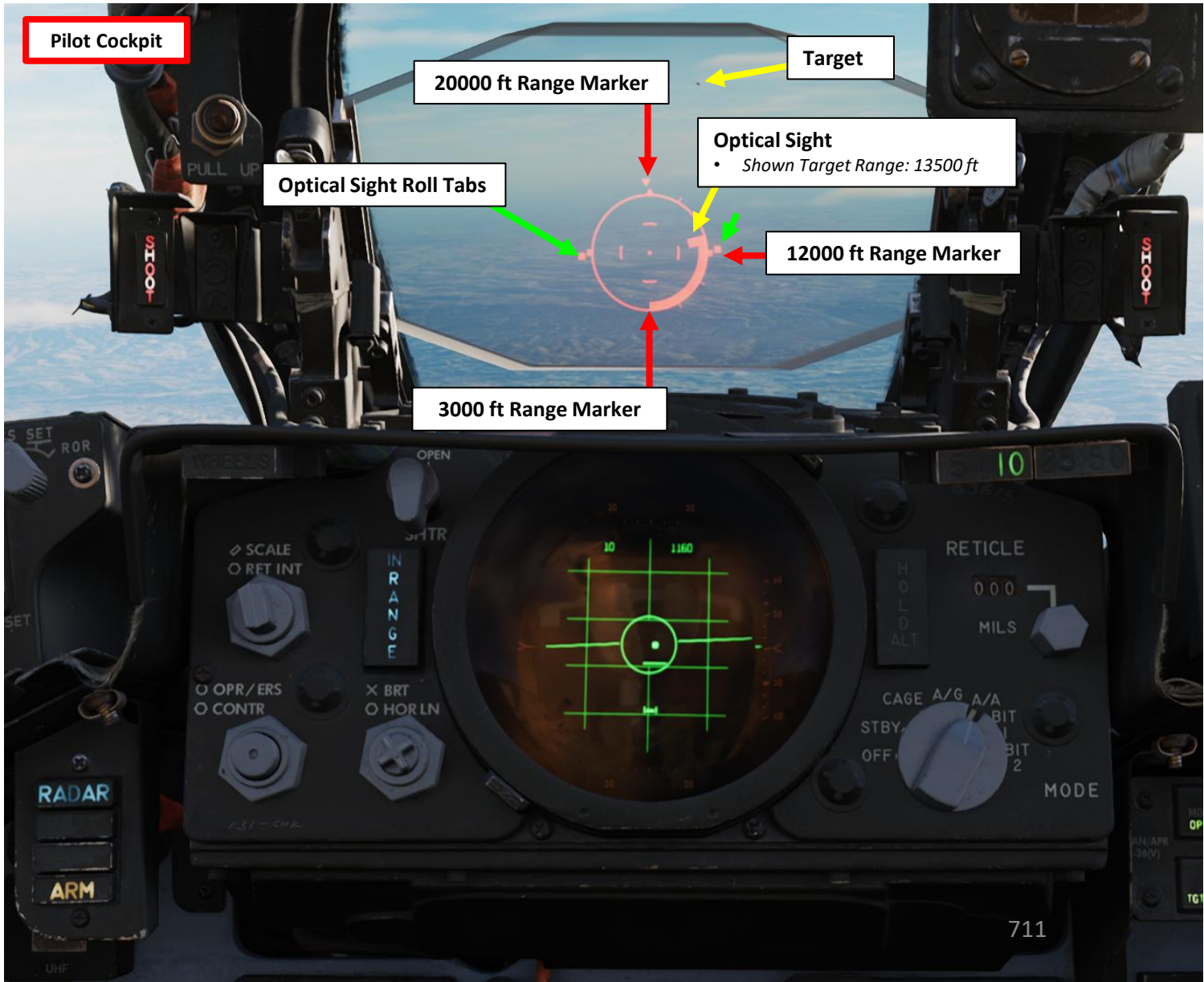
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15. *[P]* Squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired. While the missile's maximum range is 26 nm, try to launch within 10 nm (effective range).
    - Note: A second AIM-7 can be fired immediately at the same target, if desired, by releasing then squeezing the trigger a second time, holding it on the second actuation.



Trigger
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- *Full-Action (Second) Detent: SPACEBAR*

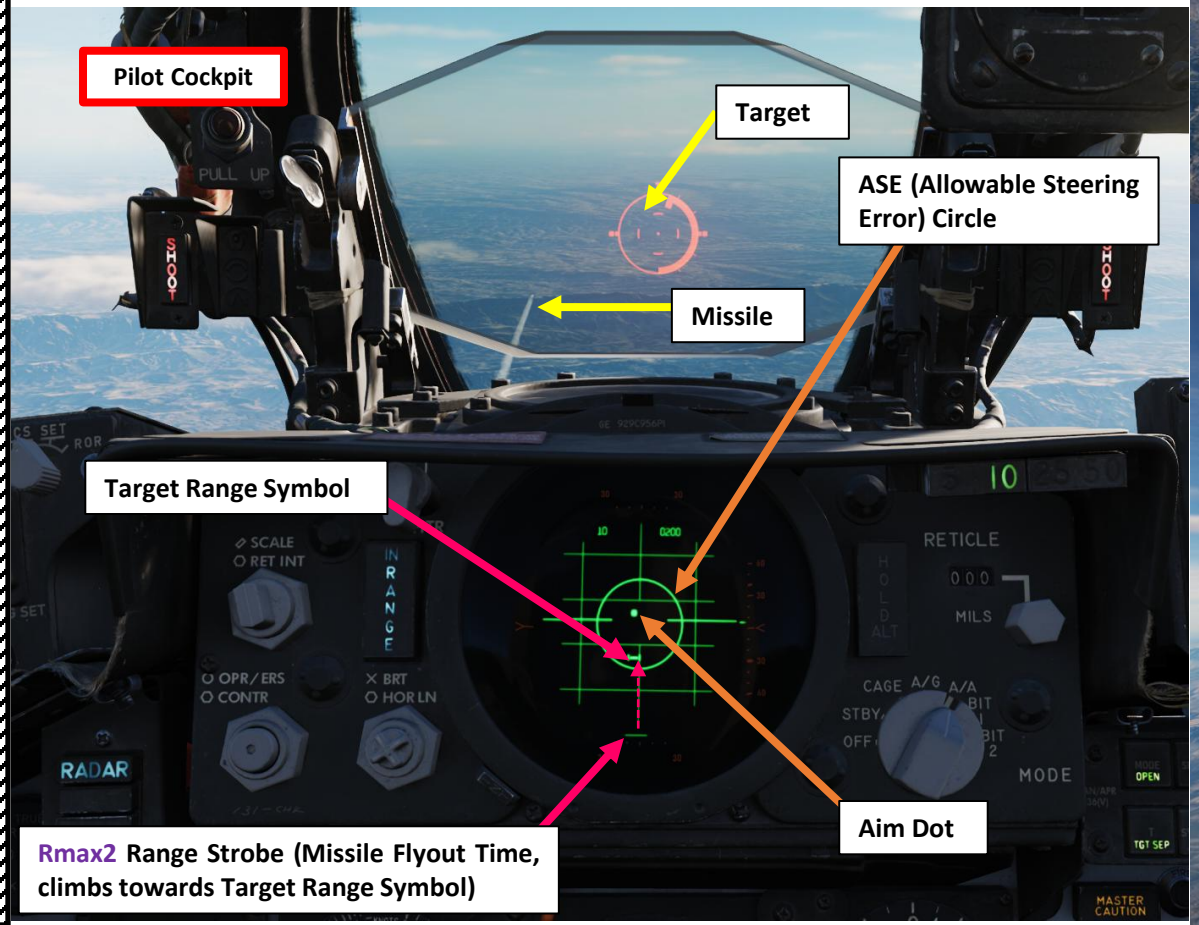




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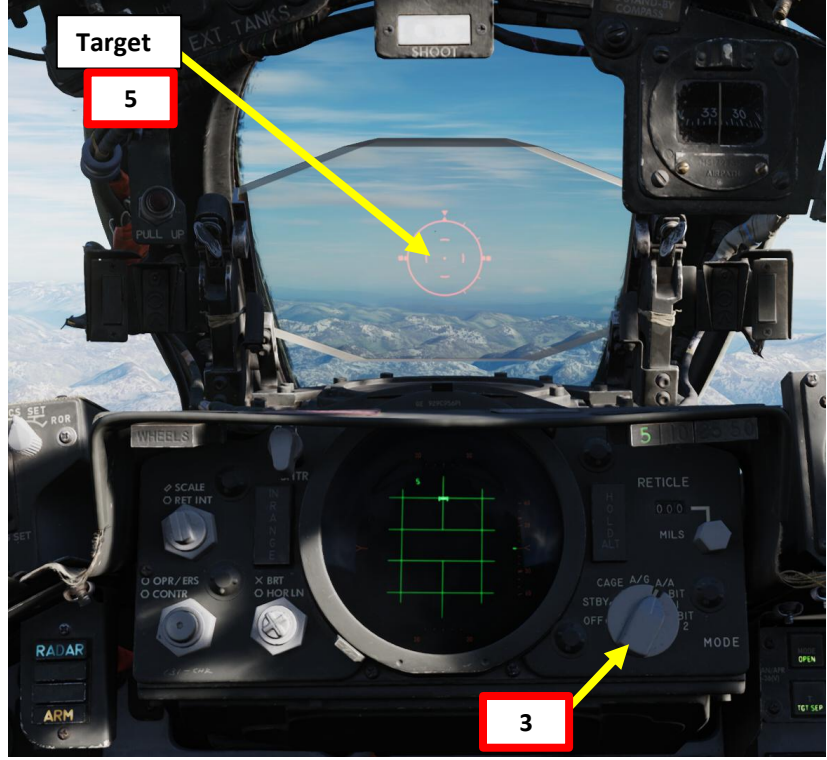


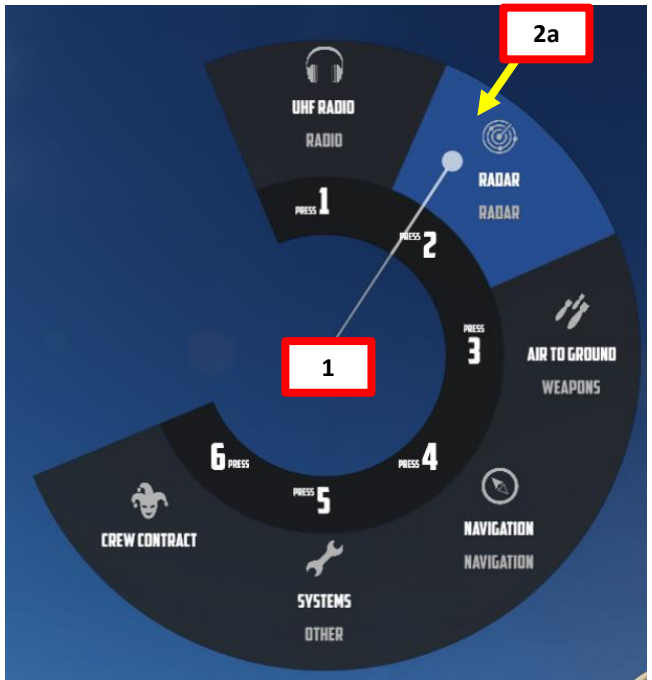
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

A – Perform Radar Lock

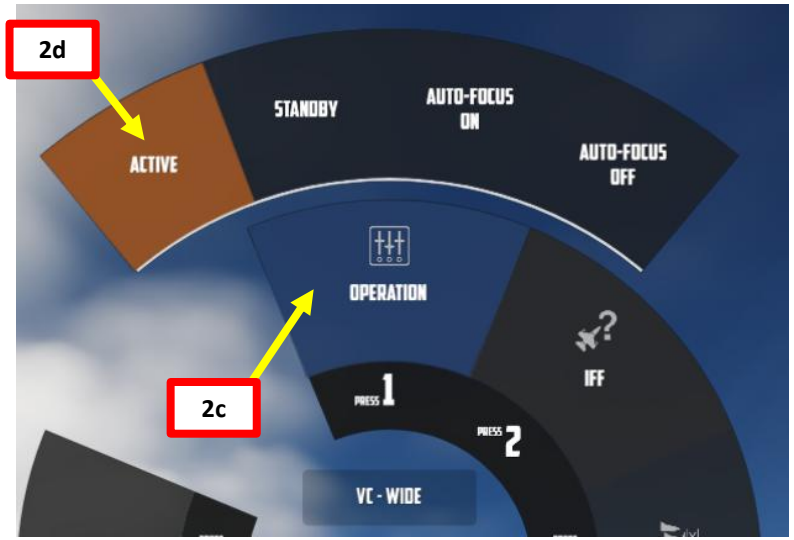
1. *[P]* To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).
2. *[P]* By default, JESTER should already have automatically set the radar to ACTIVE by himself once you are up in the air.
    - In certain situations, such as during landing, on the ground or when performing air-to-air refueling, the radar will be in Standby mode.
3. *[P]* Verify Sight Mode Selector is set to A/A (Air-to-Air)
4. *[P]* Select Cage Mode by depressing the Cage button on the pilot's throttle.
    - Cage condition limits the range to 5 nm and forces the maneuver setting into the HI position.
5. *[P]* Visually line up the optical sight near the target.









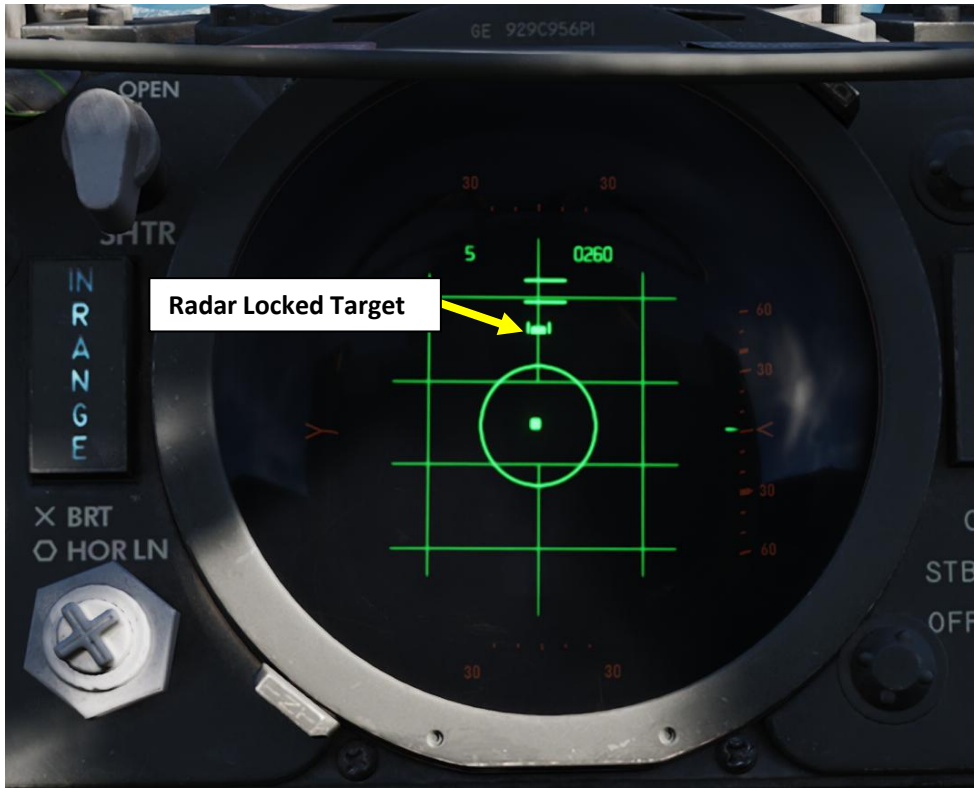


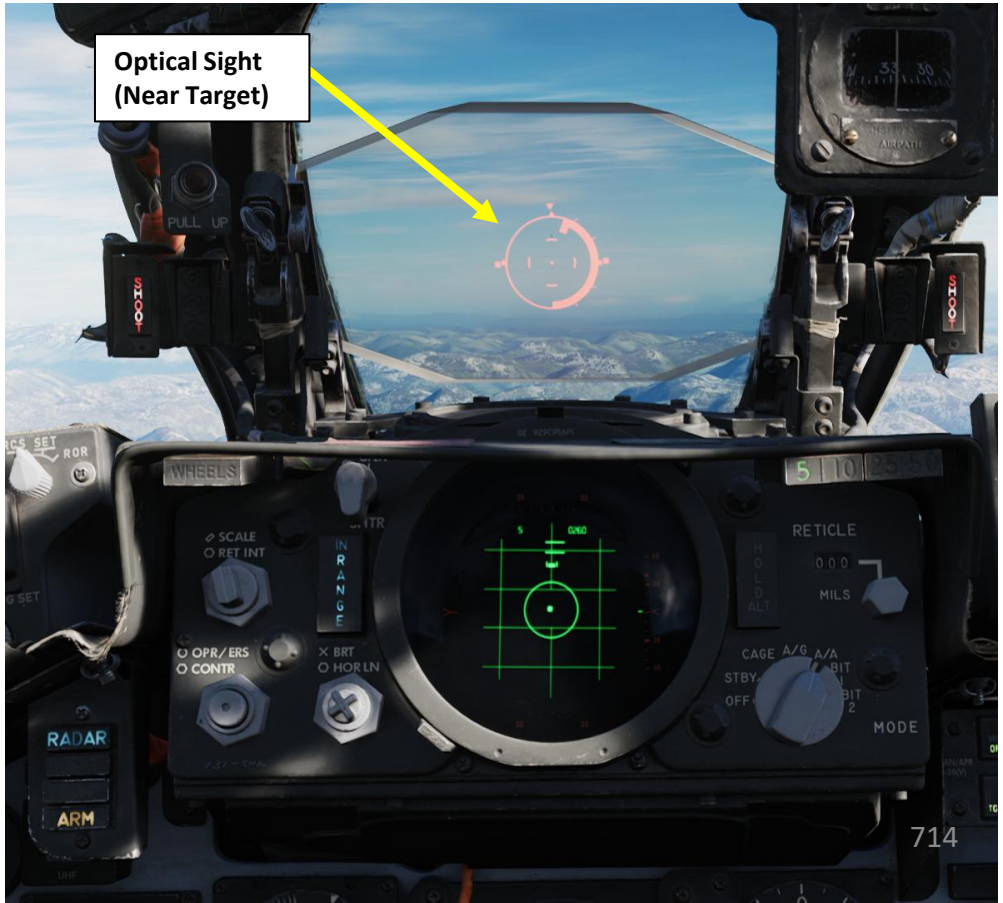
3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

[Link to JESTER Context Action Bindings]

A – Perform Radar Lock

6. *[P]* To command a radar lock/track from JESTER while in Cage Mode, use the JESTER Context Action binding (“V”).
    - Use the **JESTER Context Action binding (“V”):**
        - **Long Press**: Commands JESTER to radar lock (or unlock) the closest target (radar contact) ahead. Targets have to be within 5 degrees of his boresight or a lock attempt can result in a bad lock. JESTER expects the pilot to place the target within that zone first before being asked to perform the lock
7. *[P]* If desired, you can issue additional commands to JESTER when radar is in the Lock/Track phase, including “radar unlock”.
    - Using the **JESTER Context Action binding (“V”):**
        - **Short Press:** Commands JESTER to select Next Target Aspect (in case you want to enable no-lock "flood" shots with the Sparrow).
        - **Long Press**: Commands JESTER to unlock target (if locked).
        - **Double-Press**: Commands JESTER to exit CAGE or BORESIGHT Mode.

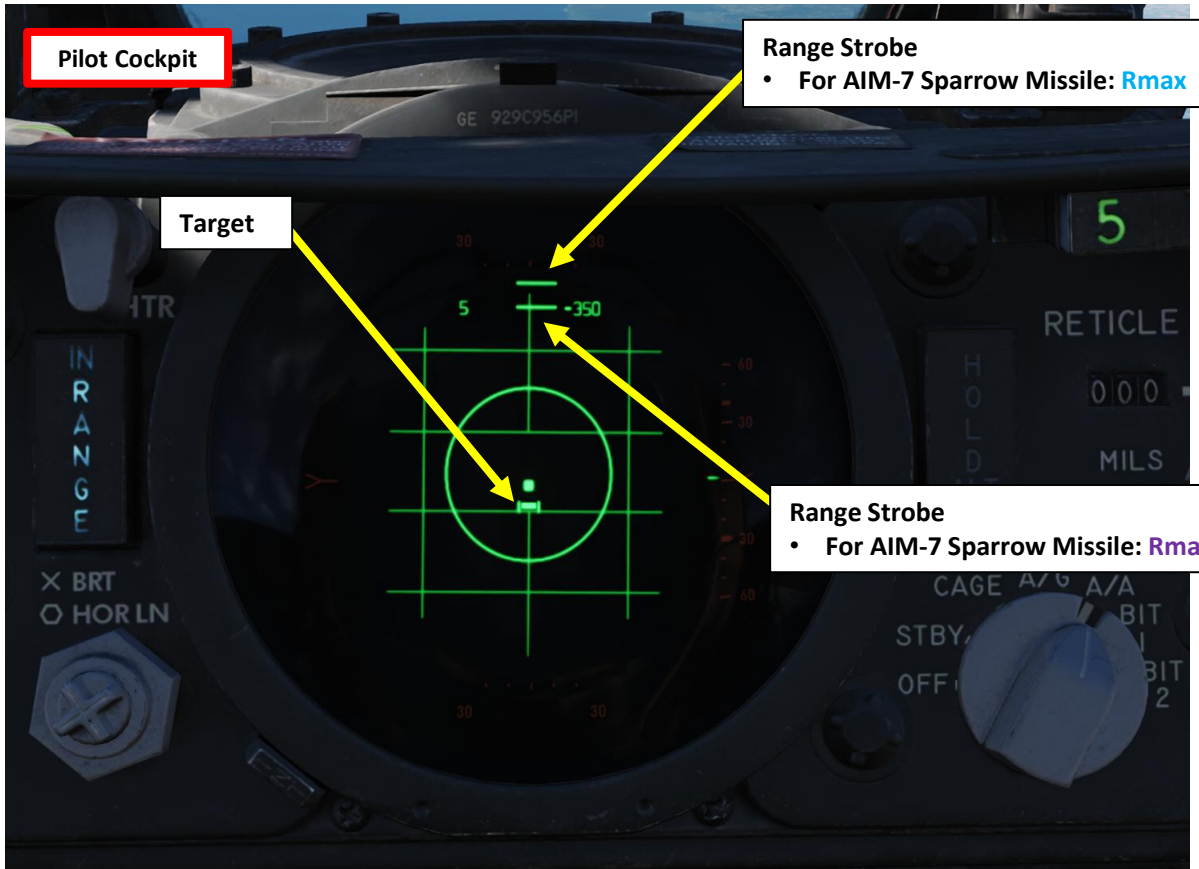


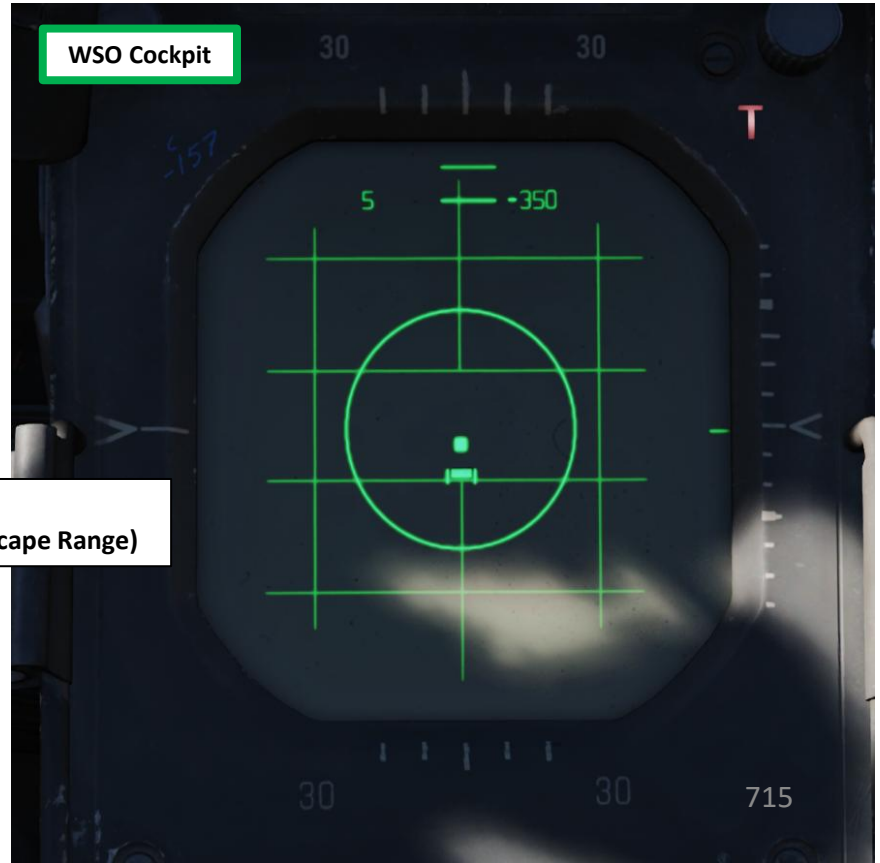


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

A – Perform Radar Lock

8. If Sparrows are selected and ready for employment, take note that the radar display will also show two range strobes. If an AIM-7 Sparrow Missile is selected: range strobes display **Rmax** (Maximum range capability of the missile provided the target continues flying on current heading and course) and **Rmax2** (Maximum range capability of the missile provided the target performs the shortest high-G turn to tail aspect, also referred as the "no escape range").
    - Note: **Rmax2** rate is based on altitude (8G up to 20000 ft, 6G to 35000 ft, and 4G above 35000 ft).
9. *[WSO]* Once radar lock is obtained, JESTER will count down 4 seconds out loud for the set-in period of the AIM-7E missile's speed-gate (or 2 seconds for the AIM-7F). This will let the pilot know when the missile is ready to be fired by calling out "1 Mississipi, 2 Mississipi, 3 Mississipi, 4 Mississipi, Shoot". Should this delay not be adhered to, the missile may fail to track because of improper target doppler injection.

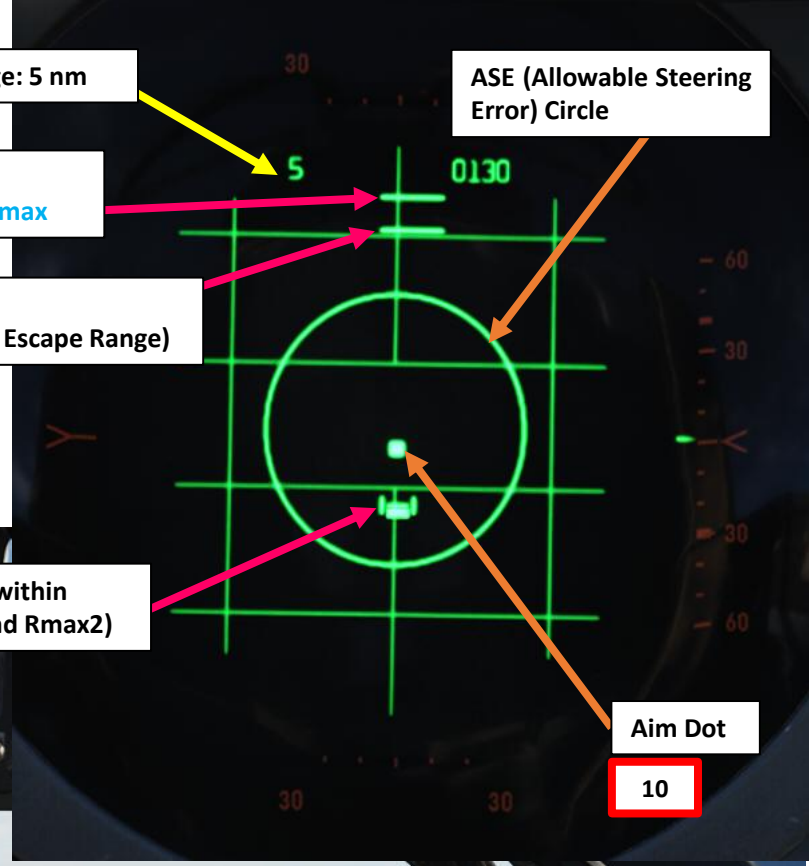


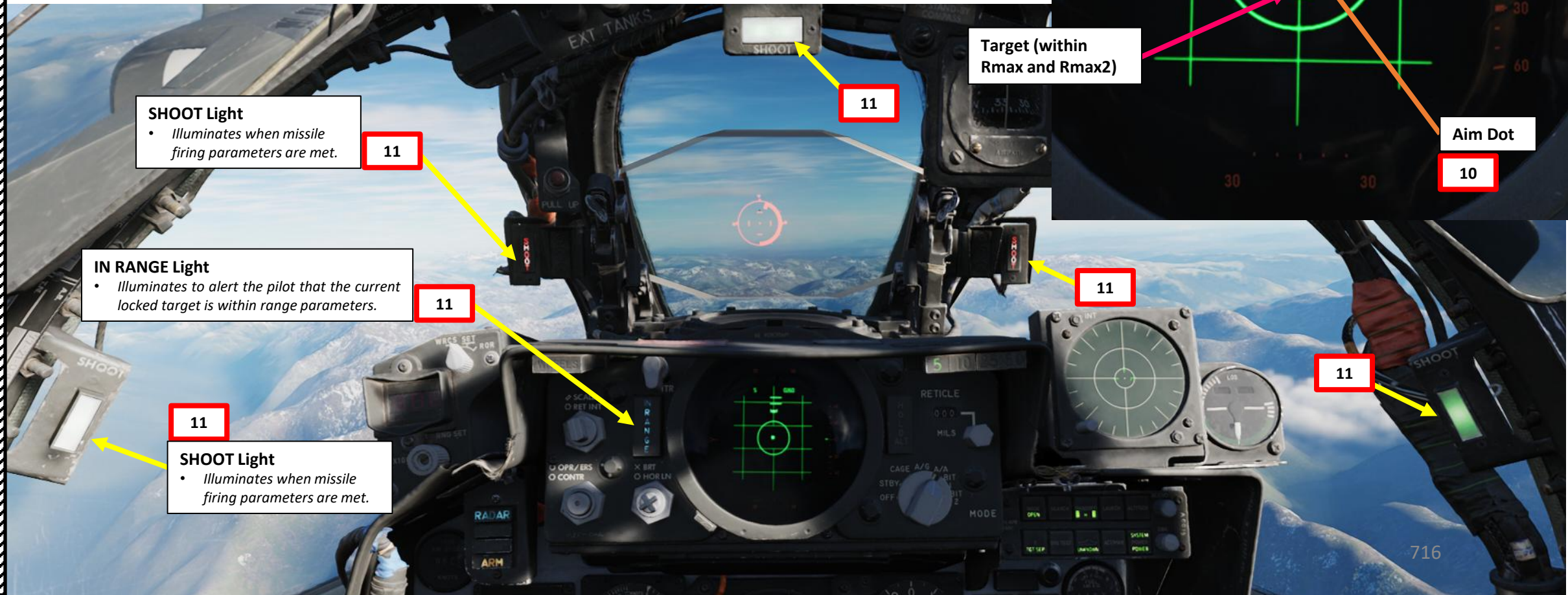


3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

B – Engage Target

10. *[P]* Manoeuver the aircraft to center the Aim Dot inside the ASE (Allowable Steering Error) Circle.
11. *[P]* When the IN RANGE and SHOOT lights illuminate, this means the Aim Dot is inside the ASE Circle and that the Target is within Rmax and Rmin (Minimum missile range). This also means that the missile interlock requirements are met and the missile can be fired. Keep in mind that firing a Sparrow at long range will very likely yield a very low PK (probability of kill).





3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

A note about interlocks:
Depending on the position of the Interlock switch, the fire control system may inhibit missile launch if range limits, ASE (Allowable Steering Error) limits or radar restrictions inhibit missile launch (Interlock Switch IN).

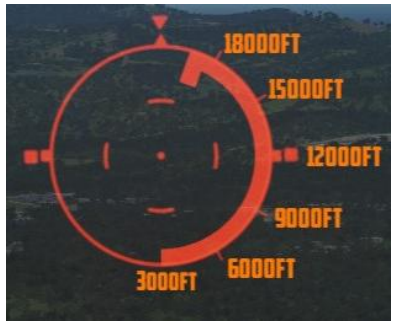
If Interlock switch is OUT, the AIM-7 will fire even if no launch conditions are met.

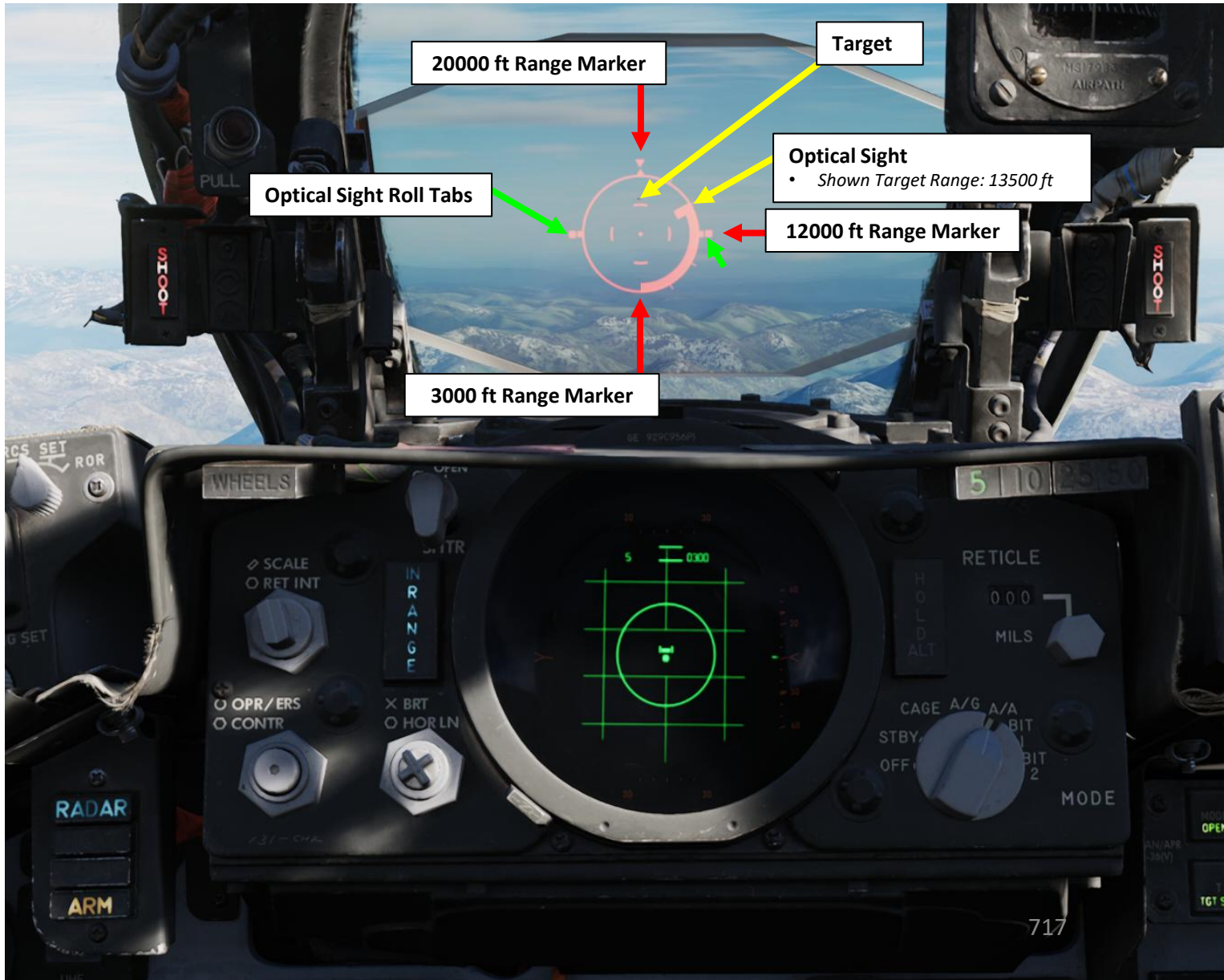
B – Engage Target

12. *[P]* With the Sight Mode Selector set to A/A (Air-to-Air), the optical sight's 50 mil diameter circle functions as a range bar when a radar lock is achieved against a target, displaying ranges up to 20,000 ft (top) to 3000 ft (bottom), with 12,000 ft signified at the 3 o-clock position. The roll tabs function to provide the pilot with relative roll attitude guidance in instrument conditions (weather or night time). The sight is stabilized at the Radar Boresight Line (RBL); **it will NOT follow the target**.
13. *[P]* Squeeze the Trigger's second detent (Full Action) (SPACEBAR) until missile is fired. While the missile's maximum range is 26 nm, try to launch within 10 nm (effective range).
    - Note: A second AIM-7 can be fired immediately at the same target, if desired, by releasing then squeezing the trigger a second time, holding it on the second actuation.



Trigger
- *Half-Action (First) Detent*
- *Full-Action (Second) Detent: SPACEBAR*

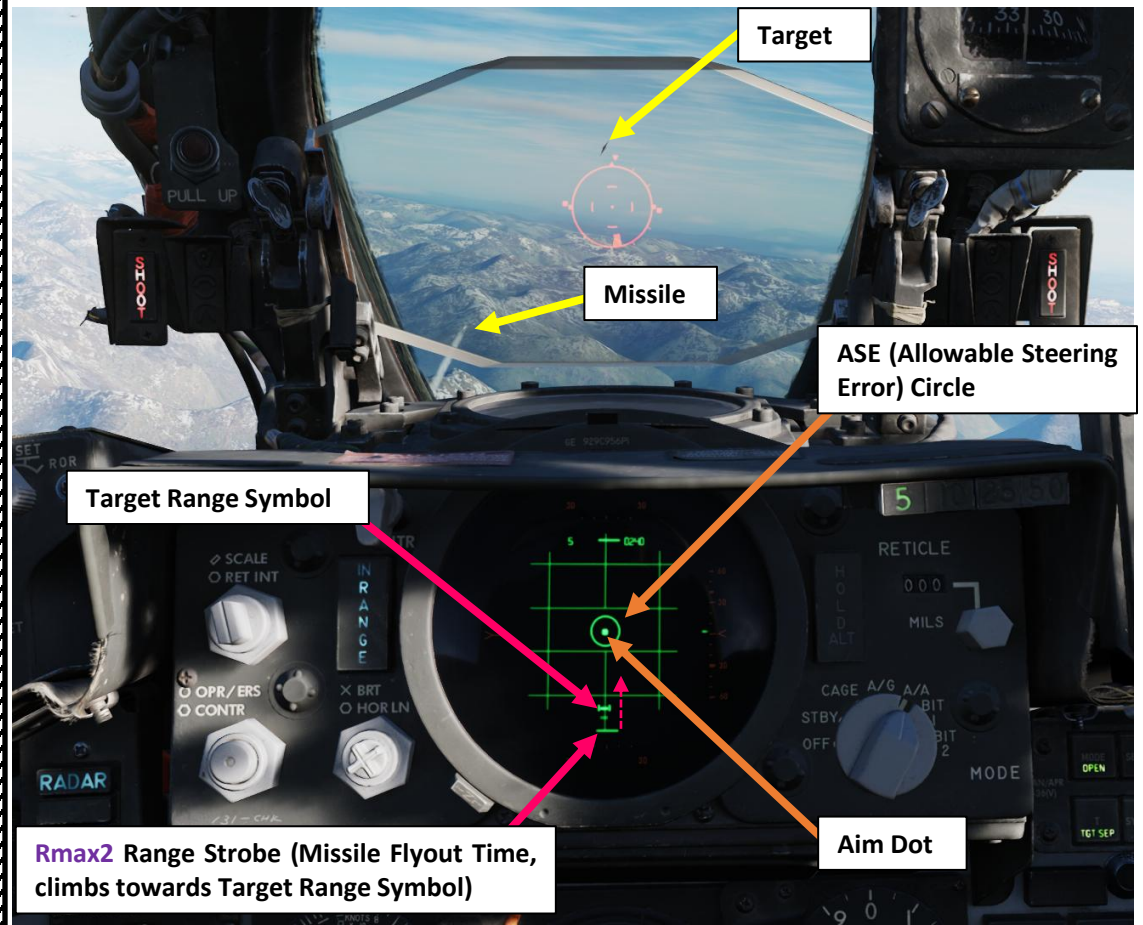




3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

B – Engage Target

14. *[P]* Once missile is fired, fly the aircraft to maintain radar lock since the missile is guided by the radar. Maintain aiming dot within the ASE (Allowable Steering Error) Circle.
15. *[P]* After missile launch, the Rmax2 strobe falls to the bottom of the display and begins driving upwards towards the target lock symbol; this functions as a missile flyout time. When the Rmax2 strobe (timer) reaches the locked target, it can be assumed that the missile has reached the target.







3 – AIR-TO-AIR WEAPONS
3.3 – Semi-Active Radar Homing AIM-7 Sparrow Missile
3.3.6 – With JESTER AI: Close Range (ACM)

B – Engage Target

16. *[P]* If you want to exit CAA mode, select position B on the Weapon Select Knob.
    - Note: Should a radar lock be in place at the time of CAA mode exit, it will be retained.







4 – ORDNANCE JETTISON
4.1 – Selective Ordnance Jettison

Weapon/ordnance stations can be jettisoned independently using the Jettison. Depending on the position of the switch (STORES, L/R FWD, L/R AFT or L/R WING), different types of ordnance will be jettisoned. Jettison does not remove pylons, and the AIM-9 Sidewinder is non-jettison-able.

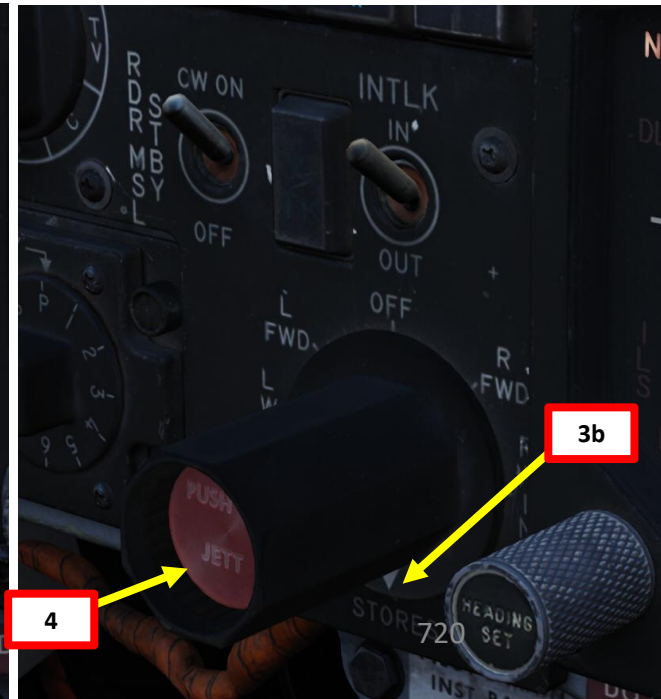
As an example, we will jettison the center station with MK-82 bombs:

1. *[P]* Select desired Station Select Buttons. We will use CTR (Center).
   - Stations: LO (Left Outer), LI (Left Inner), CTR (Center), RI (Right Inner), RO (Right Outer)
2. *[P]* Set Master Arm Switch – SAFE (DOWN)
3. *[P]* Set Selective Jettison Control Knob – STORES (DOWN position).
   - This setting releases all weapon racks, rounds or drop tanks selected on the station buttons upon pressing PUSH TO JETT.
4. *[P]* Press the PUSH TO JETT button – IN. This will jettison the selected store.









Selective Jettison Control Knob / Push to Jettison Button

- *OFF: Safety position.*
- *STORES: Releases all weapon racks, rounds or drop tanks selected on the station buttons upon PUSH TO JETT.*
- *L/R FWD: Jettisons AIM-7 missile from respective position on PUSH TO JETT. Inhibited if CL TK is ON.*
- *L/R AFT: Jettisons AIM-7 missile from respective position on PUSH TO JETT.*
- *L/R WING: In conjunction with TV or ARM, jettisons single AGM-65 Maverick or AGM-45 Shrike from wing on PUSH TO JETT.*

4 – ORDNANCE JETTISON
4.2 – Emergency Ordnance Jettison

The **External Stores Emergency Release**, also known as the panic button, will release all air to ground munitions, external tanks, and any pods subject to jettison. However, Sparrow and Sidewinder missiles (along with all pylons), will remain in place.

Performing the actuation disengages external fuel tank transfer automatically, permitting proper flow of internal wing tanks without further pilot action.

The button is active so long as the aircraft gear is up, or, in the event of a forward gear handle failure, so long as the rear gear handle remains IN, and weight is off wheels.



External Stores Emergency Release Button





1 – INTRODUCTION

Countermeasures are very simple to use. You have three countermeasure types at your disposal: flares, chaff and an ECM (Electronic Countermeasure) jammer. We will explore together what is used against what, and how.

Missiles can generally track you using 2 things: radar signature (radar waves are sent at you and you reflect them, which is called a "radar signature") and heat signature (like the exhaust of your engines). Countermeasures will only be effective against the kind of weapon it was meant to counter; a heat-seeking missile will not care if you deploy electronic countermeasures against it since it tracks heat, not radar signatures. This is why it is important to know what is attacking you in order to counter it properly. This is what the **RWR** (Radar Warning Receiver) is for: to help you know what is firing at you so you can take the adequate action to counter it.

Flares are used against missiles that track heat (infrared or IR) signatures. Instead of going for the heat signature generated by your engines, a missile will go for a hotter heat source like flares.

Chaff is a form of "passive" jamming. Passive (reflected) jamming is when a deceptive object or device reflects radar waves. Chaff is simply a bundle of small pieces of metal foil with reflective coating, which creates clusters of radar signatures that prevent a radar to get a solid lock on the aircraft itself.

The **AN/ALQ-131 Jammer Pod** is an Electronic Countermeasure/Jammer system. It is a form of "continuous" jamming, also called "active" or "transmitted" jamming. This device transmits its own synchronized radar waves back at your enemy's radar receiver to simulate erroneous radar wave returns. Simply put, active jamming will try to drown a radar in white noise.

In order to use these three forms of countermeasures, you can use "countermeasure programs", routines that will deploy a number of flares/chaff for a number of cycles at a given interval.



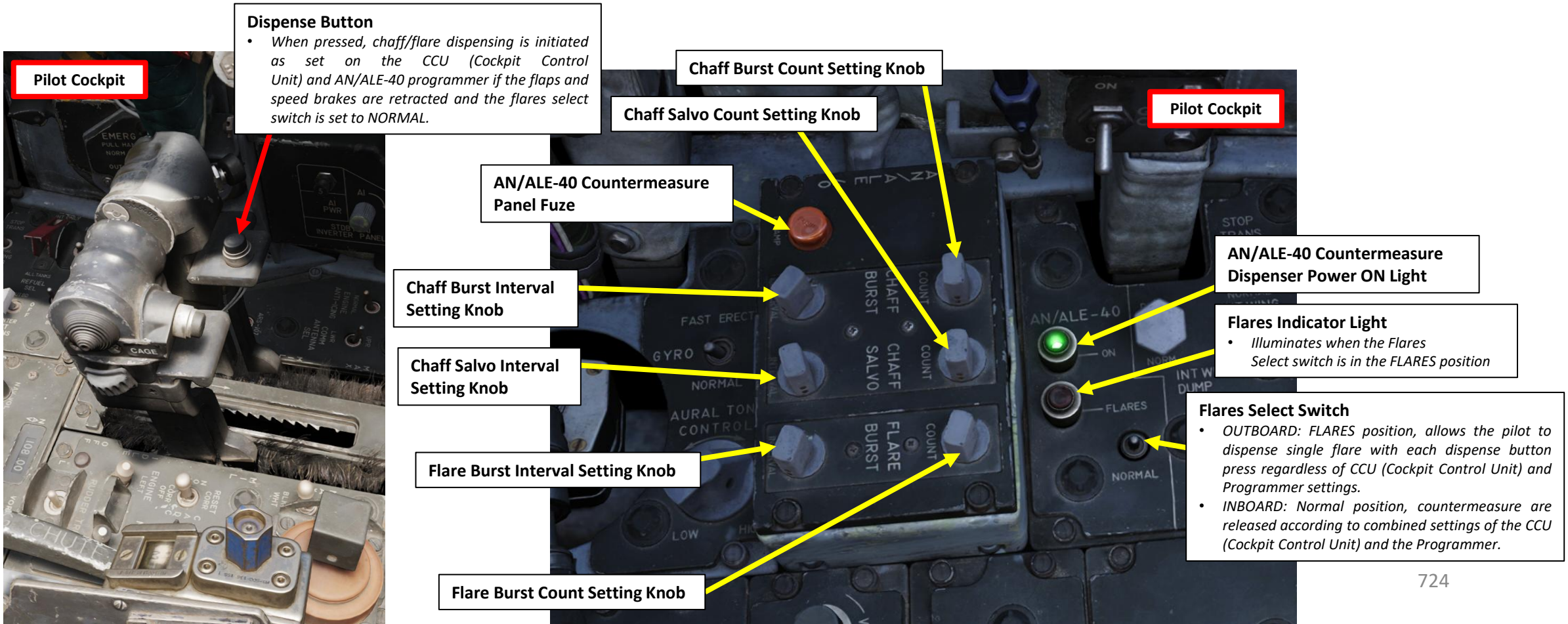
2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)

2.1 – Interface (Pilot)

Operation of the AN/ALE-40 countermeasures dispenser set is controlled from both the front and rear cockpit. The CCU (Cockpit Control Unit) in the rear cockpit of the WSO initiates the various modes of operation. The programmer will generate the firing commands in different combinations.

The pylon mounted dispensers will convert the firing commands to individually sequenced firing signals. Dispensing of countermeasures can be initiated by either the pilot (Dispense Button on the Throttle) or the WSO (Dispense Button or Ripple Switch on the CCU).

- Note 1: Countermeasures will be dispensed according to Flares Select Switch, CCU and Programmer settings.
- Note 2: To dispense countermeasures, flaps and speed brakes have to be retracted.

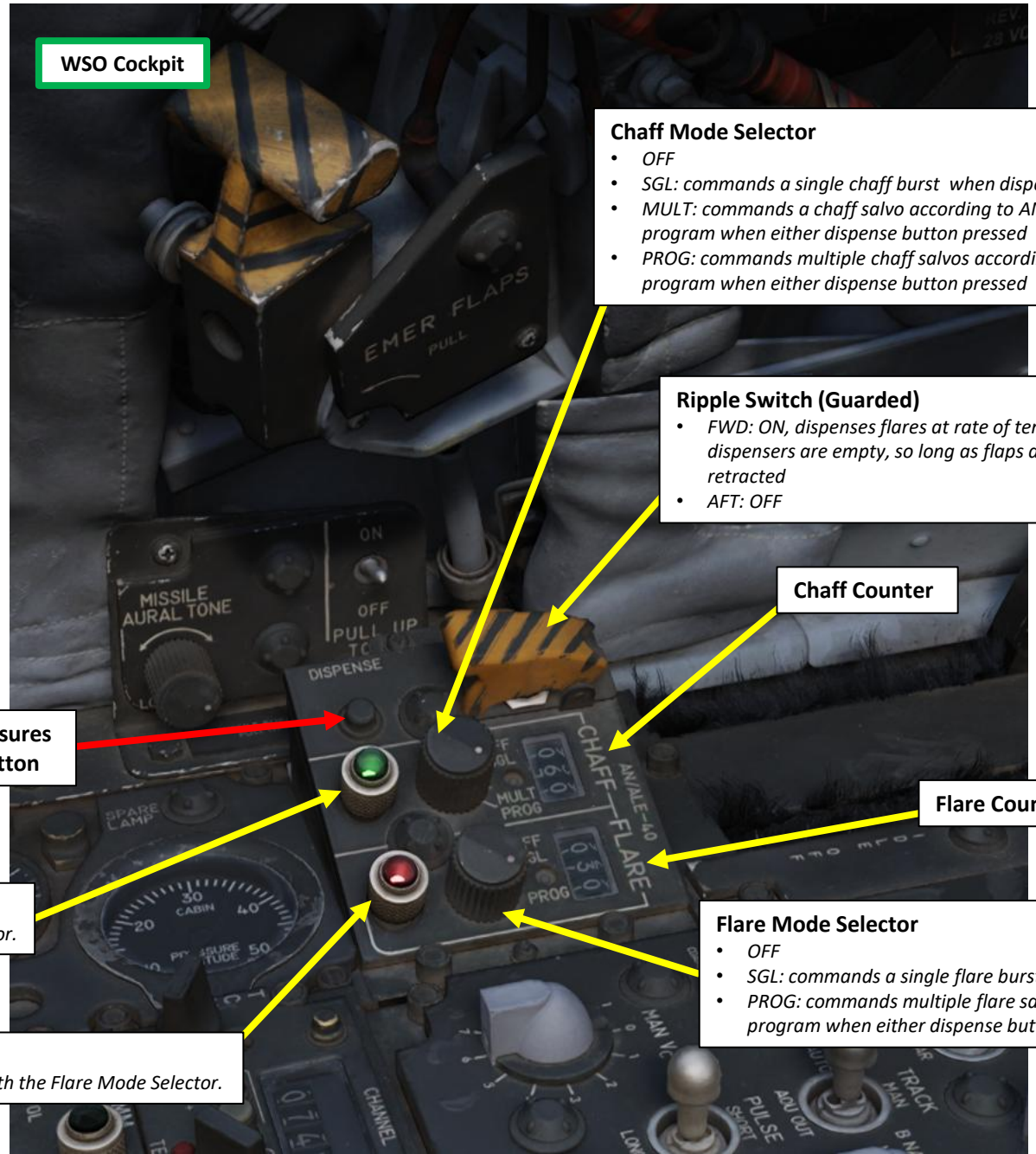


2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)

2.1 – Interface (WSO)

The WSO also has control over countermeasures through the **Cockpit Control Unit (CCU)**, which is installed on the left console of the rear cockpit. It consists of two mode knobs, two counters and two indicator lights (one for chaff and one for flare), as well as a guarded ripple switch and a dispense button.

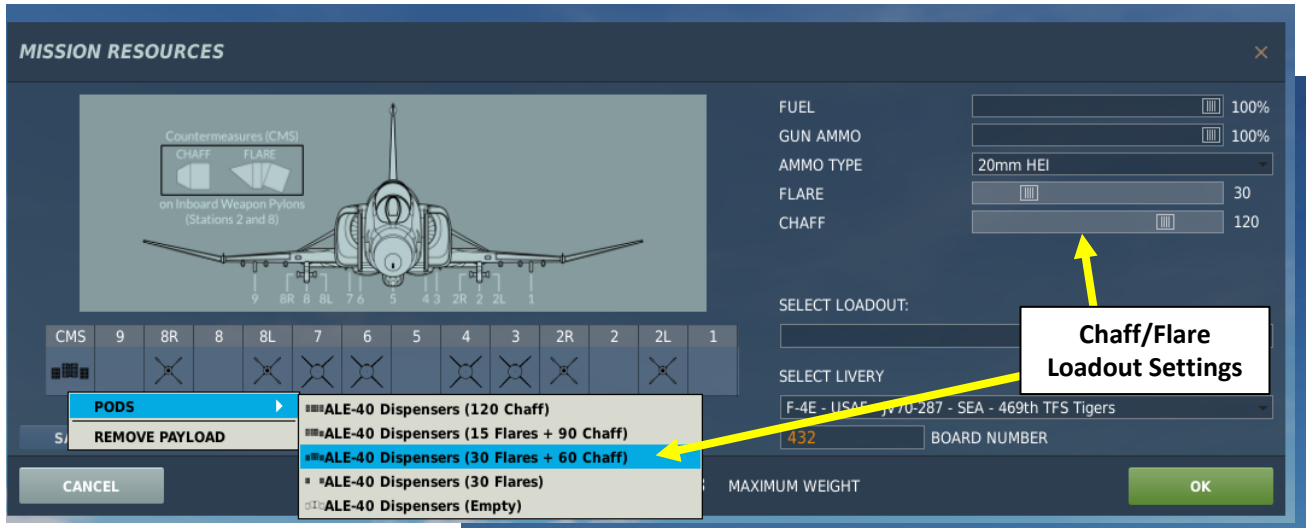
The CCU issues signals which are sent to the programmer or directly to the dispensers, depending on selected modes.

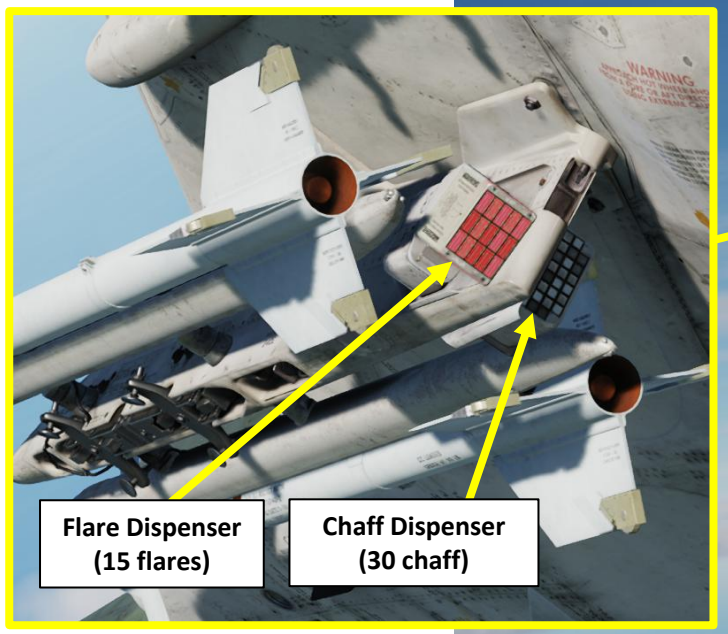


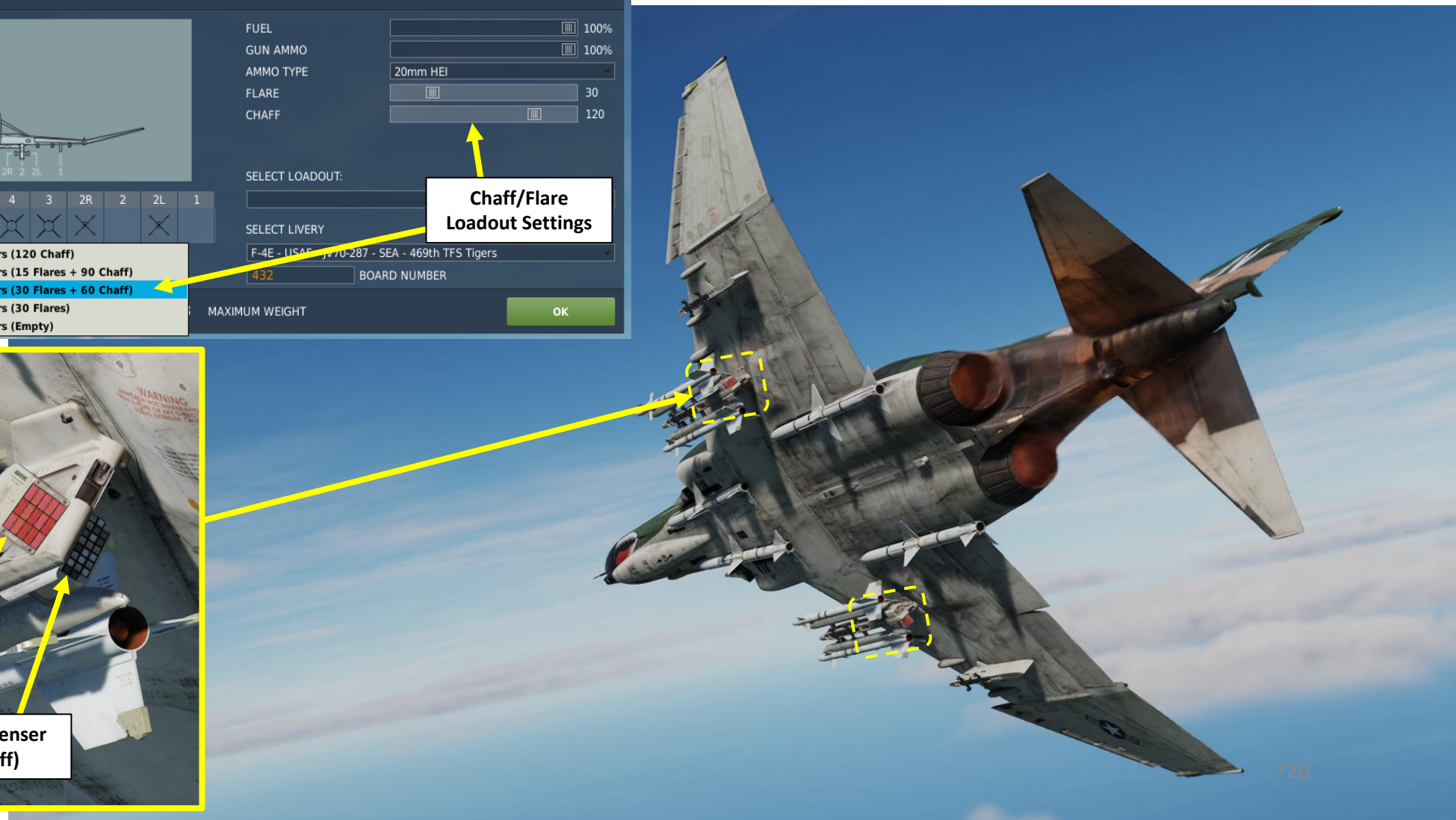
2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)

2.2 – Dispensers

The AN/ALE-40 system provides the capability of dispensing flare or chaff payloads as a means of defense against hostile radar or IR missile attack. The system consists of **four dispensers** located on the inboard armament pylons (2 on each) as well as cockpit controls. You can load up to 60 chaff cartridges + 30 flare cartridges, but you can also equip other combinations of chaff and flares. The chaff/flare loadout can be set via the Mission Editor or from the Ground Crew Menu.





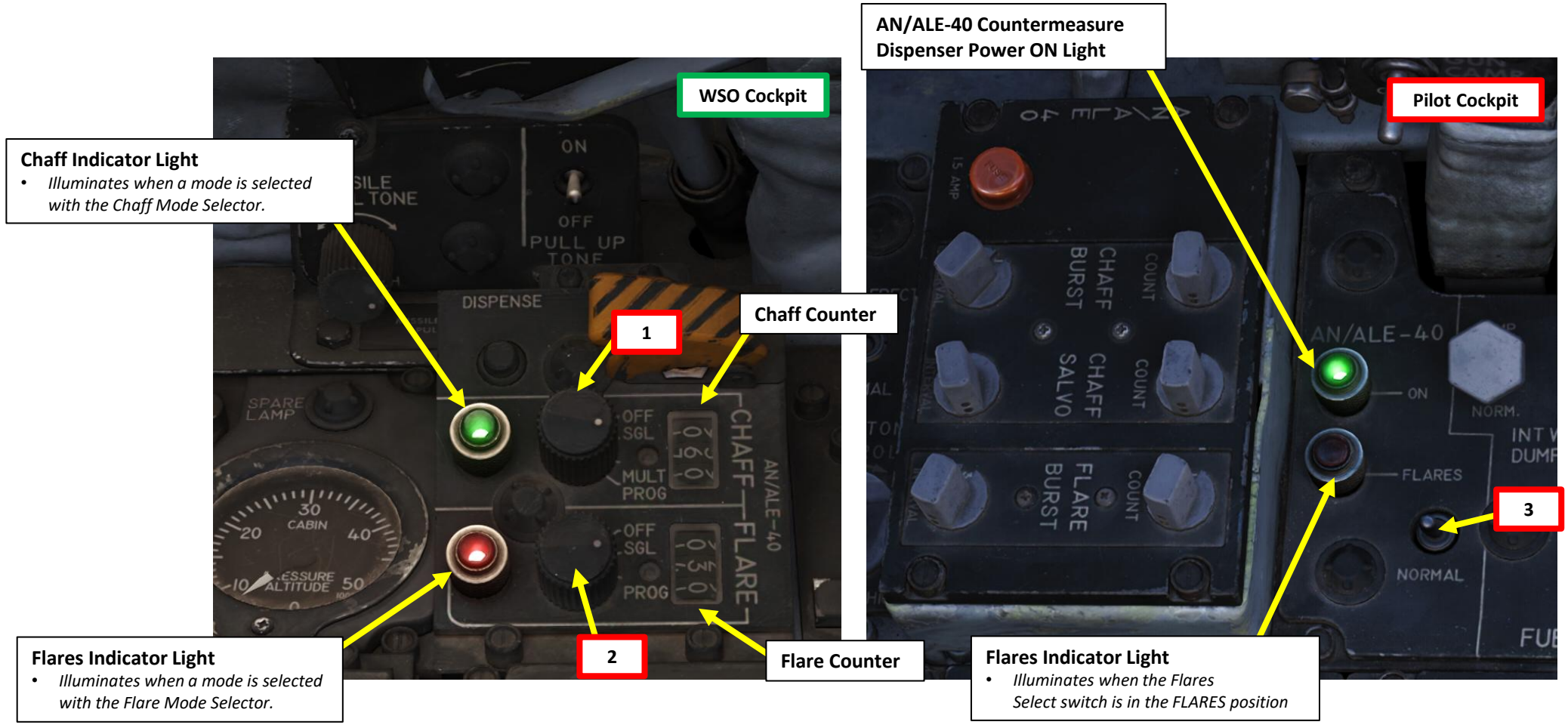


2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)

2.3 – Single Mode Tutorial

To dispense a single chaff & flare:

1. *[WSO]* Set Chaff Mode Selector – SGL (Single)
2. *[WSO]* Set Flare Mode Selector – SGL (Single)
3. *[P]* Set Flares Select Switch – As desired. I recommend leaving it to NORMAL.
    - OUTBOARD: FLARES position, allows the pilot to dispense single flare with each dispense button press regardless of CCU (Cockpit Control Unit) and Programmer settings.
    - INBOARD: Normal position, countermeasure are released according to combined settings of the CCU and the Programmer.



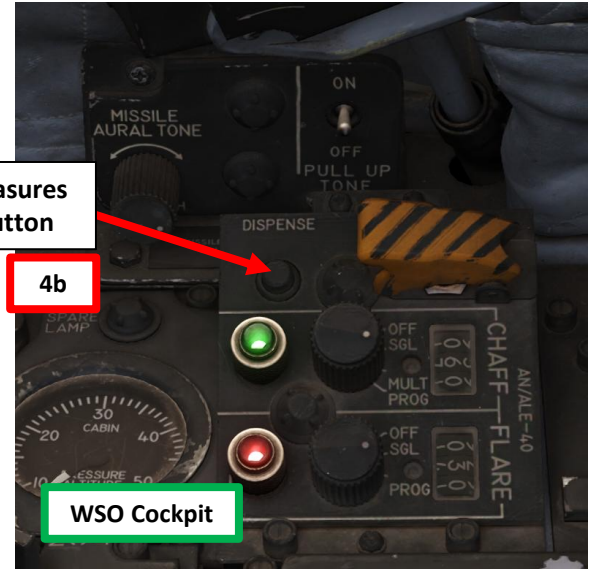
2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)

2.3 – Single Mode Tutorial

To dispense a single chaff & flare:

4. Dispense Countermeasures using either:
   - *a) [P]* Dispense Button, or;
   - *b) [WSO]* Countermeasures Dispense Button
   - *Note: flaps and speed brakes must be retracted, otherwise countermeasure dispensing is inhibited.*
5. A single chaff and flare are dispensed.



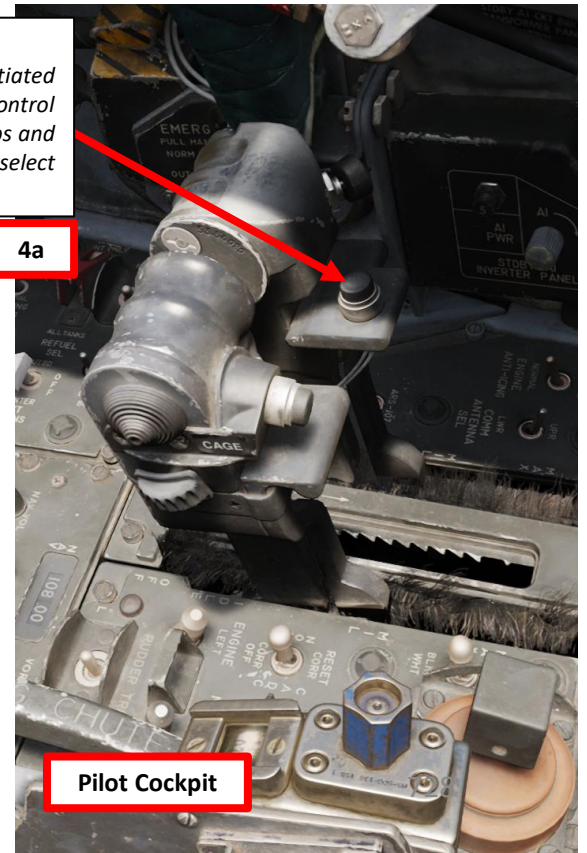


Countermeasures Dispense Button

4b

Dispense Button

- *When pressed, chaff/flare dispensing is initiated as set on the CCU (Cockpit Control Unit) and AN/ALE-40 programmer if the flaps and speed brakes are retracted and the flares select switch is set to NORMAL.*



4a

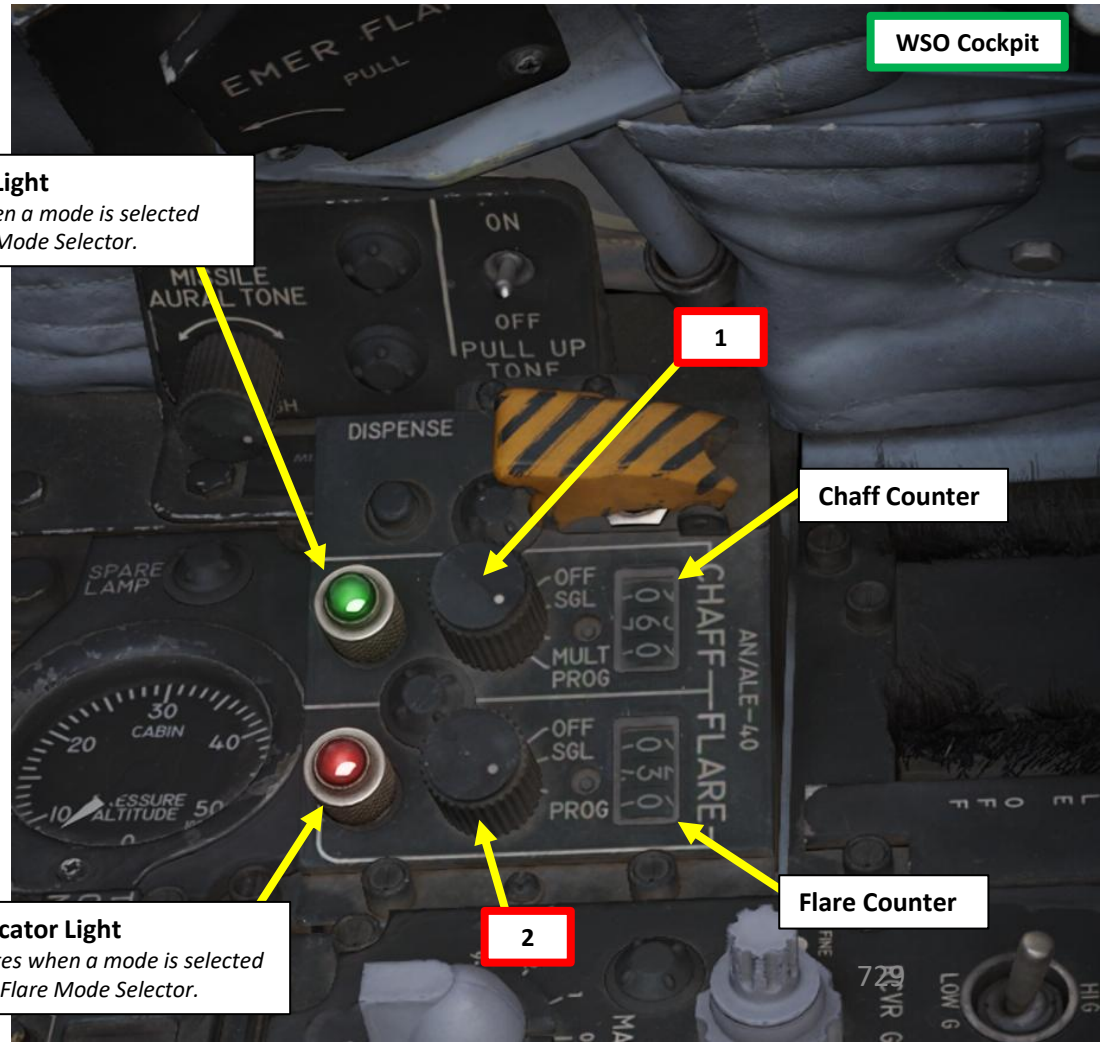
2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)
2.4 – PRGM (Program) Mode Tutorial

To dispense a programmed chaff & flares sequence:

1. *[WSO]* Set Chaff Mode Selector – PROG (Program).
   - In PROG mode, Chaff is dispensed according to CHAFF BURST and CHAFF SALVO settings of the Programmer.
   - Alternatively, you can select MULT (Multiple). In this mode, Chaff is dispensed according to CHAFF BURST settings of the Programmer.
2. *[WSO]* Set Flare Mode Selector – PROG (Program).
   - In PROG mode, flares are dispensed according to FLARE BURST settings of the Programmer.

Countermeasure Program Settings

Category	Description	Knob	Values
Chaff Burst	Quantity of bursts (per salvo)	Count	1, 2, 3, 4, 6, 8
	Time interval between each burst	Interval (sec)	0.1, 0.2, 0.3, 0.4
Chaff Salvo	Number of salvos	Count	1, 2, 4, 8, C (Continuous)
	Time interval between each salvo	Interval (sec)	1, 2, 3, 4, 5, 8, R (Random)
Flare Burst	Quantity of bursts	Count	1, 2, 4, 8, C (Continuous)
	Time interval between each burst	Interval (sec)	3, 4, 6, 8, 10
Burst Definition: Single Dispensing Signal *Salvo Definition: Group of Bursts*			

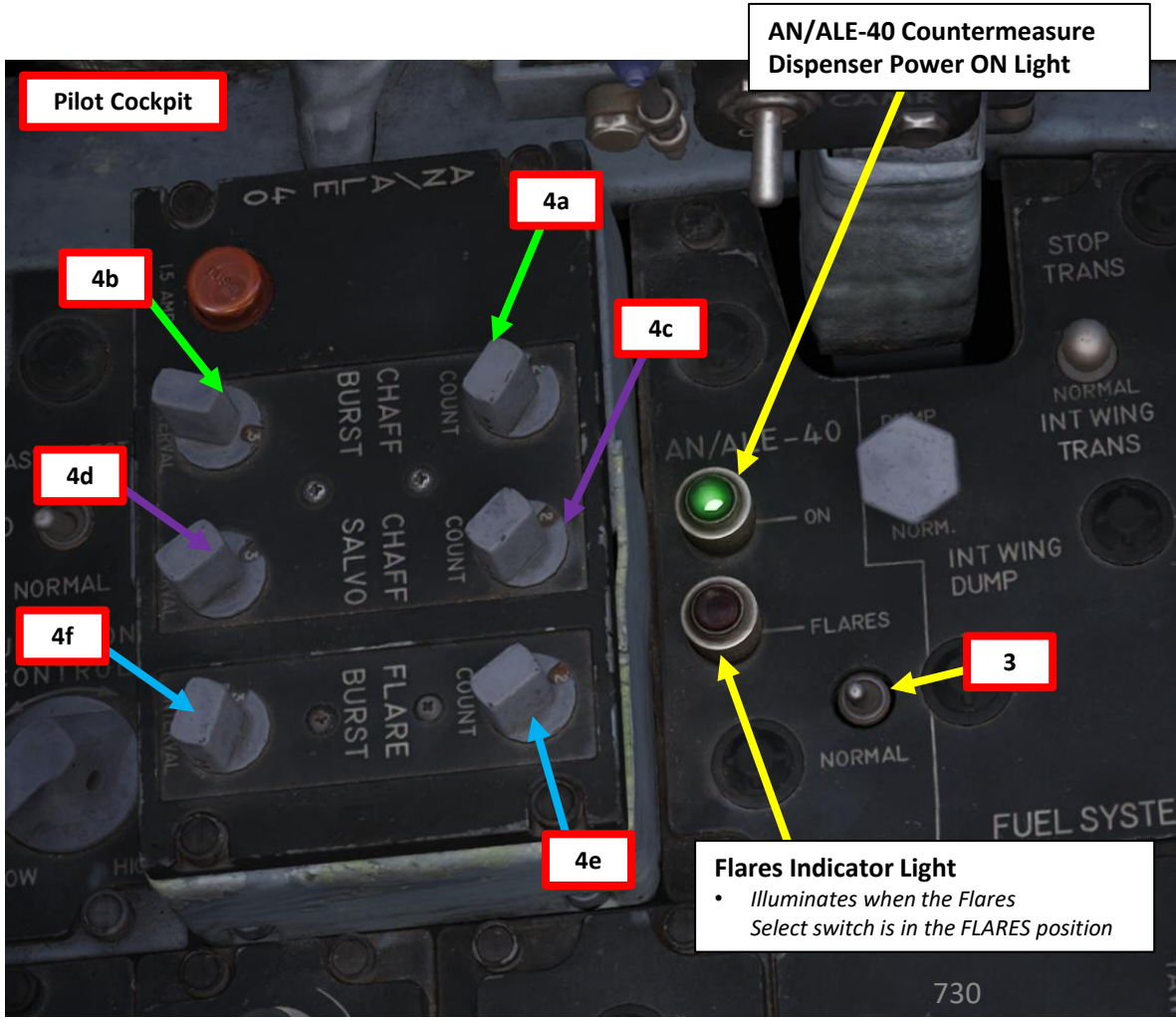


2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)
2.4 – PRGM (Program) Mode Tutorial

To dispense a programmed chaff & flares sequence:

3. *[P]* Set Flares Select Switch – As desired. I recommend leaving it to NORMAL.
   - OUTBOARD: FLARES position, allows the pilot to dispense single flare with each dispense button press regardless of CCU (Cockpit Control Unit) and Programmer settings.
   - INBOARD: Normal position, countermeasure are released according to combined settings of the CCU and the Programmer.
4. *[P]* Set desired countermeasure program settings.
   a) Chaff Burst Count: 2
   b) Chaff Burst Interval: 0.3 sec
   c) Chaff Salvo Count: 2
   d) Chaff Salvo Interval: 3 sec
   e) Flare Burst Count: 2
   f) Flare Burst Interval: 3 sec

Countermeasure Program Settings			
Category	**Description**	**Knob**	**Values**
Chaff Burst	Quantity of bursts (per salvo)	Count	1, 2, 3, 4, 6, 8
	Time interval between each burst	Interval (sec)	0.1, 0.2, 0.3, 0.4
Chaff Salvo	Number of salvos	Count	1, 2, 4, 8, C (Continuous)
	Time interval between each salvo	Interval (sec)	1, 2, 3, 4, 5, 8, R (Random)
Flare Burst	Quantity of bursts	Count	1, 2, 4, 8, C (Continuous)
	Time interval between each burst	Interval (sec)	3, 4, 6, 8, 10
Burst Definition: Single Dispensing Signal *Salvo Definition: Group of Bursts*			

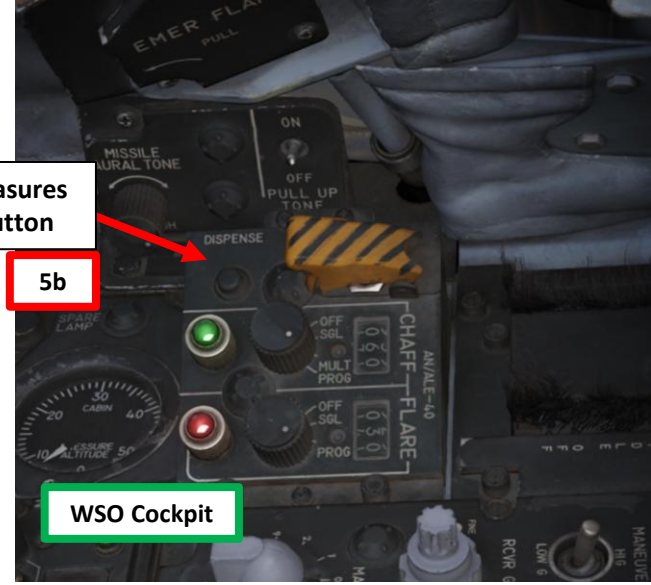


2 – AN/ALE-40 COUNTERMEASURES DISPENSER SET (CHAFF & FLARES)
2.4 – PRGM (Program) Mode Tutorial

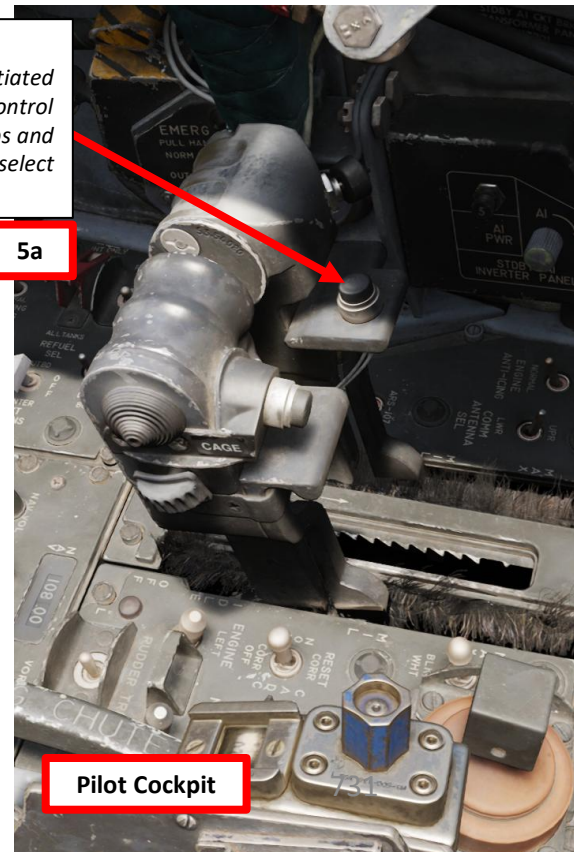
To dispense a programmed chaff & flares sequence :

5. Dispense Countermeasures using either:
   - *a) [P]* Dispense Button, or;
   - *b) [WSO]* Countermeasures Dispense Button
   - *Note: flaps and speed brakes must be retracted, otherwise countermeasure dispensing is inhibited.*
6. The chaff & flare countermeasure program is dispensed as follows:
   - Chaff Burst Count/Interval Sequence: 2 chaff bursts per salvo, 0.3 sec between each chaff burst
   - Chaff Salvo Count/Interval: 2 chaff salvos, 3 sec between each salvo
   - Flare Burst Count/Interval Sequence: 2 flare bursts, 3 sec between each burst





Dispense Button
- *When pressed, chaff/flare dispensing is initiated as set on the CCU (Cockpit Control Unit) and AN/ALE-40 programmer if the flaps and speed brakes are retracted and the flares select switch is set to NORMAL.*



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)

3.1 – Introduction & Power-Up

The AN/ALR-46 Radar Warning Receiver (RWR) is the F-4E's passive situational awareness system for detection of airborne and surface-to-air radar threats. The RWR is basically a top-down view of your aircraft. The aircraft in the upper quadrants are to your front while the aircraft on the lower quadrants are to your rear.

The system captures signals from multiple pairs of directional antennas installed at the aft of the fuselage, on each wingtip and under the nose; the difference in relative timing of detection and angle by the antennas is used by the system to define a relative bearing to the emitting radar. Further processing of the received radiation references the stored threat catalog to identify emitter type, as well as to define a relative threat range as a function of received power versus known output.

Power-Up Procedure

1. To power up the RWR, press the System Power button.
2. A BIT (Built-In Test) will occur; the RWR control panel and display will cycle through their initial 9-second warmup, with the display and illuminated buttons undergoing rapid flashing as the system is prepared for use and proper functioning is confirmed. Search mode is deactivated by default upon startup.
3. Activate Search Mode by pressing on the SEARCH button.

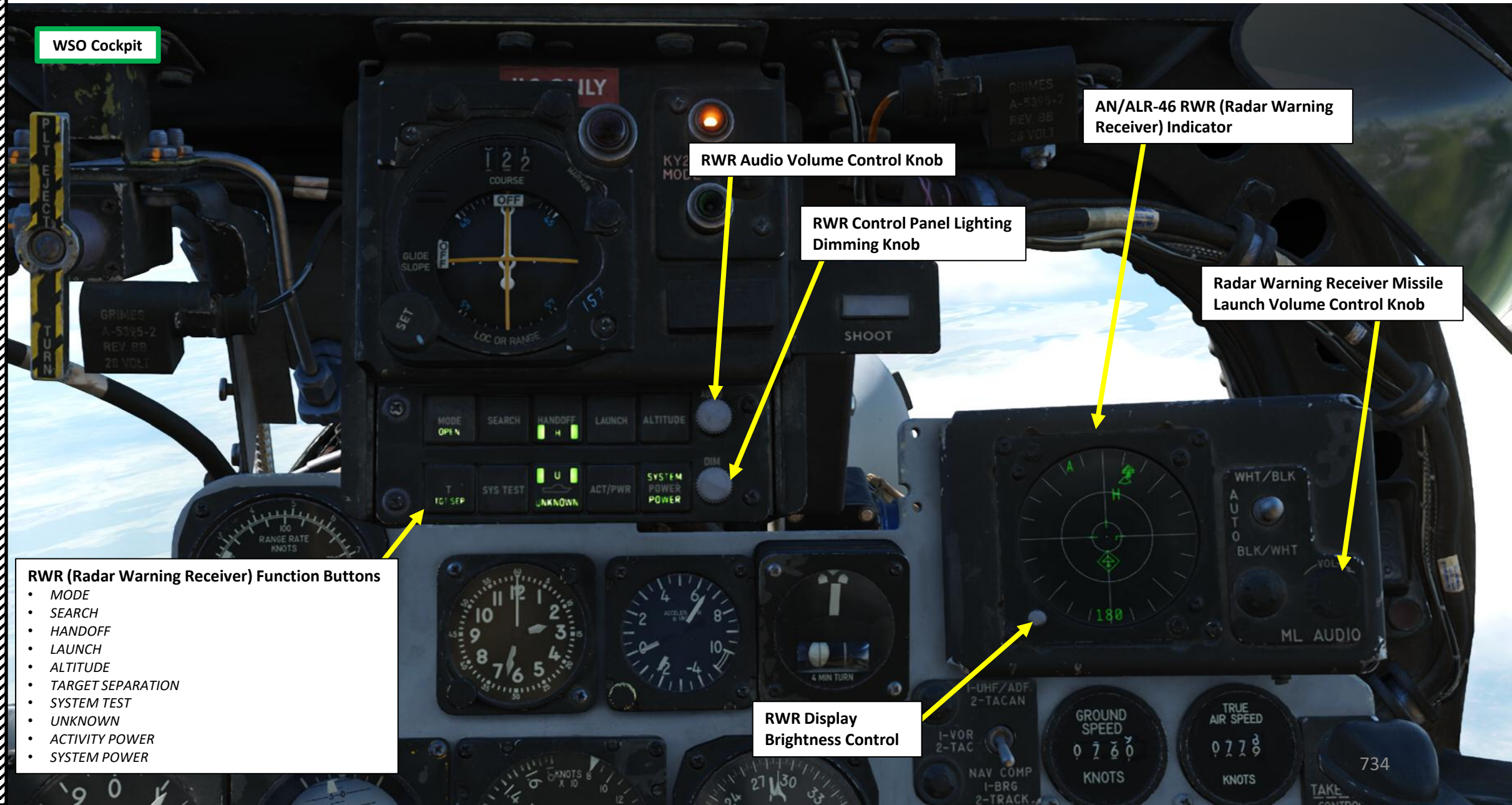


3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)

3.2 – Interface (Pilot)



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.2 – Interface (WSO)



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.3 – Symbology & Audio Cues

RWR Symbols

The processed threat signal is presented on the RWR's CRT (cathode-ray tube) display, with bearing to the radar emitter shown on the display with the top relative to the nose (12 o'clock) and the bottom the tail (6 o'clock), and with proximity to center relative to the system's calculation of the level of threat - with **closer indications being of higher danger**, and those within the **middle ring being classified within engagement range**.

In normal operation, the ALR-46 can present **16 threats concurrently**. The highest priority threat as computed by the ALR-46's threat and range catalog is presented on the display with a diamond superimposed by its symbol; this is considered "floating" diamond functionality, with the ALR-46 defining priority.

In the event of possible engagement by a threat emitter (concurrent with the illumination of the **ACTIVITY** and/or **MISSILE LAUNCH** buttons), the event is signified by a circle around the emitter symbol.

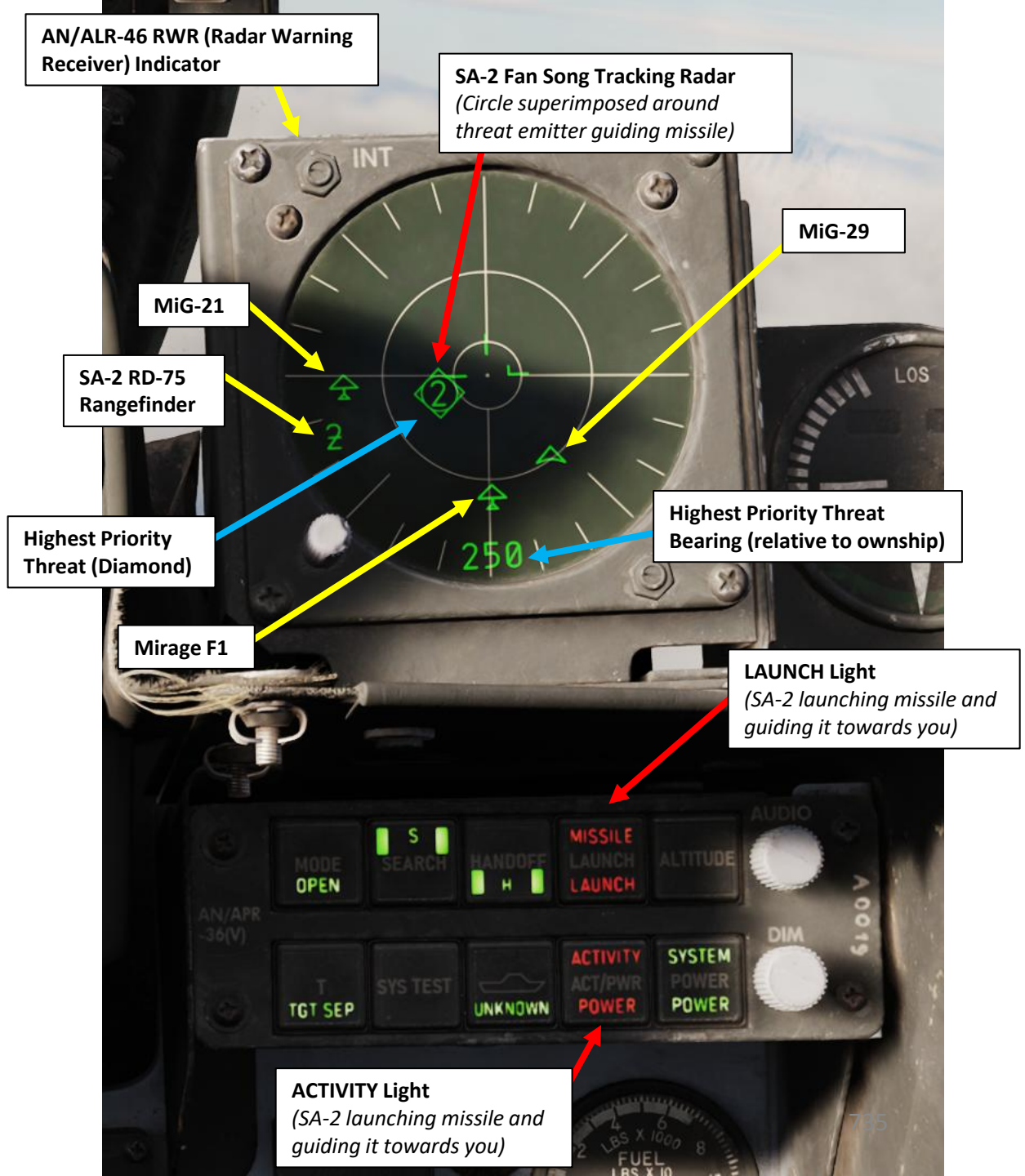
"New Guy" Audio Alert

The audio alert issued when a new emitter is first displayed, or when PRF (pulse repetition frequency) of an existing display changes is known as new guy audio. It consists of three beeps within 1.5 seconds, each at PRF of emitter which has diamond symbol. The new guy audio alerts a crewmember to a change in threat environment so he can check his azimuth indicator for update. The AUDIO control on indicator-control can adjust volume from maximum to completely off.

"Launch" Audio Alert

The synthetic launch tone generated when an emitter goes into launch state is called launch audio or ML interrupt audio. It consists of approximately seven beeps in 1.5 seconds of a 1 kHz tone generator in the signal processor. Only one launch audio is generated per launch; i.e., after approximately seven beeps, no launch audio is heard from that emitter.

Volume of the launch audio is controlled by the main RWR audio knob as well as dedicated ML audio knob in each cockpit. The resultant volume is a function of both knobs positions.



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.3 – Symbology & Audio Cues

The ALR-46 features a limited number of symbols for the different radar threats. The following symbols can stand for the different threats. The ALR-46 can save up to three files containing threat tables.

- Land file (default): land and air threats
- Sea file: sea and air threats
- Training file: additional configurable threats (empty by default)



RHAW SYMBOLS

LAND FILE

SCOPE SYMBOL	SYSTEMS	SCOPE SYMBOL	SYSTEMS
2	SA-2 - "FAN SONG"	A	SON-9 - "FIRE CAN"
2	SA-2 - RD-75	A	Gepard, C-RAM
3	SA-3 - "LOW BLOW"	H	HAWK - AN/MPQ-46
5	SA-5 - "SQUARE PAIR"	P	PATRIOT - AN/MPQ-53
6	SA-6 - "STRAIGHT FLUSH"	R	Roland, Rapier
7	HQ-7 - -	S	SEARCH: SA-6, Roland, C-RAM, "DOG EAR", HQ-7 SR, HAWK CWAR, NASAMS, Rapier Dagger, "SNOW DRIFT", "BIG BIRD", "CLAM SHELL"
8	SA-8 - "LAND ROLL"		
10	SA-10 - "FLAP LID"		
11	SA-11 - "FIRE DOME"		
15	SA-15 - "SCRUM HALF"		
19	SA-19 - "HOT SHOT"		
A	ZSU-23-4 - "GUN DISH"		

E-2D, E-3C, A-50

F-14, F-15, F-16, F-18, JF-17, M-2000C, MiG-29, Su-27, MiG-31, Tornado

F-1, AJS37, F-4, MiG-19, MiG-21, MiG-23, F-5

NOTES: 1. Aircraft are identical between LAND and SEA file

RHAW SYMBOLS

SEA FILE

SCOPE SYMBOL	SYSTEMS	SCOPE SYMBOL	SYSTEMS
4	"Rezky", Grisha class	C	Nimitz class, Forrestal class, Tarrawa class
6	"Pyotr Velikiy", "Moskva", Type 052C	G	O.H. Perry
7	Type 054A, Type 052B	L	Leander class
9	"Neustrashimy", CV 1143.5 "Kuznetsov"	P	Ticonderoga class, Arleigh Burke class
A	La Combattante II	S	SEARCH: "Rezky", "Neustrashimy", "Invinsible", "Leander", "Slava", Kuznetsov, Ropucha
A	Type 071, Leander class		
A	Ropucha class		

E-2D, E-3C, A-50

F-14, F-15, F-16, F-18, JF-17, M-2000C, MiG-29, Su-27, MiG-31, Tornado

F-1, AJS37, F-4, MiG-19, MiG-21, MiG-23, F-5

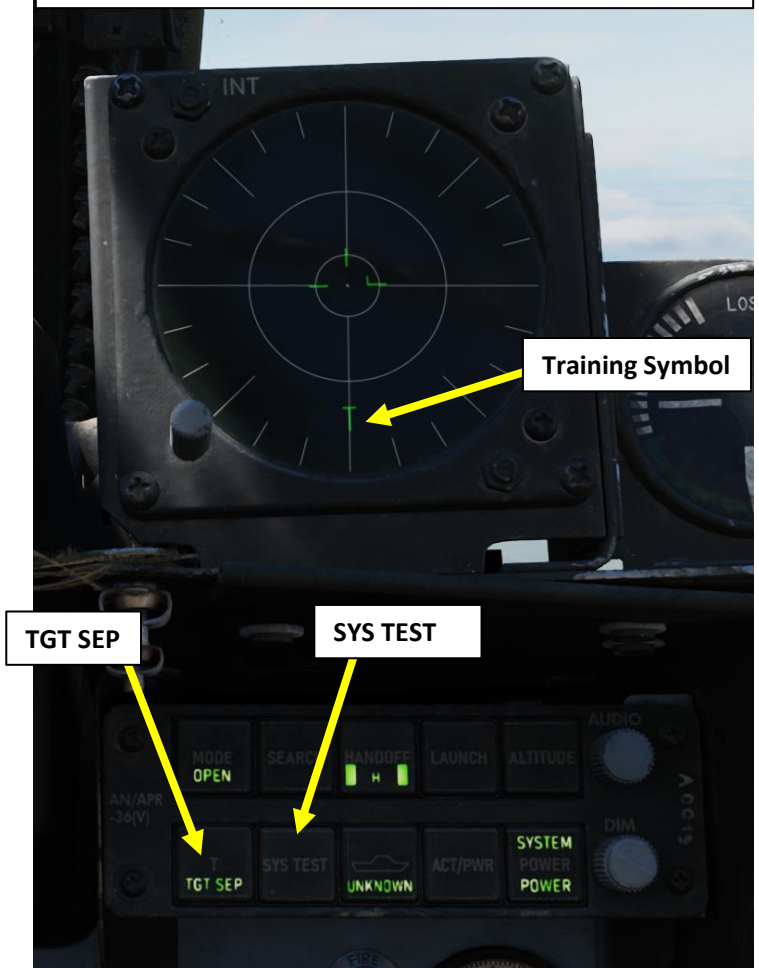
NOTES: 1. Aircraft are identical between LAND and SEA file

3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.3 – Symbology & Audio Cues

The Pilot can switch between the land and the training file by simply pressing the **SYS TEST** and within a one second timespan pressing the **TGT SEP** button. A **"T" symbol** will be displayed within the lower portion of azimuth when the training file is selected.

To switch to the sea file simply press the **SYS TEST** button and within a one second timespan press the **UNKNOWN** button. When the sea file is selected a **ship symbol** will be displayed in the lower half of azimuth.

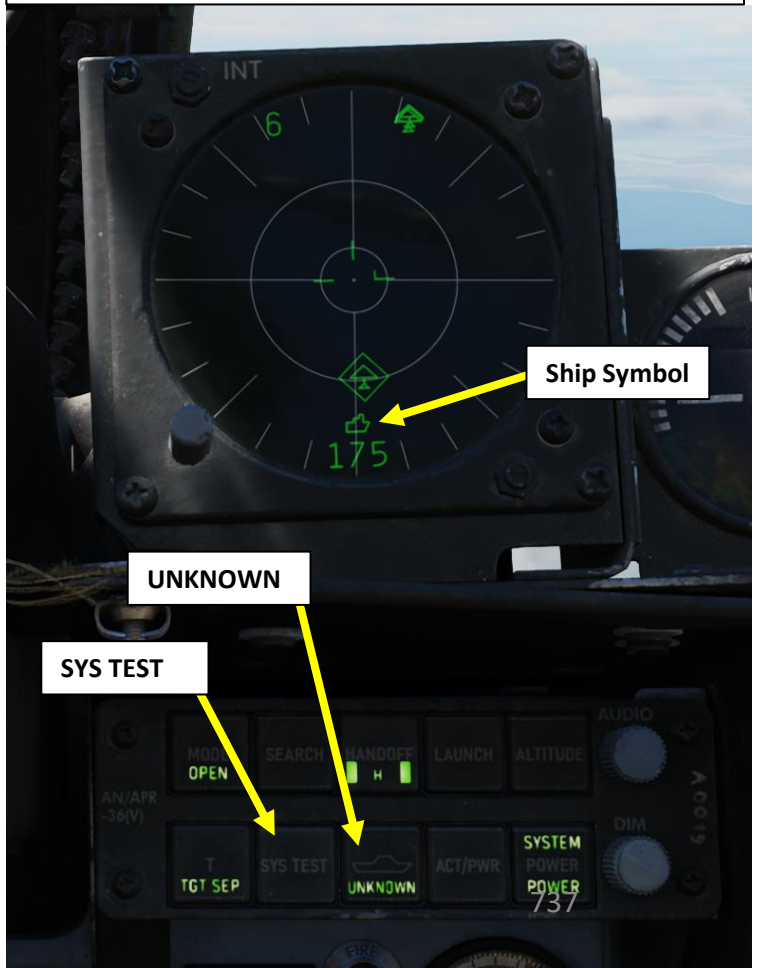
Training File Selected



Land File Selected



Sea File Selected



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.4 – Functions

SYSTEM POWER

The System Power button is the on/off switch for the ALR-46. When pressed to activate the system, the RWR control panel and display will cycle through their initial 9-second warmup, with the display and illuminated buttons undergoing rapid flashing as the system is prepared for use and proper functioning is confirmed. Search mode is deactivated by default upon startup, and if in the event the aircraft was powered down and restarted, the altitude priority mode (LOW ALT or normal) will be in the same state it was left prior to shut down.

In the event of a system power failure, the ALR-46 has an automatic restart function. Once power is recovered, the receiver will restart after a fifteen-second delay, in addition to its 9-second power on self test. The system will resume state in the same fashion as a normal restart - with Search mode deactivated and the altitude priority as when power was lost.

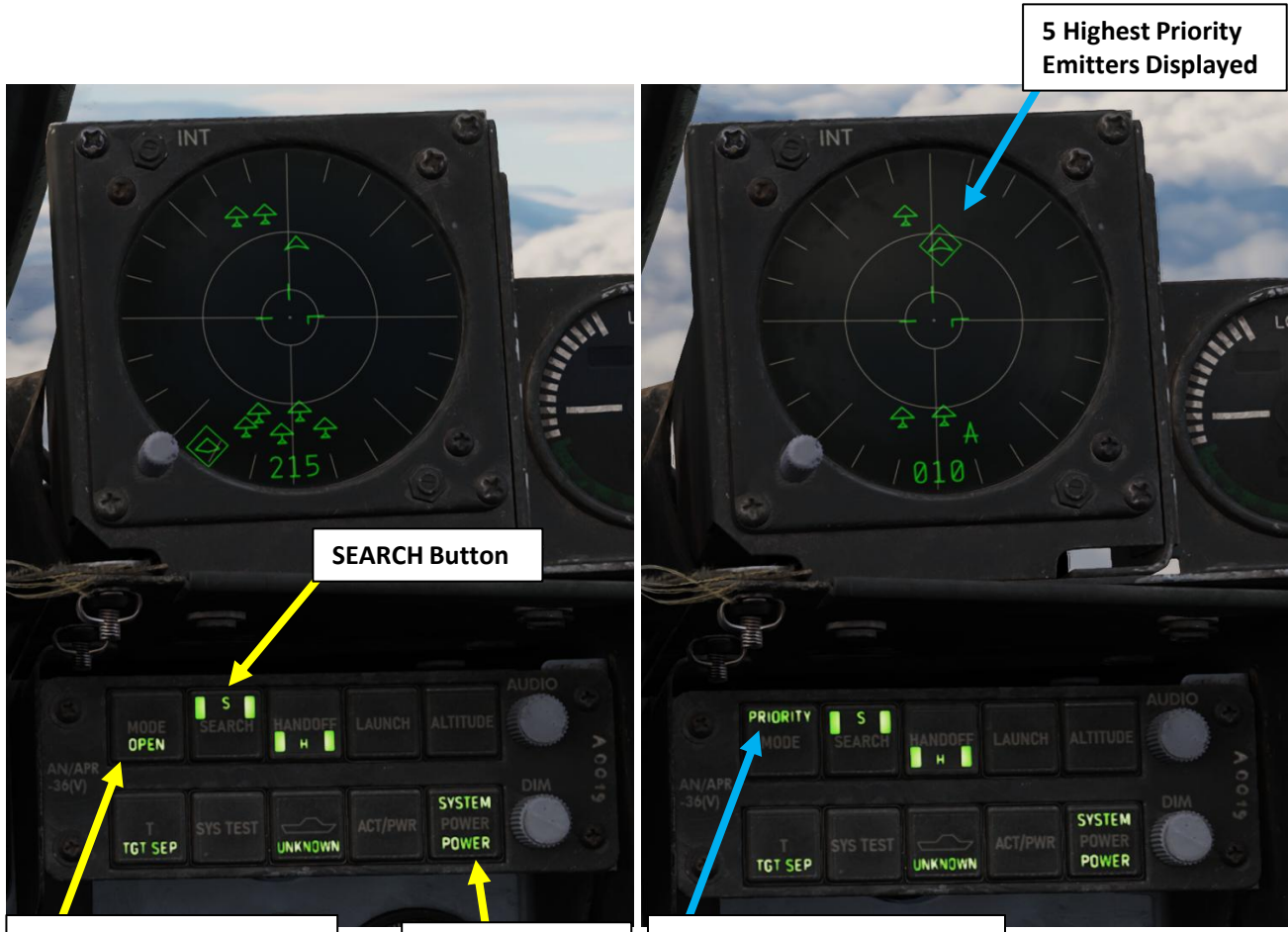
MODE

The ALR-46 defaults on power-up to OPEN mode, which presents up to 16 threats on the display at one time, depending on how many emitters are visible and current system settings (Search, LOW ALT, etc.). In the event the crew requires immediate prioritization of the most pressing threats in a saturated environment, the PRIORITY button can be pressed to display the five emitters the system deems the most dangerous. When pressed, the OPEN illumination will swap to the PRIORITY position, and revert back upon selection back to OPEN.

SEARCH

By default, the ALR-46 is programmed to prioritize and display emitters tied to weapons that can engage and destroy the aircraft. However, missions will require monitoring of early warning and search radar systems working with longer pulse-widths for extended range detection and tracking of possible intruders - i.e., the F-4. These emitters can be displayed using the Search mode, which presents them on the RWR with the S symbol to signify their function as a long range search radar. Entry into Search mode is displayed on the button with an illuminated "S".

Because of their low threat priority, it is important to note that search radar symbology may often fall off the display due to their reduced importance - especially when the ALR-46 is placed into PRIORITY mode.



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.4 – Functions

ACTIVITY POWER

In the event SAM guidance commands are detected, the ACTIVITY button will illuminate. This button's function is similar to the MISSILE LAUNCH indication insofar as that it responds to a guidance directive to a SAM, but does not respond to discrete changeover signals. Thus, an illuminated ACTIVITY warning may in fact indicate a launch, depending on the system engaging the F-4 and the circumstances surrounding it. The indication will provide a circle around the threat emitter.

LAUNCH

In the event a missile launch is detected by way of discrete SAM guidance commands being received, the MISSILE LAUNCH indications in this button will illuminate, and a circle is superimposed around the threat emitter defined as guiding the inbound weapon. Pressing the button will initiate the built-in-test which provides launch audio through the intercom.



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.4 – Functions

UNKNOWN

When an emitter is detected that does not have a catalog entry, but is recognized by received power, duration, and pulse as being a possible threat, the U indicator on the Unknown button will flash. Pressing the button will provide a U symbol on the RWR display at the correct azimuth position for reference and monitoring.

The default condition of the Unknown button is with the U symbol illuminated, but steady.

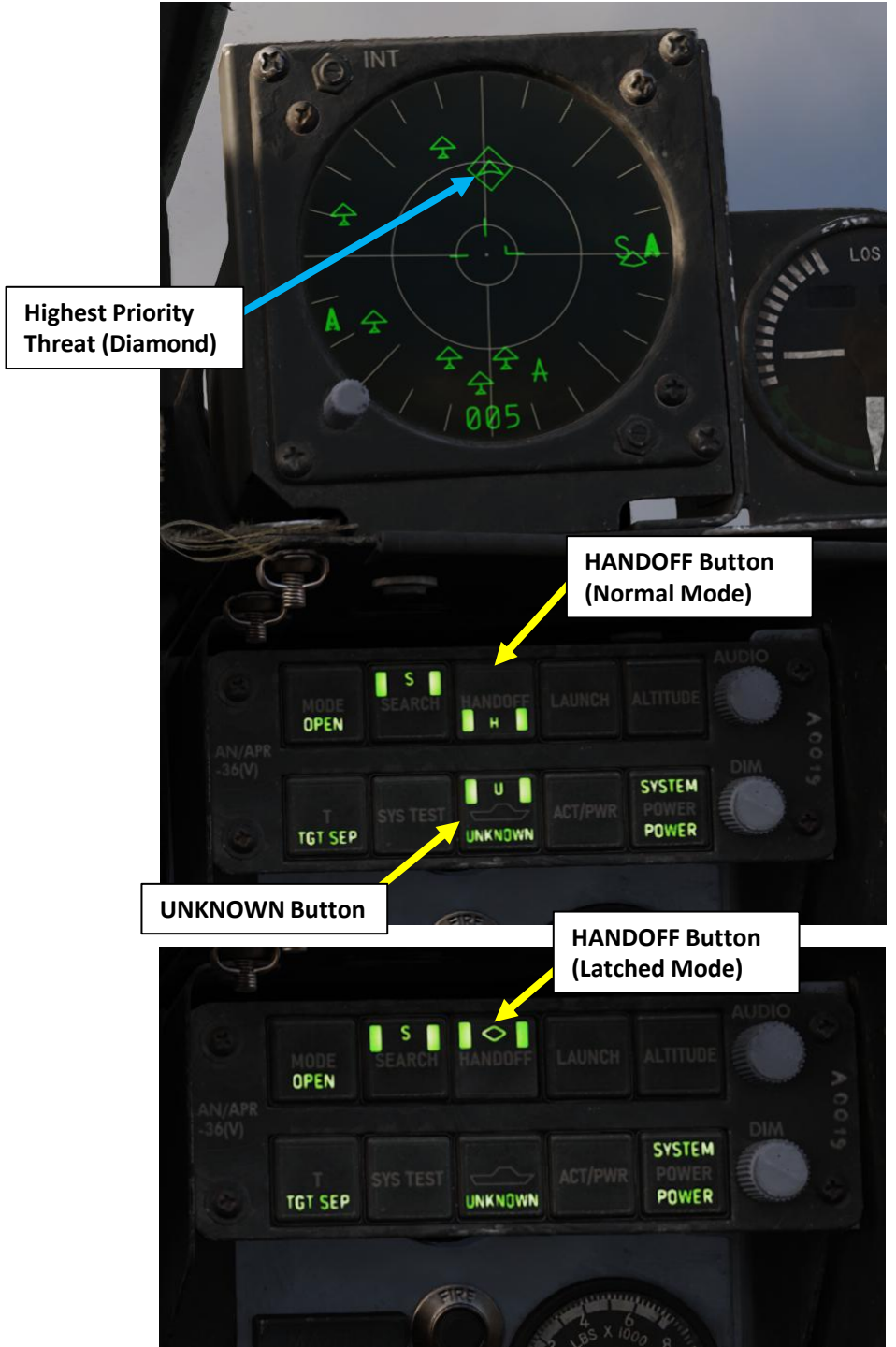
HANDOFF

The Handoff button provides the opportunity for the flight crew to define the priority emitting threat. By default, the ALR-46 defines the highest priority threat as a function of range, current transmitting mode, and the threat catalog. This priority threat is visualized with a diamond superimposed around the emitter's symbol. In the event the pilot wishes to define a different emitter as the target, the **Handoff button is pressed and held to cycle the priority diamond through the various emitters**.

Once the desired emitter is focused upon and surrounded with the diamond, the button can be released, and the priority symbol will remain latched with that emitter and the **double caret (<>) symbol** on the button illuminated to signify **latched mode**. With a latched diamond focus emitter, the system will remain focused on said emitter until the signal is either lost, the crew selects another focus emitter with the Handoff button, or the button is pressed momentarily to return to normal floating diamond threat priority mode.

In the event that the emitter is tight grouping of other symbols on the display, the TGT SEP mode will be applied.

When diamond symbol is latched, the diamond (handoff) audio can be heard through the intercom. It's a constant synthetical tone generated in the system based on the current PRF (pulse repetition frequency) of the given emitter. It's not affected by the received power so the amplitude won't change in time as in some other systems.



3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.4 – Functions

ALTITUDE

The ALR-46 utilizes own-ship altitude as a defining aspect of threat priority, thus causing low altitude AAA and SAM threats to lose priority in the event the aircraft is at an altitude that is estimated to place it outside of their threat envelope. Activating LOW ALT mode removes this envelope estimate from the threat prioritization and places low altitude threats back into priority, useful for circumstances such as a high to low dive attack or target ingress profile, and is confirmed as the active mode with the illuminated LOW ALT descriptor on the button.

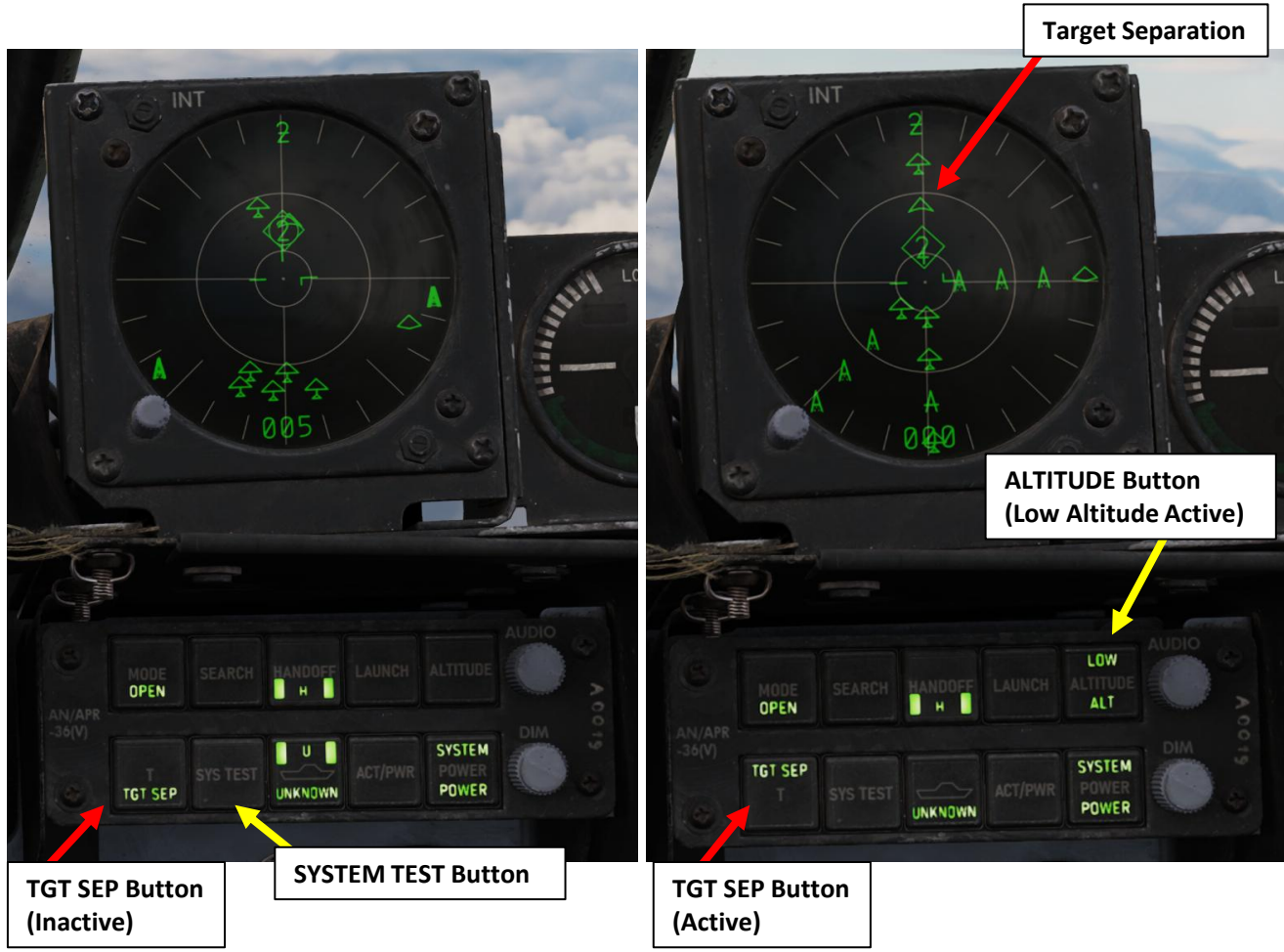
TARGET SEPARATION (TGT SEP)

In the event of a number of emitters being detected at such close proximity that the symbology overlaps on the RWR display, the Target Separation button provides the option to expand symbology on the display from emitters in the same area to allow for clarity on the type and number of radars being detected. Pressing the button triggers the lower TGT SEP illumination on the button, and any emitter groups the system defines as being eligible for the expanded presentation will do so for three seconds on the RWR display before reverting back to the standard view.

SYSTEM TEST

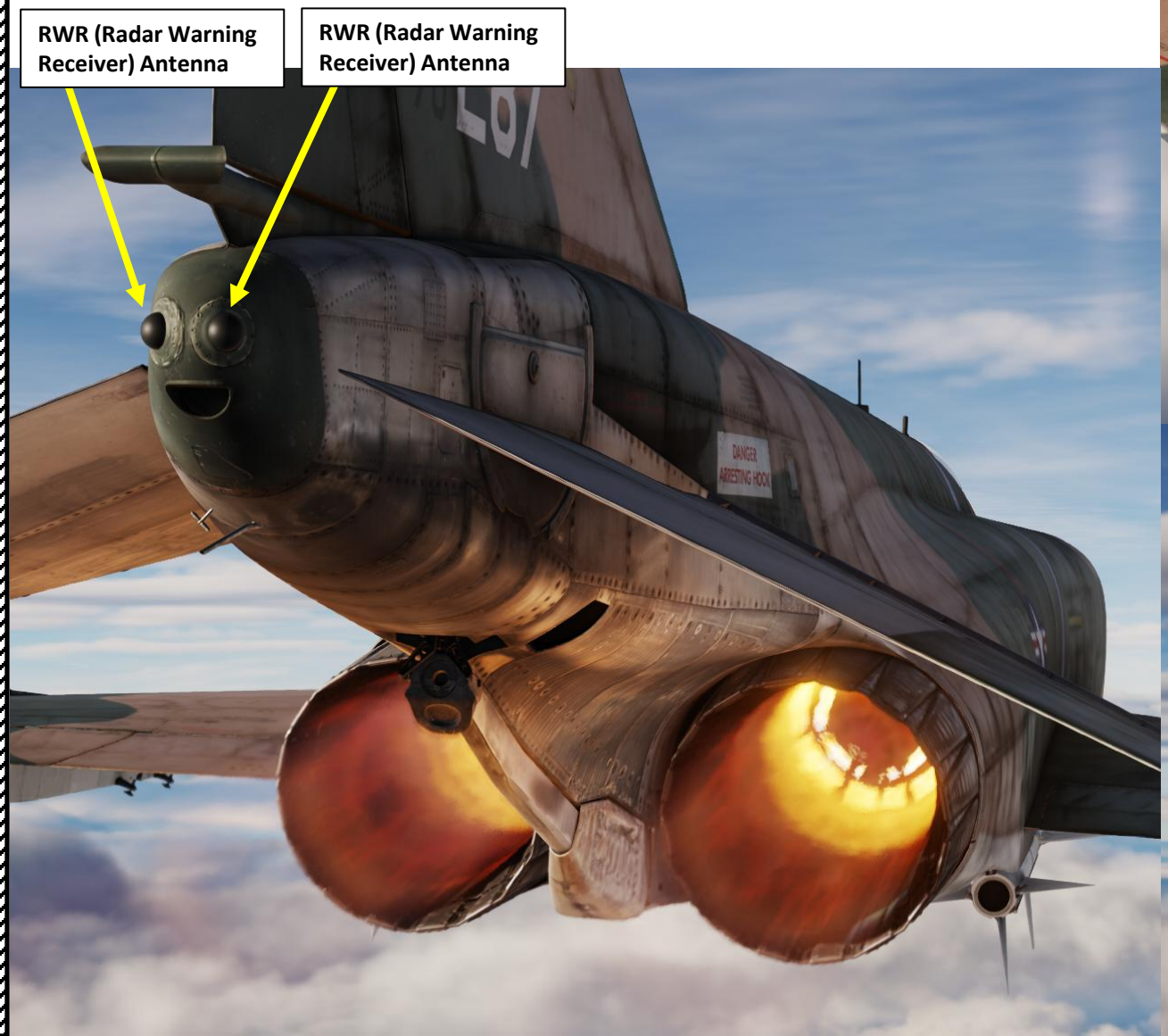
The system power on test provides a three band (1 low, 2 mid, 3 high) check in all four quadrants for proper sensitivity, along with an angle confirmation of 225 degree relative bearing for diagnostic purposes. The test sequence begins with 1s in all four quadrants, with the lower left value in a diamond (signifying a heading of 225, which is displayed on the panel); the second and third continue this process, cycling band 2 and band 3. The tests are accompanied with a sequence of tones for adjustment of audio monitoring level.

This button is also used when switching the threat files.

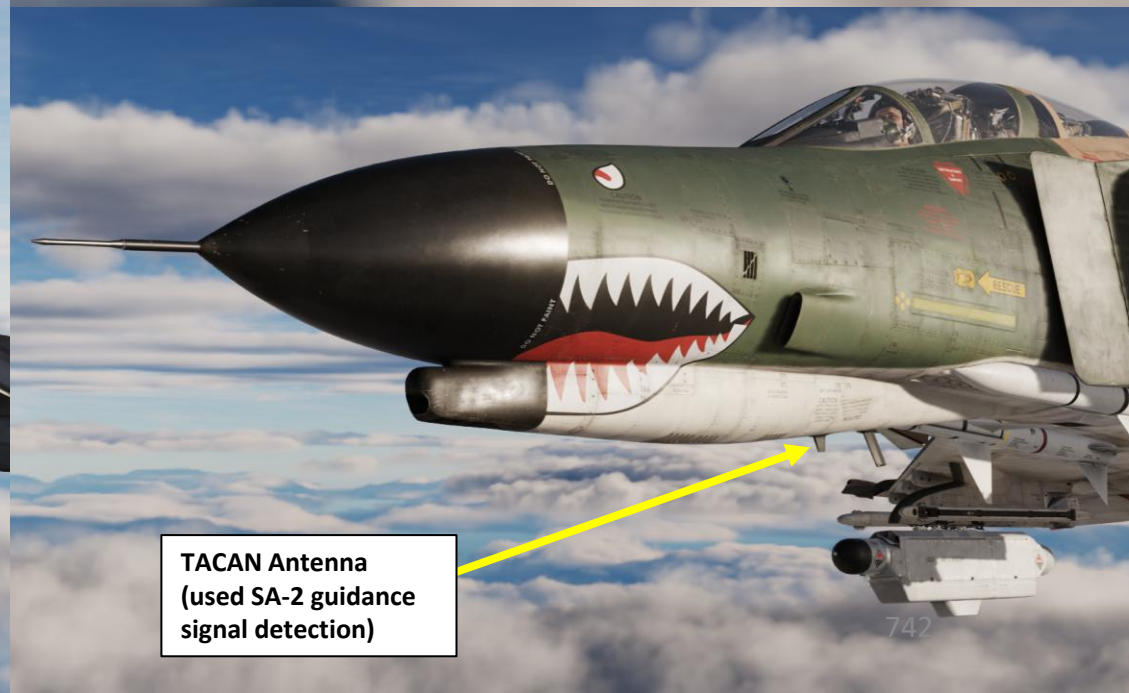


3 – AN/ALR-46 RADAR WARNING RECEIVER (RWR)
3.5 – Antennas

The RWR system captures signals from multiple pairs of directional antennas installed at the aft of the fuselage, on each wingtip and under the nose.

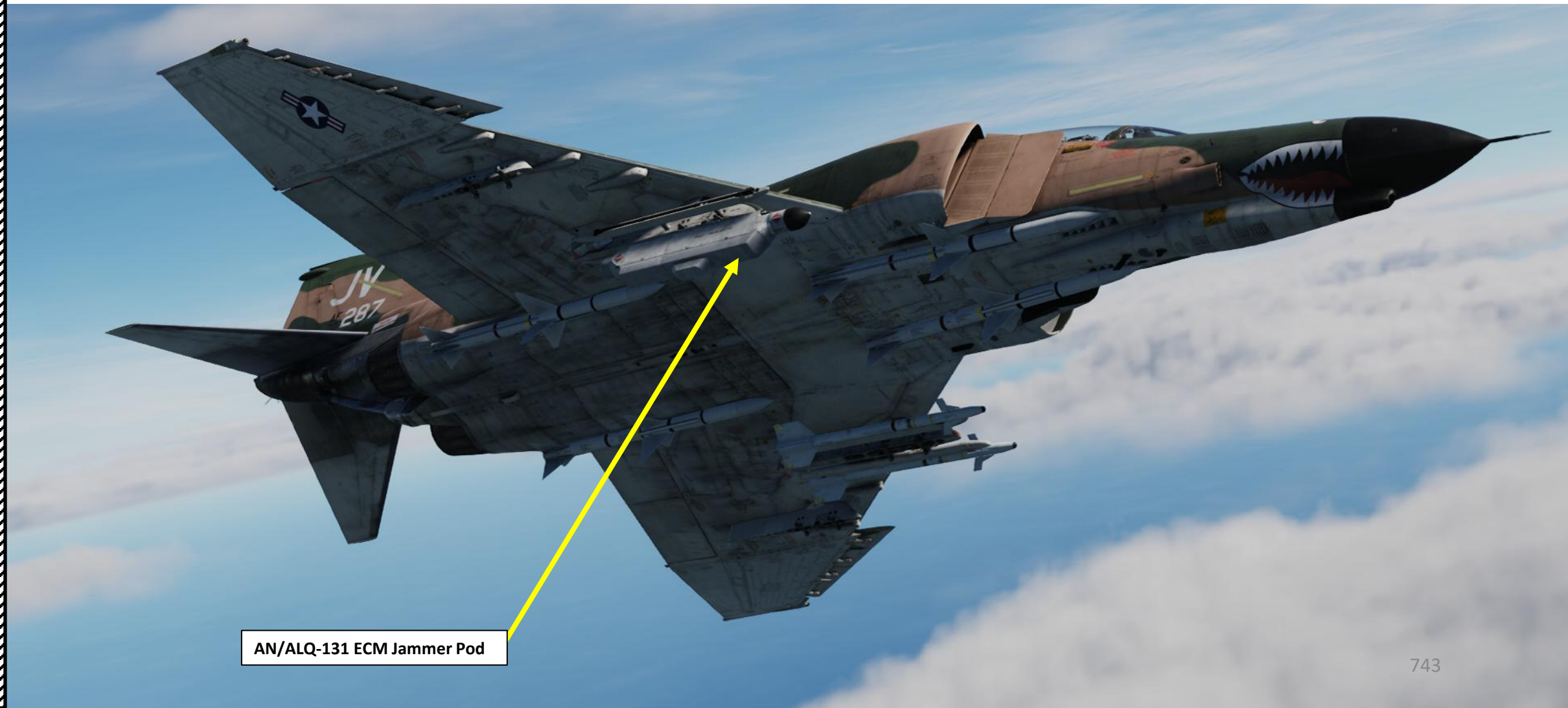






4 – ELECTRONIC COUNTERMEASURES (ECM)
AN/ALQ-131 Jammer Pod

The AN/ALQ-131 jammer pod system permits an active jamming self-protection against ground or airborne fire-control radar threats. This device transmits its own synchronized radar waves back at your enemy's radar receiver to simulate erroneous radar wave returns. Simply put, active jamming will try to drown a radar in white noise.

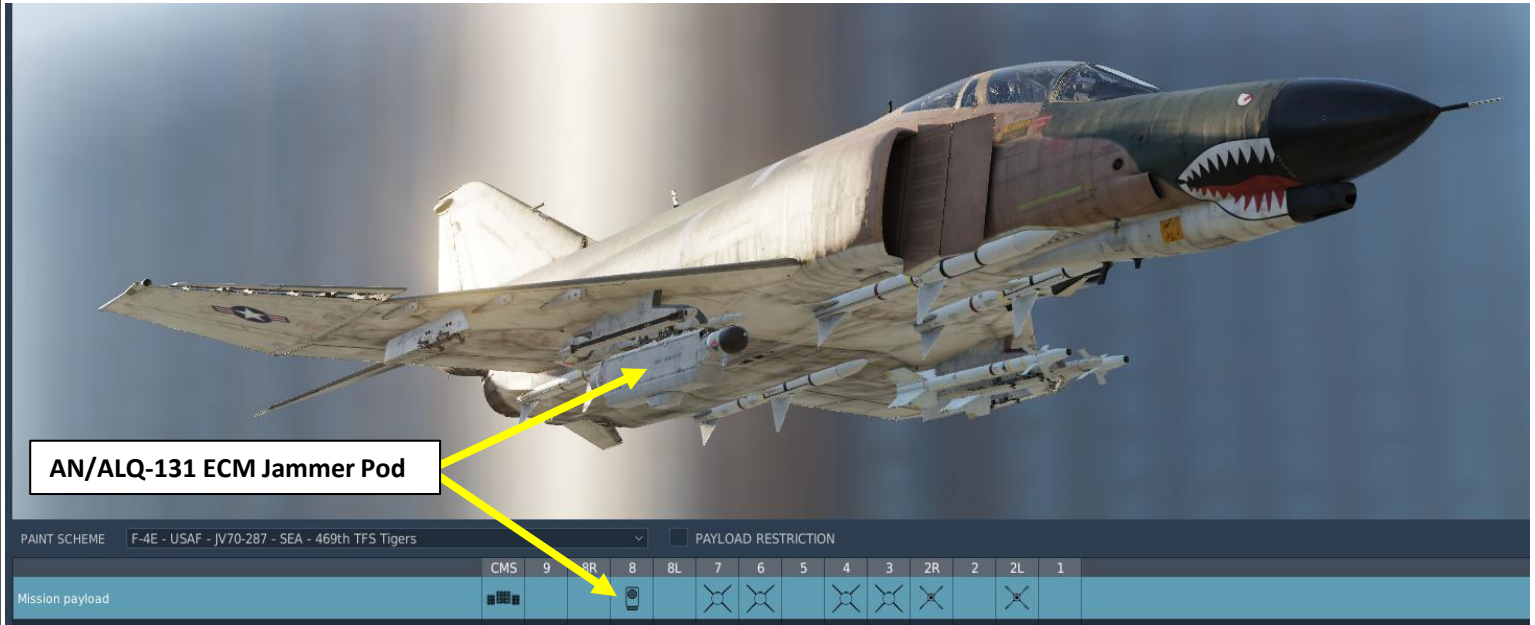


4 – ELECTRONIC COUNTERMEASURES (ECM) AN/ALQ-131 Jammer Pod

The Phantom supports ECM pods on the two inboard pylons (stations 4 and 6) and the inner wing pylons (stations 2 and 8). However, the AN/ALQ-131 pod specifically may not be equipped on the right inboard station 6.

The ECM signals are connected in a chain on each side respectively, only allowing control of one jammer pod per side.

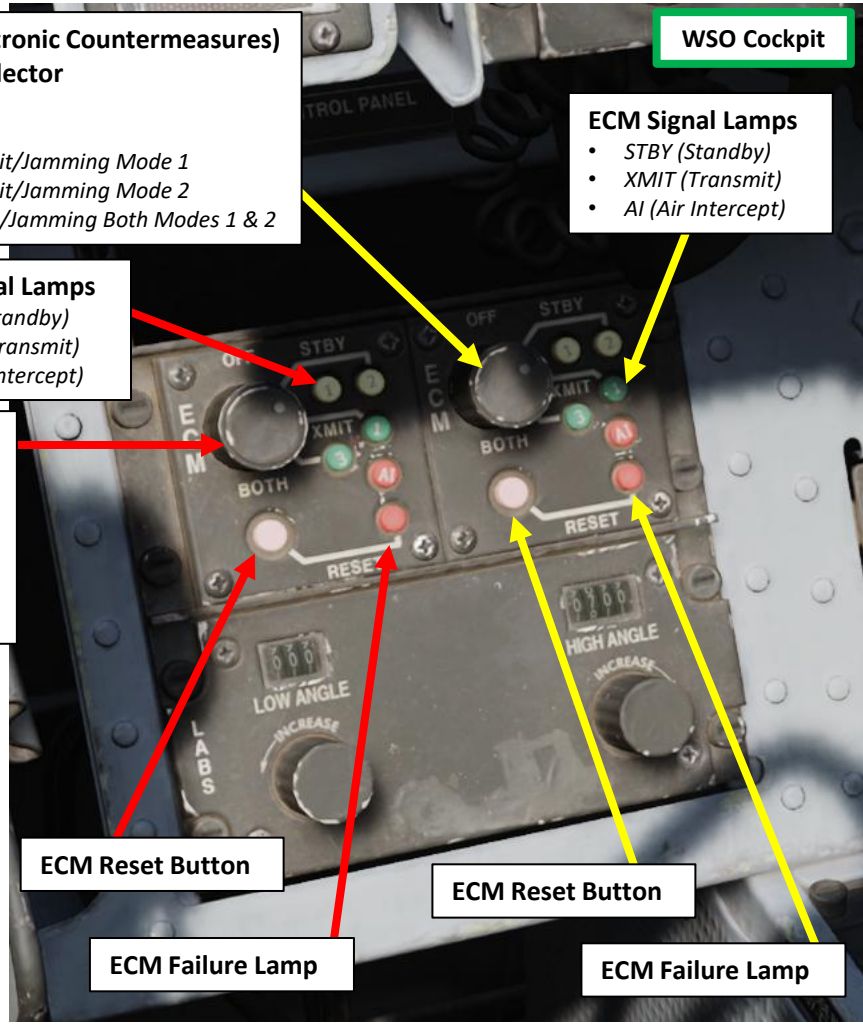
The electronic counter-measurement systems are all controlled by the WSO via controls on the right sub-panel.



Right ECM (Electronic Countermeasures) Pylons Mode Selector
- *OFF*
- *STBY (Standby)*
- *XMIT 1: Transmit/Jamming Mode 1*
- *XMIT 2: Transmit/Jamming Mode 2*
- *BOTH: Transmit/Jamming Both Modes 1 & 2*

ECM Signal Lamps
- *STBY (Standby)*
- *XMIT (Transmit)*
- *AI (Air Intercept)*

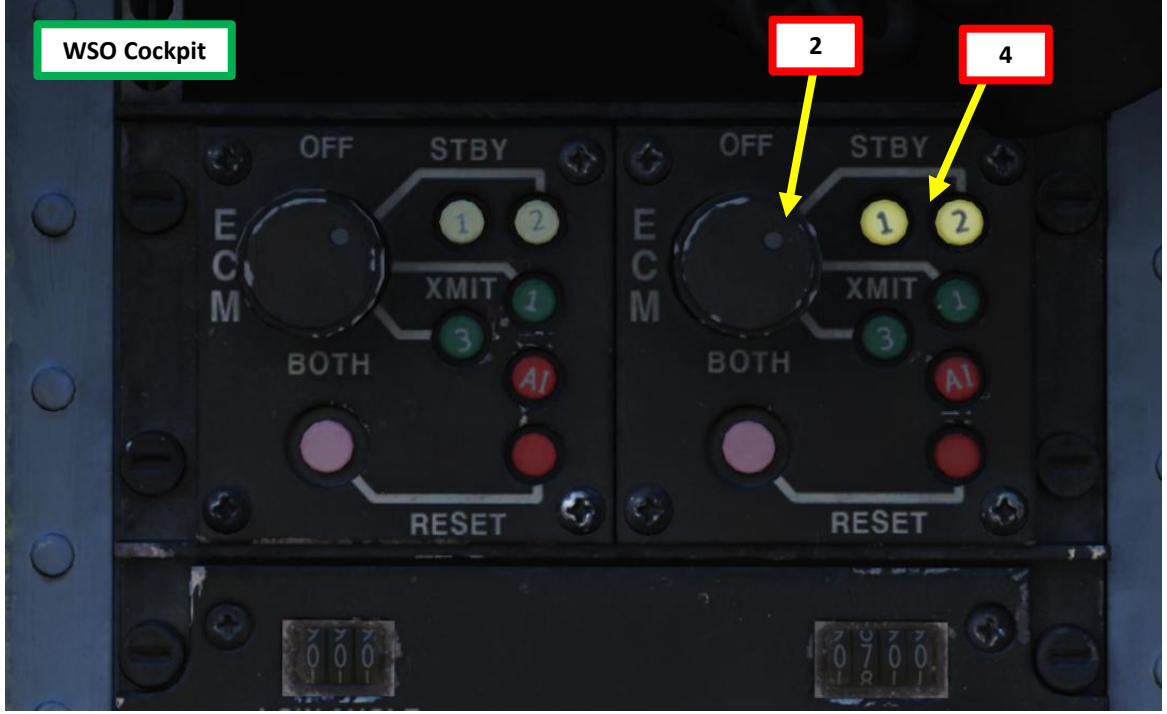
Left ECM (Electronic Countermeasures) Pylons Mode Selector
- *OFF*
- *STBY (Standby)*
- *XMIT 1: Transmit/Jamming Mode 1*
- *XMIT 2: Transmit/Jamming Mode 2*
- *BOTH: Transmit/Jamming Both Modes 1 & 2*

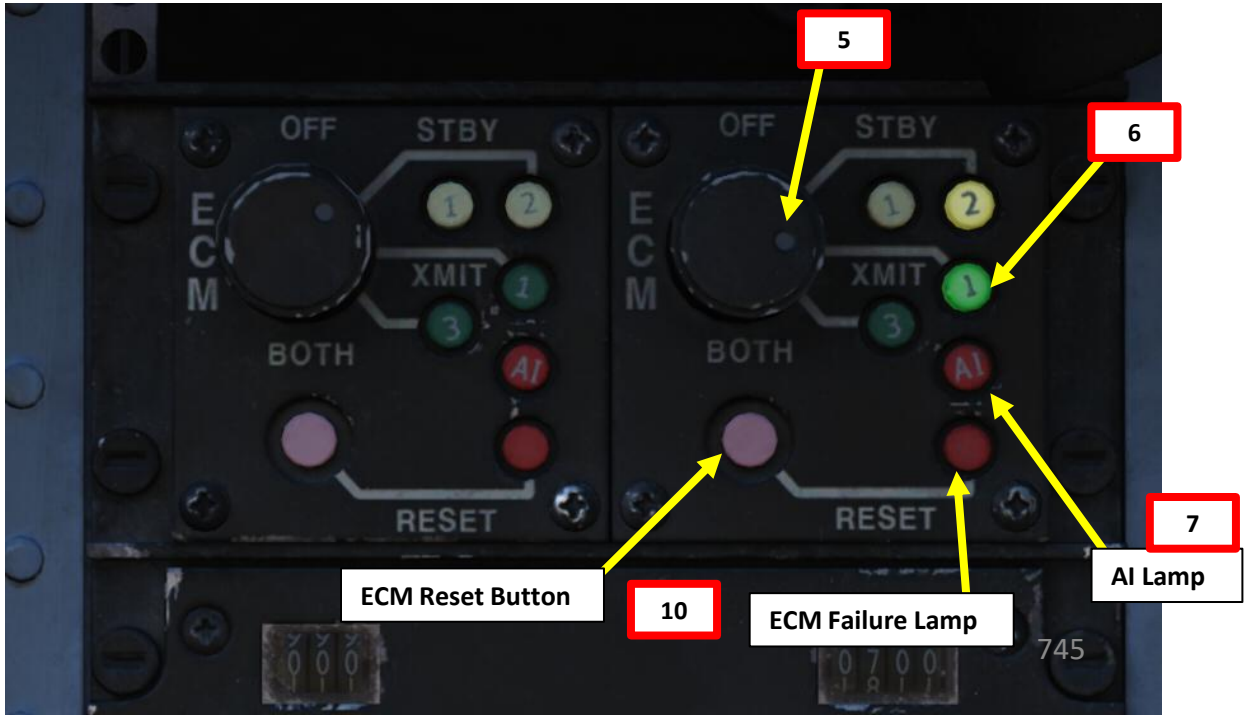


4 – ELECTRONIC COUNTERMEASURES (ECM) AN/ALQ-131 Jammer Pod

To operate the AN/ALQ-131 Jammer pod:

1. *[WSO]* Jammer pod operation on the ground is strictly prohibited to prevent exposing personnel to radiation.
2. *[WSO]* Once in the air, set desired ECM Pylon Mode Selector to STBY (Standby).
    - In this example, we have a pod installed on station 8 (right outboard pylon).
3. *[WSO]* When switching on the system, a **warming period of approximately 3 minutes** is required.
4. *[WSO]* The Standby lamps illuminate to indicate that warmup phase has finished and the pod is ready to be activated.
    - Note: The warmup logic is hardwired - flipping the pod off and on, or having a short loss of power, will result in the full warmup period being required again before use.
5. *[WSO]* To **start jamming**, desired ECM Pylon Mode Selector to either XMIT 1 (jamming mode 1 active) , XMIT 2 (jamming mode 2 active) or BOTH (modes 1 and 2 are active).
6. *[WSO]* Once ECM pod is jamming, the green XMIT light of the associated mode is illuminated.
7. *[WSO]* If the jammer detects that it is actively jamming an enemy radar, the AI (Air Intercept) lamp illuminates.
8. *[WSO]* To **stop jamming**, set desired ECM Pylon Mode Selector to STBY (Standby).
9. *[WSO]* As a rule-of-thumb, do not transmit for longer than 20 minutes without allowing for cooling between uses. Limit continued slow and low-level flight while operating the jammer to 30 minutes. For extreme outside temperatures, adjust the limits accordingly. The pod can overheat, in which case the fault lamp will illuminate. In this case, make sure to set the mode to STBY (Standby) immediately and give it some time to cool down first. Ignoring the lamp will cause parts of the pod to melt, damaging it irreparably.
10. *[WSO]* The ECM failure lamp, if lit, indicates a fault in the jammer system. Flashing indicates an overheating condition, in which case the pod should be turned off to prevent damage. In case of a fault, the reset button can be pressed to reset the jammer system (similar to turning it OFF and back ON), in which case it will run through the warmup period again. If the fault could be cleared, the light will go off.



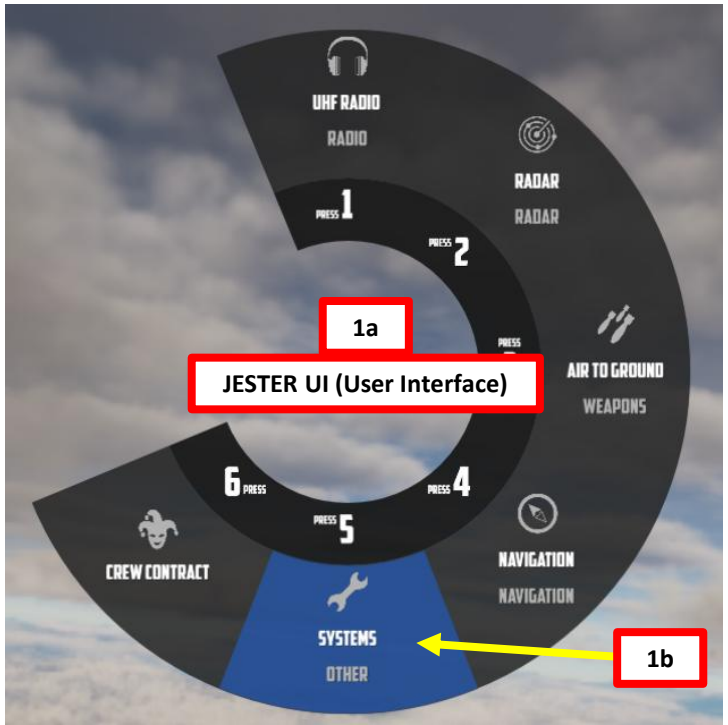


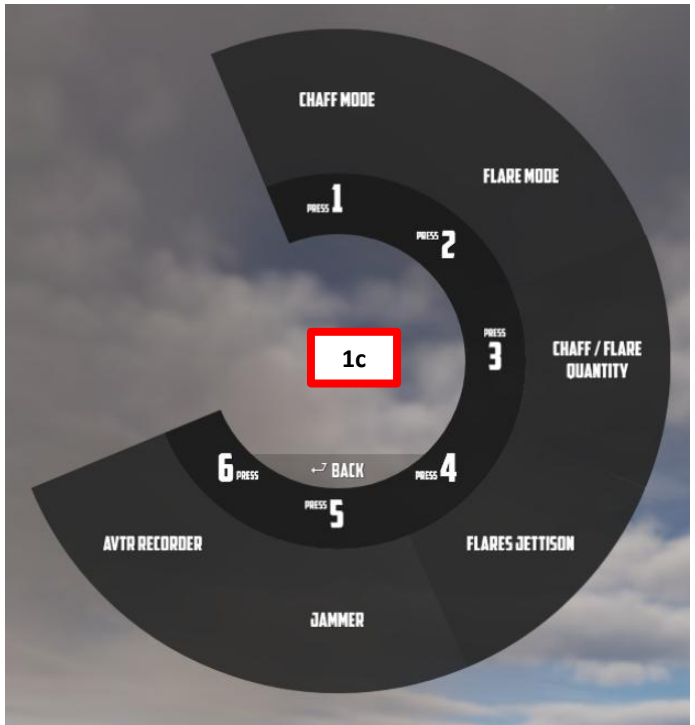
5 – JESTER AI INTERFACE

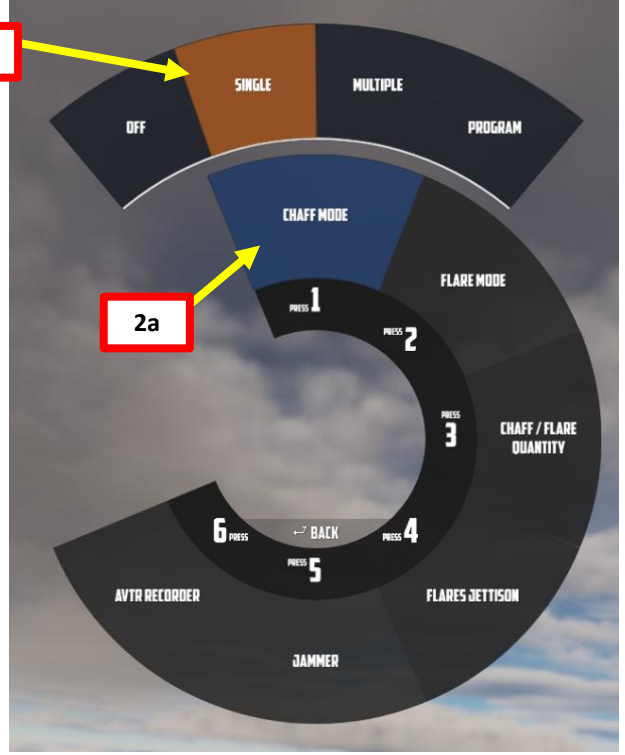
When you are flying in the pilot position and the JESTER AI takes over WSO tasks, JESTER can deploy countermeasures by himself.

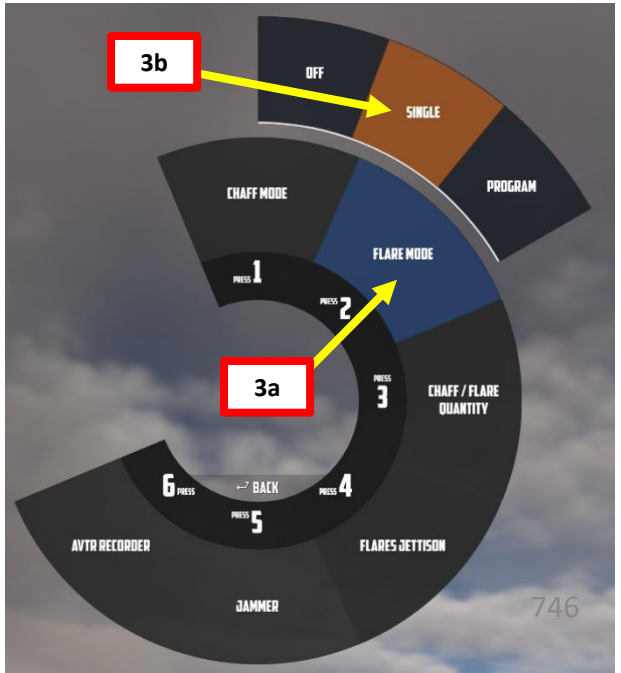
To open JESTER AI wheel, short-press "A" (JESTER UI Action binding).

1. From the **SYSTEMS** menu, you will access all countermeasures-related JESTER commands.
2. From the **CHAFF MODE** menu, you can select the way JESTER sets the chaff mode:
   - OFF: Chaff system is powered off/inactive.
   - SINGLE: A single chaff is dispensed when pressing the Countermeasures Dispense Button.
   - MULTIPLE: Chaff is dispensed according to CHAFF BURST settings of the Programmer when pressing the Countermeasures Dispense Button.
   - PROGRAM: Chaff is dispensed according CHAFF BURST and CHAFF SALVO settings of the Programmer when pressing the Countermeasures Dispense Button.
3. From the **FLARE MODE** menu, you can select the way JESTER sets the chaff mode:
   - OFF: Flare system is powered off/inactive.
   - SINGLE: A single flare is dispensed when pressing the Countermeasures Dispense Button.
   - PROGRAM: Flares are dispensed according to FLARE BURST settings of the Programmer when pressing the Countermeasures Dispense Button.





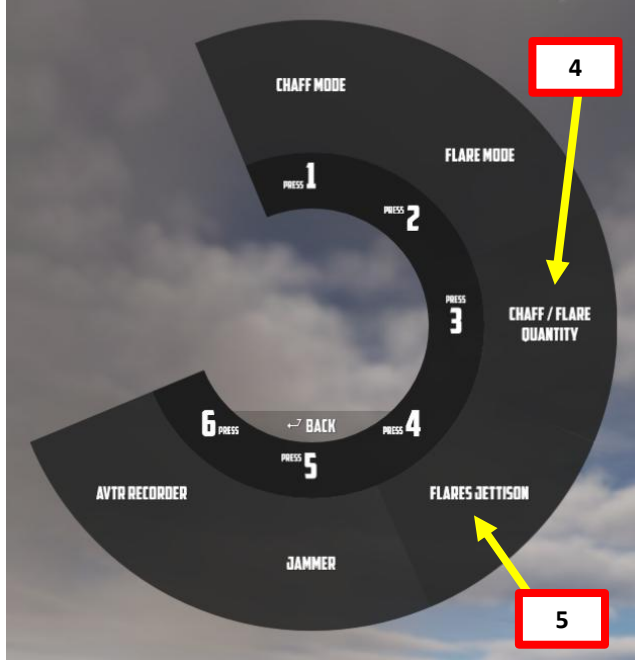


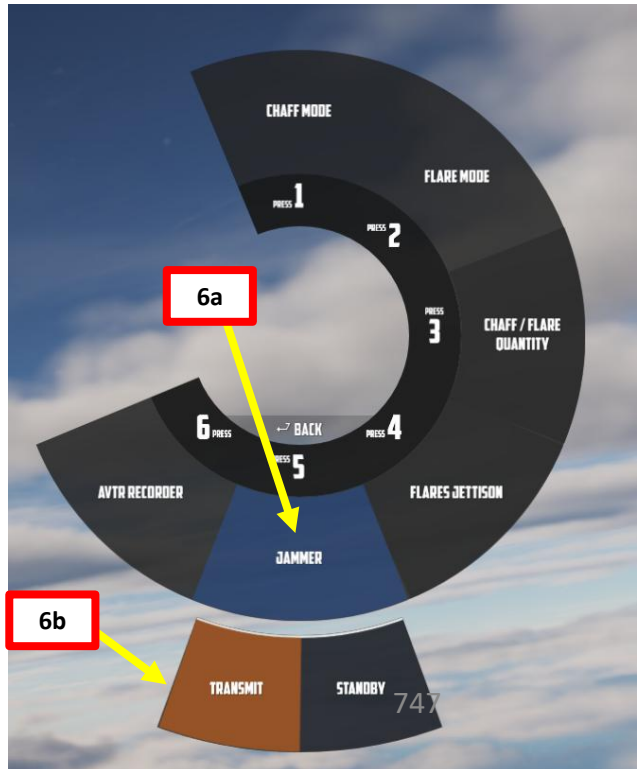


5 – JESTER AI INTERFACE

4. Selecting "**CHAFF/FLARE**" commands JESTER to call out the number of chaff, followed by the number of flares.
5. Selecting "**FLARES JETTISON**" commands JESTER to jettison all flares using the Ripple Switch (dispenses flares at rate of ten per second until dispensers are empty, so long as flaps and speed brakes are retracted).
6. From the **JAMMER** menu, you can select the way JESTER controls the AN/ALQ-131 ECM (Electronic Countermeasures) Jammer Pod:
    - STANDBY: Jammer pod is in Standby Mode (not jamming).
    - TRANSMIT: Jammer pod is jamming.

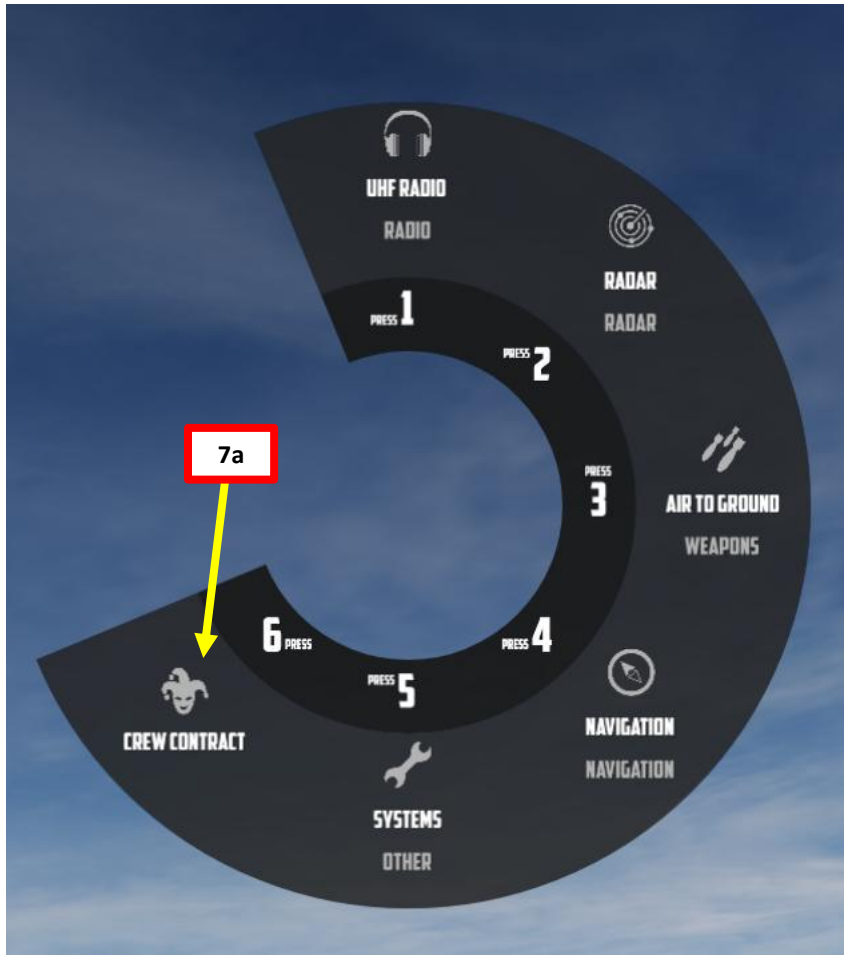


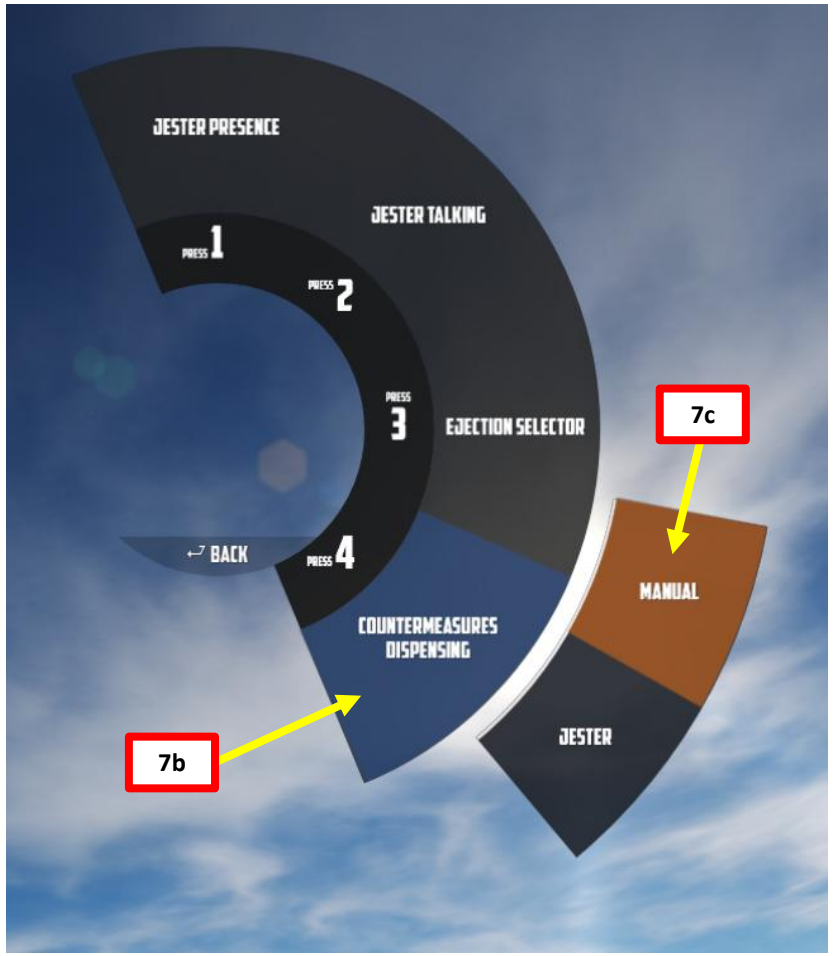




5 – JESTER AI INTERFACE

7. From the **CREW CONTRACT – COUNTERMEASURES DISPENSING** menu, you can also tell JESTER whether to dispense countermeasures by himself (JESTER setting) or if you prefer to dispense countermeasures by yourself from the pilot cockpit (MANUAL setting).





1 – IFF INTRODUCTION

Identifying what you may or may not shoot should be your primary concern at all times. This is where the IFF (Identify-Friend-or-Foe) system comes into play.

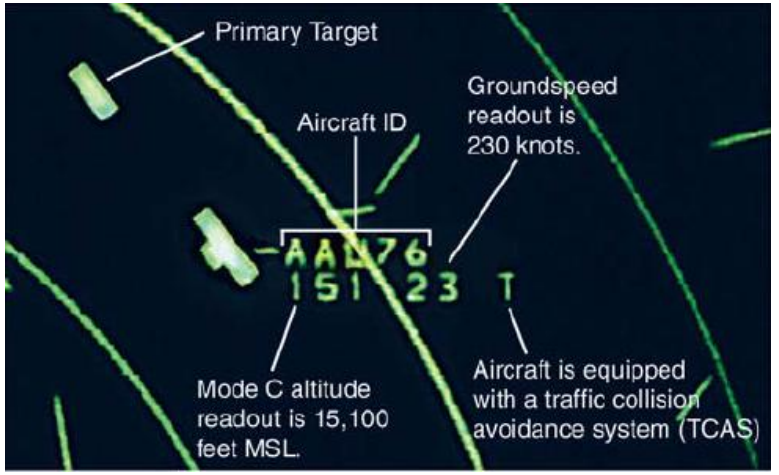
An IFF system consists of an **INTERROGATOR** component and a **TRANSPONDER** component.

The **interrogator** component broadcasts an interrogation signal with a specific "code" (pulse frequency).

A **transponder** equipped on another aircraft will receive the interrogation signal and broadcast a reply signal with its own "code" (pulse frequency) as well. The information sent from this reply signal will vary based on the transponder mode selected.

Your own aircraft transponder will then see if the interrogation code and reply codes match, which in some cases can be used to determine whether the other aircraft is a friendly contact. The nature of the information determined will vary based on the transponder mode.

Take note that if you set an incorrect transponder code, friendly contacts may not be able to identify you as a friendly.





1 – IFF INTRODUCTION

The Phantom is equipped with a set of the following interrogator systems:

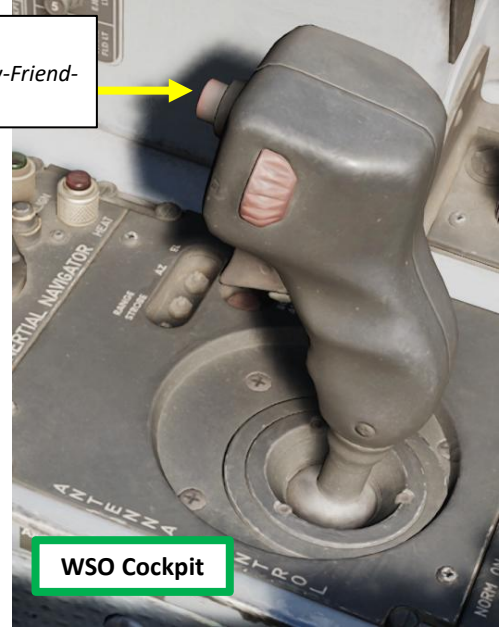
- **AN/APX-76 IFF (Identify-Friend-or-Foe) Interrogator**: Enables regular interrogation with friendly transponder systems.
- **AN/APX-81A Combat Tree**: "Combat Tree" sends compatible interrogation requests to Soviet systems which they would identify as friendly systems, hence sending back a valid response. This allows the Phantom to not only identify friendly systems, but also some likely-hostile aircraft. Soviets quickly realized the problem and patched their IFF transponder systems, while also encrypting the communication to prevent another breach.
- **AN/APX-80A Control Panel**: Combines the AN/APX-76 IFF Interrogator System and the AN/APX-81A Combat-Tree system.

****

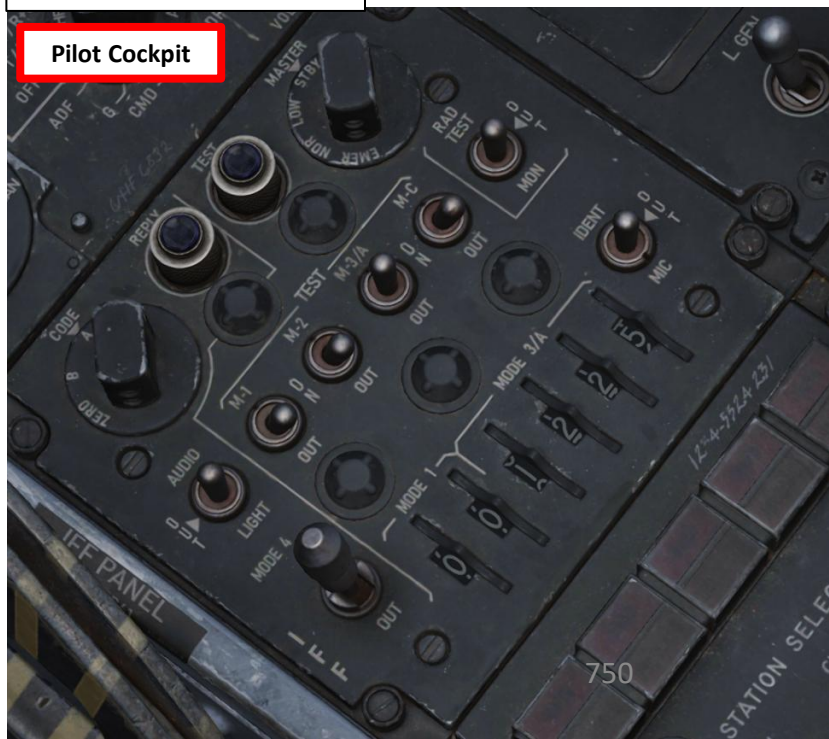
The aircraft is equipped as well as with a transponder to react to interrogations from other aircraft.

- The **transponder** automatically responds to challenges from surface or airborne radar sets and serves supplementary purposes such as providing momentary identification of position upon request and transmitting a specially coded response to indicate an emergency. The system operates by receiving coded interrogation signals and transmitting coded response signals to the source of the challenge, with a proper reply indicating the target is friendly. The system features four modes. Mode 1, Mode 2, and Mode 3/A—are provided for security identification, personal identification, and traffic identification, respectively. Mode 4 is controlled through the interrogator panel by the WSO. Codes for Modes 1 and 3/A can be set in the cockpit, while the code for Mode 2 must be set on the ground, ranging from 0000 to 7777.

Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*



Transponder Control Panel



AN/APX-80 Control Panel
- *Combines the APX-76 IFF (Identify-Friend-or-Foe) Interrogator System and the APX-81A Combat Tree system.*



2 – IFF MODES & PRINCIPLES

In its simplest form, a "Mode" or interrogation type is generally determined by pulse spacing between two or more interrogation pulses. Various modes exist from Mode 1 to 5 for military use, to Mode A, C, and Mode S for civilian use. The takeaway from this table should be:

- **Mode 4 is the preferred mode in a combat** scenario because it is highly secure (encrypted). Encrypted interrogation codes cannot be detected by an enemy transponder, and your transponder will not broadcast a reply signal to the other team.
- **Mode 4 invalid/lack of reply cannot guarantee that an aircraft is hostile**, but a **valid reply is a guarantee of a friendly contact** (within DCS)
- **Modes 1, 2, and 3 are not secure to use** since any other aircraft from the opposing team could find what your Interrogator code is and set his transponder to it, fooling you into thinking he is a friendly contact. These modes also easily give away your position since every time your transponder broadcasts an answer, this signal can be intercepted by an enemy transponder, which can send your position to other enemy fighters via datalink.

Military Interrogation Mode	Civilian Interrogation Mode	Description
1		Provides 2-digit 5-bit mission code
2		Provides 4-digit octal unit code (set on ground for fighters, can be changed in flight by transport aircraft)
3	A	Provides a 4-digit octal identification code for the aircraft, set in the cockpit but assigned by the air traffic controller. Mode 3/A is often combined with Mode C to provide altitude information as well.
	C	Provides the aircraft's pressure altitude and is usually combined with Mode 3/A to provide a combination of a 4-digit octal code and altitude as Mode 3 A/C, often referred to as Mode A and C
4		Provides a 3-pulse reply, delay is based on the encrypted challenge
5		Provides a cryptographically secured version of Mode S and ADS-B GPS position
S		Mode S (Select) is designed to help avoiding overinterrogation of the transponder (having many radars in busy areas) and to allow automatic collision avoidance. Mode S transponders are compatible with Mode A and Mode C Secondary Surveillance Radar (SSR) systems. This is the type of transponder that is used for TCAS or ACAS II (Airborne Collision Avoidance System) functions

2 – IFF MODES & PRINCIPLES

The “Interrogator” component of the IFF system is used to interrogate unknown contacts.

The “Transponder” component of the IFF system is used to respond to interrogations from other aircraft.



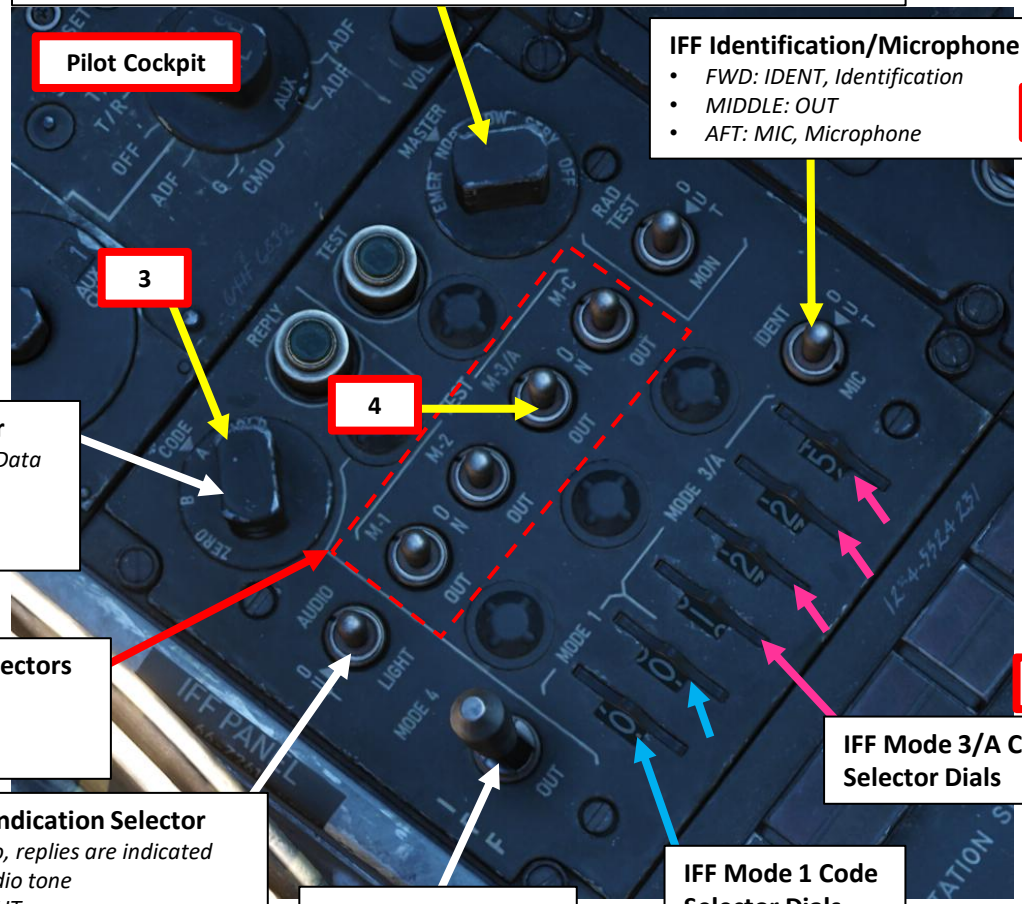
Interrogation Code (Who are you?)	Transponder Code (Who am I?)
Mode 4	Mode 4
Key A	Key A

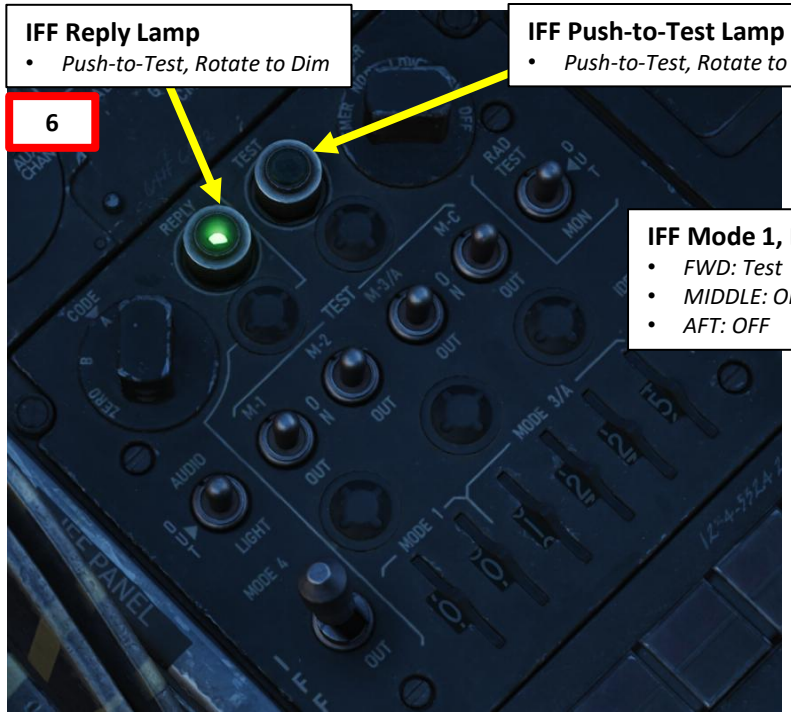
3 – IFF TRANSPONDER SETUP

In this example, we want to set up the transponder code "1225" for Mode 3/A :

1. Consult mission briefing to find what IFF (Identify-Friend-or-Foe) Transponder Code required. As an example, if we need an IFF Transponder set to Mode 3/A Code 1225.
2. *[P]* Set IFF Master Selector to STANDBY. After an approximate 80-second warmup delay, the system receives full power, but interrogations are blocked. Once warmup is performed, set IFF Master Selector from STANDBY to NORMAL.
3. *[P]* Set IFF Code Selector to A
4. *[P]* Set IFF Mode 3/A Switch – ON (MIDDLE)
5. *[P]* Set IFF Mode 3/A Channel Wheel Selectors to "1225".
6. *[P]* If you are interrogated with mode 3A with a code set to 1225, the transponder will then send a response signal (reply) to the interrogator with the transponder code you entered previously.
7. *[P]* If the tower wants to know your position, they are likely to send you a specific IFF mode and code *("Squawk")*, then ask you to "*Identify*". This requires you to press the IFF Identification/Microphone Switch to IDENT (FWD), which will allow the tower to know where you are from your transponder's identification signal/transmission.

IFF (Identify-Friend-or-Foe) Transponder Master Mode Selector — 2
- *OFF*
- *STBY: Standby, full power is supplied to the system but with interrogations blocked.*
- *LOW: System operates with low/reduced sensitivity.*
- *NORM: Normal operation mode with full sensitivity.*
- *EMER: Emergency mode, allows the system to respond to interrogations in Modes 1, 2 and 3/A. The reply for Modes 1 and 2 is a special emergency signal of the codes selected on the applicable dials, while Mode 3/A replies are special emergency signals of code 7700.*



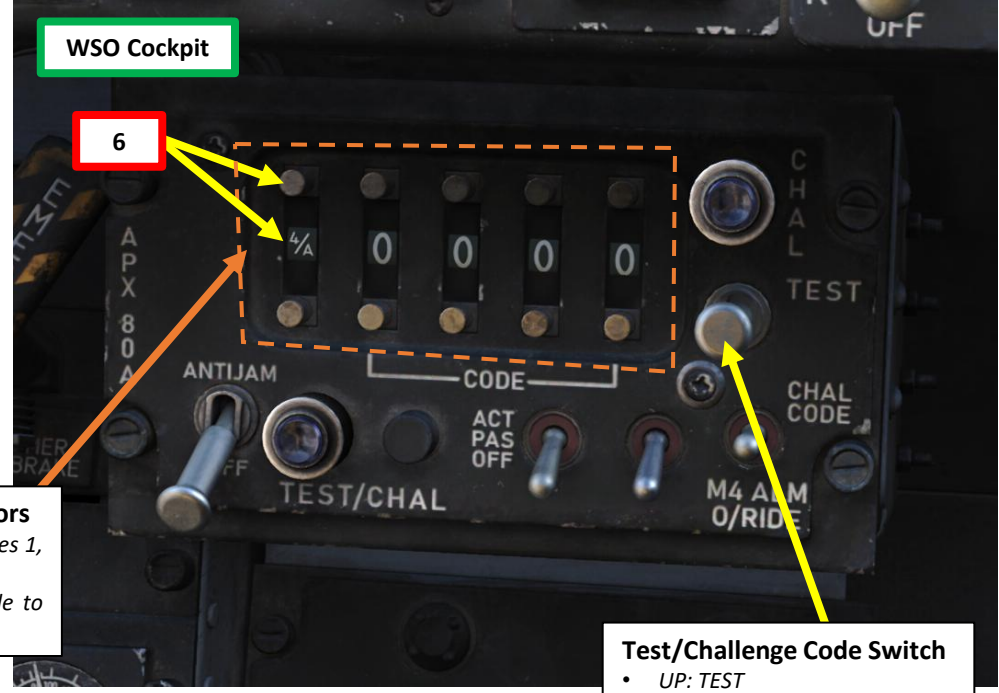


4 – AN/APX-76 IFF INTERROGATOR (MODE 4)

In this example, we will interrogate a target with Mode 4A:

1. Consult mission briefing to find what IFF (Identify-Friend-or-Foe) Transponder and Interrogation Codes are required. As an example, if we need an IFF Transponder and Interrogator both set to Mode 4A.
2. *[P]* Set IFF Master Selector to STANDBY. After an approximate 80-second warmup delay, the system receives full power, but interrogations are blocked. Once warmup is performed, set IFF Master Selector from STANDBY to NORMAL.
3. *[P]* Set IFF Transponder Code Selector to A
4. *[P]* Set IFF Mode 4 Selector – ON (FWD)
5. *[P]* Set IFF Mode 4 Indication Selector – As desired. We will set it to LIGHT (AFT).
6. *[WSO]* Set IFF Interrogation Code Selector – 4/A.
7. *[WSO]* Set Test/Challenge Code Switch – CHALLENGE (DOWN)

WSO Cockpit

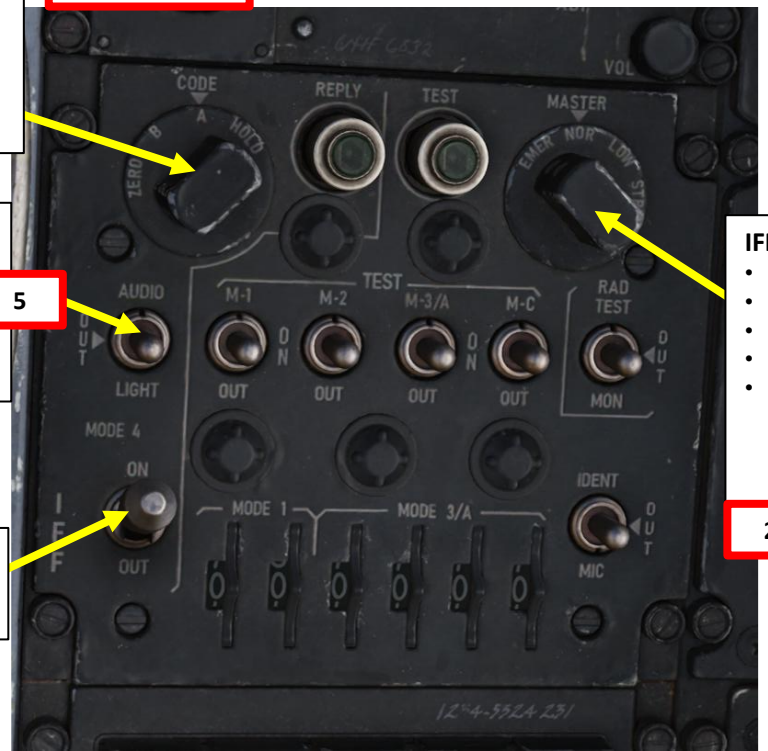


IFF (Identify-Friend-or-Foe) Code Selectors
- *First digit: indicates current IFF Mode (Modes 1, 2, 3, 4/A and 4/B).*
- *Digits 2, 3, 4 & 5: used to set the IFF code to interrogate for Modes 1 to 3*

Test/Challenge Code Switch
- *UP: TEST*
- *DOWN: CHALLENGE*

7

Pilot Cockpit



IFF Mode 4 Function Selector
- *ZERO: Zeroize / Erase Mode 4 Data*
- *A: Code A is selected*
- *B: Code B is selected*
- *HOLD*

3

IFF Mode 4 Indication Selector
- *FWD: Audio, replies are indicated with an audio tone*
- *MIDDLE: OUT*
- *AFT: Light, replies are indicated with the IFF Reply Lamp*

5

IFF (Identify-Friend-or-Foe) Transponder Master Mode Selector
- *OFF*
- *STBY: Standby, full power is supplied to the system but with interrogations blocked.*
- *LOW: System operates with low/reduced sensitivity.*
- *NORM: Normal operation mode with full sensitivity.*
- *EMER: Emergency mode, allows the system to respond to interrogations in Modes 1, 2 and 3/A. The reply for Modes 1 and 2 is a special emergency signal of the codes selected on the applicable dials, while Mode 3/A replies are special emergency signals of code 7700.*

2

IFF Mode 4 Selector
- *FWD: Mode 4 ON*
- *AFT: Mode 4 OFF*

4

4 – AN/APX-76 IFF INTERROGATOR (MODE 4)

8. *[WSO]* Ensure the radar is powered up.
9. *[WSO]* Initiate interrogation by pressing the Challenge Button on the Antenna Hand Control Stick.
10. *[WSO]* During active IFF interrogation, the IFF Challenge Lamp illuminates.
11. *[WSO]* The radar screen will now display symbology relevant to the interrogation response.
    - Lines above and below a radar return if it was able to detect that a contact is friendly.
    - A single line is shown above the return if the transponder is set to a compatible mode, but the code differs. This is usually the case for civilian aircraft.
    - No lines above or below a radar return indicate that the target is not responding.

One of the biggest challenges of IFF is **that a lack of IFF response does NOT guarantee that the contact you are interrogating is an enemy**. If no IFF response is obtained, you will have to visually identify the target or obtain additional instructions by the surveillance assets or information donors like an AWACS.

A lack of response could be explained by:
- A friendly aircraft that is damaged and has a damaged transponder
- A friendly aircraft that has not set correct transponder (response) codes
- A friendly aircraft that forgot to turn on his IFF
- A friendly aircraft that is not equipped with an IFF system compatible with yours
- A hostile aircraft

10

IFF Challenge Lamp
- *Illuminates to indicate IFF active interrogation with the APX-76 system.*



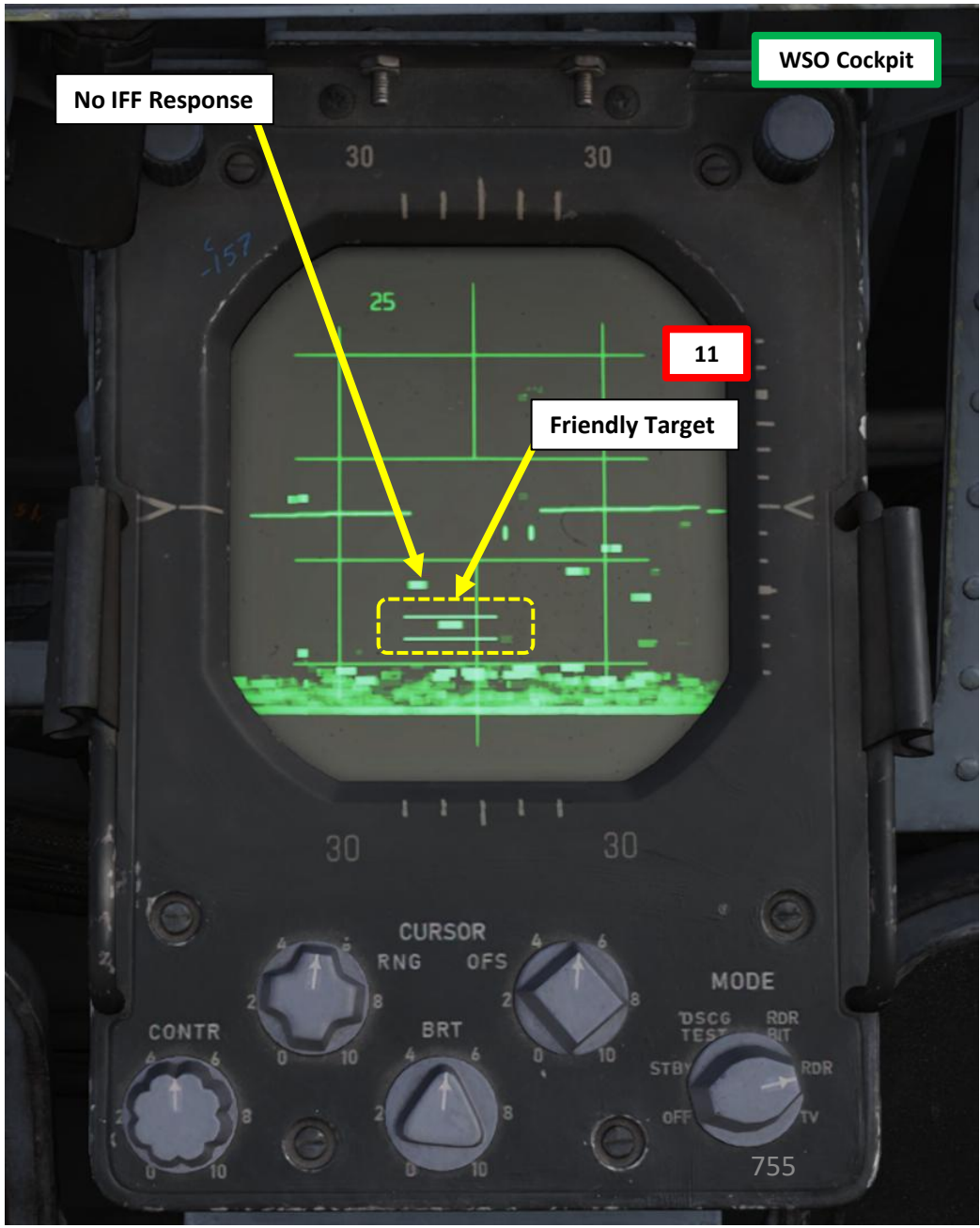
WSO Cockpit

9

Challenge Button
- *If controlling the radar, initiates an IFF (Identify-Friend-or-Foe) interrogation.*



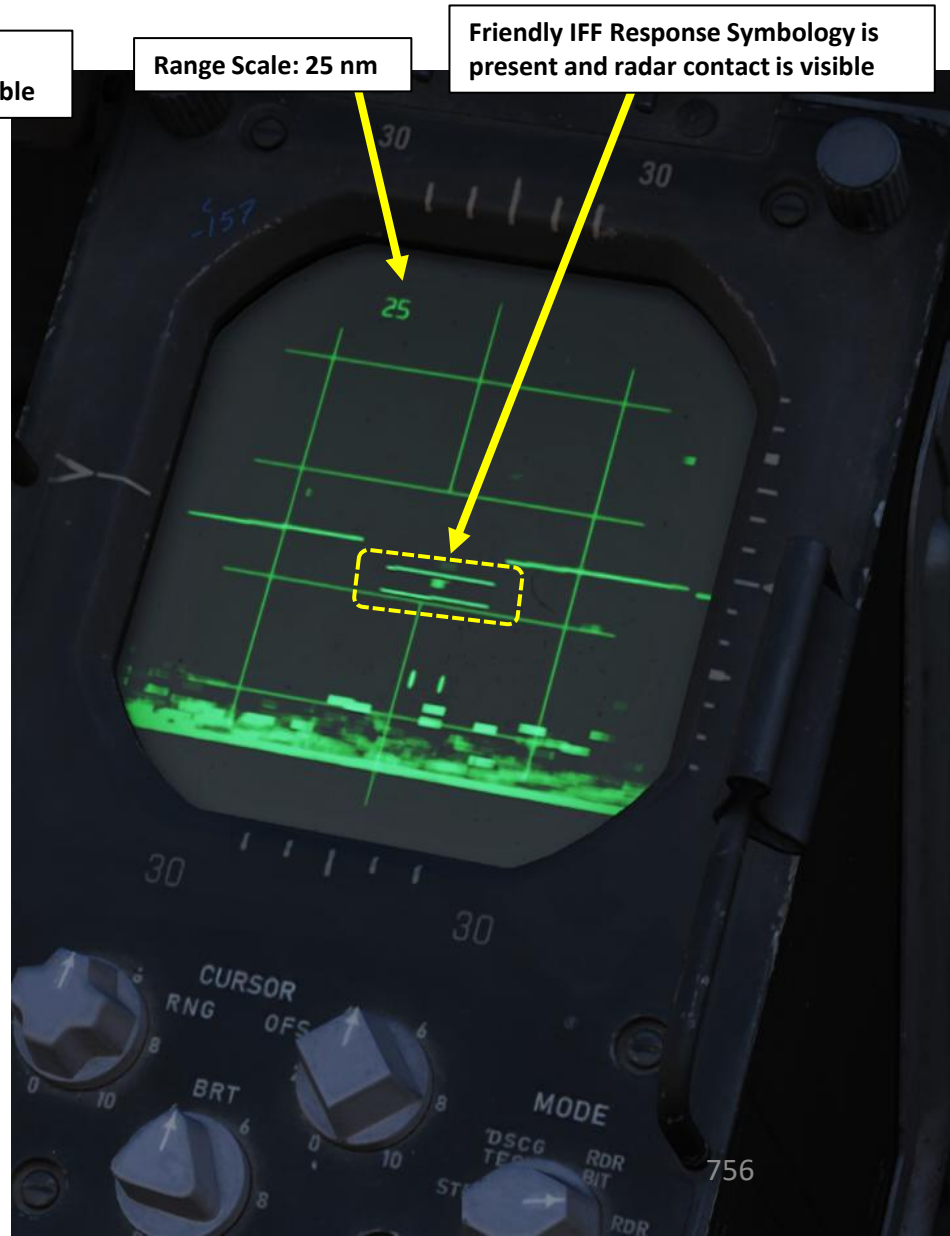
WSO Cockpit



4 – AN/APX-76 IFF INTERROGATOR (MODE 4)

Note: The range of the IFF interrogator exceeds the effective radar scanning range, which allows you to quickly spot friendly targets that are out of your radar range.





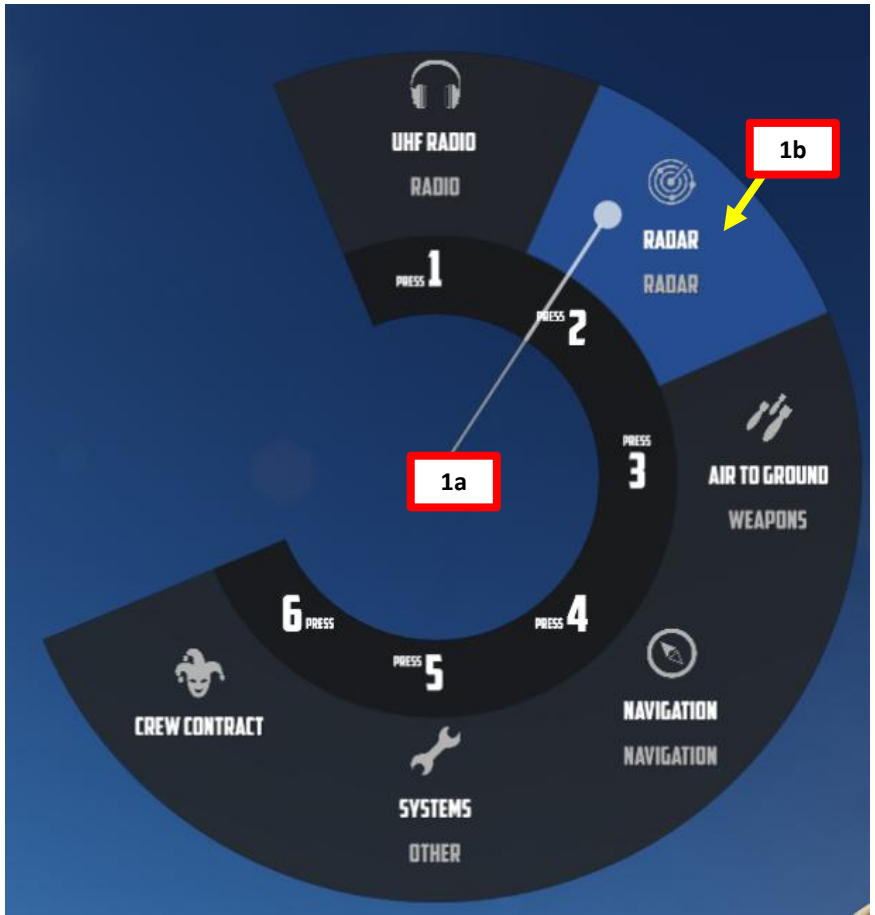
4 – AN/APX-76 IFF INTERROGATOR (MODE 4)

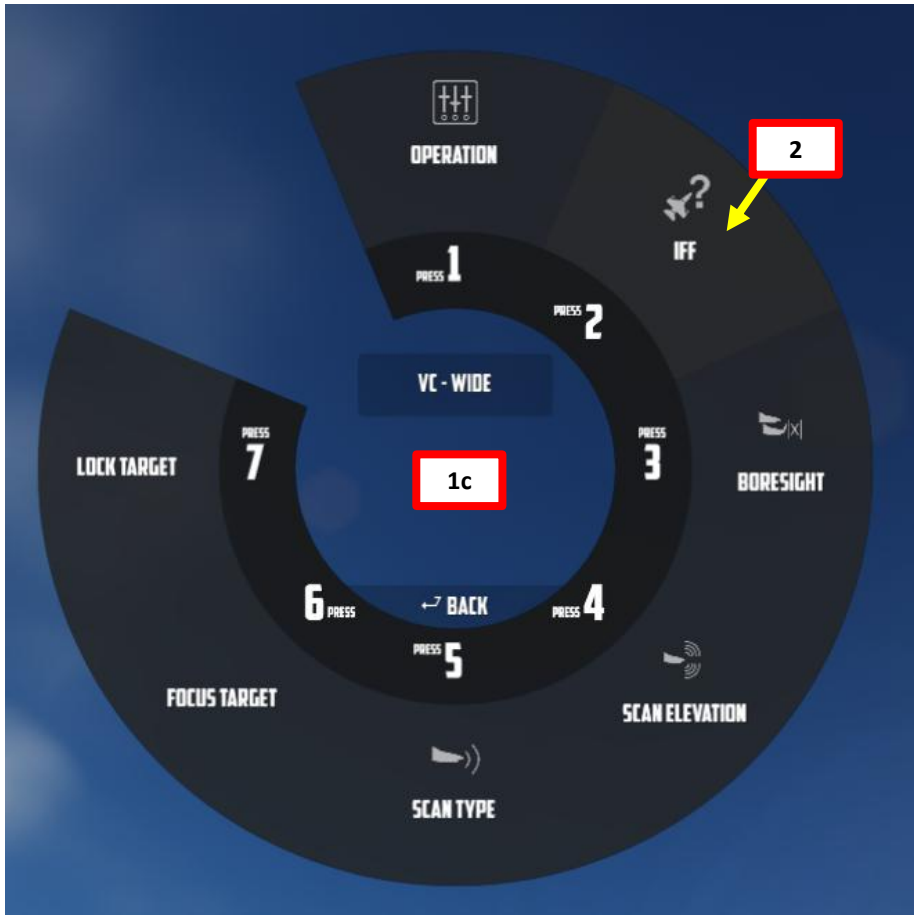
JESTER User Interface (UI) Functions

As the pilot, you can request JESTER to perform interrogation. Keep in mind that JESTER performs these interrogations automatically.

To open JESTER AI wheel, short-press “A” (JESTER UI Action binding). Consult the Heatblur Simulations wiki for more information.

1. From the **RADAR** menu, you will access all radar-related JESTER commands.
2. Selecting “**IFF**” commands JESTER to identify whether a selected radar contact is friendly or foe.



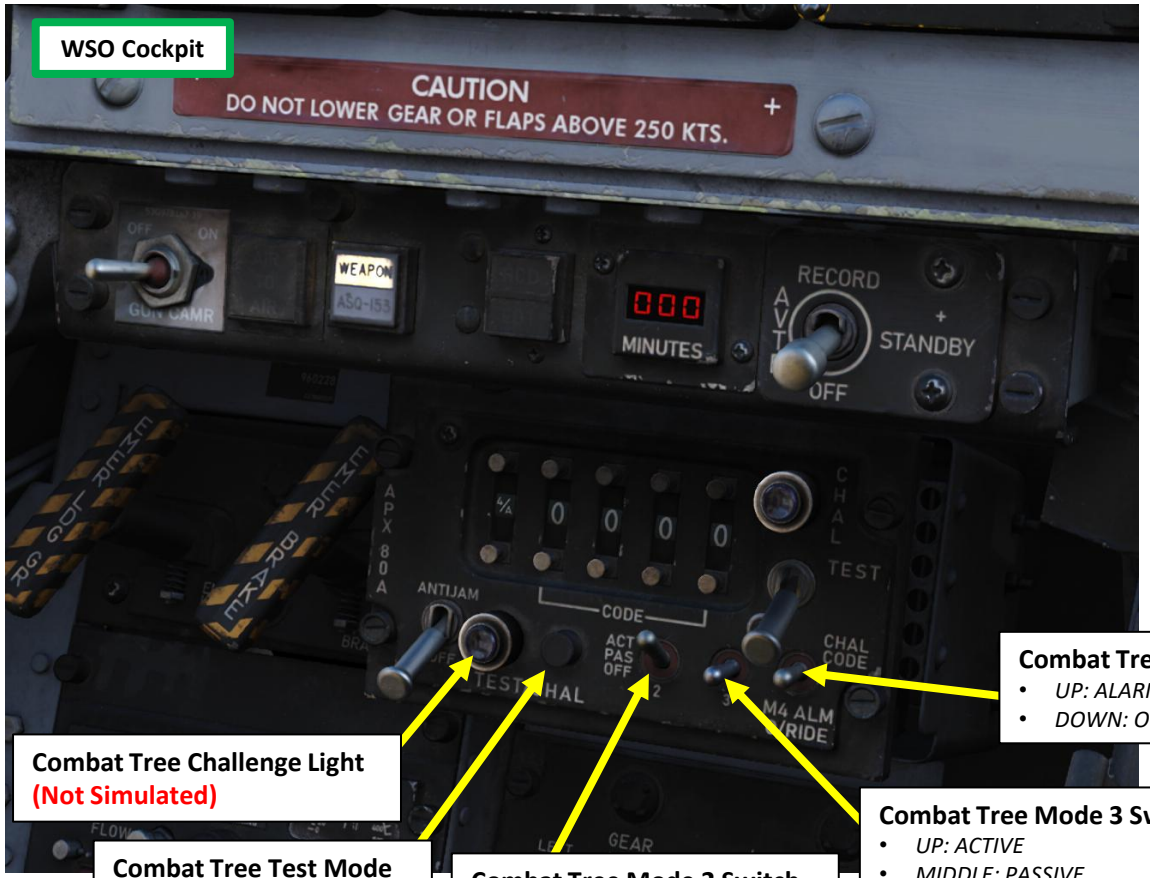


5 – AN/APX-81A COMBAT TREE

The AN/APX-81A “Combat Tree” system was basically a reverse-engineered Soviet transponder system actively used between 1960 and 1980 that acted as a sort of ”spoofing” system. Combat Tree sends compatible interrogation requests to early Soviet systems like the SRO-2 “Khrom”, which would in turn identify the Phantom’s interrogation as a friendly, hence sending back a valid response. This allowed the Phantom to not only identify friendly systems, but also some likely-hostile aircraft. It could also determine range and azimuth to the source of this response signal.

Soviets quickly realized the problem and patched their IFF transponder systems (SRO-2M), while also encrypting the communication to prevent another breach. Combat Tree can be considered an early precursor of modern Non-Cooperative Target Recognition (NCTR) systems and remains shrouded in secrecy to this day.

Take note that Combat Tree is not simulated yet.



5 – AN/APX-81A COMBAT TREE

The APX-81A Activity Lights Illuminate each time the “Combat Tree” system detects being interrogated by other aircraft.





COMMUNICATION SYSTEMS OVERVIEW

AN/ARC-164V COMM UHF Radio Frequency Range
- 225.000 to 399.975 MHz (AM, UHF)

AUX UHF Radio Receiver Frequency Range
- 265.000 to 284.9 MHz (AM, UHF)

The F-4E voice communications are provided by the following systems:

- **AN/ARC-164V UHF** Transmitter-Receiver Radio Set (referred as **COMM unit**), which has 18 preset channels. This is used for primary communications. There is an **emergency guard frequency receiver set to 243.000 MHz**.
- **Auxiliary UHF Radio Receiver Set** (amplifier power supply-receiver referred as **AUX unit**), which has 20 preset channels. This is used to monitor frequencies but does not allow any transmission.

The **Intercom (ICS, Intercom Set)** is used for communications between the pilot and WSO (Weapon Systems Officer).

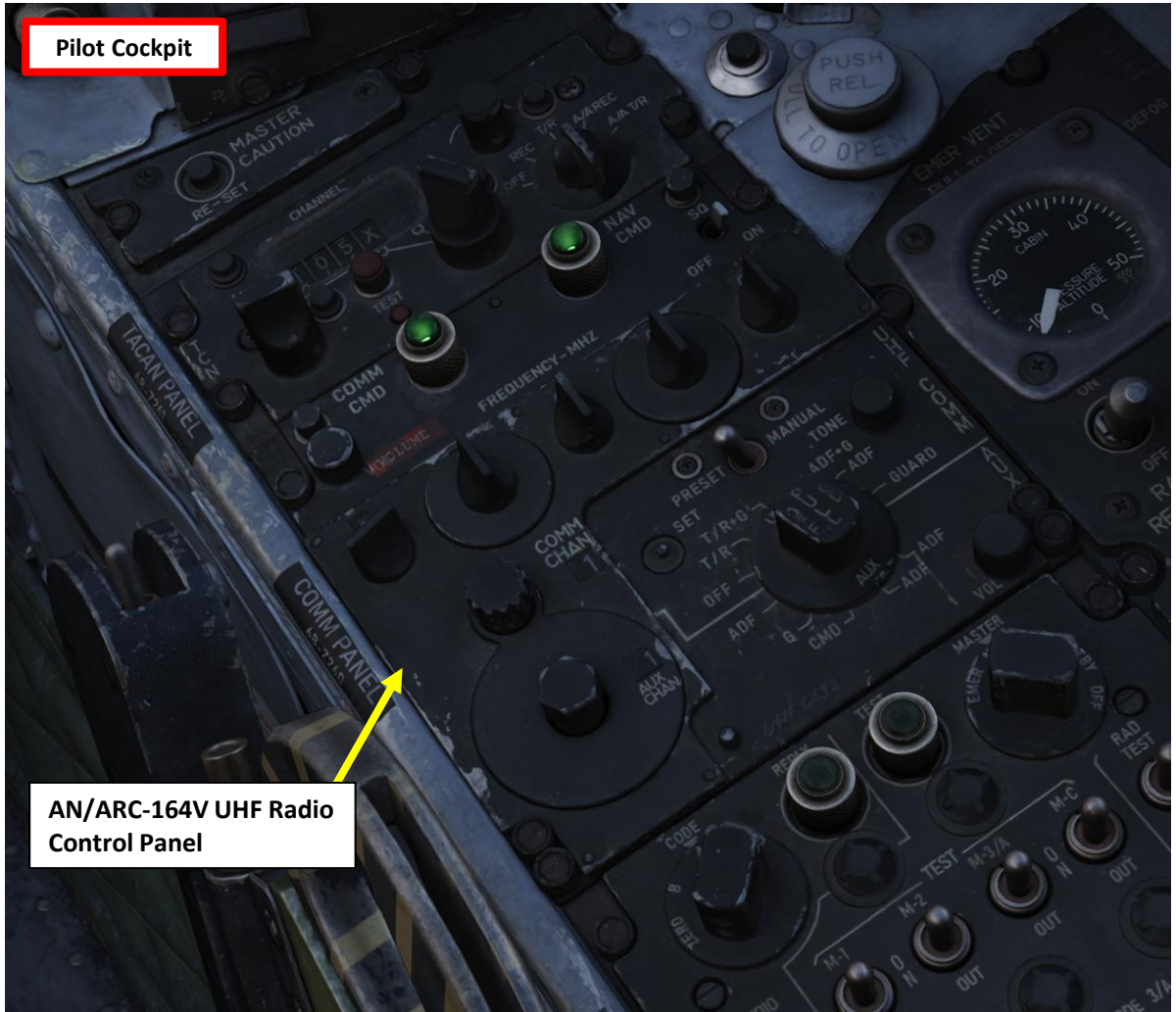


COMMUNICATION SYSTEMS OVERVIEW

Control over radio systems systems is facilitated by two **control panels**, one located in each cockpit. The panel that is currently active assumes full command over the radio operations.

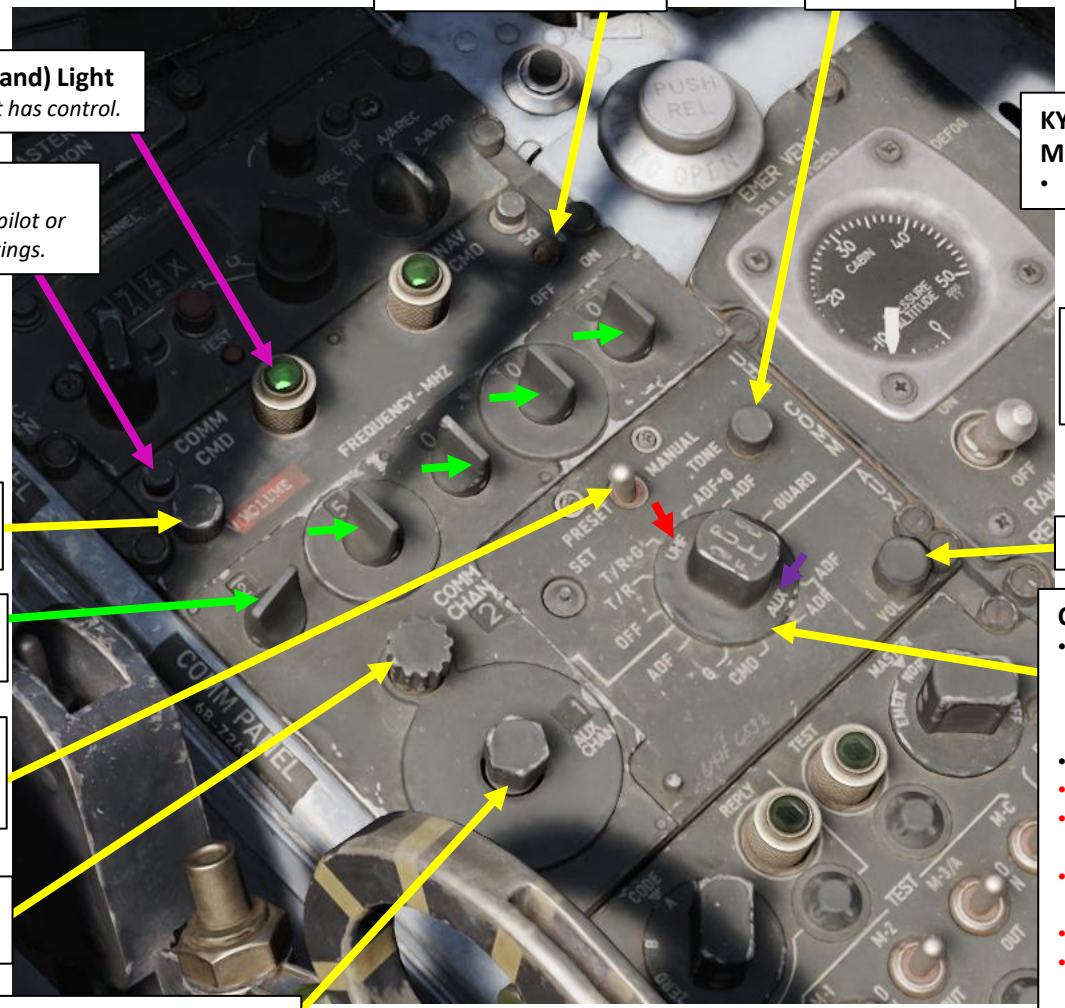
The UHF communication system is capable of providing either conventional or crypto voice transmission and reception. Both UHF and intercom systems can be used in combination with the **KY-28 Speech Security Unit.**

Both the COMM and AUX receivers have the capability to process ADF (Automatic Direction Finder) signals, which can be displayed on the Horizontal Situation Indicator (HSI) or Bearing Distance Heading Indicator (BDHI). The AUX frequencies are set by the unit radio maintenance shop, set for the frequencies that are needed for the area of operations. Two blade antennas, one upper and one lower, as well as an ADF antenna, are provided. Once the antenna mode is set for the primary channel, the AUX receives signals from the other antenna.





COMMUNICATION SYSTEMS OVERVIEW INTERFACE (PILOT COCKPIT)

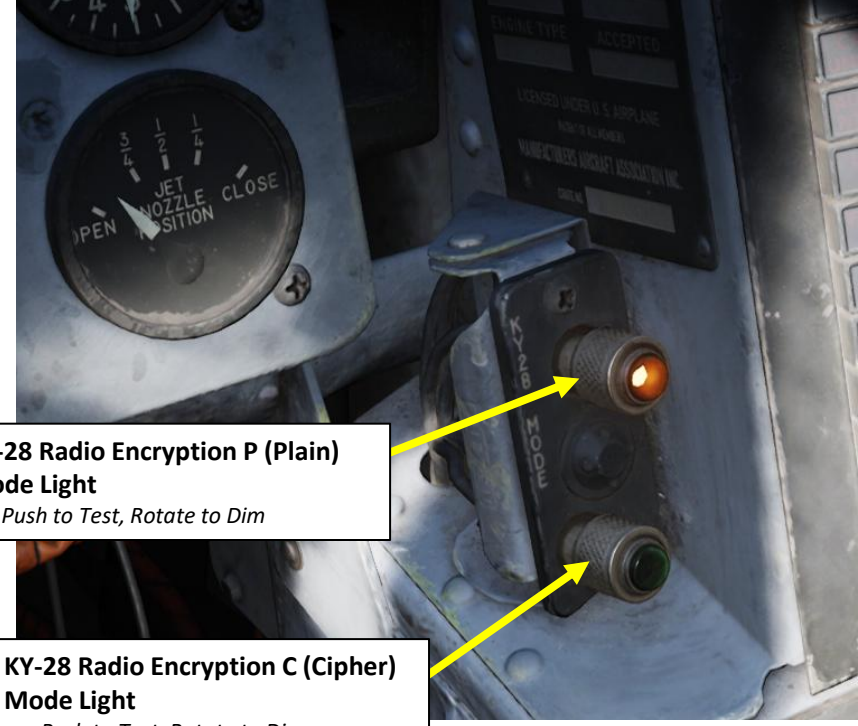


UHF Squelch Switch
- *LEFT: OFF*
- *RIGHT: Squelch ON*

COMM Tone Button

COMM CMD (Communication Command) Light
- *Illuminated light indicates that your seat has control.*

COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*



KY-28 Radio Encryption P (Plain) Mode Light
- *Push to Test, Rotate to Dim*

KY-28 Radio Encryption C (Cipher) Mode Light
- *Push to Test, Rotate to Dim*

AN/ARC-164V UHF COMM Radio Volume Control Knob

AN/ARC-164V UHF COMM Radio Frequency Selector Dials

Radio Frequency Mode Selector
- *LEFT: Preset Channel*
- *RIGHT: Manual Frequency*

AN/ARC-164V UHF COMM Radio Preset Channel Selector

AUX (Auxiliary) UHF Radio Preset Channel Selector

Auxiliary (AUX) Radio Volume Control Knob

Communications (COMM) Function Selector
- *The selector's front « **UHF** » label shows the function selected for the AN/ARC-164V COMM UHF Radio, while the rear « **AUX** » label shows the function selected for the Auxiliary UHF Radio.*

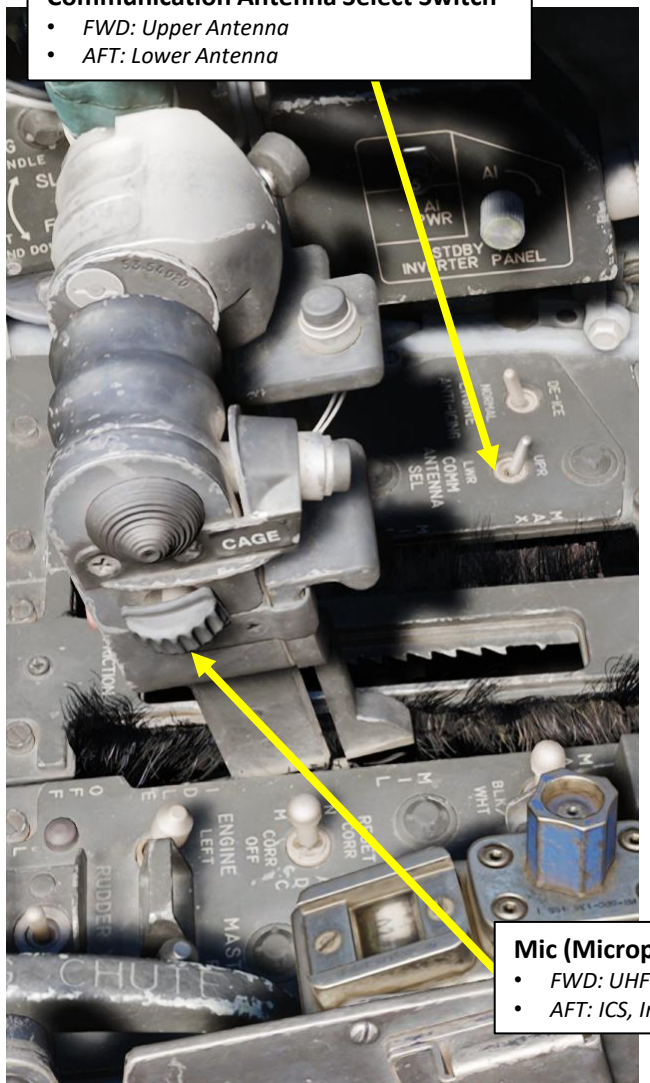
- ***OFF**: All UHF Radios (AN/ARC-164V and AUX) are OFF.*
- ***T/R ADF**: COMM Transmit/Receive, AUX Automatic Directional Finder Reception*
- ***T/R+G ADF**: COMM Transmit/Receive + Guard Frequency, AUX Automatic Directional Finder Reception*
- ***ADF+G CMD**: COMM Automatic Directional Finder + Guard Frequency, AUX Comm Reception*
- ***ADF+G**: COMM Automatic Directional Finder, AUX Guard Frequency Reception*
- ***GUARD ADF**: COMM Guard Frequency Transmit/Receive, AUX Automatic Directional Finder*

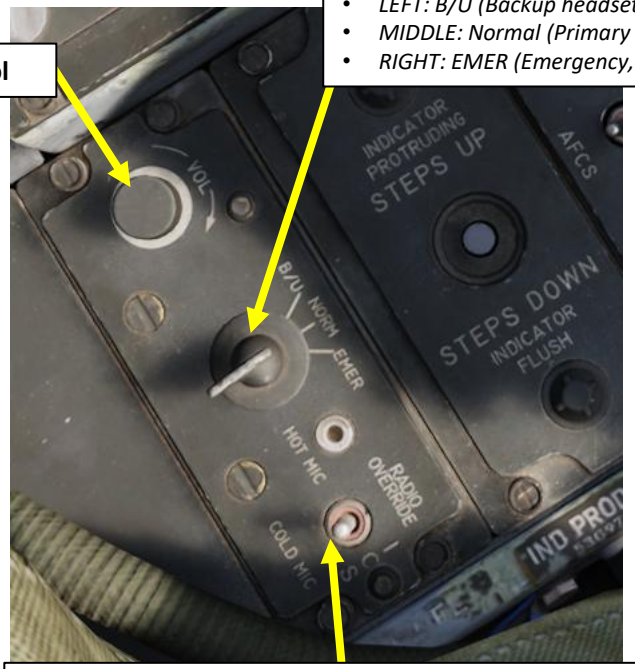
COMMUNICATION SYSTEMS OVERVIEW INTERFACE (PILOT COCKPIT)

Intercom Volume Control

Amplifier Selector
- *LEFT: B/U (Backup headset amplifier)*
- *MIDDLE: Normal (Primary headset amplifier)*
- *RIGHT: EMER (Emergency, amplifier from other cockpit)*

Communication Antenna Select Switch
- *FWD: Upper Antenna*
- *AFT: Lower Antenna*





ICS (Intercom Set) Mode Selector
- *FWD: Radio Override, Voice automatically transmitted on intercom. All volumes but Shrike tone and Stall Warning are reduced in volume.*
- *MIDDLE: Hot Mic, Voice automatically transmitted on intercom.*
- *AFT: Cold Mic, Mic switch on throttle must be held to activate intercom*

Mic (Microphone) Switch
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

UHF Remote Channel Indicator
- *Currently selected channel value when the radio is set to PRESET. Otherwise, the indicator displays M if the radio is set to Manual, G when the COMM function is set as GUARD/ADF, or A when the A-3-2-T switch is in A.*



COMMUNICATION SYSTEMS OVERVIEW INTERFACE (WSO COCKPIT)

COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*

AN/ARC-164V UHF COMM Radio Volume Control Knob

AN/ARC-164V UHF COMM Radio Frequency Selector Dials

COMM CMD (Communication Command) Light
- *Illuminated light indicates that your seat has control.*

AN/ARC-164V UHF COMM Radio Preset Channel Selector

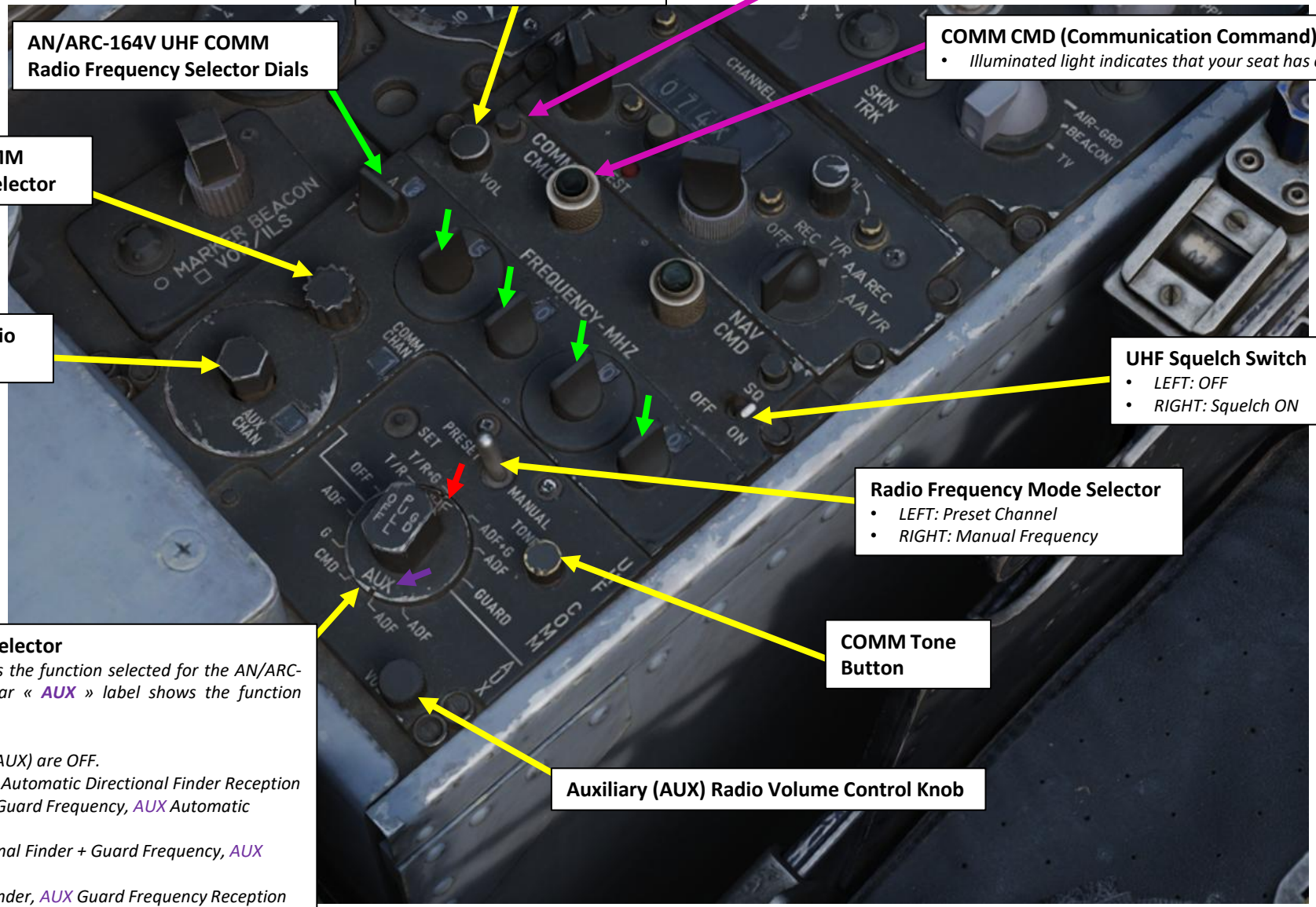
AUX (Auxiliary) UHF Radio Preset Channel Selector

UHF Squelch Switch
- *LEFT: OFF*
- *RIGHT: Squelch ON*

Radio Frequency Mode Selector
- *LEFT: Preset Channel*
- *RIGHT: Manual Frequency*

COMM Tone Button

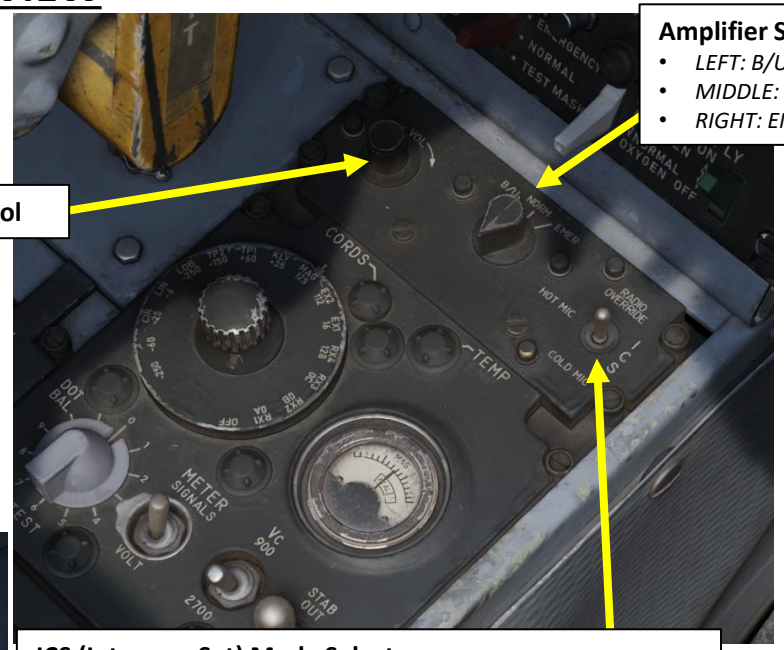
Auxiliary (AUX) Radio Volume Control Knob



Communications (COMM) Function Selector
- *The selector's front « **UHF** » label shows the function selected for the AN/ARC-164V COMM UHF Radio, while the rear « **AUX** » label shows the function selected for the Auxiliary UHF Radio.*

- ***OFF**: All UHF Radios (AN/ARC-164V and AUX) are OFF.*
- ***T/R ADF**: COMM Transmit/Receive, AUX Automatic Directional Finder Reception*
- ***T/R+G ADF**: COMM Transmit/Receive + Guard Frequency, AUX Automatic Directional Finder Reception*
- ***ADF+G CMD**: COMM Automatic Directional Finder + Guard Frequency, AUX Comm Reception*
- ***ADF+G**: COMM Automatic Directional Finder, AUX Guard Frequency Reception*
- ***GUARD ADF**: COMM Guard Frequency Transmit/Receive, AUX Automatic Directional Finder*

COMMUNICATION SYSTEMS OVERVIEW
INTERFACE (WSO COCKPIT)



Intercom Volume Control

Amplifier Selector
- *LEFT: B/U (Backup headset amplifier)*
- *MIDDLE: Normal (Primary headset amplifier)*
- *RIGHT: EMER (Emergency, amplifier from other cockpit)*

ICS (Intercom Set) Mode Selector
- *FWD: Radio Override, Voice automatically transmitted on intercom. All volumes but Shrike tone and Stall Warning are reduced in volume.*
- *MIDDLE: Hot Mic, Voice automatically transmitted on intercom.*
- *AFT: Cold Mic, Mic switch on throttle must be held to activate intercom*

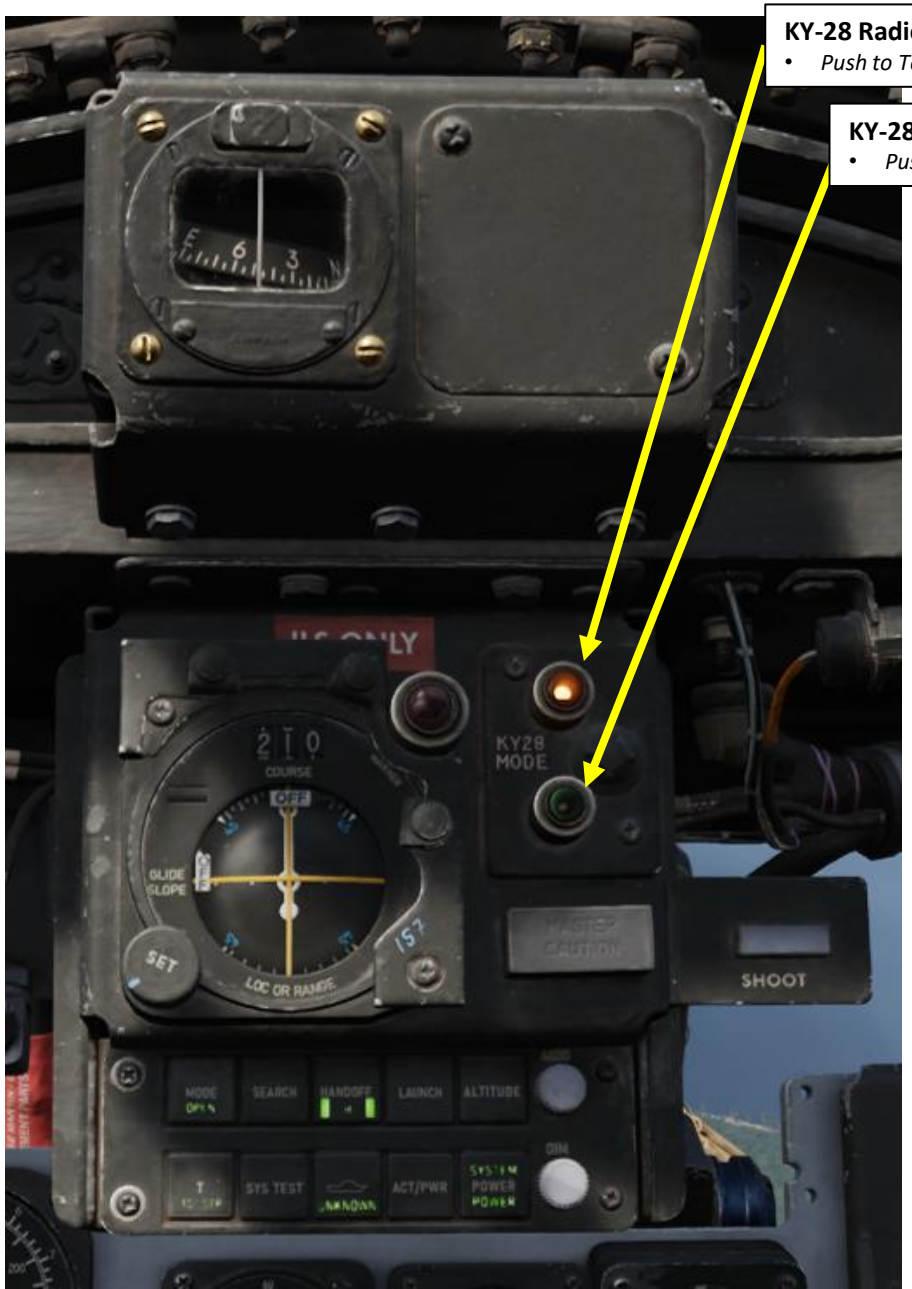


Mic (Microphone) Switch
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

UHF Remote Channel Indicator
- *Currently selected channel value when the radio is set to PRESET. Otherwise, the indicator displays M if the radio is set to Manual, G when the COMM function is set as GUARD/ADF, or A when the A-3-2-T switch is in A.*

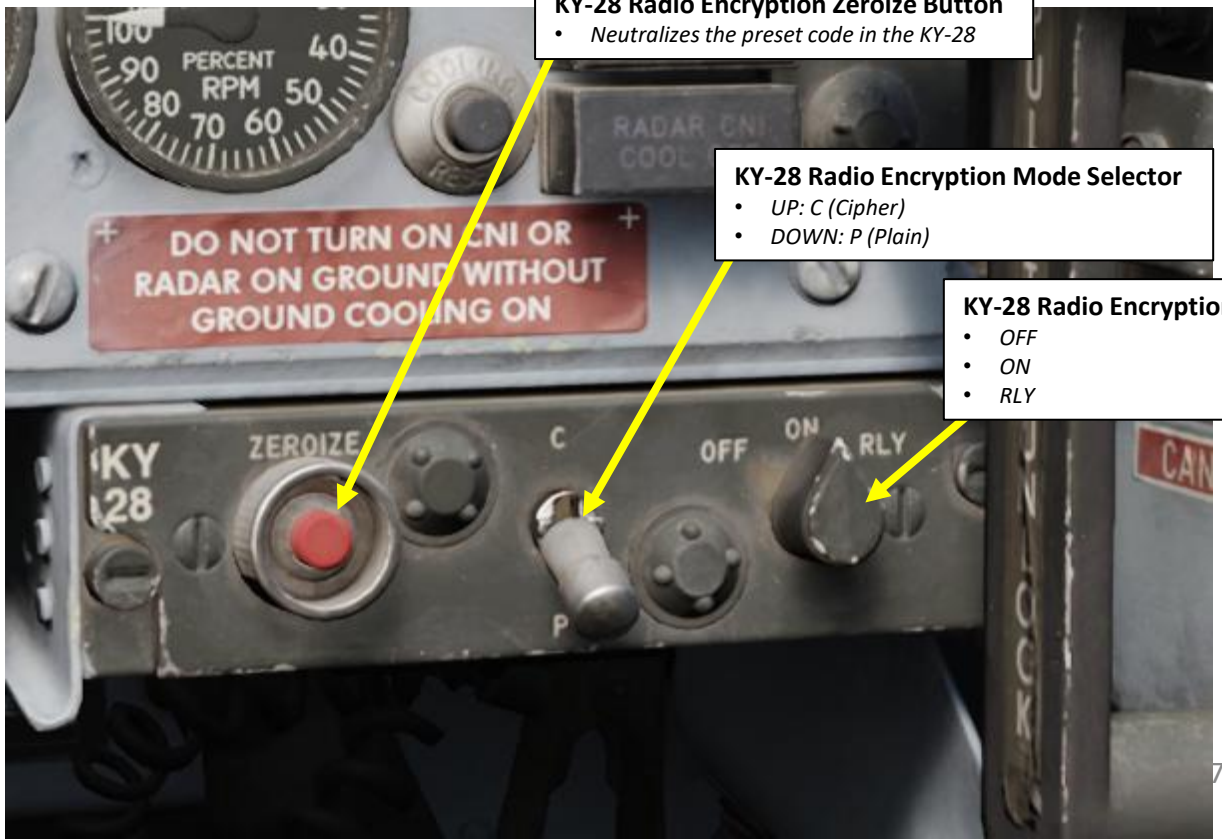


COMMUNICATION SYSTEMS OVERVIEW
INTERFACE (WSO COCKPIT)



KY-28 Radio Encryption P (Plain) Mode Light
- *Push to Test, Rotate to Dim*

KY-28 Radio Encryption C (Cipher) Mode Light
- *Push to Test, Rotate to Dim*



KY-28 Radio Encryption Zeroize Button
- *Neutralizes the preset code in the KY-28*

KY-28 Radio Encryption Mode Selector
- *UP: C (Cipher)*
- *DOWN: P (Plain)*

KY-28 Radio Encryption Power Selector
- *OFF*
- *ON*
- *RLY*

COMMUNICATION SYSTEMS OVERVIEW
COMMUNICATION COMMAND (COMM CMD)

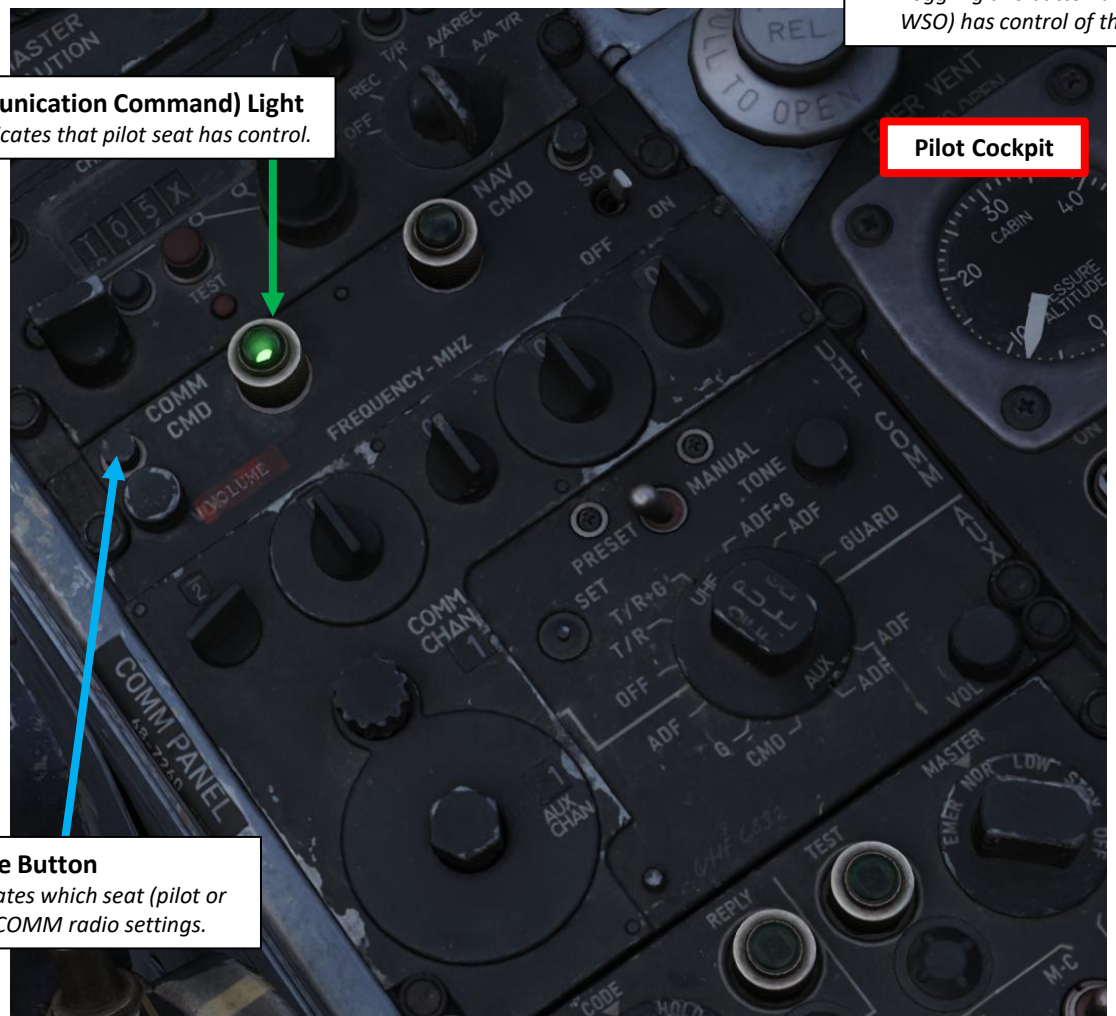
The **Communication Command Button (COMM CMD)** in each cockpit allows any crew member to take or relinquish command of the COMM radio transmitter-receiver, AUX (auxiliary) receiver and ADF (Automatic Direction Finder) functions. A **green light** to the right of the button illuminates in the cockpit which has command of communications.

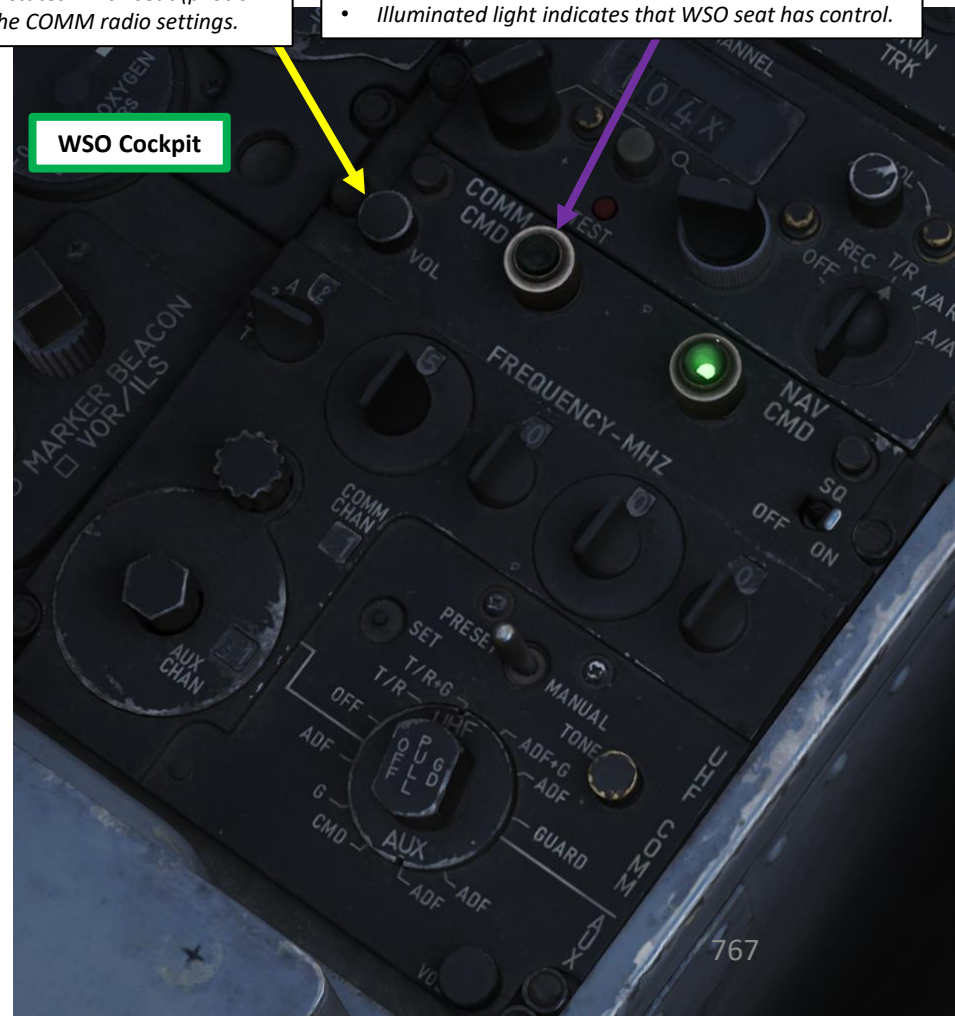
In the example below, the pilot has **pressed on the COMM Command Toggle Button**, and the **illuminated green COMM CMD light** indicates that the pilot has control over the radio. WSO radio controls will be overridden by whatever the pilot has selected. In the WSO cockpit, the **COMM CMD light is extinguished**, indicating that the WSO does not have command of the radio systems.

COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*

COMM CMD (Communication Command) Light
- *Illuminated light indicates that WSO seat has control.*

COMM CMD (Communication Command) Light
- *Illuminated light indicates that pilot seat has control.*





COMM Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the COMM radio settings.*

COMMUNICATIONS IN THE F-4E

In the F-4E, there was a clear way of doing things when it came to communicating. The intercom was used mainly between the pilot and WSO.

US Air Force Phantom crews had specific roles: the **WSO (Weapon System Officer)** was meant to **select radio channels/frequencies** to communicate and monitor on, while the **pilot** was meant to fly the aircraft and do the **talking** on these frequencies.

US Navy Phantom crews, on the other hand, had the **RIO (Radar Intercept Officer**, the Navy terminology equivalent for a WSO) **managing channels/frequencies** to communicate and monitor on and also do the **talking**. The pilot was meant to fly the aircraft.

Talking on the radio involved all sorts of tasks… communicating with other aircraft, controlling agencies (air traffic controllers), etc. These frequencies should be listed on your kneeboard. One very important frequency to remember is the squadron's common frequency (Tactical, or "TAC" frequency). This is what you will use with your flight members. However, do keep in mind that managing the COMM CMD is very important since you can only communicate on one single channel at a time and receive on two (COMM and AUX) channels at a time, which means that you need to carefully choose what you listen to.

In real life, hand signals were also used to tell your wingman to change channels (the number of fingers referring to which channel number to select, the five fingers pointing up referring to Channels 1 through 5, and the five fingers pointing forward referring to Channels 6 through 10).



RED FLAG
FREQUENCIES/CHANNELIZATION

UHF CH	MANUAL UHF	AGENCY
1	265.4	Squadron Common
2	289.4	Nellis Clearance Delivery
3	275.8	Nellis Ground
4	324.3	Nellis Tower
5	353.6	Nellis Departure RWY21/ Arrival RWY03
6	279.7	Nellis Departure RWY03/ Arrival RWY21
7	343.0	Nellis Control Sally
8	253.4	Nellis Control Lee
9	302.2	SOF (Bullseye 05)
10	321.1	Single Frequency Approach
11	270.1	ATIS
12	358.3	Indian Springs Tower
13	297.7	Silverbow Tower
14	295.4	AR-641A (Texaco)
15	361.6	FAC
16	282.8	Attack common
17	324.4	Strike Primary
18	377.8	Blackjack

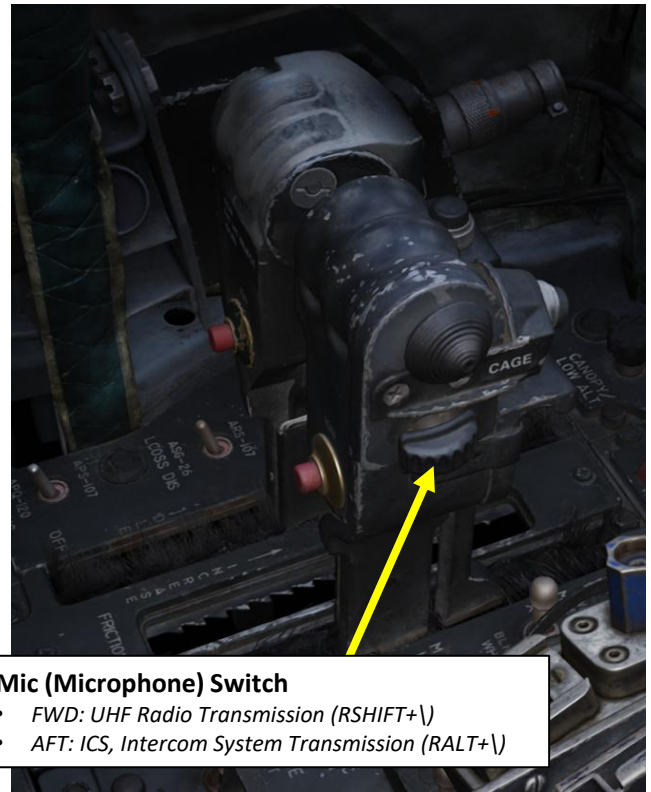
Typical Radio Comms
(from Reflected Simulations' Red Flag 81-2 Campaign)
https://youtu.be/I-d3ItUaqic

AN/ARC-164V (COMM) UHF RADIO TRANSMITTING ON MANUAL FREQUENCY

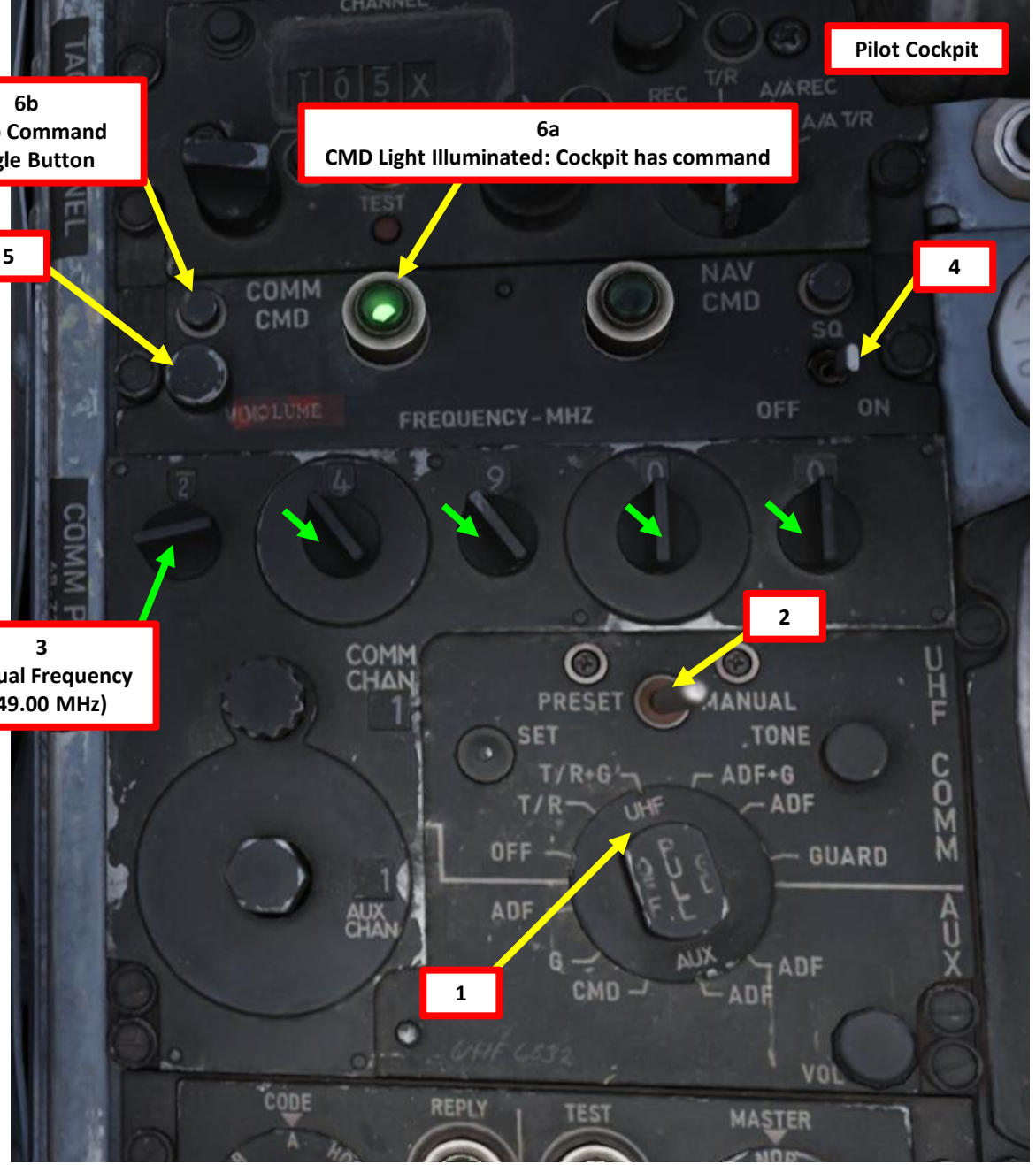
To transmit on UHF manual frequency:

1. Set UHF Radio Mode Selector – T/R+G (Transmit/Receive + Guard Frequency).
2. Set UHF Radio Frequency Mode Selector – Manual.
3. Set UHF Radio Frequency with Frequency Tuning knobs. We will select 249.00 MHz.
4. Set Radio Squelch Switch – ON (OUTBOARD).
5. Set UHF Radio Volume – As desired.
6. Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to your own cockpit.
7. Transmit by pressing Mic Switch – FWD (UHF).
    - Binding: RSHIFT+\

AN/ARC-164V COMM UHF Radio Frequency Range
- 225.000 to 399.975 MHz (AM, UHF)



7
Mic (Microphone) Switch
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

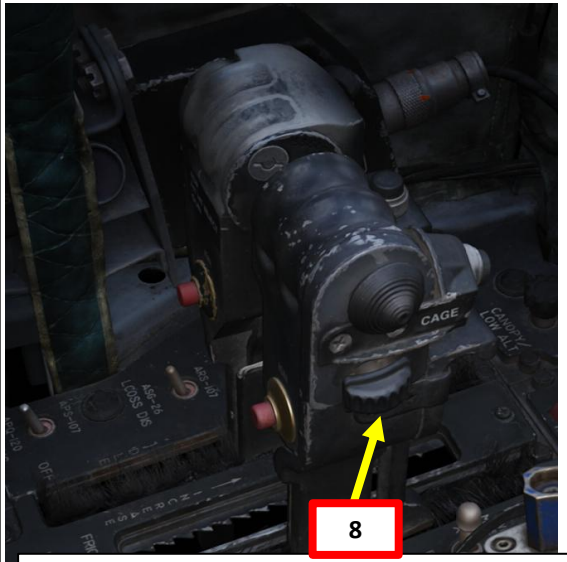


AN/ARC-164V (COMM) UHF RADIO TRANSMITTING ON PRESET CHANNEL

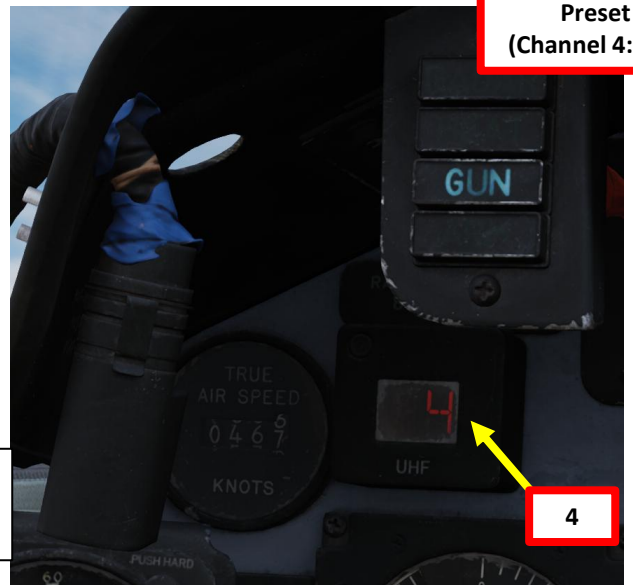
To transmit on UHF preset channel:

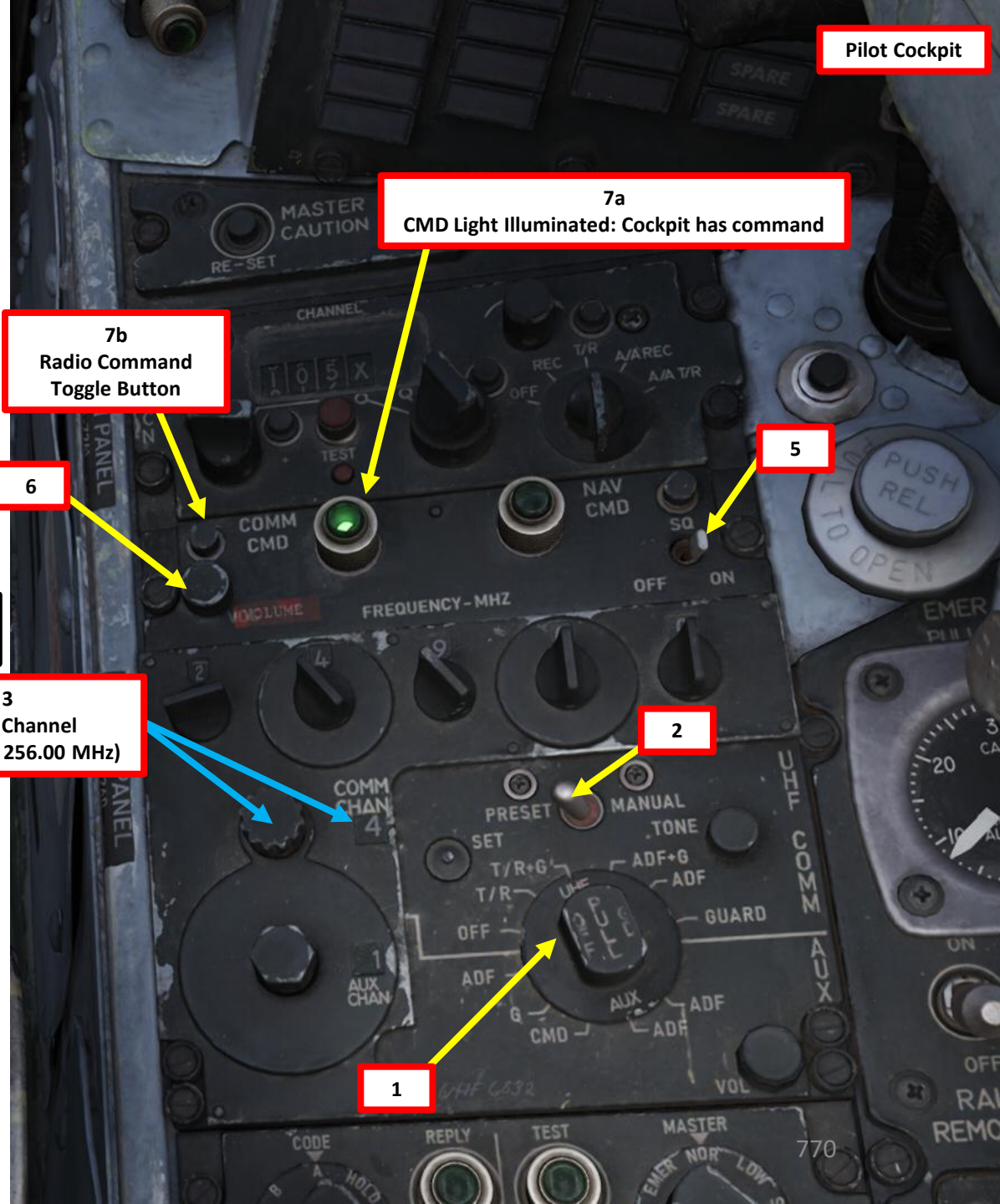
1. Set UHF Radio Mode Selector – T/R+G (Transmit/Receive + Guard Frequency).
2. Set UHF Radio Frequency Mode Selector – Preset.
3. Set UHF Radio Frequency with COMM CHAN selector. We will select Channel 4 (256.00 MHz).
4. The UHF Remote Channel Indicator should display Preset Channel 4.
    - The Remote Channel indicator displays the currently selected channel value when the radio is set to PRESET. Otherwise, the indicator displays M if the radio is set to Manual, G when the COMM function is set as GUARD/ADF, or A when the A-3-2-T switch is in A.
5. Set Radio Squelch Switch – ON (OUTBOARD).
6. Set UHF Radio Volume – As desired.
7. Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to your own cockpit.
8. Transmit by pressing Mic Switch – FWD (UHF).
    - Binding: RSHIFT+\

AN/ARC-164V COMM UHF Radio Frequency Range
- 225.000 to 399.975 MHz (AM, UHF)



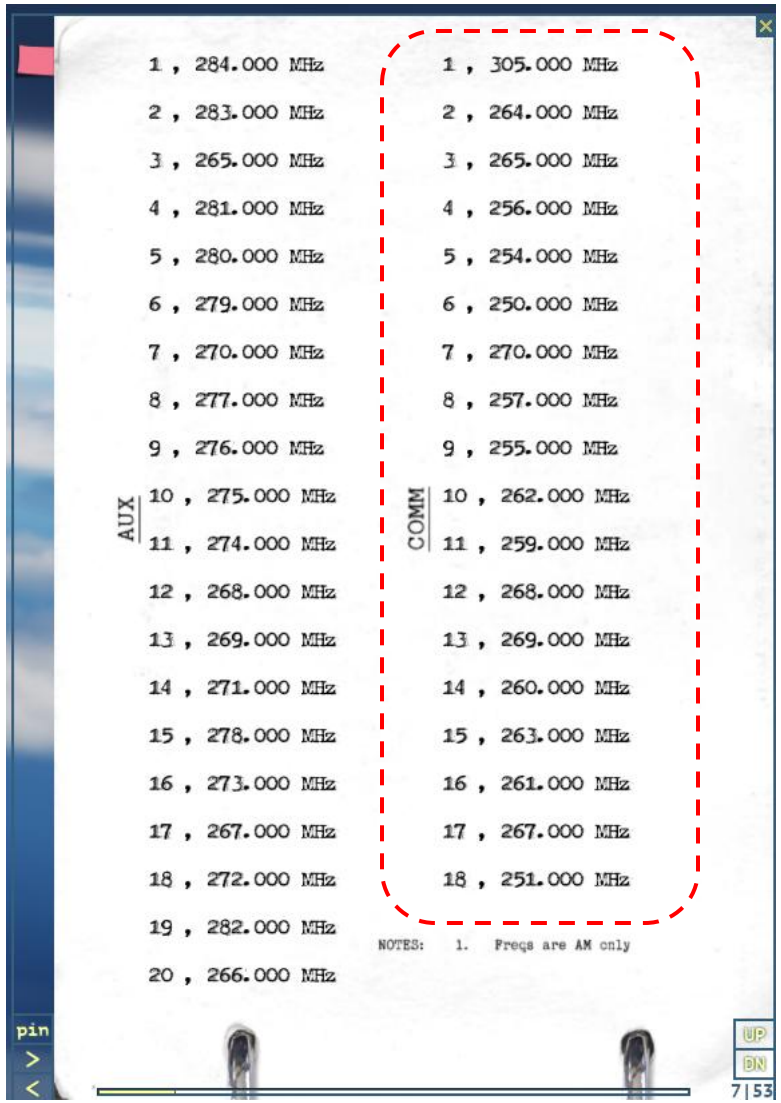
Mic (Microphone) Switch
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

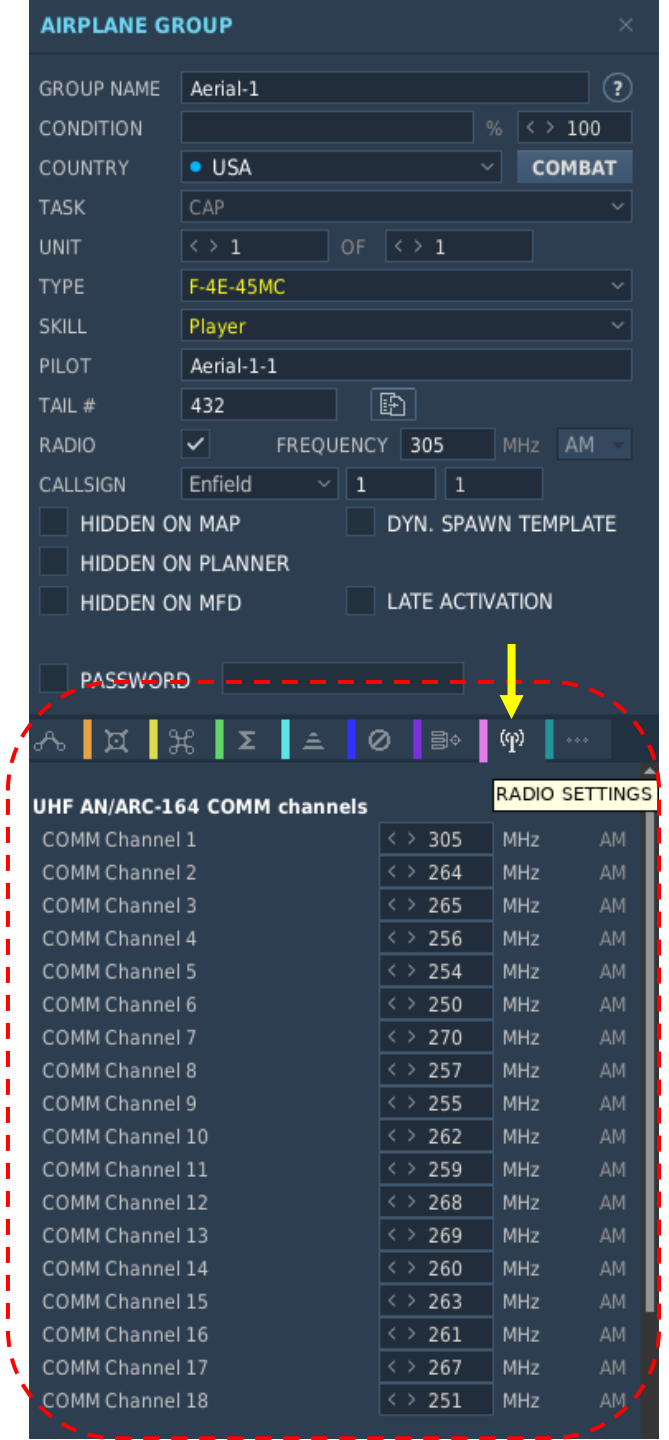




AN/ARC-164V (COMM) UHF RADIO TRANSMITTING ON PRESET CHANNEL

18 preset channels are already set via the Mission Editor and cannot be changed during flight. Channel frequencies should be detailed in the Mission Briefing and in the Kneeboard (RSHIFT+K).





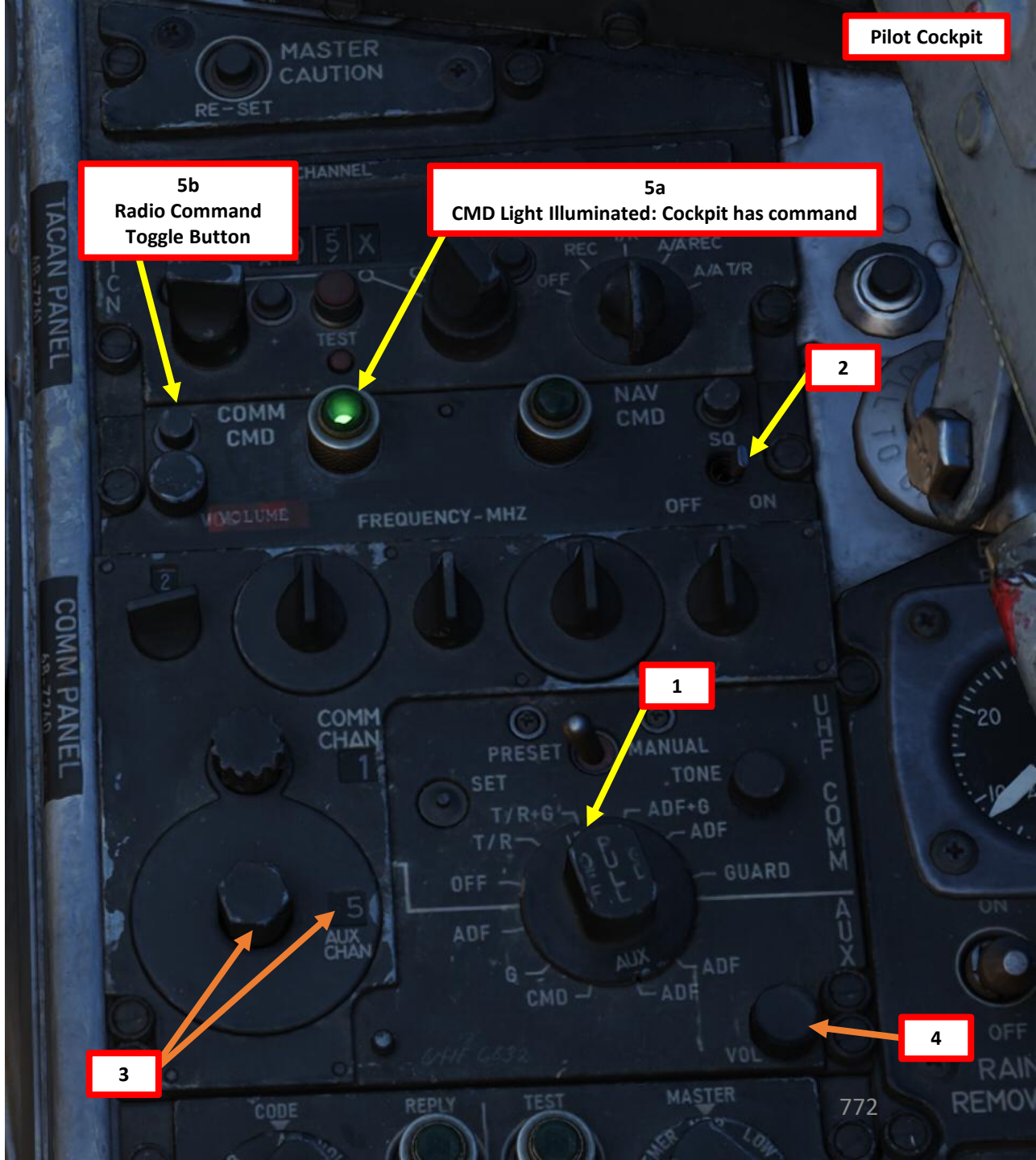
AUXILIARY (AUX) UHF RADIO RECEIVER

To monitor a preset channel on UHF AUX receiver:

1. Set UHF Radio Mode Selector – T/R+G (Transmit/Receive + Guard Frequency).
2. Set Radio Squelch Switch – ON (OUTBOARD).
3. Set AUX Radio Channel – As required. We will select AUX Channel 5 (280.00 MHz)
4. Set AUX Radio Volume – As desired.
5. Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button.
6. You will then be able to receive transmissions on AUX Channel 5. The AUX channels are receive-only; transmission is not possible.

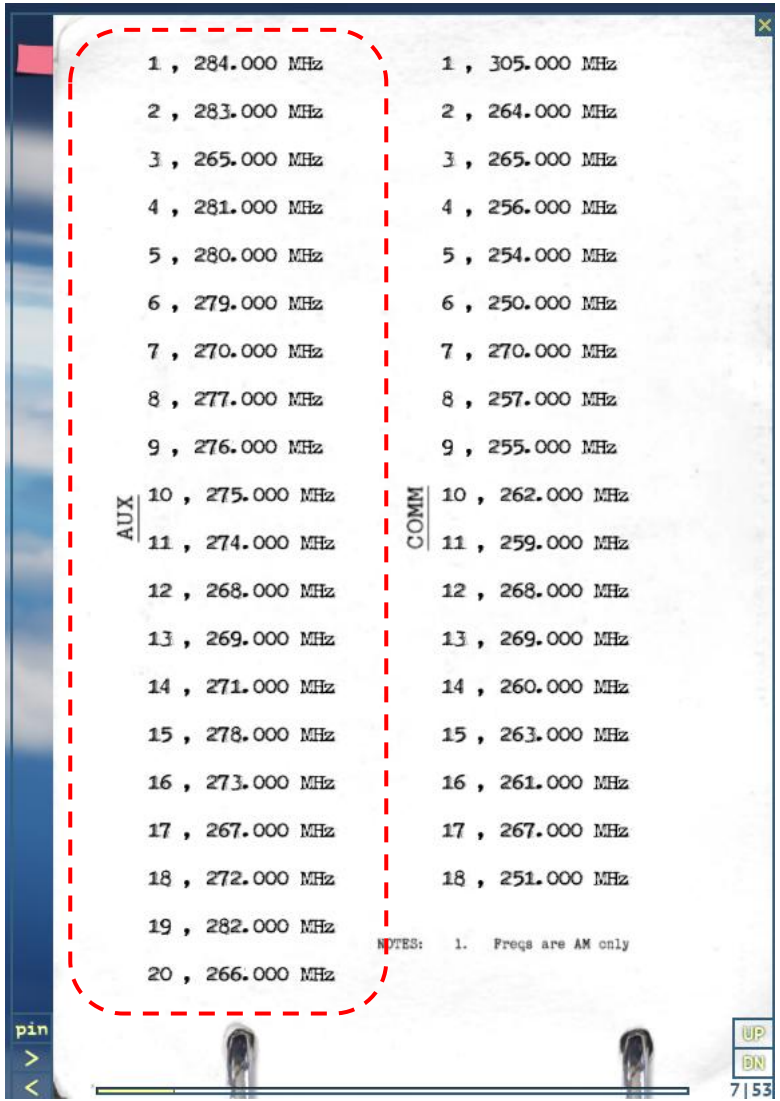
AUX UHF Radio Receiver Frequency Range

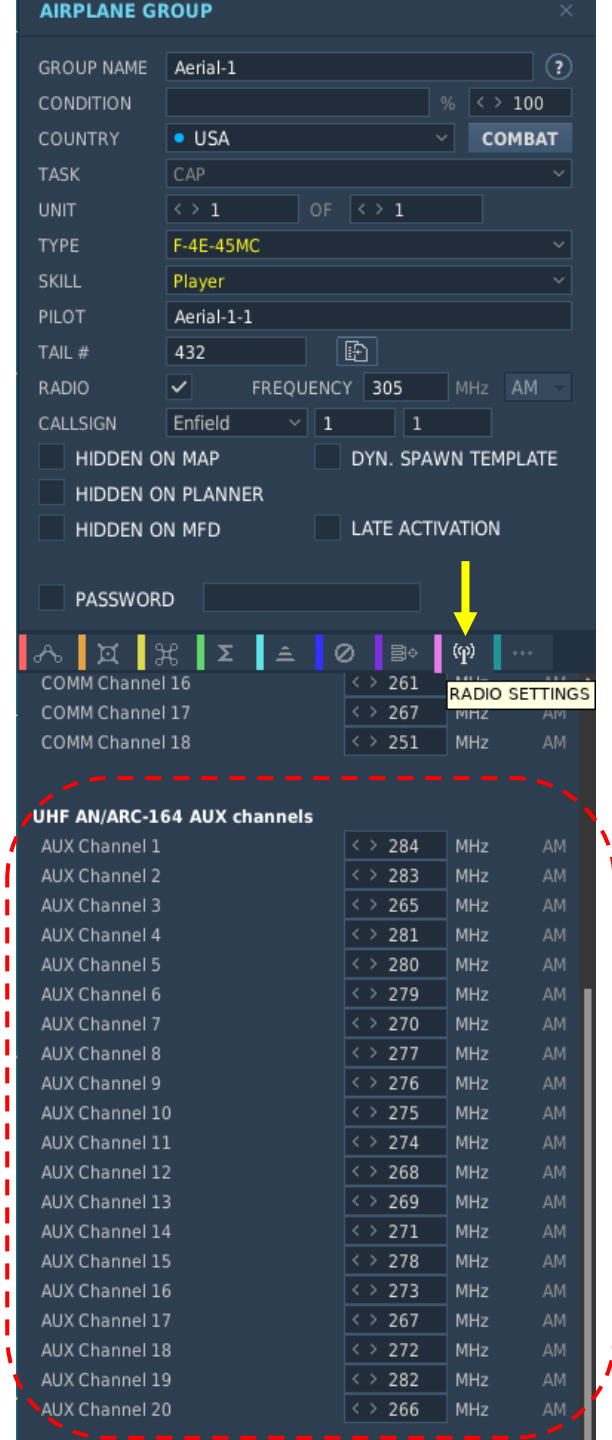
- 265.000 to 284.9 MHz (AM, UHF)



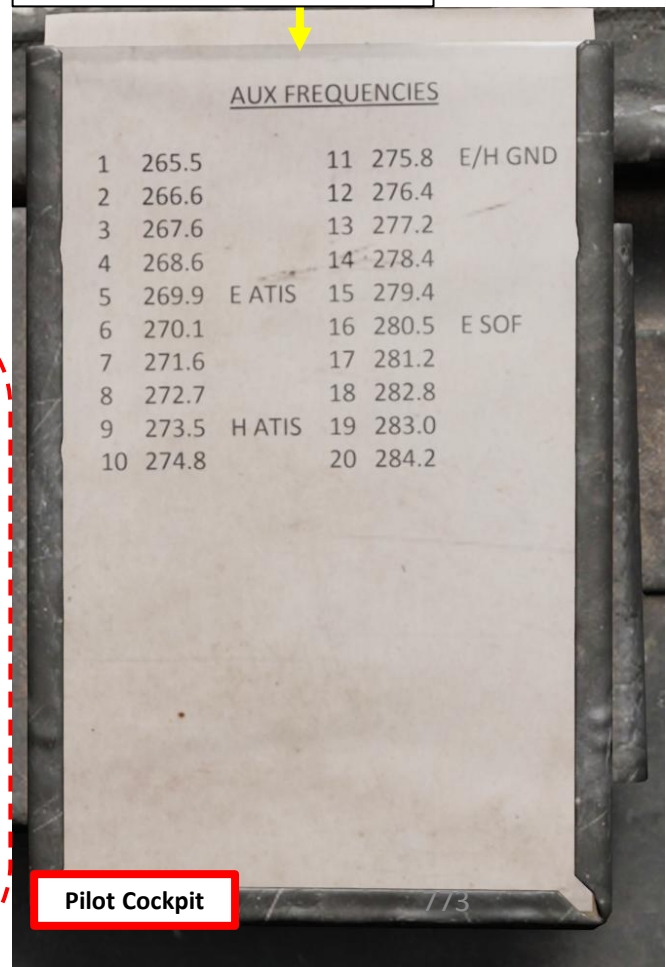
AUXILIARY (AUX) UHF RADIO RECEIVER

The AUX unit is designed to receive signals on 20 preset frequency channels. These preset channels are already set via the Mission Editor and cannot be changed during flight. Channel frequencies should be detailed in the Mission Briefing and in the Kneeboard (RSHIFT+K).





Auxiliary Radio Frequencies Card



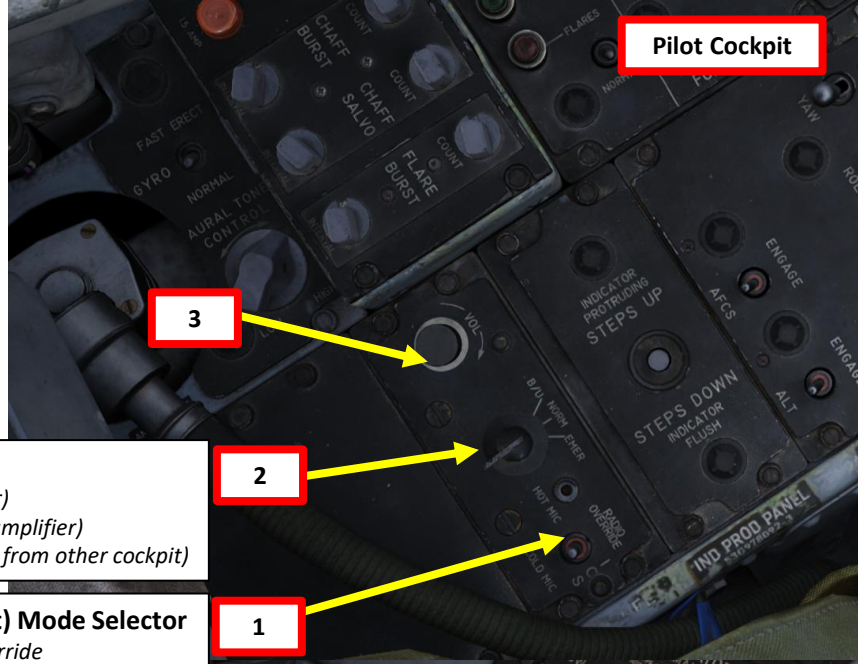
Pilot Cockpit

INTERCOM SYSTEM (ICS)

Setting the ICS (Intercom Set) will allow communication between the pilot and WSO (Weapon Systems Officer) with the intercom.

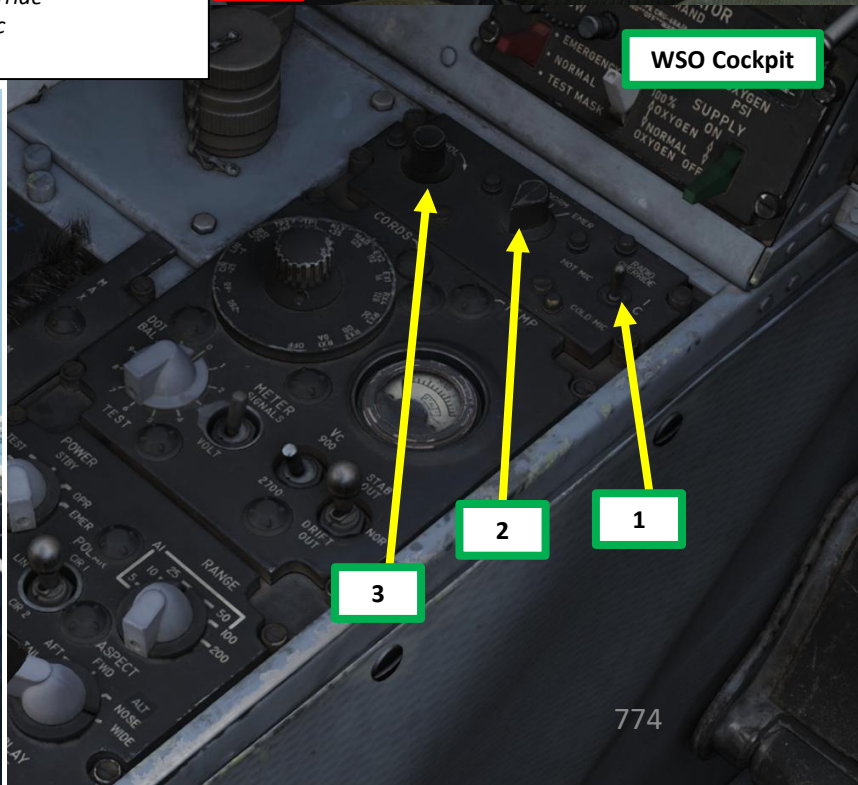
1. *[P+WSO]* Set ICS Switch – HOT MIC (MIDDLE).
   - **Radio Override**: Voice automatically transmitted on intercom. All volumes but Shrike tone and Stall Warning are reduced in volume.
   - **Hot Mic**: Voice automatically transmitted on intercom.
   - **Cold Mic**: Mic switch on throttle must be held to activate intercom
2. *[P+WSO]* Set Amplifier Selector – NORM
3. *[P+WSO]* Set Intercom Volume – As desired.
4. If Hot Mic is selected, your voice is automatically transmitted when talking.
5. If Cold Mic is selected, transmit on Intercom by pressing Mic Switch – AFT (ICS).
   - Binding: RALT+\

Note: the WSO's ICS Switch must be set to HOT MIC to allow aircraft to communicate with ground crew.



Amplifier Selector
- *LEFT: B/U (Backup headset amplifier)*
- *MIDDLE: Normal (Primary headset amplifier)*
- *RIGHT: EMER (Emergency, amplifier from other cockpit)*

ICS (Intercom Set) Mode Selector
- *FWD: Radio Override*
- *MIDDLE: Hot Mic*
- *AFT: Cold Mic*







5 **Mic (Microphone) Switch**
- *FWD: UHF Radio Transmission (RSHIFT+\)*
- *AFT: ICS, Intercom System Transmission (RALT+\)*

KY-28 SPEECH SECURITY UNIT (VOICE ENCRYPTION)

The UHF communication system is capable of providing either conventional or crypto voice transmission and reception. Both UHF and intercom systems can be used in combination with the KY-28 Speech Security Unit, if so desired in a tactical or hostile environment. The KY-28 can either cipher outgoing voice transmissions or decipher received voice transmissions; however, these functions cannot be performed simultaneously. The crew can choose between plain or cipher mode of operation. In the cipher mode operation the KY-28 converts voice inputs through the microphone into crypto transmissions and deciphers crypto replies that are being received to the crews headsets. In the plain mode operation the UHF functions as a conventional voice transceiver.

All transmitted and received signals are routed through the KY-28 unit. When the KY-28 mode is set to P (plain), the UHF transceiver operates in the conventional voice manner, whether the KY-28 is powered or not.

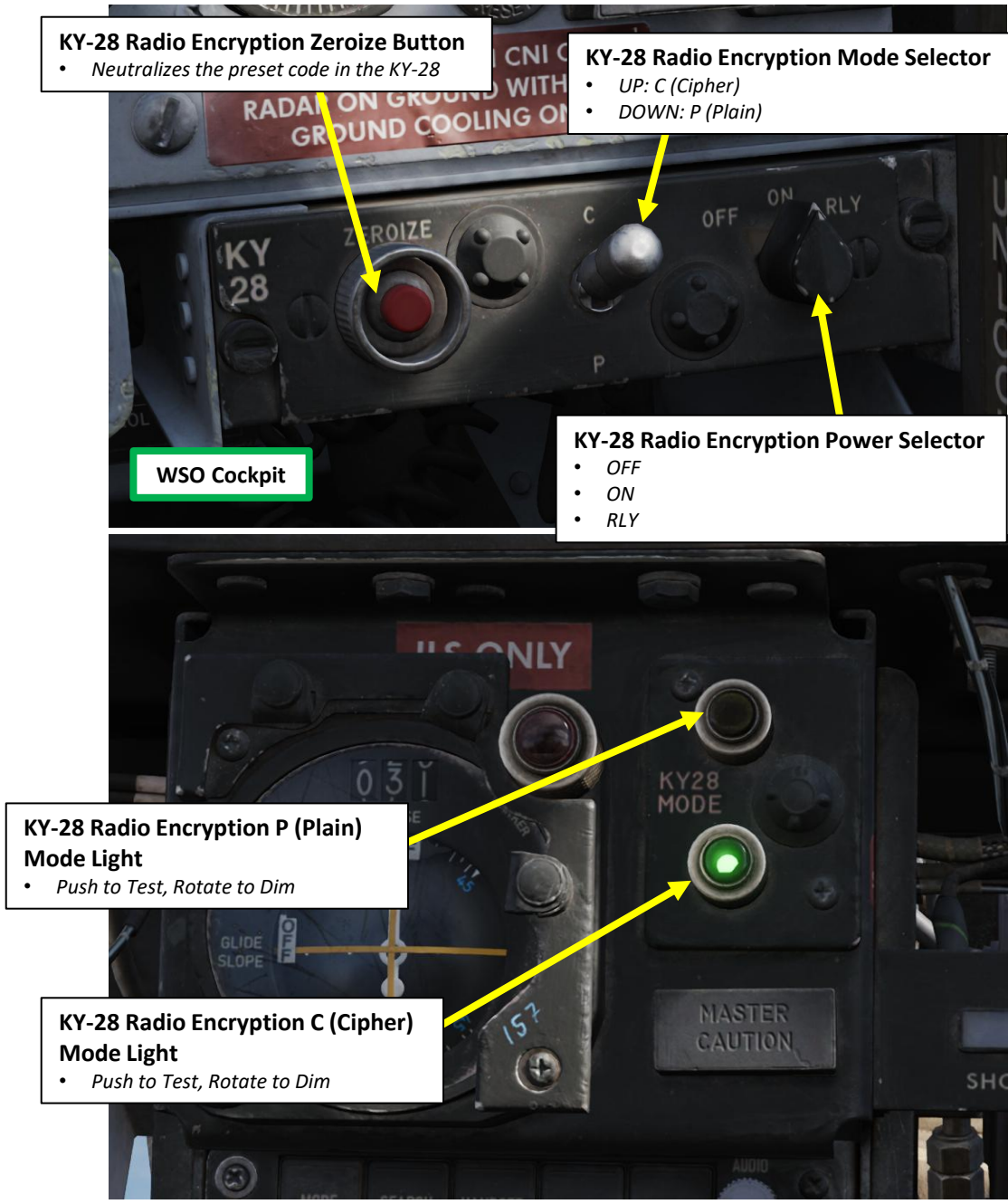
When operating in the cipher mode, the KY-28 unit functions in either standby, receive, or transmit.

All KY-28 units remain in the STANDBY condition until either the microphone button is actuated or a sync preamble is received. Once transmission or reception of the crypto message has been completed the KY-28 automatically reverts to the standby condition. While the KY-28 is in the standby condition the radio equipment also functions as a traditional receiver as all incoming non-crypto transmissions are passed directly to the headsets.

The unit switches to the cipher RECEIVE condition whenever a sync preamble is received. The sync preamble is generated by other KY-8, KY-28 or KY-38 units when the transmitting stations operator actuates the microphone switch. The sync preamble ensures that all units in the network are in the cipher receive condition. The enciphered message is received immediately after the sync preamble signal and the message is decoded by the KY-28 and passed to the aircrew headsets in the form of plain language.

When the UHF microphone switch is set to the UHF position, the KY-28 switches to the TRANSMIT condition. The sync preamble signal is transmitted to all receiving KY stations to switch to the cipher receive condition. After actuating the microphone switch, a brief tone is heard in the aircrew headsets. The tone signal indicates that the sync preamble signal has been completed and transmitted, after which the KY-28 is ready to transmit the crews voice input. When the mic button is released again, the KY-28 reverts to the standby condition. The WSO must select UHF communications with the radio selector switch to transmit ciphered messages. The UHF transmitter is automatically selected for front cockpit transmissions if the KY-28 is operated in mode C.

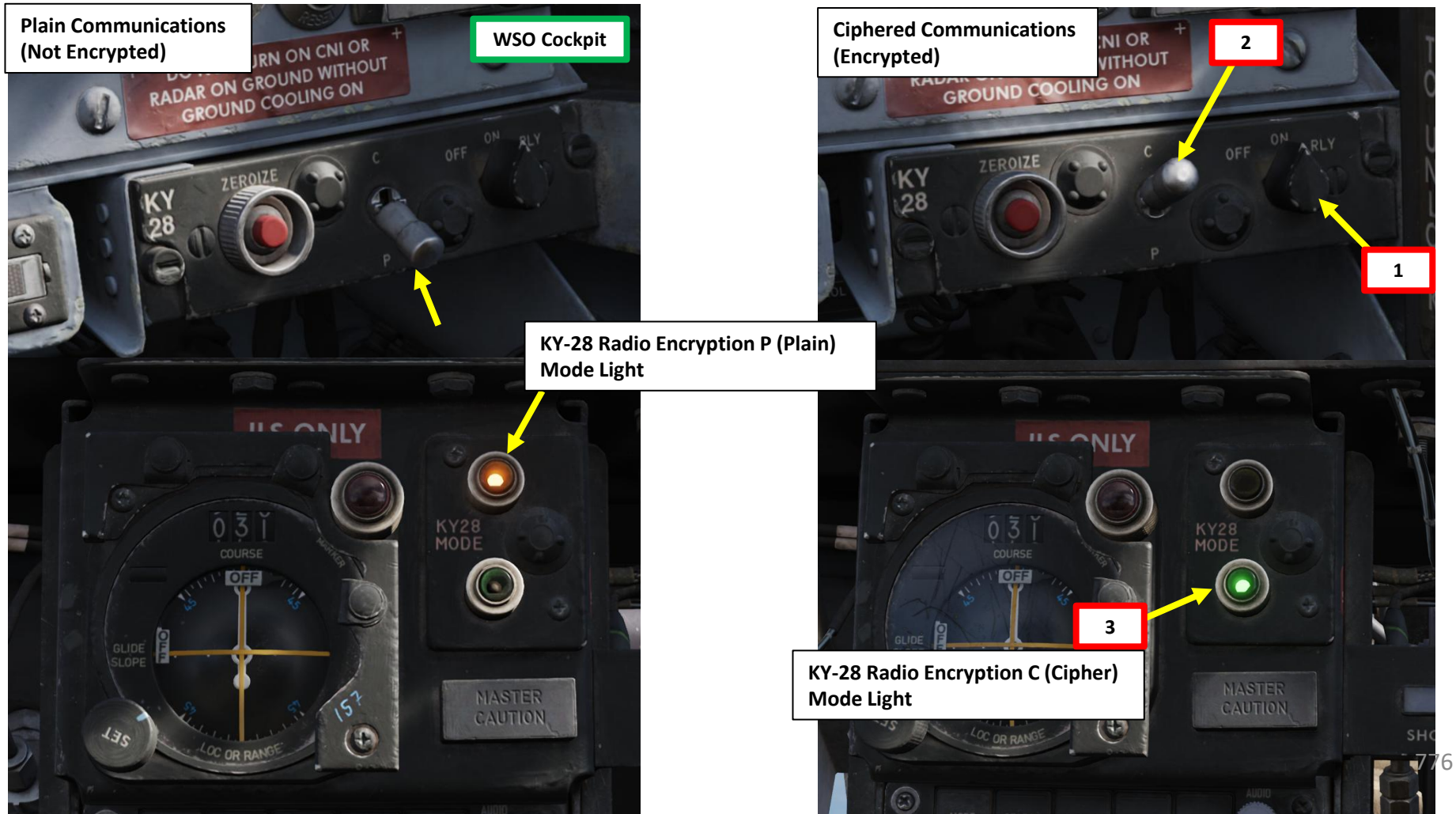
Source: Heatblur Simulations Wiki



KY-28 SPEECH SECURITY UNIT (VOICE ENCRYPTION)

To operate the UHF transceiver in the KY-28s C (cipher) mode:

1. *[WSO]* Set KY-28 Radio Encryption Power Selector – ON
2. *[WSO]* Set KY-28 Radio Encryption Mode Selector – CIPHER (UP)
3. *[WSO]* The KY-28 Radio Encryption C (Cipher) Mode Light should illuminate.
4. Radio Transmissions should now be encrypted.

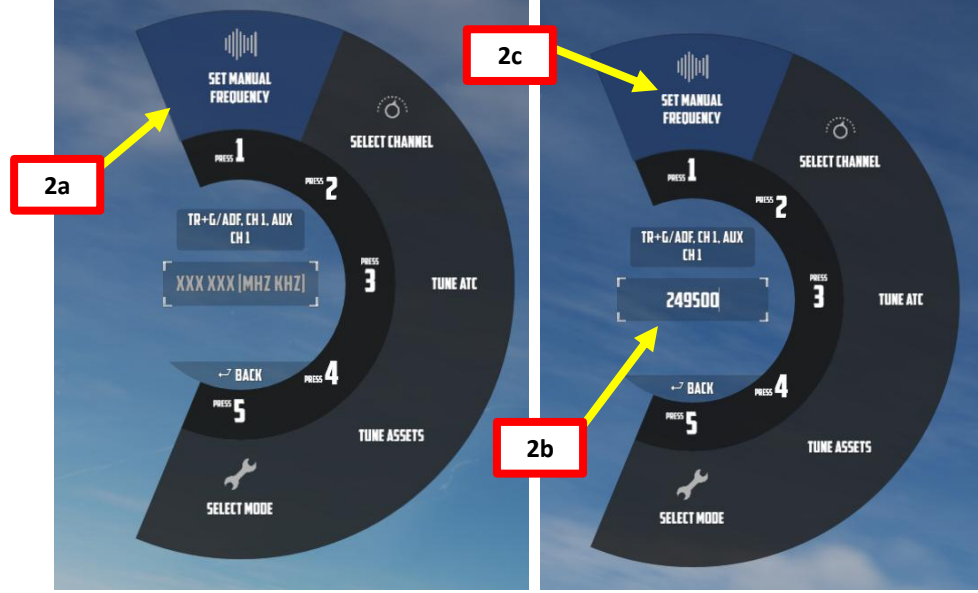


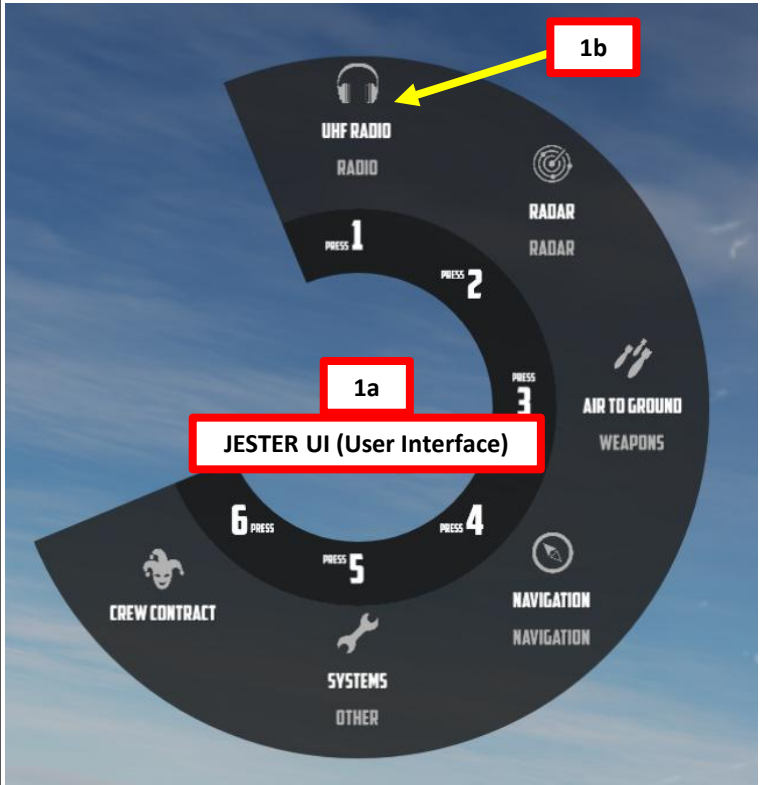
JESTER AI INTERFACE

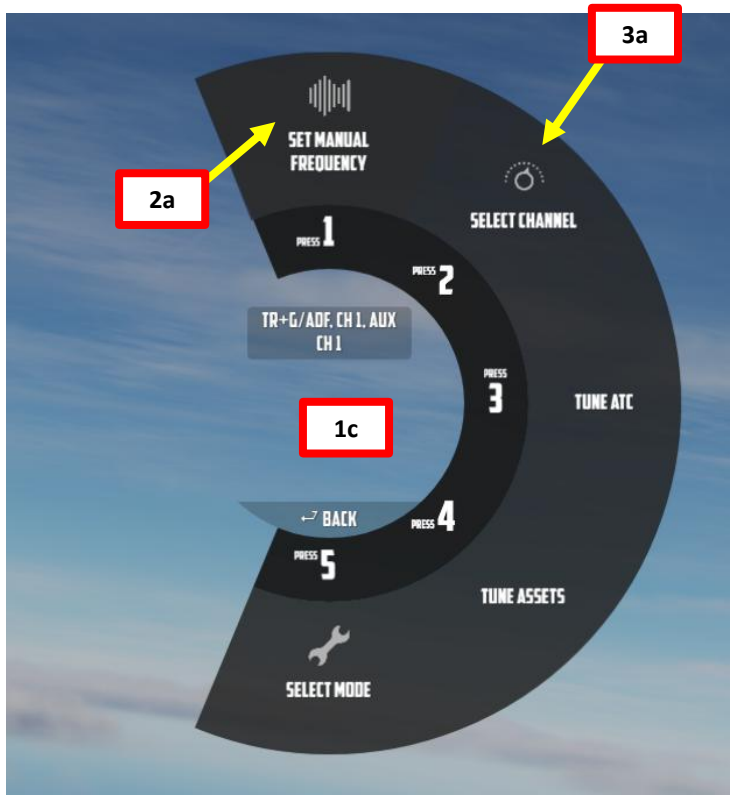
When you are flying in the pilot position and the JESTER AI takes over WSO tasks, JESTER can set radio channels.

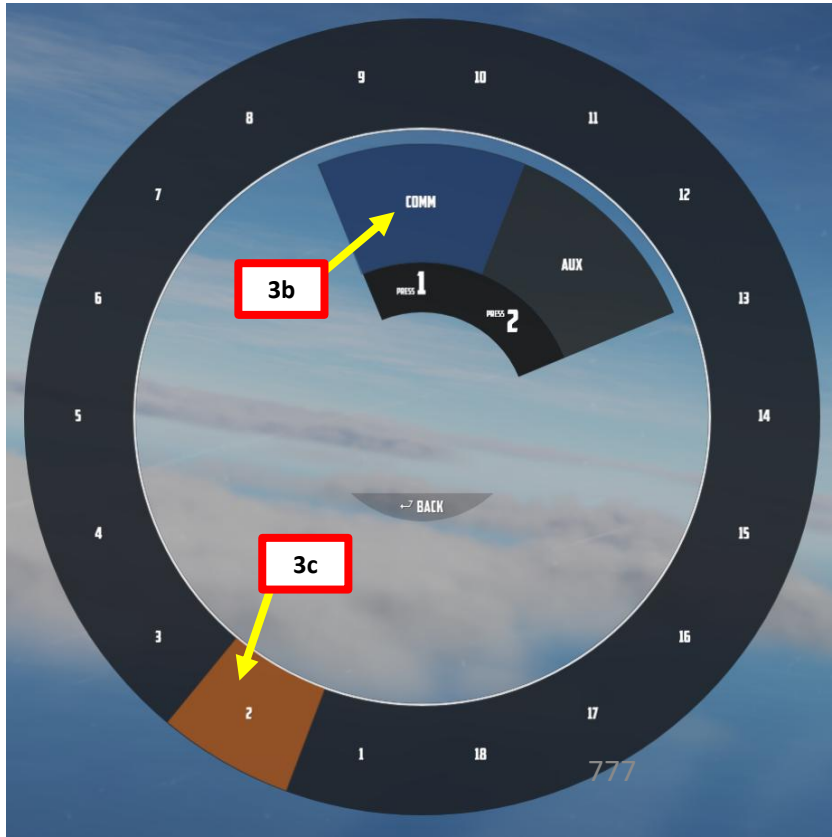
To open JESTER AI wheel, short-press “A” (JESTER UI Action binding).

1. From the **UHF RADIO** menu, you will access all communications-related JESTER commands.
2. From the **SET MANUAL FREQUENCY** menu, you can ask JESTER to set a manual radio frequency:
   a) Click on SET MANUAL FREQUENCY.
   b) Enter frequency with keyboard (249500 for 249.50 MHz).
   c) Click on SET MANUAL FREQUENCY again.
3. From the **SELECT CHANNEL** menu, you can ask JESTER to set a manual radio frequency :
   a) Click on SELECT CHANNEL.
   b) Select desired radio (COMM for Main UHF Radio or AUX for Auxiliary UHF Radio Receiver)
   c) Click on desired preset channel



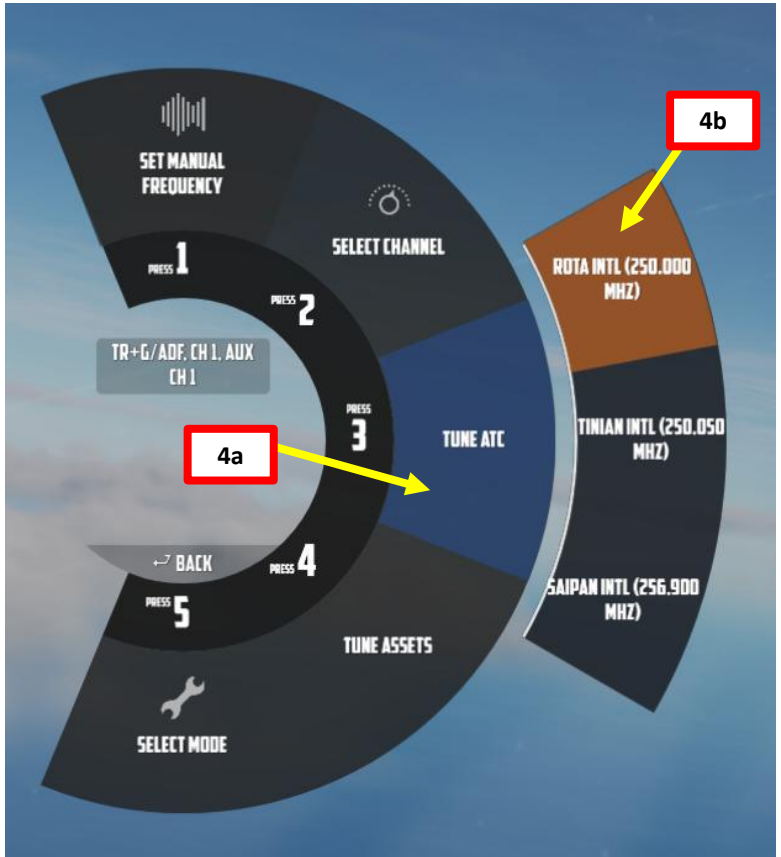


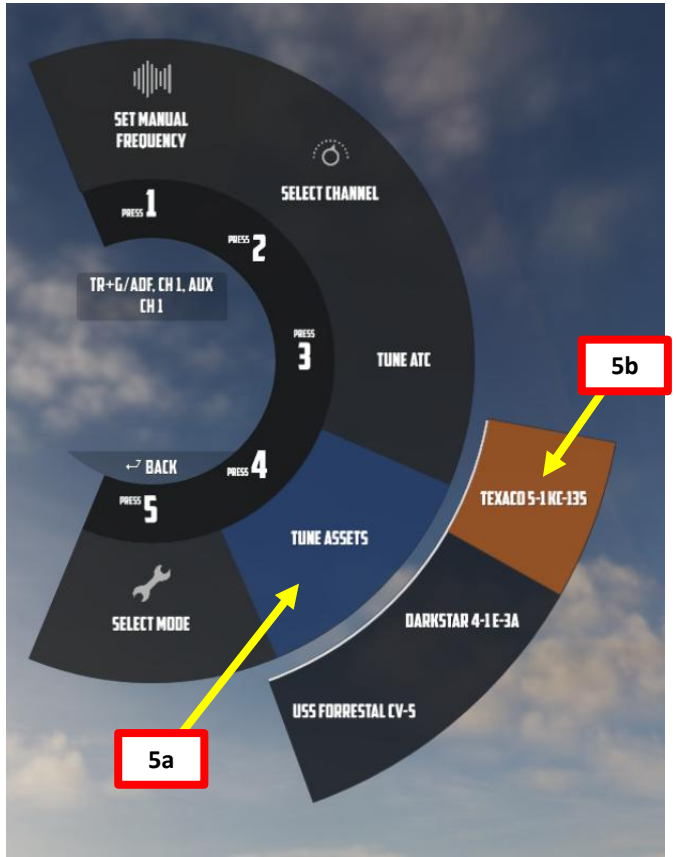


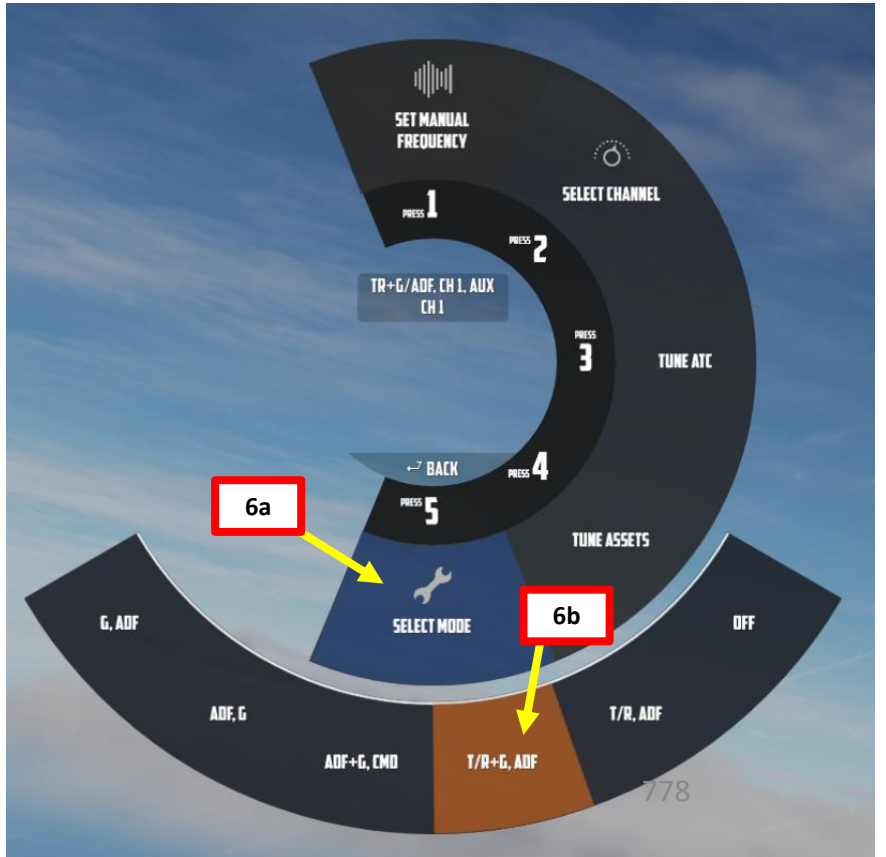


JESTER AI INTERFACE

4. Selecting "**TUNE ATC**" commands JESTER to tune the radio to the frequency of an existing nearby Air Traffic Controller.
5. Selecting "**TUNE ASSETS**" commands JESTER to tune the radio to the frequency of an existing nearby asset such as ships, air-to-air refueling tankers or ground stations.
6. From the **SELECT MODE** menu, you can select which radio Mode JESTER has selected.







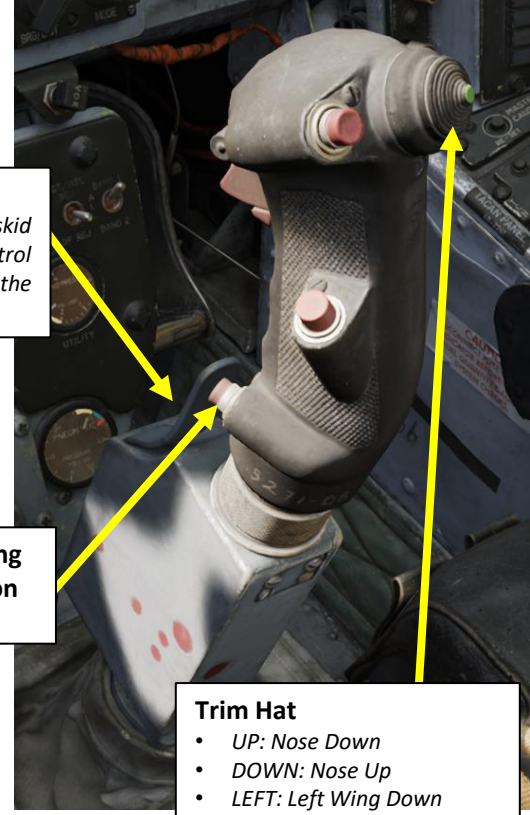
AFCS (AUTOMATIC FLIGHT CONTROL SYSTEM) INTRODUCTION

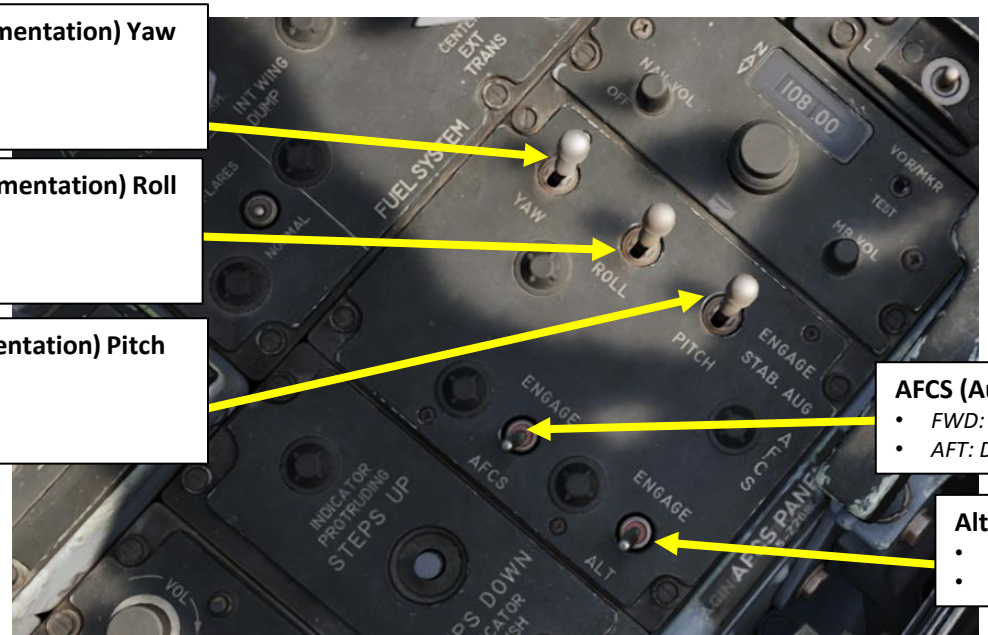
The **automatic flight control system (AFCS)** is an electro-hydraulic system designed to provide stable, accurate, and coordinated flight maneuvers without interfering with manual control. The automatic flight control system is capable of performing two modes of operation, stability augmentation and AFCS. The term "AFCS" is the name of the whole system but also its sub-mode in which the aircraft attitude and/or heading is held and altitude hold can be activated. An automatic pitch-trim feature is included in the AFCS which attempts to keep the airplane longitudinally trimmed to the flight conditions experienced while in AFCS mode.

- **Stability augmentation** improves airplane stability in pitch, roll, and yaw. It opposes any change of attitude but does not return the airplane to a given attitude or ground track. This mode of operation may be used while the aircraft is under manual control. Stability augmentation can be engaged individually or in any combination for pitch, roll, or yaw axis.

- The **AFCS mode of operation** maintains any aircraft heading and/or attitude selected within the AFCS limits and corrects for any deviation from the selected heading or attitude of the aircraft within the AFCS limits.

A spring-loaded **Emergency Quick Release Lever** is on each control stick. This lever operates in the same manner from both the front and the rear cockpits. Depressing the lever causes the AFCS and altitude hold switch to return to OFF. The stability augmentation mode, ARI (Aileron-Rudder Interconnect) and anti-skid, are disengaged as long as the lever is held depressed. When the lever is released, the stability augmentation, anti-skid, and ARI are again in operation, but the AFCS is no longer engaged.

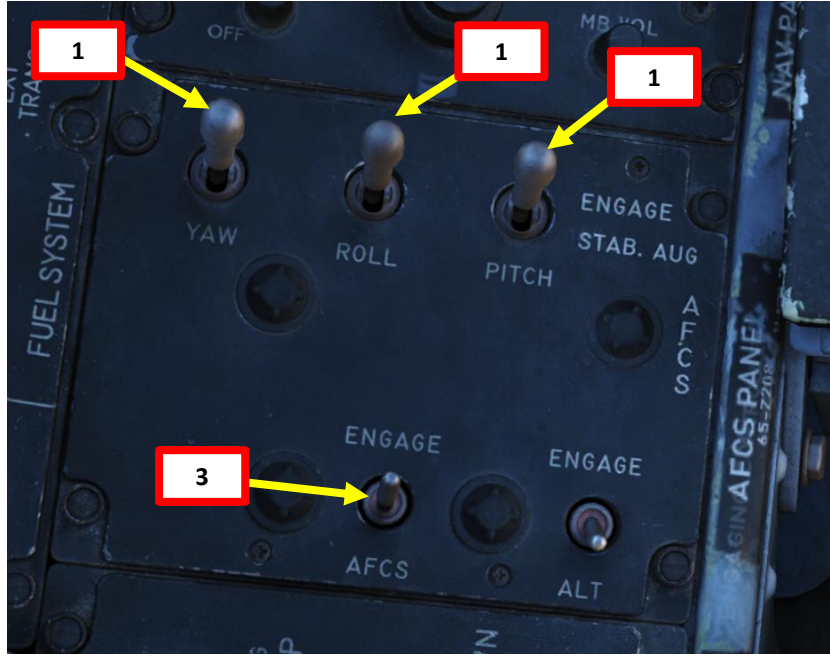




AFCS (AUTOMATIC FLIGHT CONTROL SYSTEM) AUTOPILOT MODES – AFCS MODE

To use the autopilot AFCS Mode:

1. Engage Stability Augmentation Mode by setting Yaw, Roll & Pitch Stability Augmentation System Switches – ENGAGE (FWD)
2. Trim aircraft in the stability augmentation mode before engaging AFCS mode.
3. To engage AFCS mode, establish an aircraft attitude within AFCS limits, then place the AFCS Mode switch to ENGAGE (FWD).
    - The AFCS system can be engaged and hold maneuvers and attitudes within a range of ±70° pitch and 70° in bank, providing the G limits are not being exceeded.
4. When selecting the AFCS mode, have the hand on the control stick to counteract any abrupt control movements in the event of an AFCS malfunction.
5. If the AFCS switch is engaged when the airplane is **less than ± 5° from wings level**, then the airplane will **maintain a wings level attitude**, and will **hold the engaged heading**. If the airplane attitude is **greater than ± 5° from wings level** when the AFCS switch is engaged, then the airplane will **maintain the bank attitude** at the time of engagement.
6. When the **Nose Gear Steering Button** on the stick grip is pressed, heading hold drops out and attitude hold is available. Heading hold can be re-established by once again pressing the nose gear steering button
7. An **automatic pitch-trim** feature is included in the AFCS which attempts to keep the airplane longitudinally trimmed to the flight conditions experienced while in AFCS mode. Thus, an out-of-trim condition (which would not be sensed while in autopilot mode) is prevented, ensuring against an excessive pitch transient when disengaging the autopilot. The automatic pitch trim operates at approximately 40% the speed of the normal trim system, resulting in a slight delay after changing flight conditions before the basic airplane is properly trimmed.
    - Note 1: During control stick steering maneuvering, the auto-trim is inoperative. Auto-trim operation can be observed on the pitch trim indicator after changing flight conditions in the AFCS mode.
    - Note 2: The AUTOPILOT PITCH TRIM indicator light on the telelight panel illuminates during AFCS operation if the automatic pitch trim follow up is inoperative or lagging sufficiently behind airplane maneuvering to cause an out-of-trim condition in the basic airplane.
8. There is a **normal load factor interlock (G-disengage) feature** of the AFCS, which is designed to inhibit the system from commanding excessive load factors on the airplane. The system reverts automatically from whatever mode is engaged to stability augmentation in the event that +4 or -1 G is sensed by the G-disengage accelerometer switch. If the airplane is rotated rapidly into a maneuver, disengagement occurs at lower values of normal load factor due to the anticipation resulting from the forward location sensing a component of pitching acceleration.
    - The G-disengage feature is inoperative outside the ±70° limits of the autopilot.
    - The G switch does not disengage the autopilot under conditions of low airspeed or heavy gross weight before the aircraft stalls. If the autopilot remains engaged during a stall, the autopilot provides pro-spin controls.





6 **Nose Gear (Nosewheel) Steering / Radar Auto Acquisition Button**
- *Binding: N*

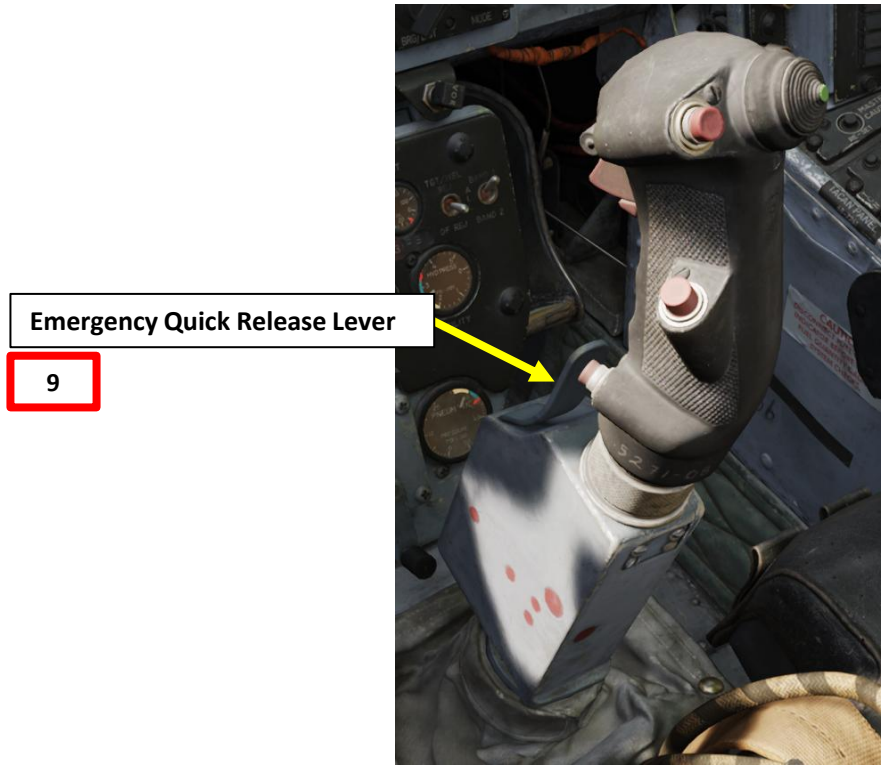
AFCS (AUTOMATIC FLIGHT CONTROL SYSTEM) AUTOPILOT MODES – AFCS MODE

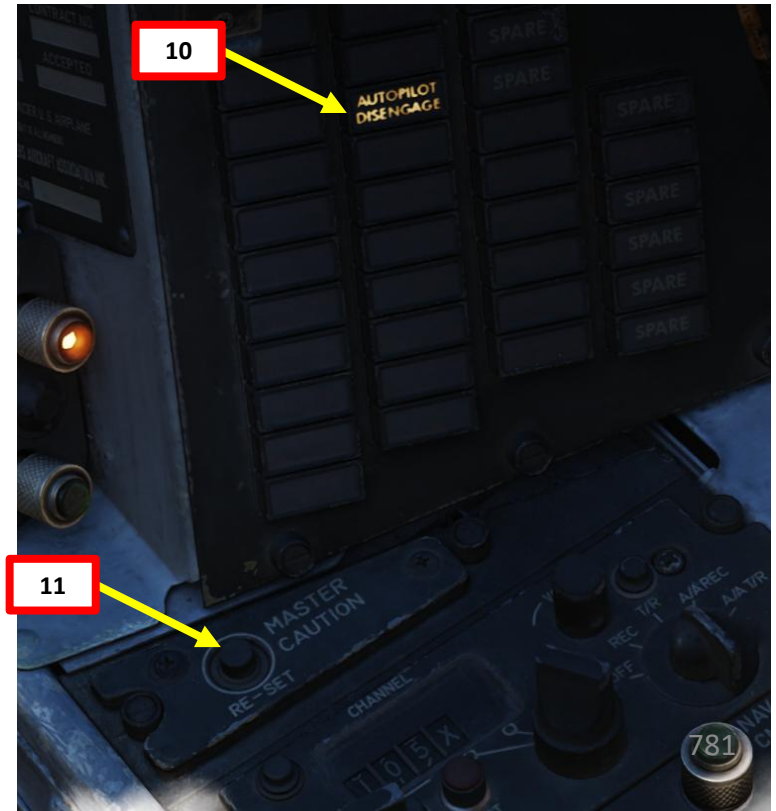
To use the autopilot AFCS Mode:

9. The **AFCS is disengaged** when the **Emergency Quick Release Lever** on the control stick is depressed. The stability augmentation and ARI (Aileron-Rudder Interconnect) are disengaged as long as the lever is held depressed but returns to operation when the lever is released.
10. The AUTOPILOT DISENGAGE indicator light and the MASTER CAUTION light both illuminate when the AFCS is disengaged.
11. The AUTOPILOT DISENGAGE indicator light and the MASTER CAUTION light are extinguished by pressing the Master Caution Reset switch. The lights remain extinguished until the AFCS is again engaged and disengaged.

Very important: Do not attempt to change pitch attitude of the aircraft from the rear cockpit in the AFCS mode. Since no force-transducer is in the rear cockpit control stick, applying force will cause pitch trim to run up and down depending on pressure applied. If the pilot attempts to take control at that point, violent transients may be encountered.



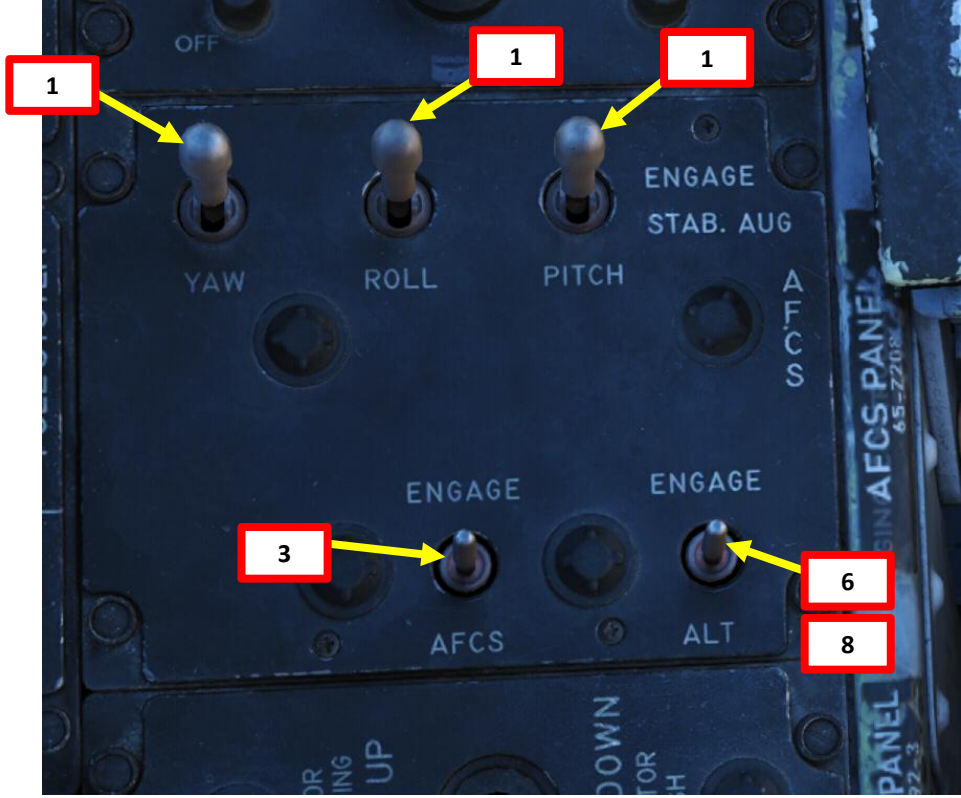


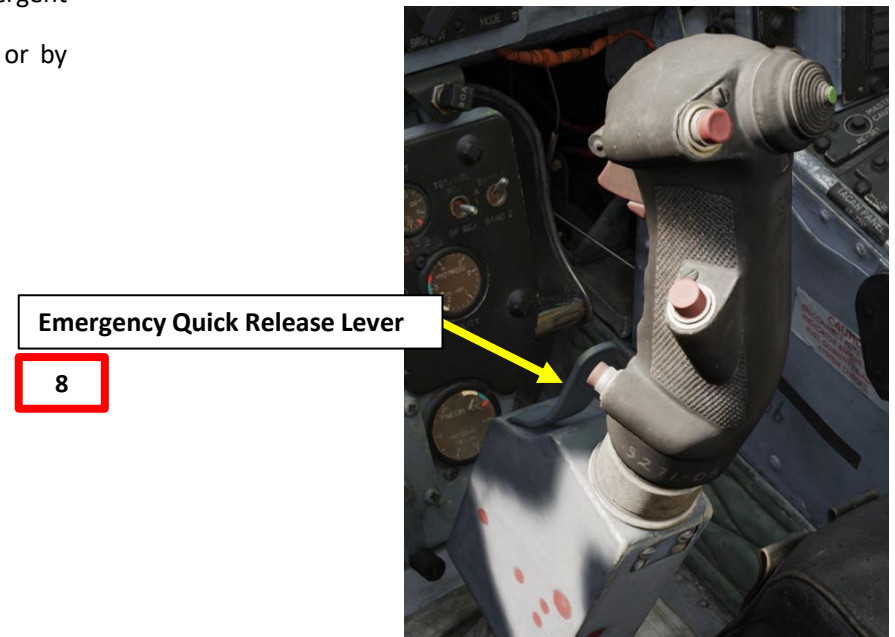


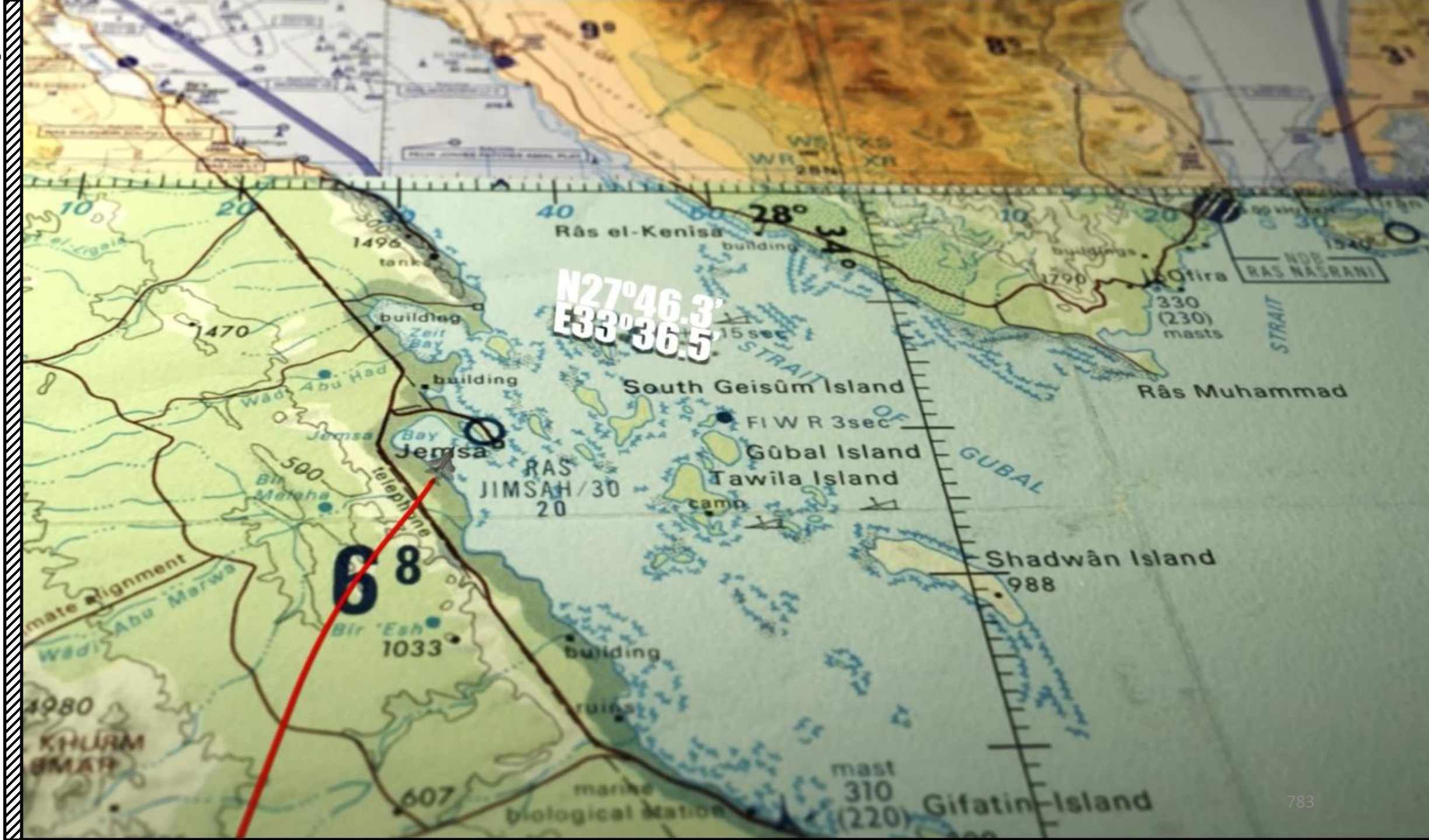
AFCS (AUTOMATIC FLIGHT CONTROL SYSTEM) AUTOPILOT MODES – ALTITUDE HOLD MODE

To use the autopilot Altitude Hold Mode:

1. Engage Stability Augmentation Mode by setting Yaw, Roll & Pitch Stability Augmentation System Switches – ENGAGE (FWD)
2. Trim aircraft to maintain a level altitude before engaging AFCS mode.
3. Engage AFCS mode by placing the AFCS Mode switch to ENGAGE (FWD).
    - The AFCS system can be engaged and hold maneuvers and attitudes within a range of ±70° pitch and 70° in bank, providing the G limits are not being exceeded.
4. When selecting the AFCS mode, have the hand on the control stick to counteract any abrupt control movements in the event of an AFCS malfunction.
5. If the AFCS switch is engaged when the airplane is **less than ± 5° from wings level**, then the airplane will **maintain a wings level attitude**, and will **hold the engaged heading**. If the airplane attitude is **greater than ± 5° from wings level** when the AFCS switch is engaged, then the airplane will **maintain the bank attitude** at the time of engagement.
6. Engage Altitude Hold mode by placing the Altitude Hold switch to ENGAGE (FWD).
7. Current aircraft altitude will be maintained by the AFCS.
    - Note: Altimeter fluctuations while accelerating through the transonic range (0.9 to 1.0 Mach) will produce transient fluctuations due to fluctuations in the air data computer airspeed system, which may cause the reference altitude to slip. Engaging the altitude hold mode in climbs greater than 1000 feet per minute may result in a reference altitude other than the engage altitude.
    - The nature of these oscillations vary from stick pumping to divergent pitch oscillations. Divergent pitch oscillations should not be allowed to develop.
8. Altitude Hold Mode can be disengaged by either setting the Altitude Hold switch to OFF (AFT) or by depressing the **Emergency Quick Release Lever** on the control stick.






N27°46.3'
E33°36.5'
Râs el-Kenisa
South Geisûm Island
Gûbal Island
Tawila Island
Râs Muhammad
Shadwân Island
Gifatin Island
Jemsa
RAS JIMSAH/30
20
STRAIT OF GUBAL
RAS NASRANI
15 sec
Fl W R 3sec
building
camp
ruins
mast
310
(220)
988
1033
1496
1470
1790
1540
330
(230)
masts
Wadi Abu Marwa
Bir 'Esh
KHURM BMAP
607
500
4980

SECTION STRUCTURE

- **1 – NAVIGATION INTRODUCTION**
- **2 – MAGNETIC VARIATION**
- **3 – NAVIGATION SYSTEMS OVERVIEW**
  - 3.1 – Overview
  - 3.2 – Navigation Modes
- **4 – FLIGHT PLAN**
  - 4.1 – Flight Plan Basics
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- **5 – NAVIGATION COMMAND (NAV CMD)**
- **6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION**
- **7 – TACAN NAVIGATION**
- **8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION**
- **9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)**
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    - 9.2.1 – Basic Concepts
    - 9.2.2 – Navigation using TGT 1 Mode
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    - 9.3.2 – Coordinate Correction using Position Update (Overfly) Fix
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- **10 – ILS (INSTRUMENT LANDING SYSTEM)**
- **11 – JESTER AI NAVIGATION**
  - 11.1 – Navigation Menu
  - 11.2 – JESTER Functions
    - 11.2.1 – Go To / Resume
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    - 11.2.3 – Divert To
    - 11.2.4 – Edit Flight Plan
    - 11.2.5 – TACAN

1 – NAVIGATION INTRODUCTION

Navigation is an extensive subject. You can check chapter 16 of FAA manual for more details on navigation.

Link: https://www.faa.gov/sites/faa.gov/files/18_phak_ch16.pdf

- **NDB** is what we call a non-directional beacon. It transmits radio waves on a certain frequency on long distances, but it does not include inherent directional information. These waves are read by an ADF (Automatic Direction Finder) system. NDBs only have **bearing** information relative to the beacon, **no distance** information is provided. Non-directional beacons are nowadays considered very old technology used from the 1930's to the 50's and are being decommissioned

- **VOR** is what we call a VHF Omnidirectional Range system. It transmits radio waves on a certain frequency. These waves are read by a VOR receiver. VOR systems, just like NDBs, can be used for radio navigation. A VOR station provides **bearing** information, but **no distance** information by itself. Unlike the NDB, a VOR can be intercepted by following a specific **radial** (direction).

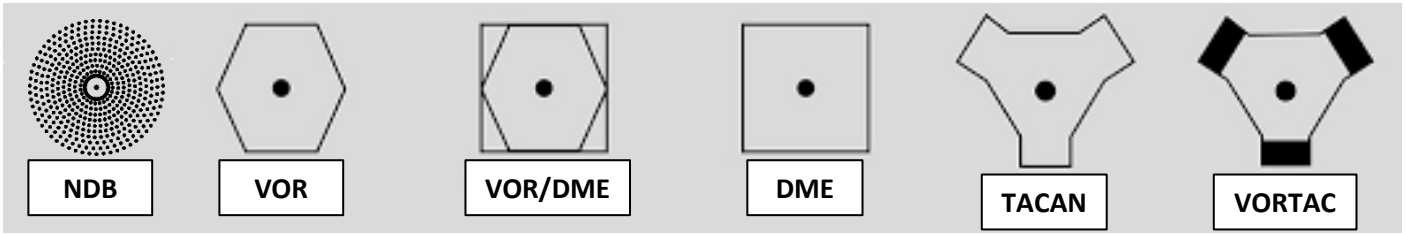
NDBs and VORs are used just like lighthouses were used to guide ships. This way, air corridors and airways are created to help control an increasingly crowded sky.

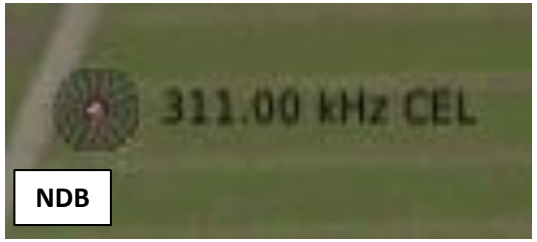
- **DME (Distance Measuring Equipment)** is a radio navigation technology that measures the slant range (distance) between an aircraft and a ground station. This technology can be used for combined **VOR/DME** stations to provide **distance** information.

- **TACAN** is a Tactical Air Navigation System used by the military. TACAN beacons can be placed on ground stations, airfields or even aircraft themselves like tankers. TACAN is also used on aircraft carriers. The TACAN station equipment on the ground has two parts, one provides **bearing** and the other one provides **distance**. Similarly to a VOR, a TACAN can be intercepted by following a specific **radial** (direction).

- **VORTAC** combines the VOR and TACAN in one location. Civil users will use the VOR signals which have the same performance as ordinary VOR signals, providing **bearing** information. In addition, they use the DME from the TACAN, providing **distance** information. Effectively, a VORTAC is like a VOR/DME.

- **ILS** (Instrument Landing System) allows an aircraft find their way to an airstrip (provided it is equipped with a VOR or NDB) despite bad visibility conditions. This provides localizer (lateral) deviation and glide slope deviation information to approach a runway from a specific direction.



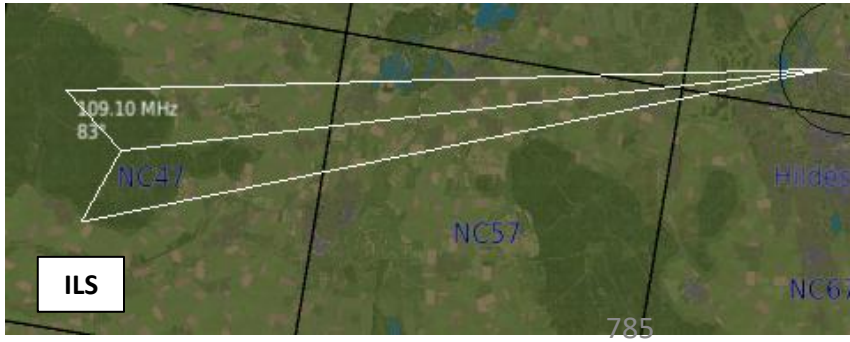




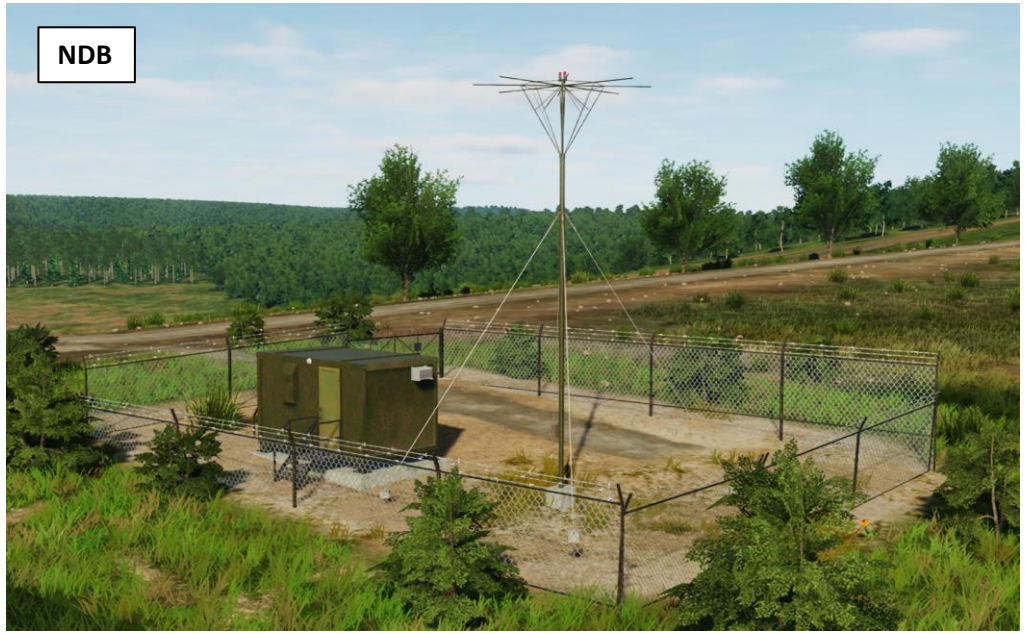




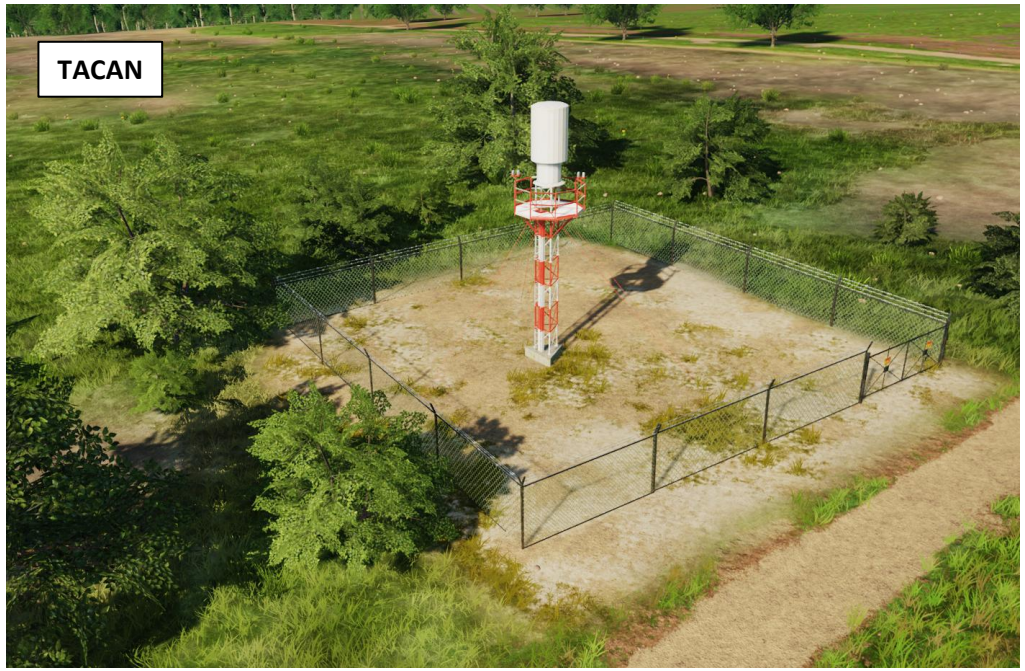




1 – NAVIGATION INTRODUCTION





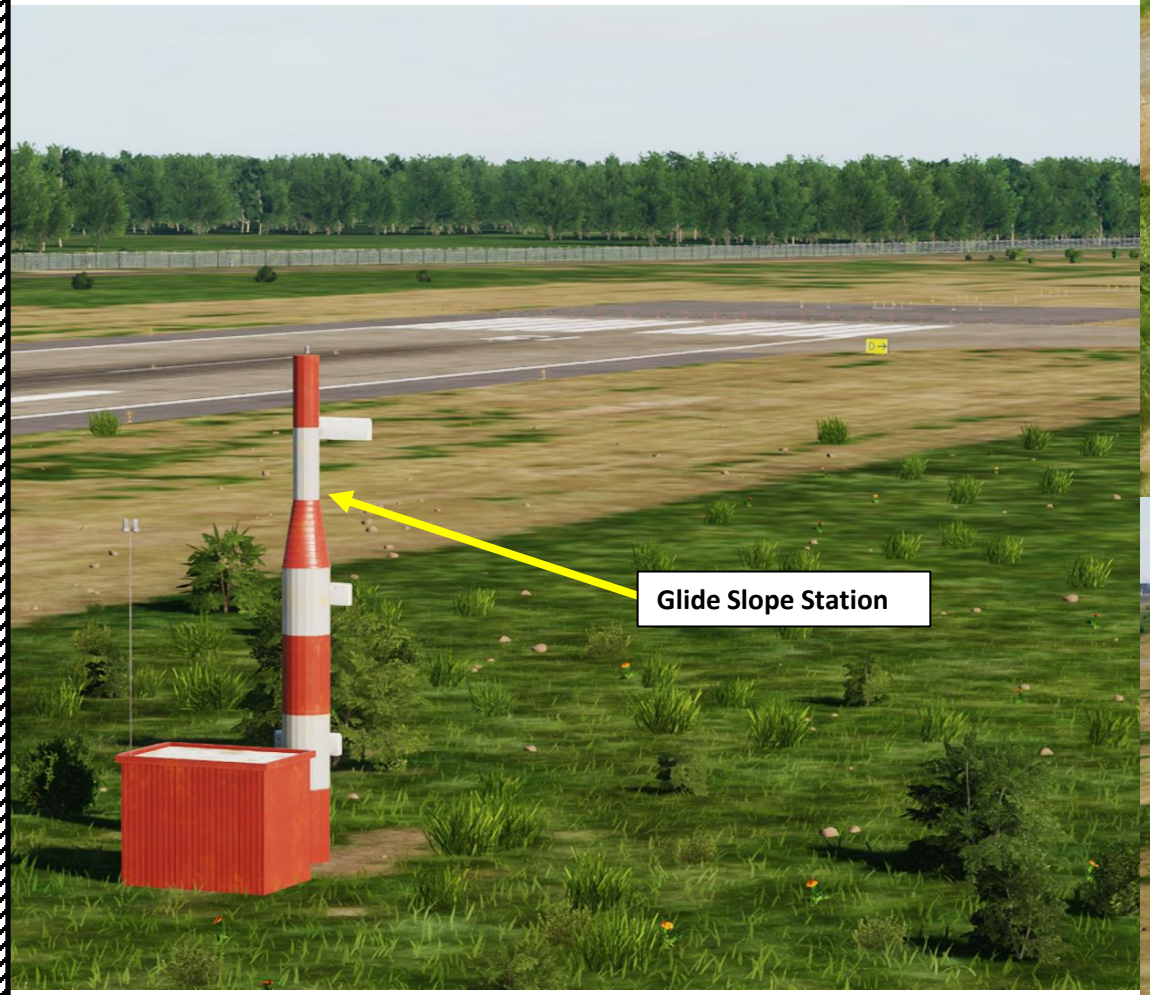




1 – NAVIGATION INTRODUCTION



1 – NAVIGATION INTRODUCTION







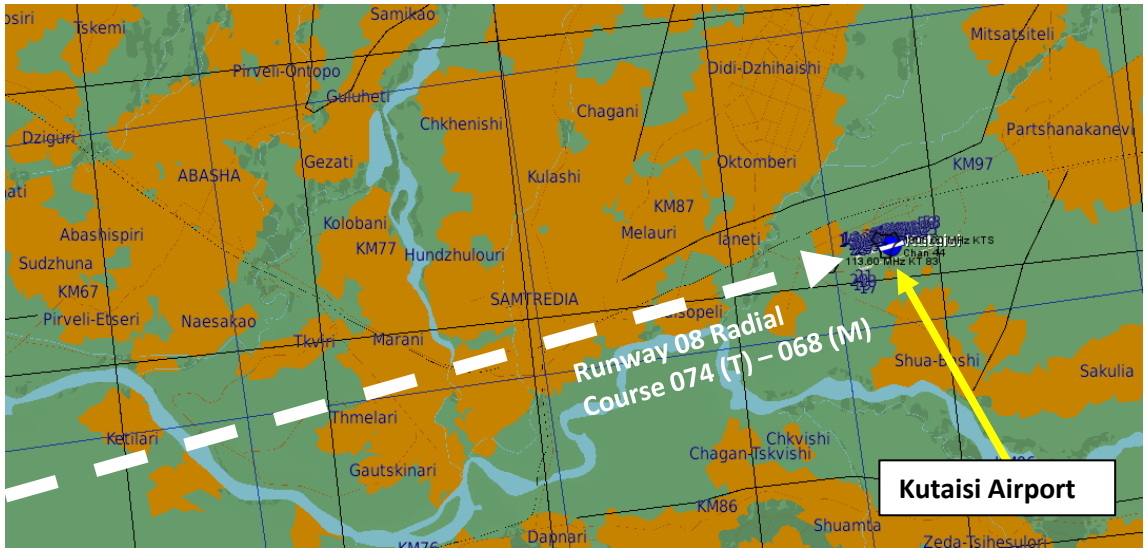
2 – MAGNETIC VARIATION

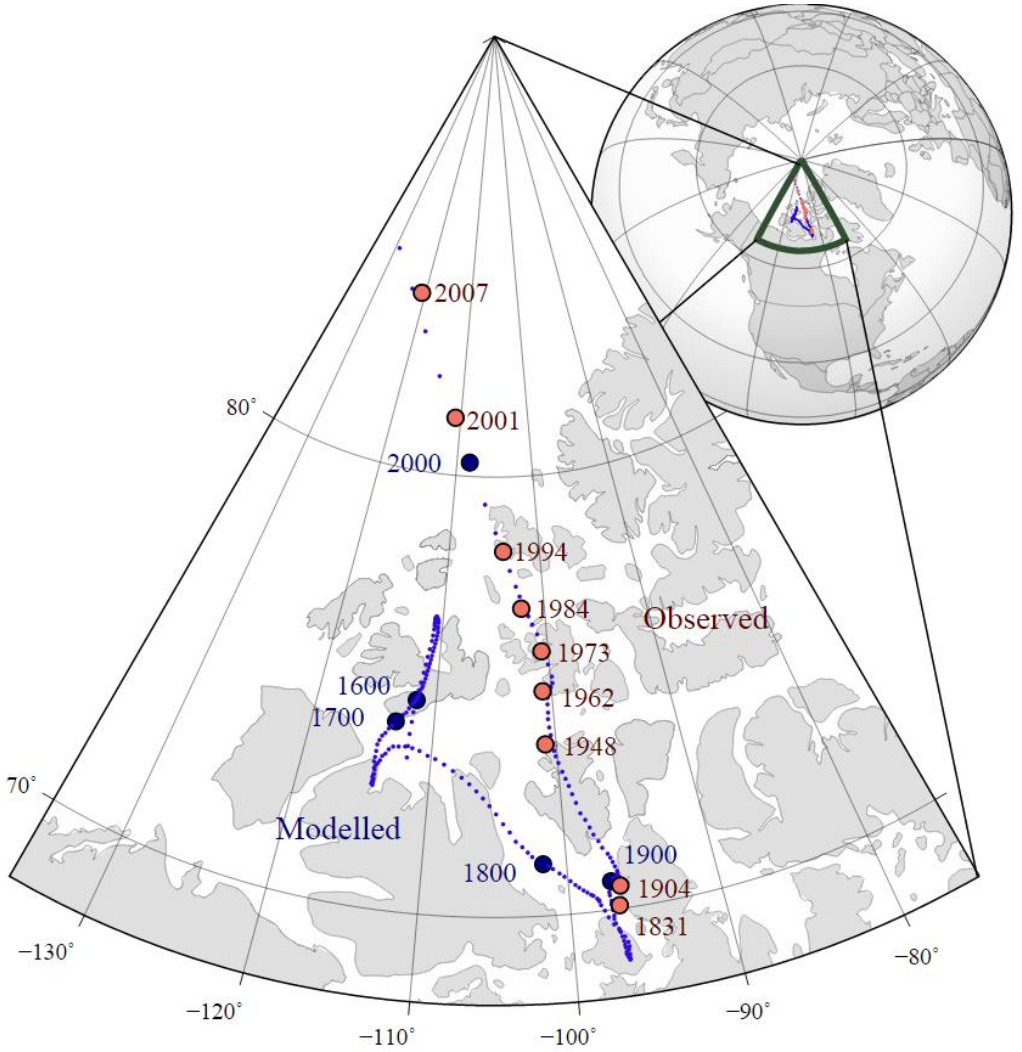
The direction in which a compass needle points is known as magnetic north. In general, this is not exactly the direction of the North Magnetic Pole (or of any other consistent location). Instead, the compass aligns itself to the local geomagnetic field, which varies in a complex manner over the Earth's surface, as well as over time. The local angular difference between magnetic north and true north is called the magnetic variation. Most **map coordinate** systems are based on **true north**, and magnetic variation is often shown on map legends so that the direction of true north can be determined from north as indicated by a compass. This is the reason why in DCS the course to a runway needs to be "adjusted" to take into account this magnetic variation of the magnetic North pole (actually modelled in the sim, which is pretty neat).

True Heading = Magnetic Heading + Magnetic Variation

As an example, if the runway heading that you read on the F10 map in Kutaisi is 074 (True Heading), then the input to your magnetic compass course should be 074 subtracted with the Magnetic Variation (+6 degrees), or 068. You would need to enter a course of 068 (M) on the HSI (Horizontal Situation Indicator).

Magnetic variation varies from place to place, but it also changes with time. This means this value will be highly dependent on the mission time and map.



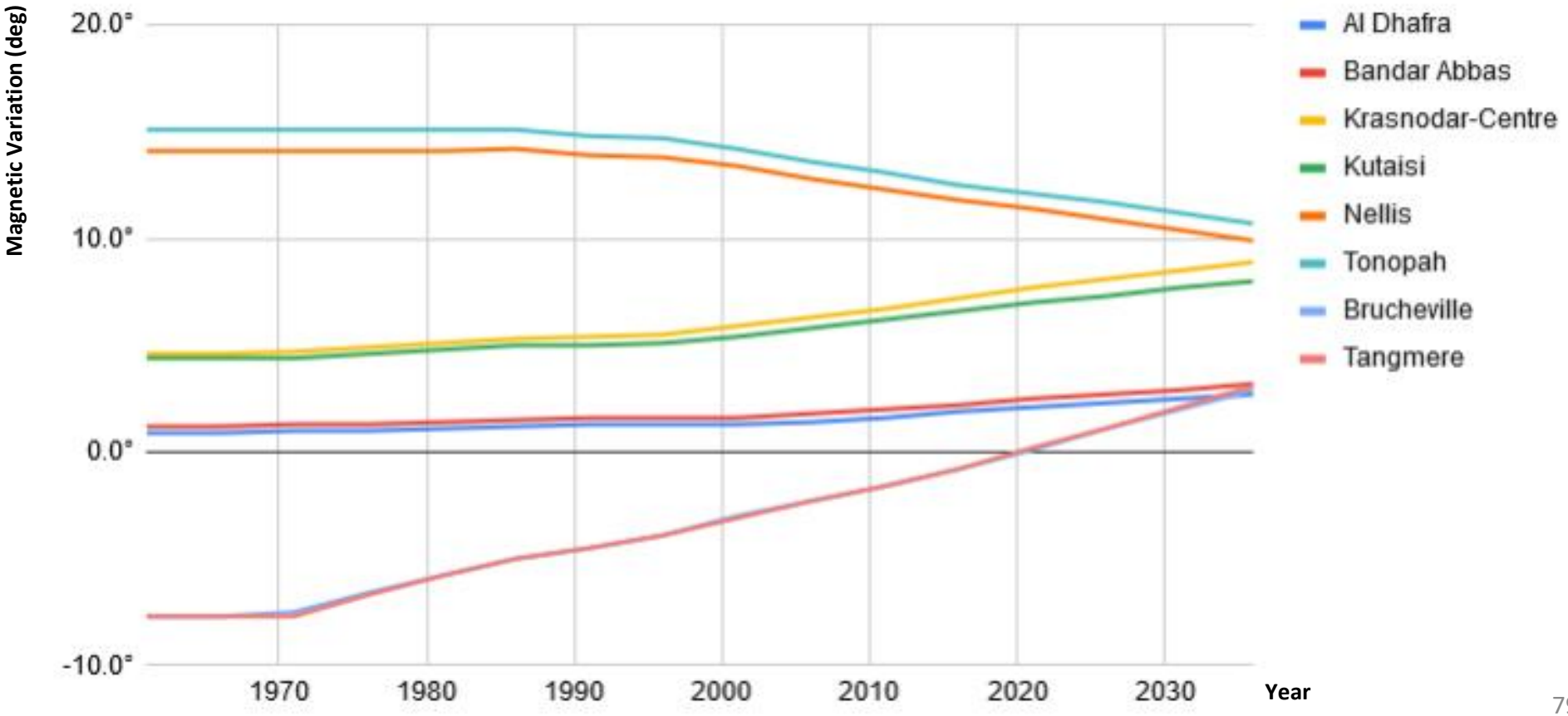


The movement of Earth's north magnetic pole across the Canadian arctic, 1831–2007

2 – MAGNETIC VARIATION

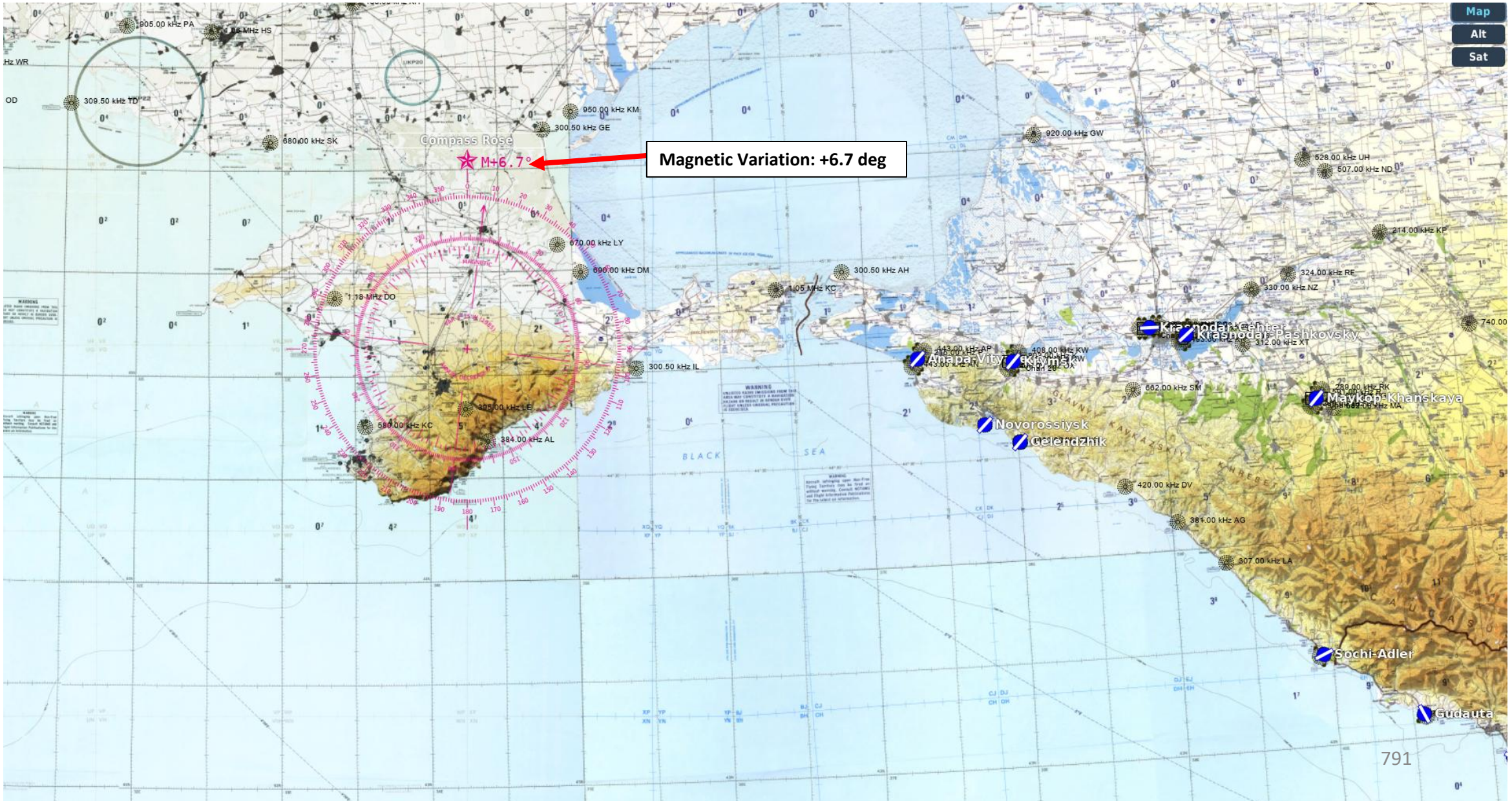
Magnetic variation varies from place to place, but it also changes with time. This means this value will be highly dependent on the mission time and map.

MagVar Evolution Sample (from FlyAndWire)



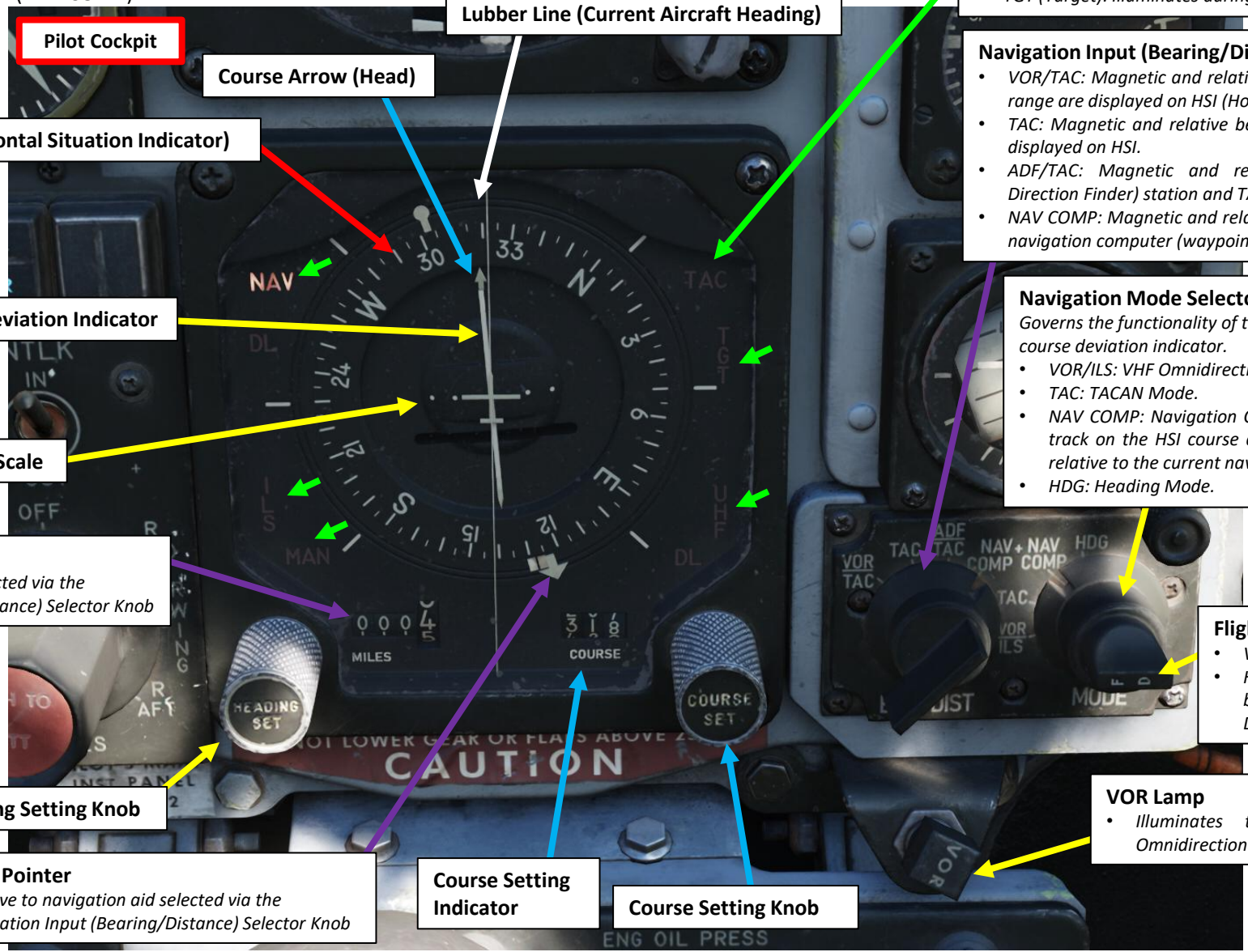
2 – MAGNETIC VARIATION

Checking the magnetic variation is now very easy: you can access it directly from the F10 map, shown with the Compass Rose.



3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The **HSI (Horizontal Situation Indicator)** displays a top-down plan view of current navigation, with cues provided relative to the selected navigation mode selector position. It interacts closely with several navigational aids like VOR, TACAN, ADF, and the aircraft's Navigation Computer (NAV COMP).



Pilot Cockpit

Lubber Line (Current Aircraft Heading)

Course Arrow (Head)

HSI (Horizontal Situation Indicator)

Course Deviation Indicator

Course Deviation Scale

Range Indicator (nm)
- *Relative to navigation aid selected via the Navigation Input (Bearing/Distance) Selector Knob*

Heading Setting Knob

Bearing Pointer
- *Relative to navigation aid selected via the Navigation Input (Bearing/Distance) Selector Knob*

Course Setting Indicator

Course Setting Knob

Navigation Mode Lights
- *VOR: VOR/ILS mode is selected and VOR frequency is selected.*
- *ILS: VOR/ILS mode is selected and ILS frequency is selected.*
- *TAC: TACAN mode is active.*
- *NAV: Navigation Computer mode is in use.*
- *MAN: Heading Mode is selected.*
- *UHF: ADF (Automatic Direction Finder) mode is active.*
- *TGT (Target): Illuminates during radar offset bombing operations.*

Navigation Input (Bearing/Distance) Selector
- *VOR/TAC: Magnetic and relative bearing to VOR station and TACAN range are displayed on HSI (Horizontal Situation Indicator).*
- *TAC: Magnetic and relative bearing and range to TACAN station is displayed on HSI.*
- *ADF/TAC: Magnetic and relative bearing to ADF (Automatic Direction Finder) station and TACAN range are is displayed on HSI.*
- *NAV COMP: Magnetic and relative bearing and range provided from navigation computer (waypoints) are displayed on HSI.*

Navigation Mode Selector (Outer Knob)

Governs the functionality of the heading marker, course arrow, and the course deviation indicator.
- *VOR/ILS: VHF Omnidirectional Range / Instrument Landing System.*
- *TAC: TACAN Mode.*
- *NAV COMP: Navigation Computer Mode, displays magnetic ground track on the HSI course arrow and the HSI course selector window relative to the current navigation computer fix*
- *HDG: Heading Mode.*

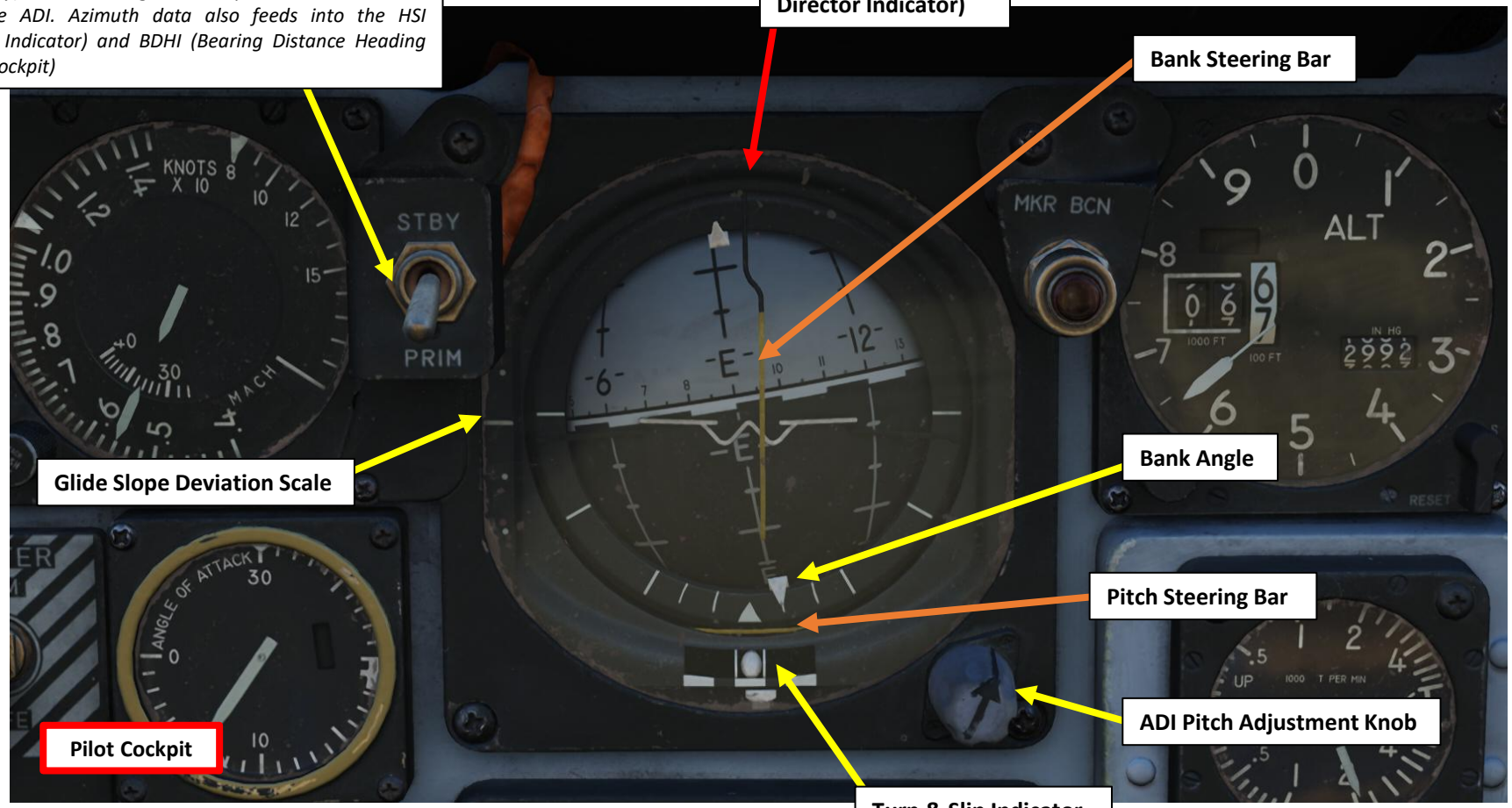
Flight Director (FD) Selector (Inner Knob)
- *Vertical FD Position: OFF*
- *Horizontal FD Position: Activates pitch and bank steering bars on the ADI (Attitude Director Indicator).*

VOR Lamp
- *Illuminates to indicate that the VOR (VHF Omnidirectional Range) system is ready and receiving.*

3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

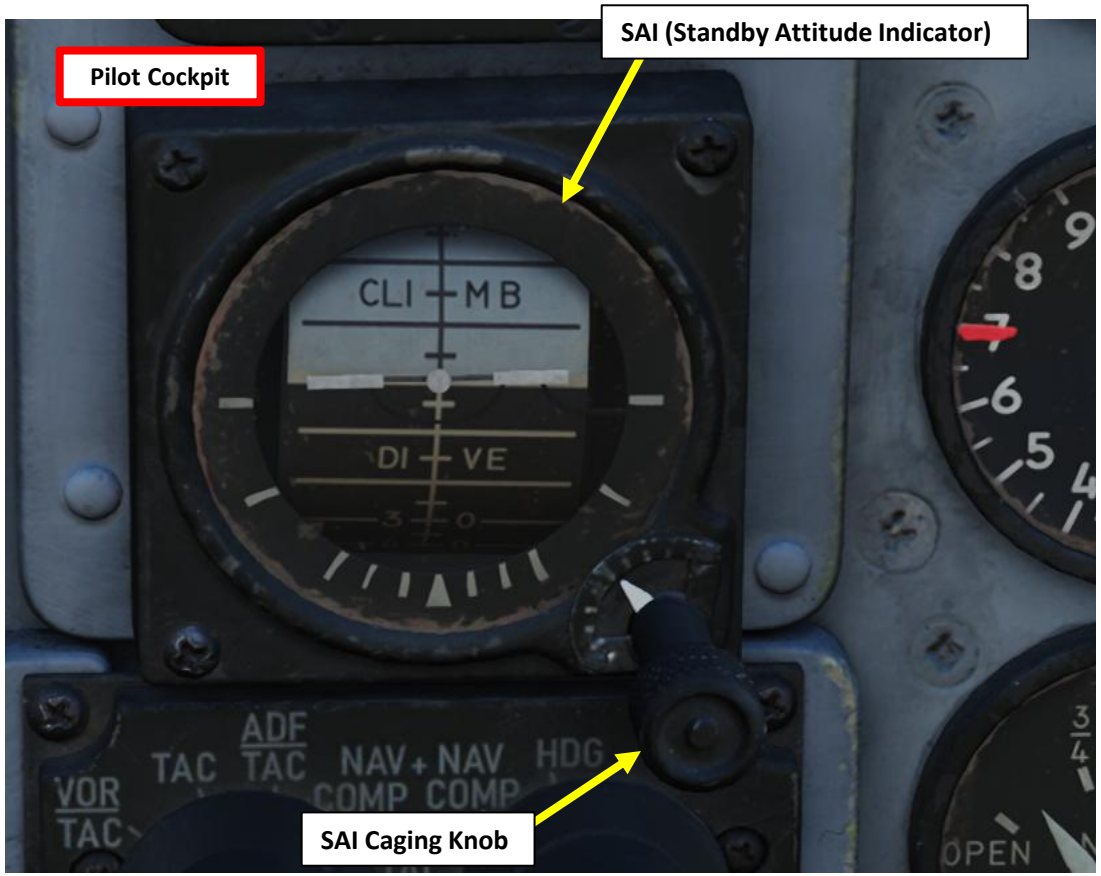
The **ADI (Attitude Director Indicator)** provides command steering to intercept selected headings, TACAN stations, tracks, VOR radials, or navigation computer destinations.

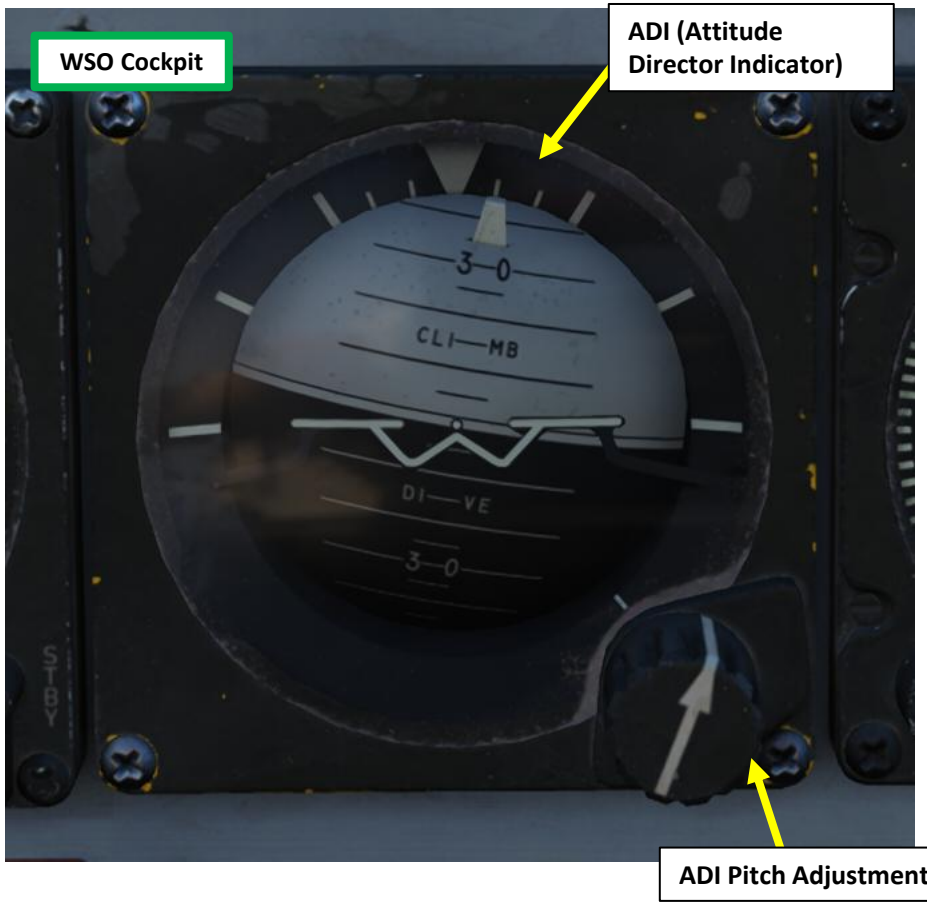
Reference System Selector Switch
- *UP: STBY (Standby), AN/AJB-7 ARBCS (Attitude Reference and Bombing Computer Set) provides azimuth and attitude data to the ADI*
- *DOWN: PRIM (Primary), inertial navigation set provides azimuth and attitude data to the ADI. Azimuth data also feeds into the HSI (Horizontal Situation Indicator) and BDHI (Bearing Distance Heading Indicator in the rear cockpit)*



3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The front cockpit has a **SAI (Standby Attitude Indicator)** used as a backup to the ADI. There is another **ADI (Attitude Director Indicator)** in the rear cockpit as well.

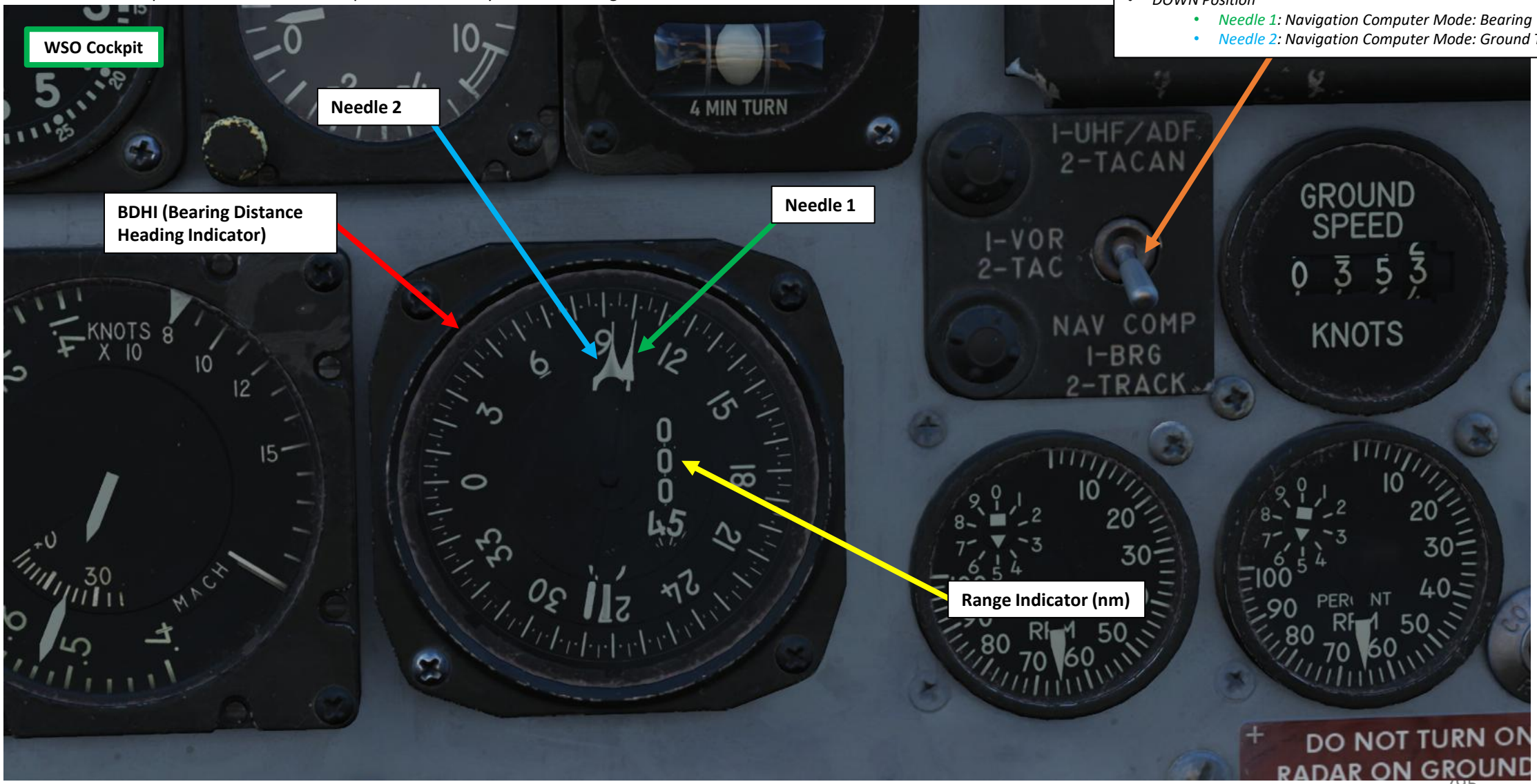




3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

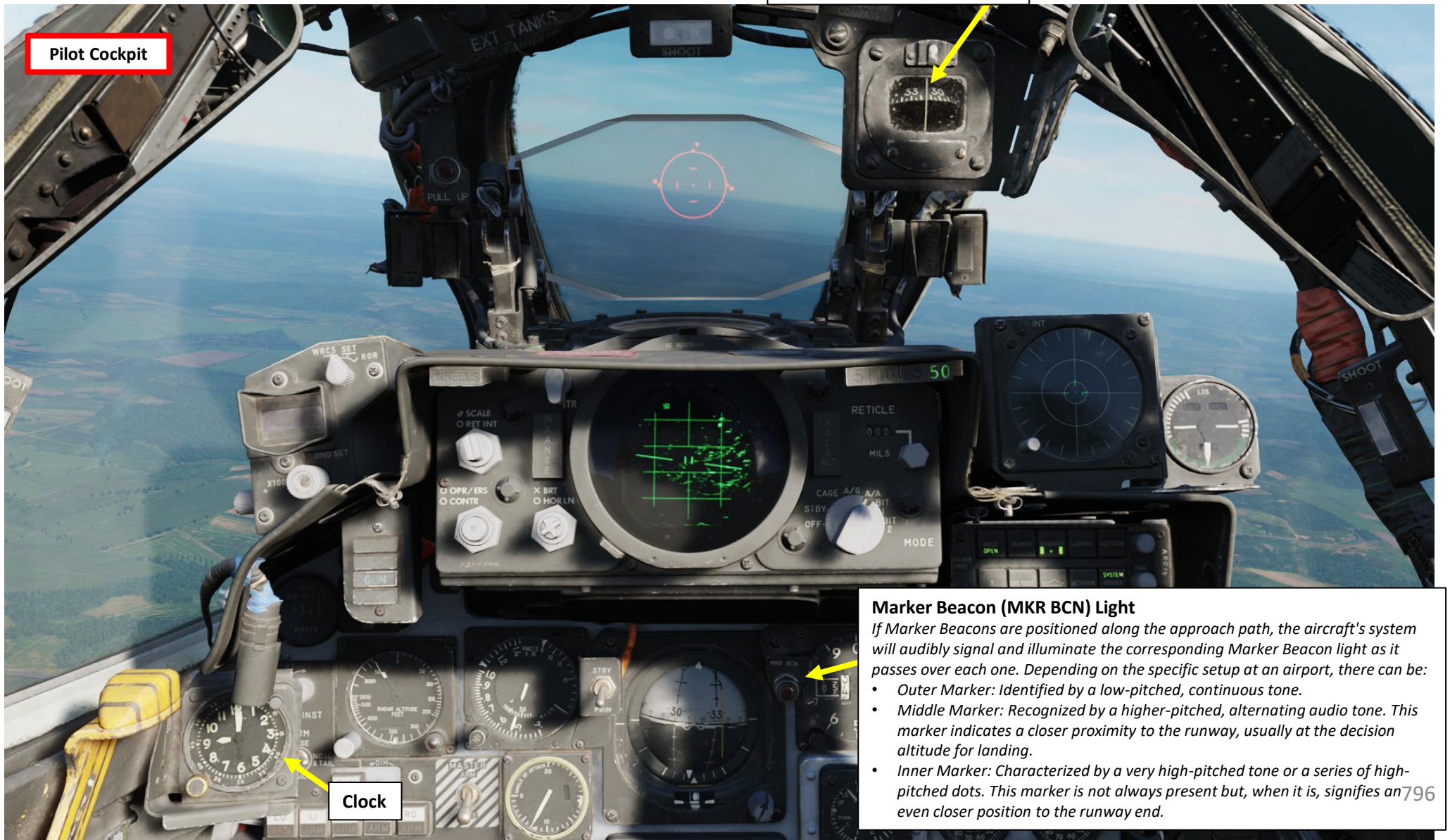
The **BDHI (Bearing Distance Heading Indicator)** displays navigation information using two needles, referred to as the No. 1 and No. 2 pointers, which receive inputs controlled by the WSO Navigation Mode Selector Switch.

WSO Navigation Mode Selector Switch
- *UP Position*
  - *Needle 1: UHF/Automatic Direction Finder*
  - *Needle 2: TACAN Station*
- *MIDDLE Position*
  - *Needle 1: VOR Station*
  - *Needle 2: TACAN Station*
- *DOWN Position*
  - *Needle 1: Navigation Computer Mode: Bearing*
  - *Needle 2: Navigation Computer Mode: Ground Track*



3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The **Magnetic Compass** is used as a standby instrument to determine the aircraft heading.



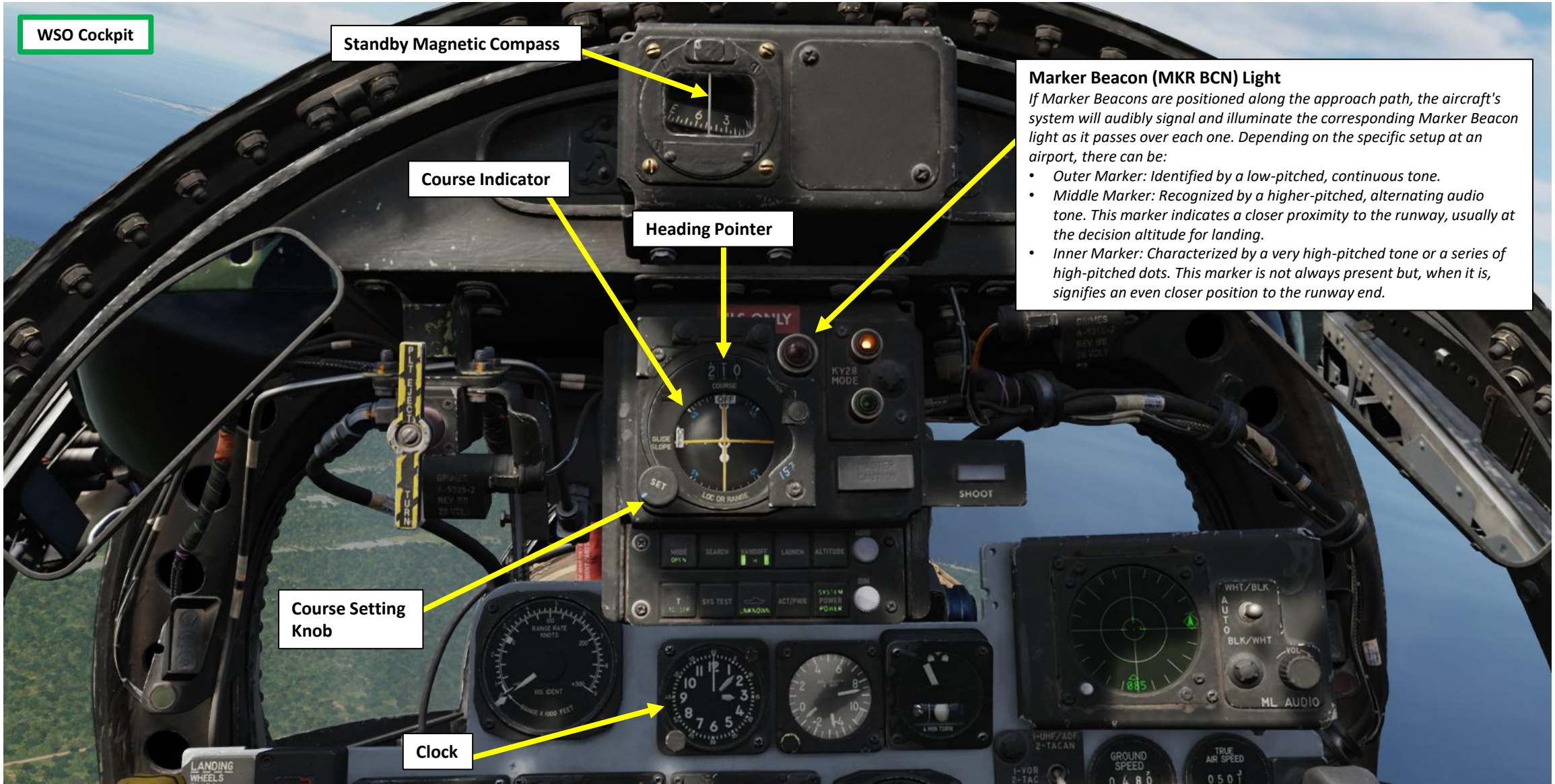
Marker Beacon (MKR BCN) Light

If Marker Beacons are positioned along the approach path, the aircraft's system will audibly signal and illuminate the corresponding Marker Beacon light as it passes over each one. Depending on the specific setup at an airport, there can be:

- *Outer Marker: Identified by a low-pitched, continuous tone.*
- *Middle Marker: Recognized by a higher-pitched, alternating audio tone. This marker indicates a closer proximity to the runway, usually at the decision altitude for landing.*
- *Inner Marker: Characterized by a very high-pitched tone or a series of high-pitched dots. This marker is not always present but, when it is, signifies an even closer position to the runway end.*

3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The WSO seat has a **Magnetic Compass** as well. **The Course Indicator** is used during an ILS approach; the indicator displays relative heading for the course set in the course selector window, as well as horizontal and vertical position relative to the ILS localizer and glide slope entered by the pilot. In this way, the WSO can assist the pilot in achieving and maintaining glide slope. The controls for the indicator are purely for the WSOs reference, and do not interact with the Flight Director Group displays in the front cockpit.



3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The **Compass Mode selector** is used to manage essential controls for the proper operation of the AJB-7 azimuth system. Essential for accurate azimuth output to instruments like ADI (Attitude Director Indicator), HSI (Horizontal Situation Indicator), BDHI (Bearing Distance Heading Indicator), but also to the rear seat attitude indicator, autopilot, and bombing computer.

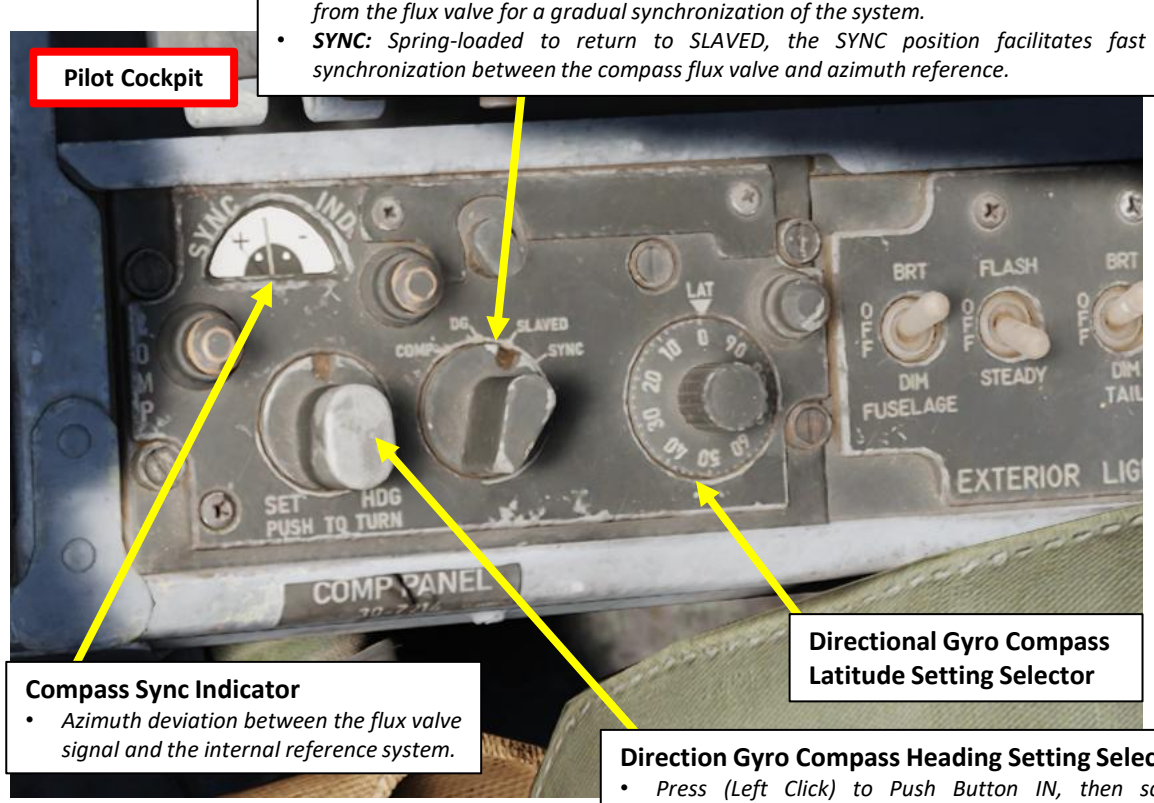
Compass Mode Selector

- ***COMP (Compass):*** *Use in emergencies when the reference systems fail. Supplies magnetic heading directly from the flux valve.*
- ***DG (Directional Gyro):*** *Used in extreme latitudes and regions with magnetic distortion, the initial magnetic heading needs manual adjustment. If the reference system is set to STBY (Standby), the aircraft's latitude must be adjusted with the Latitude Setting Selector.*
- ***SLAVED:*** *Primary operational mode under typical conditions, it depends on signals from the flux valve for a gradual synchronization of the system.*
- ***SYNC:*** *Spring-loaded to return to SLAVED, the SYNC position facilitates fast synchronization between the compass flux valve and azimuth reference.*

Gyro Fast Erect Switch

Due to rapid maneuvering during a bombing run, gyro deviation can occur due to fluid migration. While this deviation will resolve naturally at a rate of 1 to 2 degrees correction per minute over time, it can quickly be corrected by using the FAST ERECT switch found in the front pilot cockpit on the left side console, at a rate of 15 degrees per minute. This switch should not be held for more than 60 seconds, or damage can occur to the gyro.

- *OUTBOARD: Fast Erect*
- *INBOARD: Normal Mode*



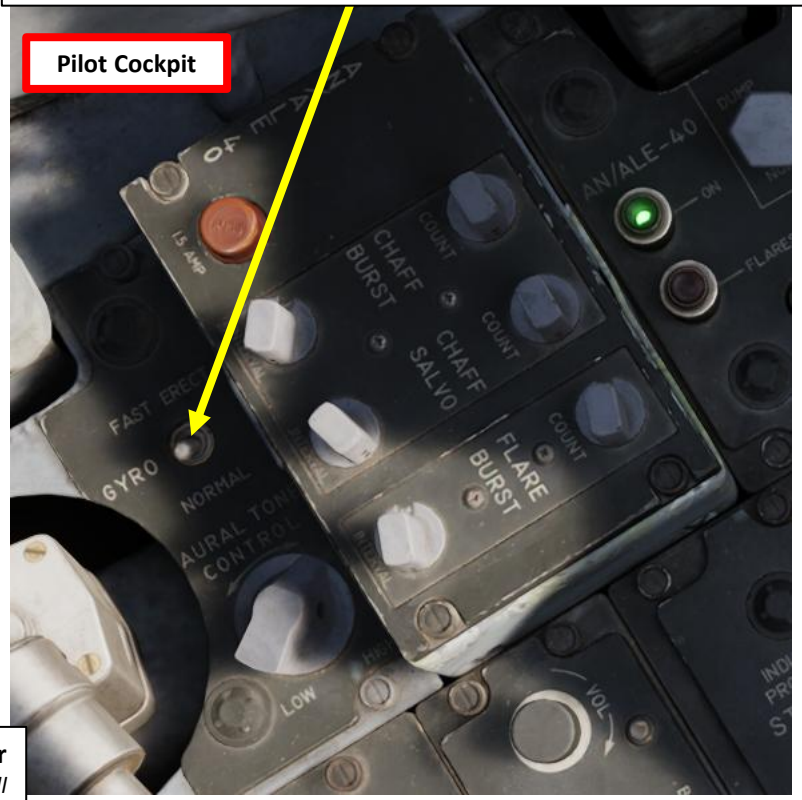
Compass Sync Indicator

- *Azimuth deviation between the flux valve signal and the internal reference system.*

Directional Gyro Compass Latitude Setting Selector

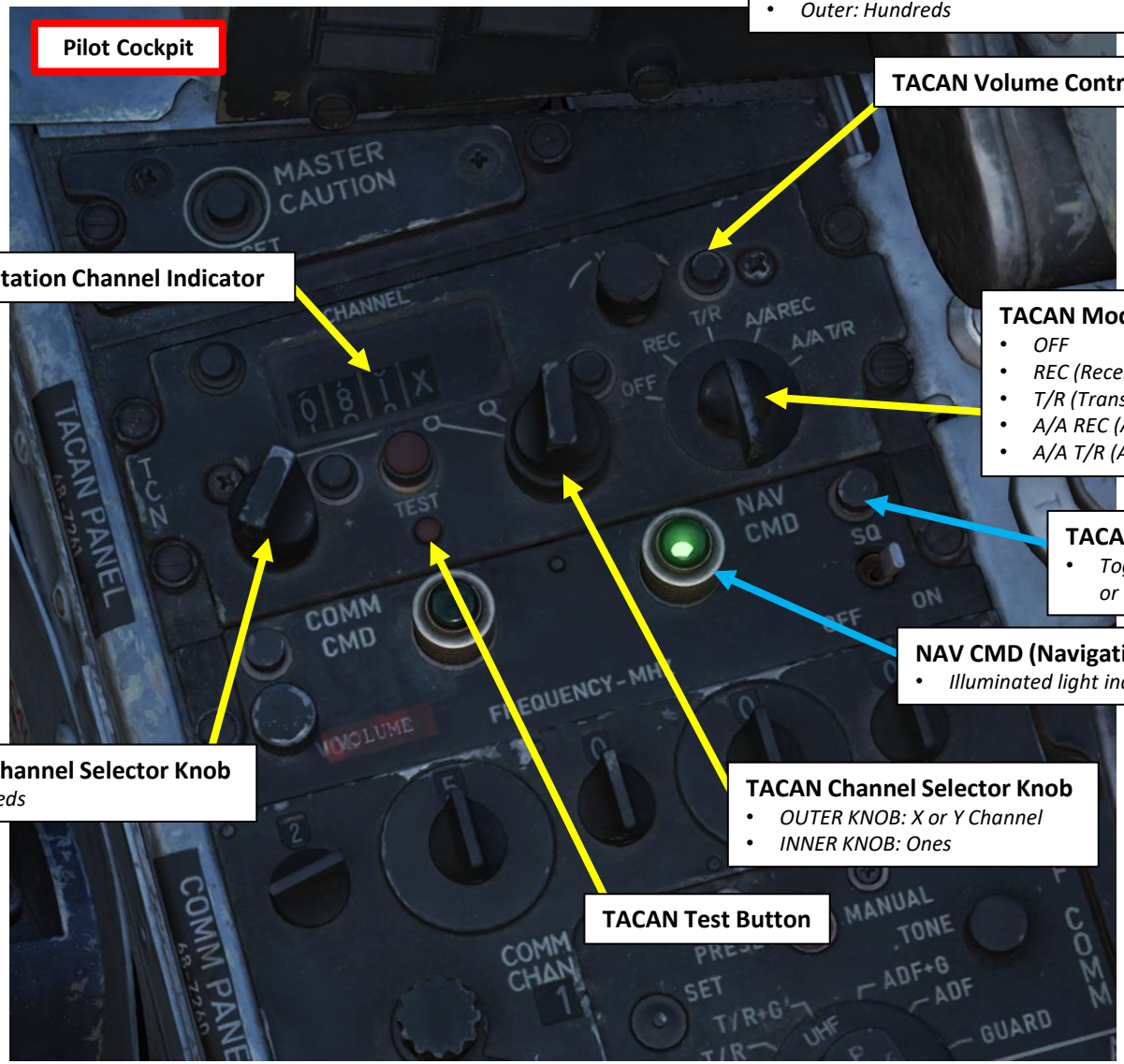
Direction Gyro Compass Heading Setting Selector

- *Press (Left Click) to Push Button IN, then scroll mousewheel to rotate.*
- *This knob permits manual adjustment of the azimuth, crucial when operating in the DG mode*



3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The **TACAN Control Panel** and the **Navigation (NAV) panel** are the primary interface to tune to desired navigation aids.



Pilot Cockpit

Navigation VOR/ILS Frequency Tuning Knobs
- *Inner: Decimals*
- *Outer: Hundreds*

TACAN Volume Control Knob

TACAN Station Channel Indicator

TACAN Mode Selector
- *OFF*
- *REC (Receive)*
- *T/R (Transmit/Receive)*
- *A/A REC (Air-to-Air Receive)*
- *A/A T/R (Air-to-Air Transmit/Receive)*

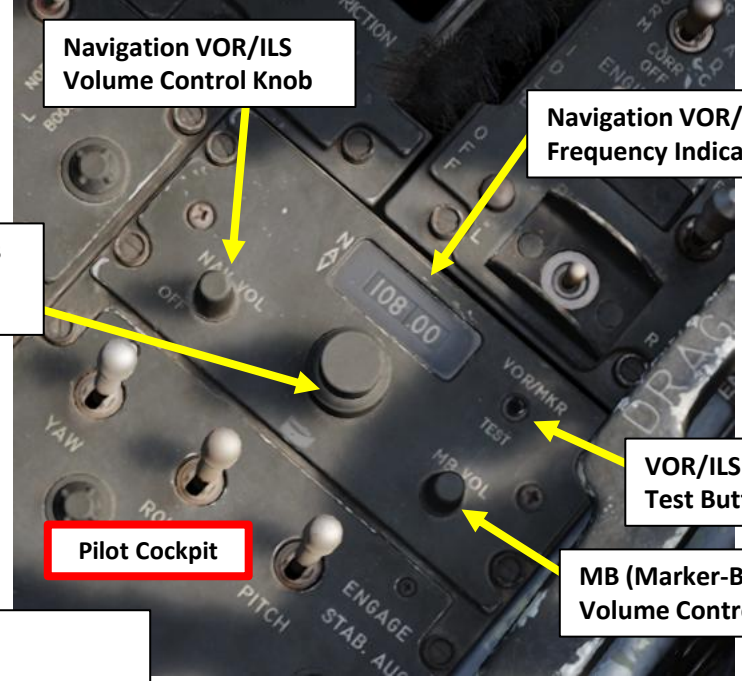
TACAN Command Toggle Button
- *Toggling this button dictates which seat (pilot or WSO) has control of the TACAN settings.*

NAV CMD (Navigation Command) Light
- *Illuminated light indicates that your seat has control.*

TACAN Channel Selector Knob
- *Hundreds*

TACAN Channel Selector Knob
- *OUTER KNOB: X or Y Channel*
- *INNER KNOB: Ones*

TACAN Test Button



Navigation VOR/ILS Volume Control Knob

Navigation VOR/ILS Frequency Indicator

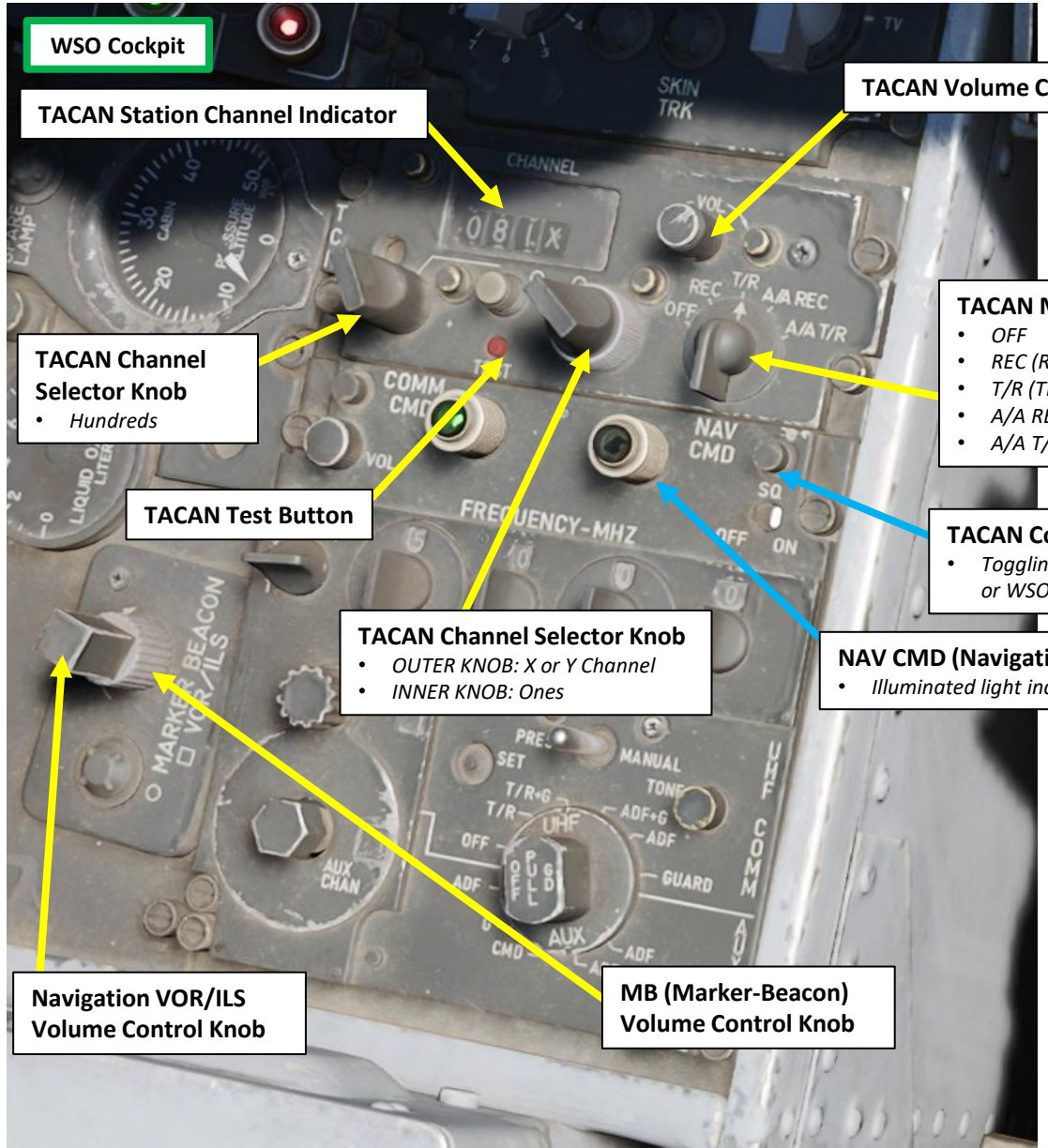
Pilot Cockpit

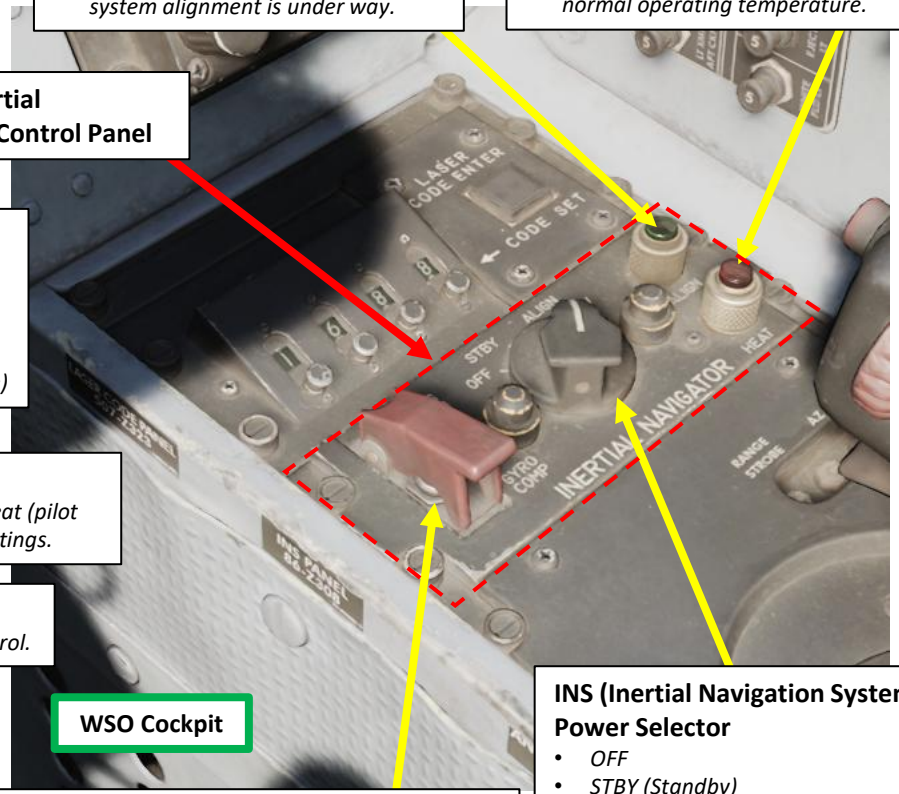
VOR/ILS System Test Button

MB (Marker-Beacon) Volume Control Knob

3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The WSO seat has a **TACAN Control Panel** and the **INS Control Panel** to perform alignments for the inertial navigation system.

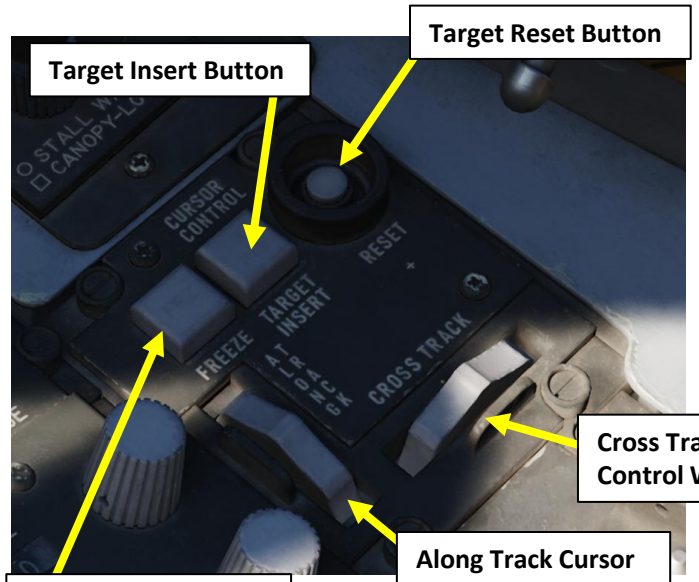


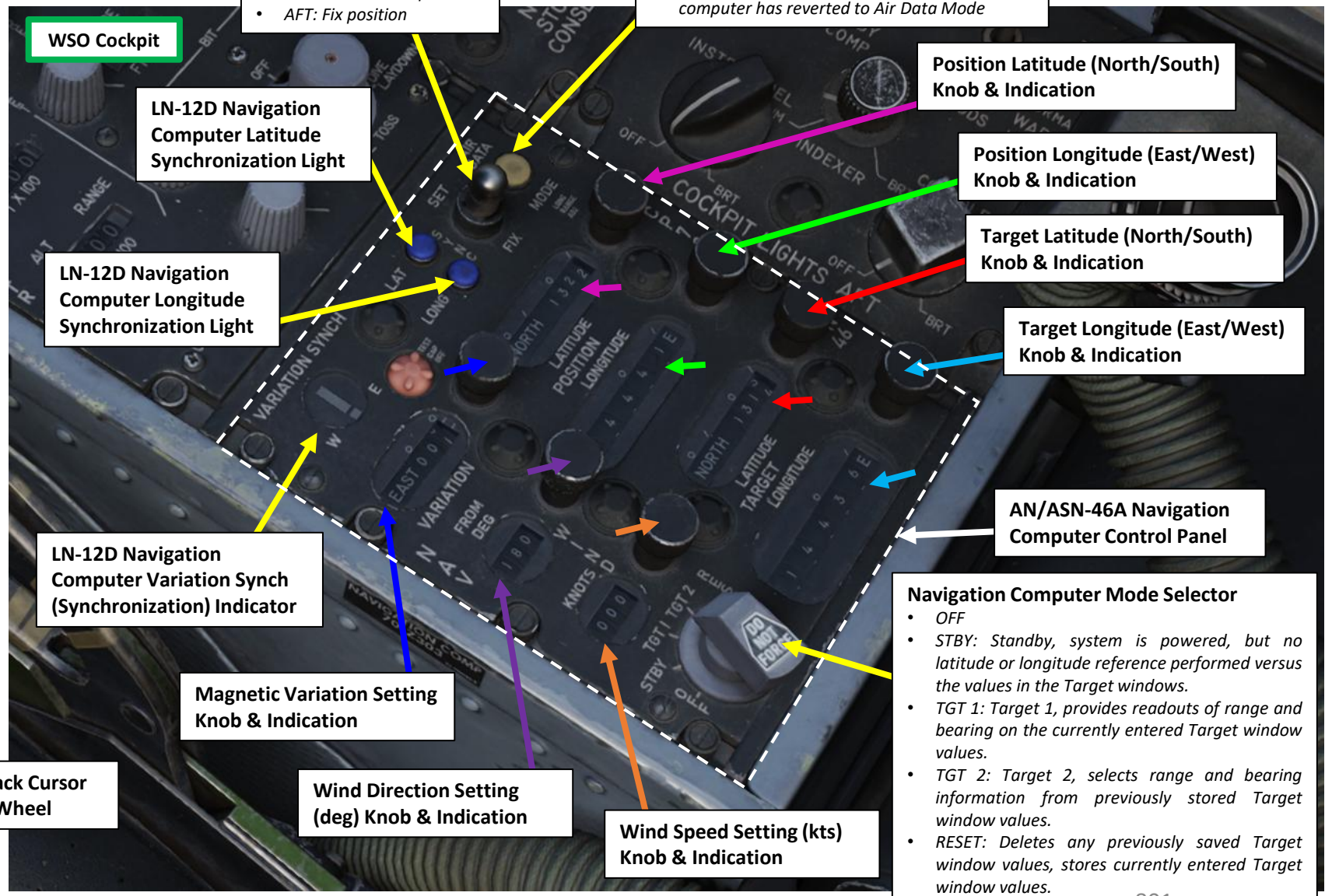


3 – NAVIGATION SYSTEMS
3.1 – OVERVIEW

The WSO seat also have a control panel for the **ASN-46A Navigational Computer**, which is used for general navigation with the INS (Inertial Navigation System) and tactical route planning.

The Target Insert, Freeze & Reset Buttons are used to perform a navigation fix as well.





3 – NAVIGATION SYSTEMS
3.2 – NAVIGATION MODES

Navigation modes can be selected with the Navigation Mode Selector, which governs the functionality of the heading marker, course arrow, and the course deviation indicator. Here are the following modes:

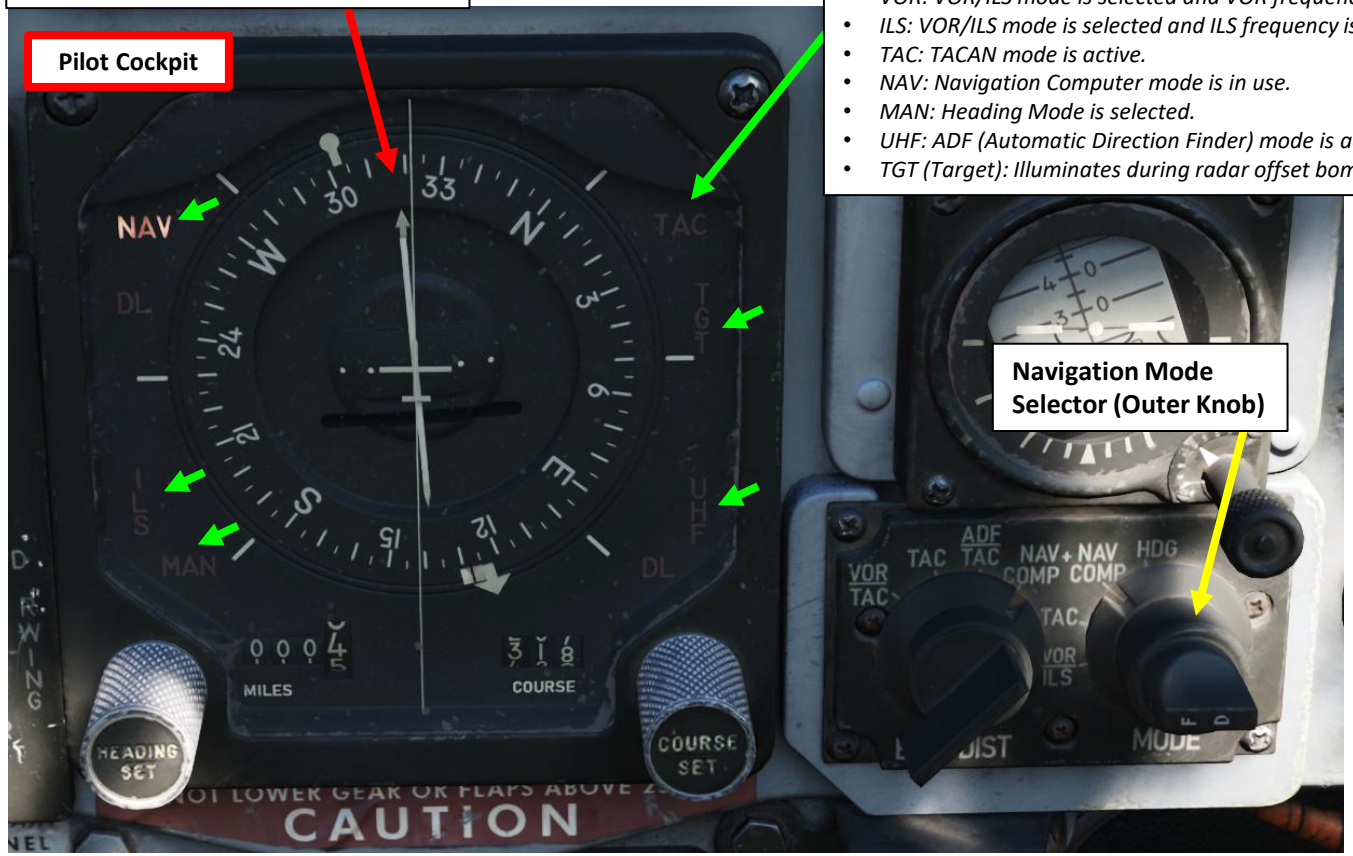
- **VOR/ILS**: VHF Omnidirectional Range / Instrument Landing System
- **TAC**: TACAN Mode
- **NAV COMP**: Navigation Computer Mode
- **HDG**: Heading Mode

HSI (Horizontal Situation Indicator)

Pilot Cockpit

Navigation Mode Lights

- *VOR: VOR/ILS mode is selected and VOR frequency is selected.*
- *ILS: VOR/ILS mode is selected and ILS frequency is selected.*
- *TAC: TACAN mode is active.*
- *NAV: Navigation Computer mode is in use.*
- *MAN: Heading Mode is selected.*
- *UHF: ADF (Automatic Direction Finder) mode is active.*
- *TGT (Target): Illuminates during radar offset bombing operations.*

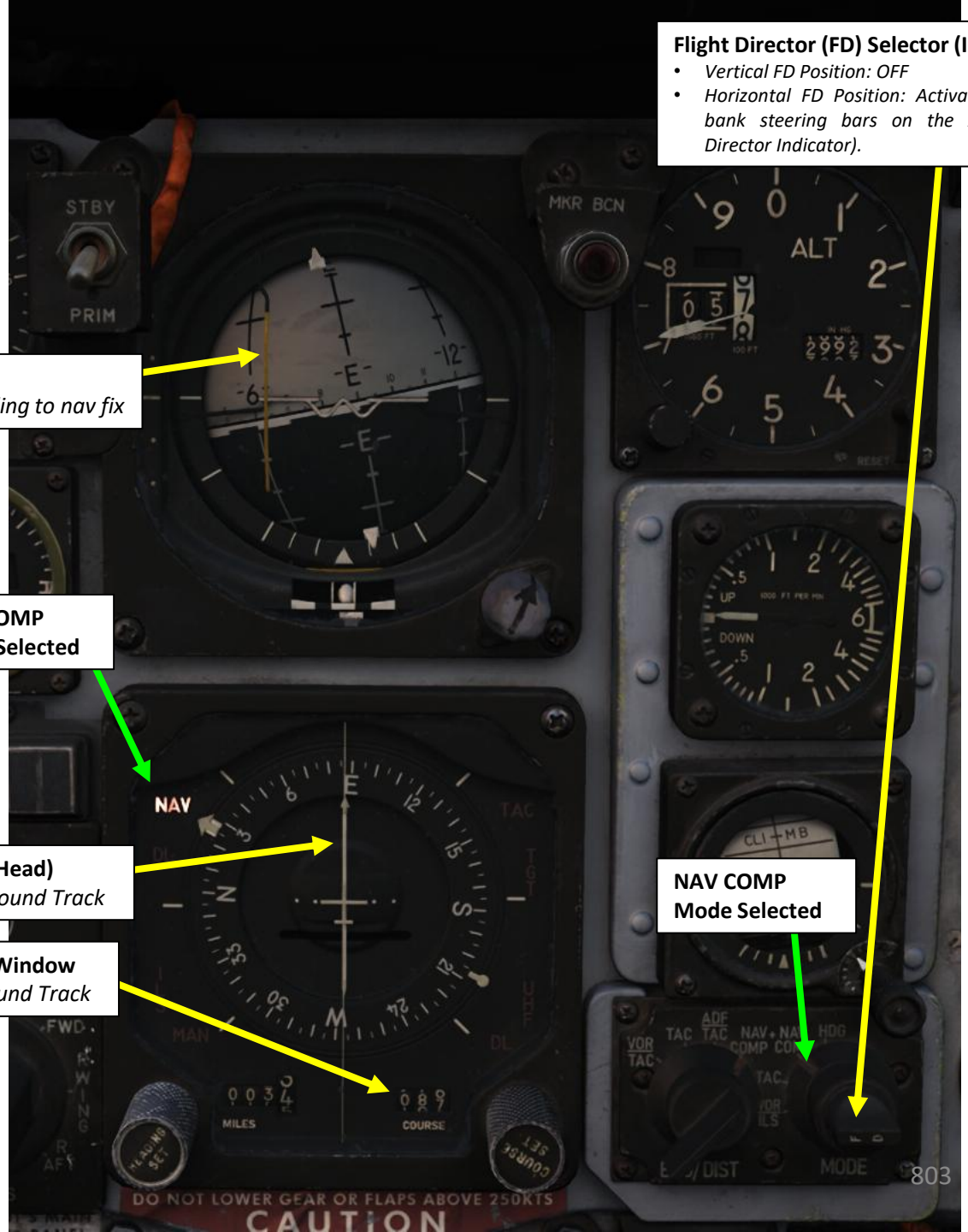


Navigation Mode Selector (Outer Knob)

3 – NAVIGATION SYSTEMS
3.2 – NAVIGATION MODES

NAV COMP Mode

Navigation Computer Mode displays magnetic ground track on the **HSI course arrow** and the **HSI course selector window** relative to the current navigation computer fix/waypoint. The **ADI bank steering bar** provides steering information to direct an approach to the command heading towards the current navigation computer fix/waypoint.



3 – NAVIGATION SYSTEMS
3.2 – NAVIGATION MODES

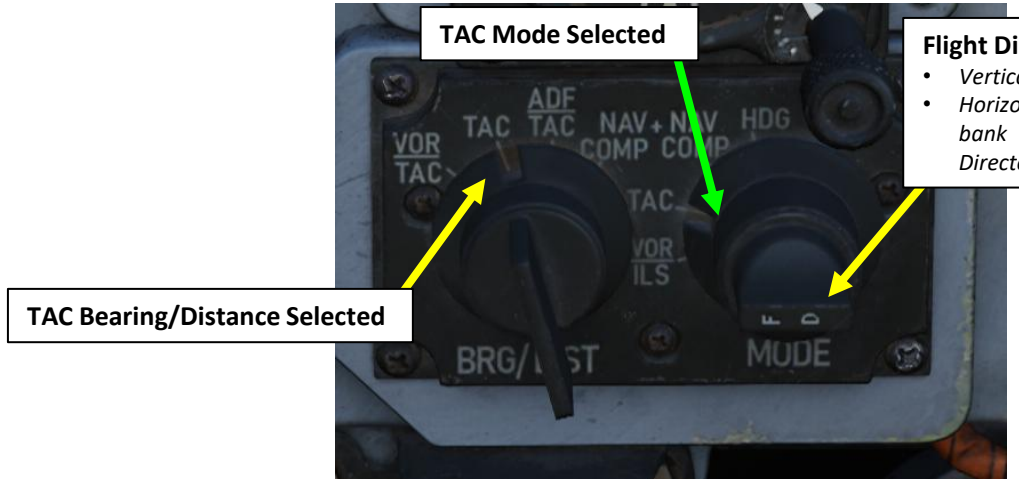
TAC Mode

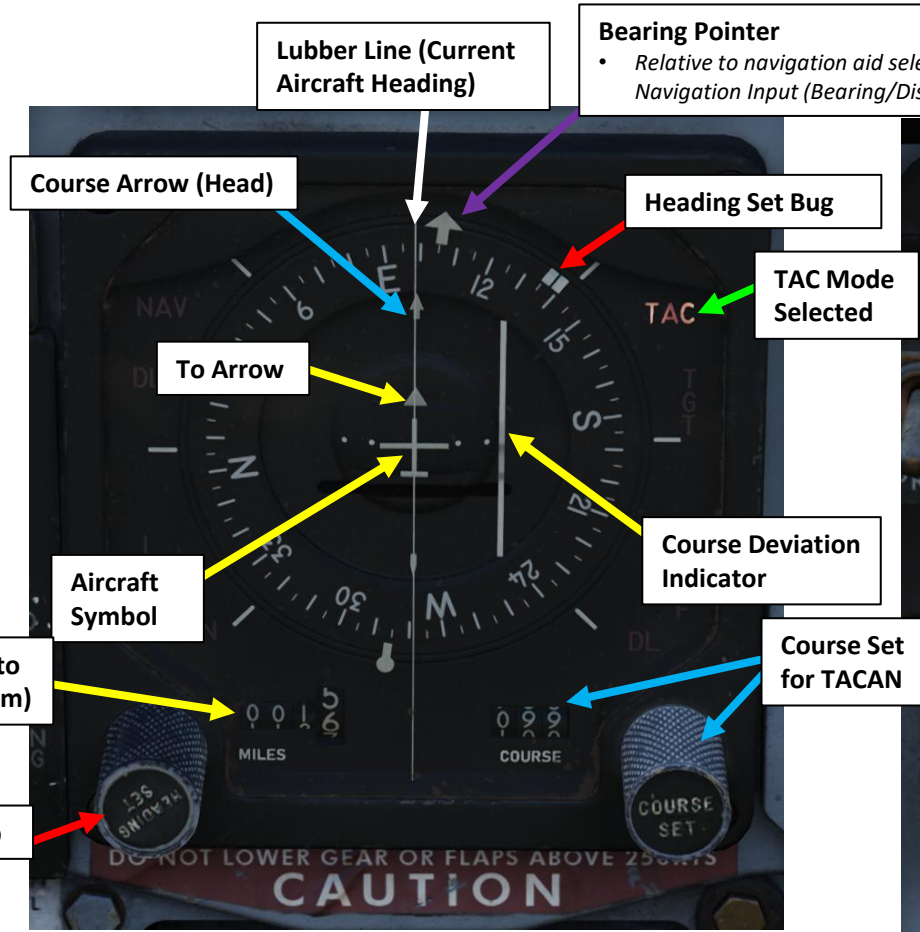
TACAN mode presents navigation information to the currently selected TACAN beacon. To provide full information, the Bearing/Distance Switch should be set to TAC. The **HSI course arrow** and **course selector window** are set using the **Course Set knob** to the desired TACAN course.

Once set, the HSI Deviation Indicator and aircraft symbol provide the top-down display relative to the set course, with a maximum deviation deflection of +/-5 degrees.

The **HSI Heading Set knob** is used to set a **desired TACAN course for bank steering bar presentation on the ADI**. As the bank steering is based on the heading marker position, if it is not set properly, bank steering on the ADI will not be correct to intercept the desired course.

A **To-From indicator** displays when the mode selector is in TACAN or VOR/ILS mode when either are tuned and received; once the course is intercepted, the indication references whether the current course is taking the aircraft to or from the tuned station.





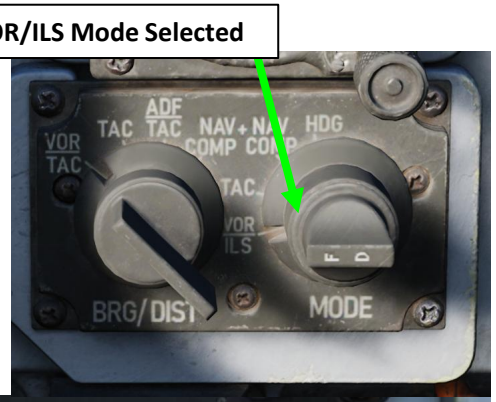


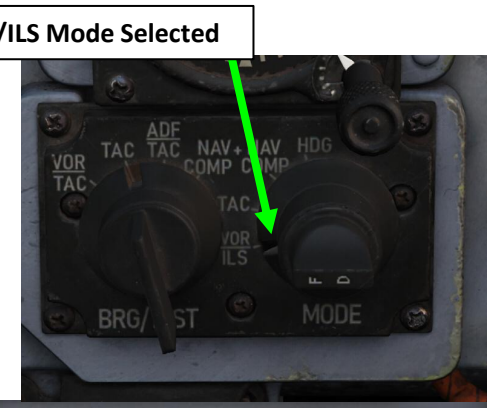
3 – NAVIGATION SYSTEMS
3.2 – NAVIGATION MODES

VOR/ILS Mode

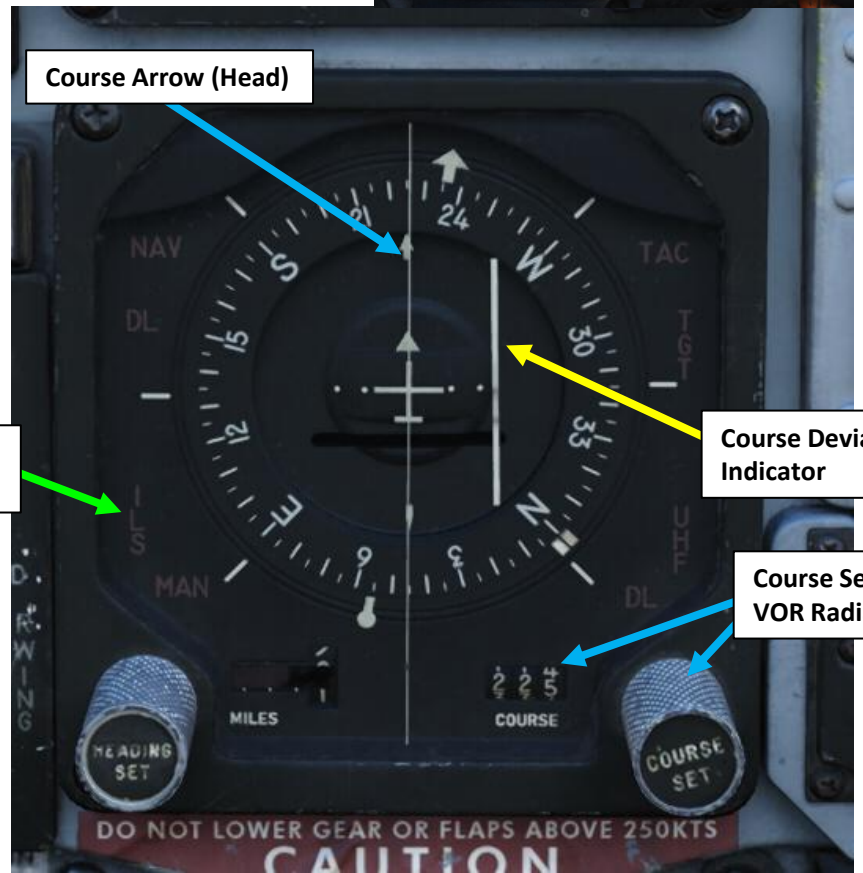
When VOR/ILS mode is selected, the frequency on the **nav radio panel** determines whether VOR or ILS is selected:

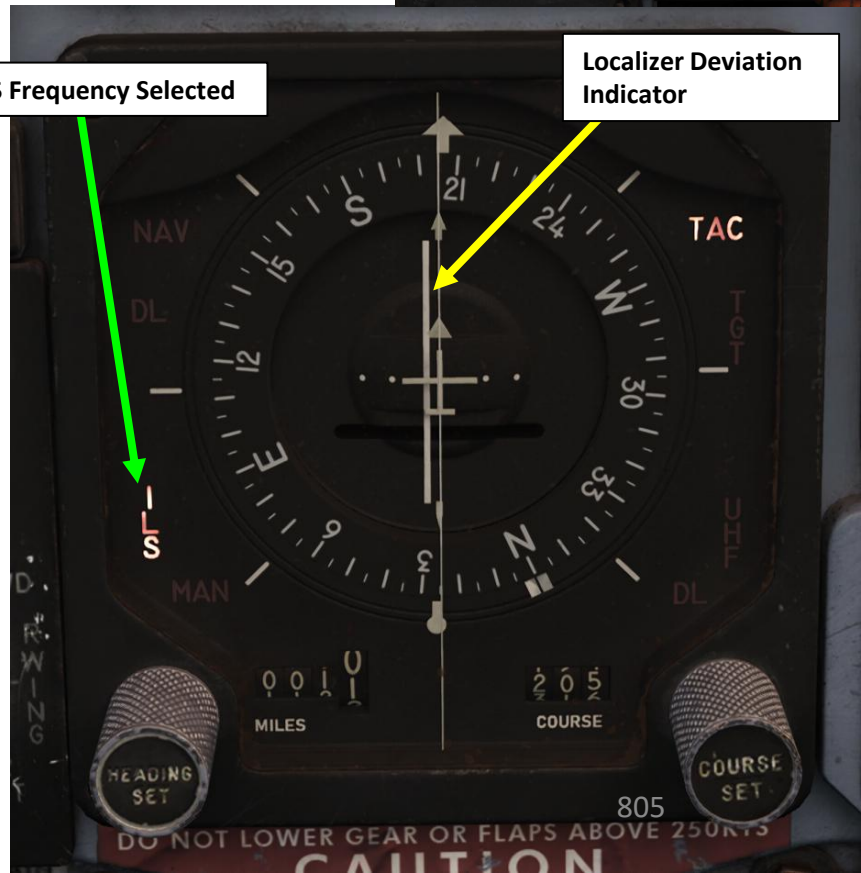
- If a **VOR frequency** is selected, the HSI Course Set knob is used to set the VOR radial. Once set, the HSI Deviation Indicator shows current deviation from the selected course.
- If an **ILS frequency** was selected, the localizer signal will be shown on the deviation indicator.







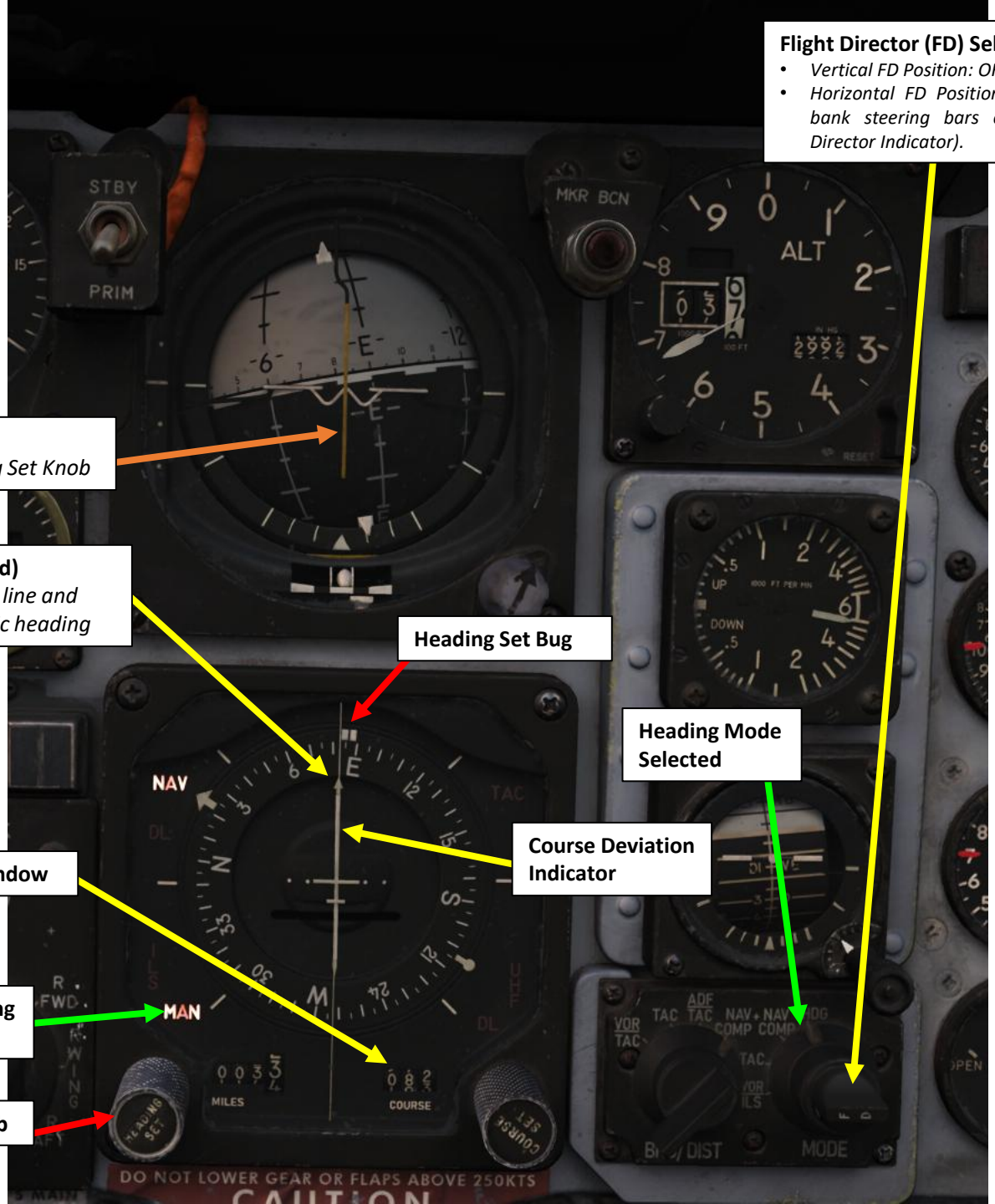




3 – NAVIGATION SYSTEMS
3.2 – NAVIGATION MODES

HDG Mode

In Heading Mode, the **HSI course arrow and course deviation** are slaved to the lubber line and aircraft magnetic heading. The **HSI course selector window** displays the current selected magnetic heading, which is adjusted using the **Heading Set knob**. The given course information is applied for an ADI bank steering command.



4 – FLIGHT PLAN
4.1 – Flight Plan Basics

When flying a mission in the F-4 Phantom, getting to the target is a much more involved process than meets the eye. Most missions should have a primary flight plan available and a secondary flight plan. A **flight plan** is simply a series of waypoints that form a route that you should follow towards your objective. Here are a few basic concepts.

A « **Strike Package** » (also referred as the « **Alpha Strike** » concept in the US Navy) is a group of aircraft with different capabilities that are launched together to perform a single attack mission. The term is normally applied to ground attack missions, where the strike package for attacking the primary target will include bombers, fighters to defend them from enemy aircraft, wild weasels to defend against ground-based anti-aircraft weapons, reconnaissance aircraft for pre-raid and post-raid reconnaissance and tanker aircraft to extend the mission radius.

An **ATO (Air Tasking Order)** is a large document that lists air sorties for a fixed 24-hour period, with individual call signs, aircraft types, and mission types (e.g. close air support, etc).

Time is a critical when flying a mission; you are expected to **start the engine** and **taxi** at a specific hour and reach the target at a precise **TOT (Time On Target)**.

Radio frequencies given for **mission control** are given in MHz.

Fuel quantity for the mission is often given in thousands of lbs. **BINGO fuel** is the amount of fuel that once reached triggers an immediate return to home plate (home base). It takes into account the fuel needed to fly the return leg of the flight, the fuel required to fly the briefed approach, the fuel to go to the alternate (if necessary) and the emergency fuel which is not supposed to be used except in an emergency.

Mission types in the F-4 are usually referred as STRIKE (air-to-ground attack), SEAD (Suppression of Enemy Air Defenses, often referred as « Wild Weasel » or « Iron Hand » missions), DEAD (Destruction of Enemy Air Defenses), CAP (Combat Air Patrol), ESCORT (protect other air elements), DCA (Defensive Counter-Air), OCA (Offensive Counter-Air), etc.

Waypoints are generally listed by name and are used to navigate. In this example, **HOLD** refers to holding point « New York » where aircraft are marhsalling before the push, **BLOCKS** refer to altitude blocks (in thousands of ft) used during marshalling for deconfliction, and **DIVERT** refers to an alternate airfield to divert to and land at in case the planned home base is unavailable (TQQ for Tonopah Test Range Airfield in that example).

Codewords are used to communicate various mission events. In this example, mission success is communicated by using the codeword « Coconut Cream », the start of an OCA **Push** (an Offensive Counter-Air element moving into enemy territory at a specific turnpoint) is communicated by using the codeword « Pineapple Juice », etc.

MISSION DATA

ENGINE START:	TAXI:	MISSION:	TOT:
0820	0840	DEAD	0922
CONTROL:	**HOLD:**	**BLOCKS:**	**DIVERT:**
324.4	New York	16-19	TQQ
FUEL:	**BINGO:**	**ARMAMENT:**	
16.9	7.0	4xCBU-52, ECM pod, 2xWT	

LINEUP

CALLSIGN	A/C	AC#
Pappy	Rocket 11	160
Waldo	Rocket 12	624
Mac	Rocket 13	297
Sledge	Rocket 14	301

OCA PUSH	Pineapple Juice	SUCCESS	Coconut Cream
SEAD PUSH	Mango Juice	UNSUCC	Reef Shark
STRIKE PUSH	Orange Juice	STOP JAM	Angry Baboon

REMARKS:

Lotus 1 Departure

Push at 0910

Nav fix/ Music on at FEBA

Split at Cedar

IP: T-junction
Pop to >15k
Target Launchers on N side

Reioin at Mt. Irish

Plaza 1 Star recovery

Source: Red Flag 81-2 Campaign by Reflected Simulations

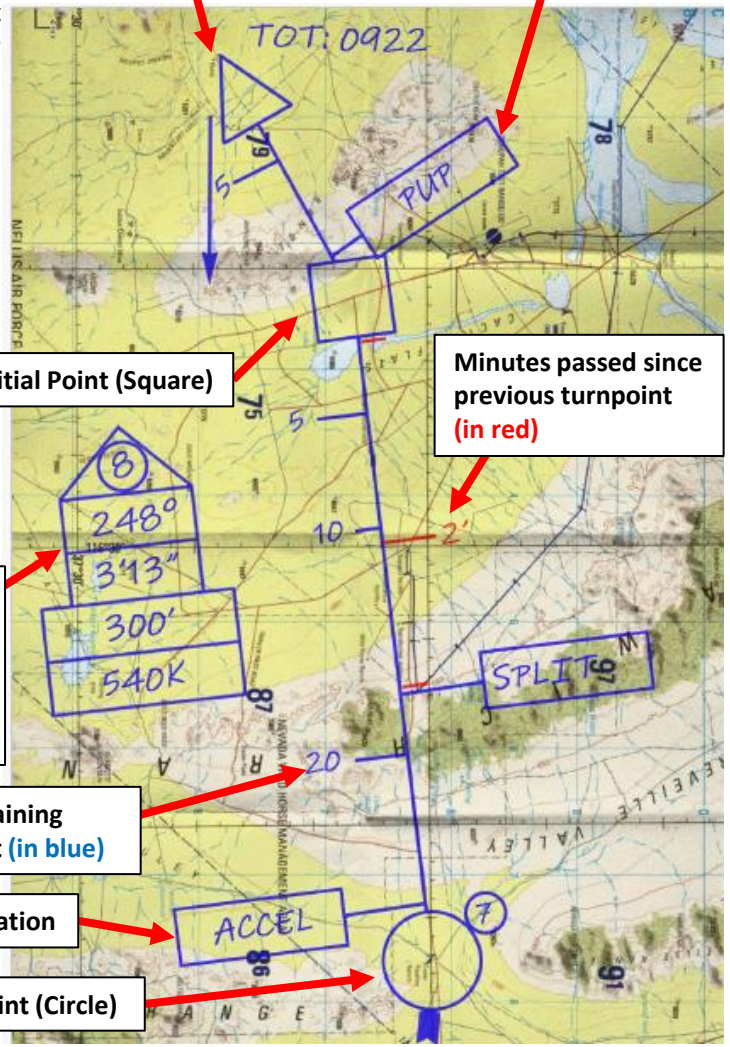
4 – FLIGHT PLAN
4.1 – Flight Plan Basics

Here we have an example of legs and waypoints for a full mission. A "leg" refers to a single segment between two points. Turnpoints are represented as circles, the Initial Point (IP) as a square and the target as the tip of a triangle.

ACCEL and DECEL refer to when you can start accelerating or decellerating the aircraft, with the target speed in knots.

Navigation Procedures by Reflected Simulations:
https://youtu.be/dqck5kiNqg4

Source: Red Flag 81-2 Campaign by Reflected Simulations



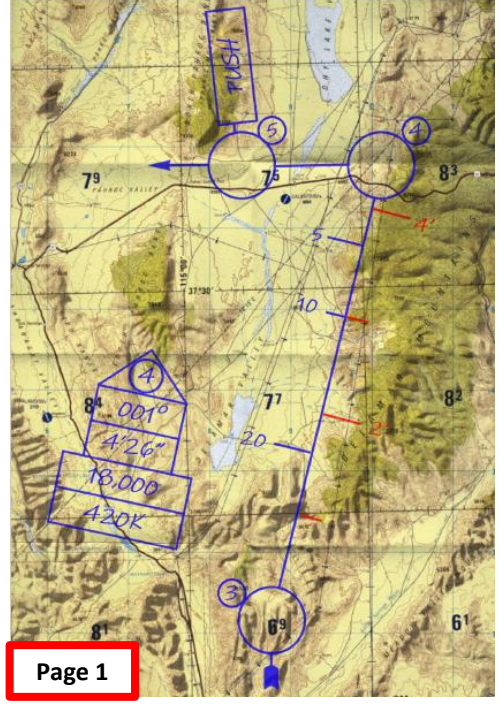
PILOT'S FLIGHT PLAN

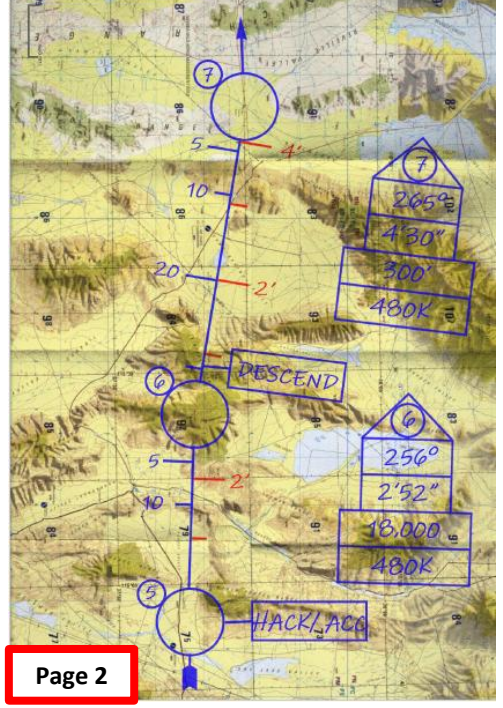
A/C #297 PILOT CAPT. MCALLISTER	MISSION DEAD SA-3	NAV TIME	ALIGN.VAR. 15° 6' E	DIST TOTAL 372	TIME TOTAL 49'19"	TYPE ALIGN FULL
CHECK POINT	LAT / LONG	ALTITUDE	MAG COURSE	LEG / REMAIN	LEG / ACCUM	GROUND SPEED
SE.-TO. & ACC.	BASE	-	-	- / 372		ACCEL
#1 APEX	36-21.3 / 114-55.3	7500'	025°	9 / 363	1'17" / 1'17"	420K
#2 PLAZA	36-43.4 / 114-53.0	15,000'	344°	22 / 341	3'8" / 4'25"	
#3 NUGET	37-08.0 / 114-53.0	15,000'	344°	24 / 317	3'25" / 7'50"	
#4 MARSHAL	37-38.0 / 114-42.5	18,000'	001°	31 / 286	4'26" / 12'16"	
#5 NEW YORK	37-38.0 / 114-55.0	18,000'	255°	10 / 276	1'26" / 13'42"	ACCEL 480K
#6 MT. IRISH	37-38.5 / 115-24.0	18,000'	256°	23 / 253	2'52" / 2'52"	
#7 CEDAR RANCH	37-45.2 / 116-07.7	300'	265°	36 / 217	4'30" / 7'22"	ACCEL 540K
#8 IP-PUP	37-41.8 / 116-43.5	PUP 15,000'	248°	29 / 188	3'13" / 10'35"	
#9 TARGET	37-36.0 / 116-56.5	4731'	226°	12 / 176	1'20" / 11'55"	
#10 FEBA-EGRESS	37-35.6 / 116-04.5	300'	75°	41 / 135	4'33" / 16'28"	DECEL 480K
#11 MT. IRISH	37-38.5 / 115-24.0	15,000'	69°	32 / 103	4' / 20'28"	DECEL 420K
#12 NUGET	37-08.0 / 114-53.0	15,000'	125°	39 / 64	5'34" / 26'2"	
#13 PLAZA	36-43.4 / 114-53.0	15,000'	164°	24 / 40	3'26" / 29'28"	
#14 CRAPS	36-48.0 / 116-02.0	10,000'	120°	15 / 25	2'9" / 31'37"	DECEL 300K
#15 APEX	36-21.3 / 114-55.3	3500	210°	16 / 9	2'12" / 33'49"	
NELLIS AFB	36-14.0 / 115-02.0		206°	9 / -	1'48" / 35'37"	
					808	

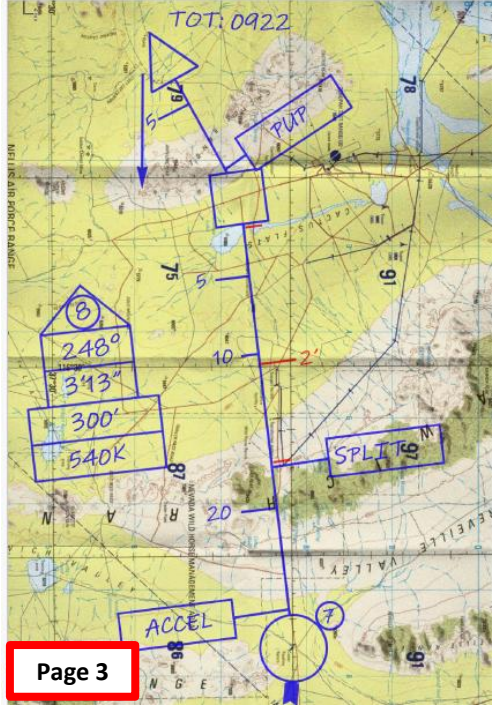
4 – FLIGHT PLAN
4.1 – Flight Plan Basics

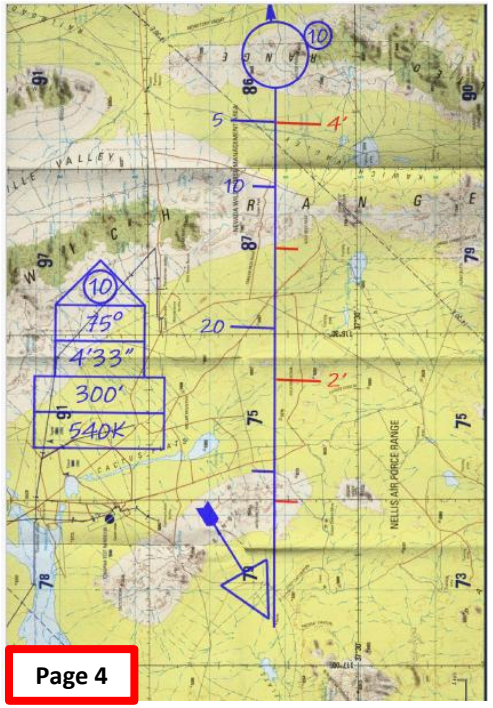
Here is an example of a full flight plan chart.

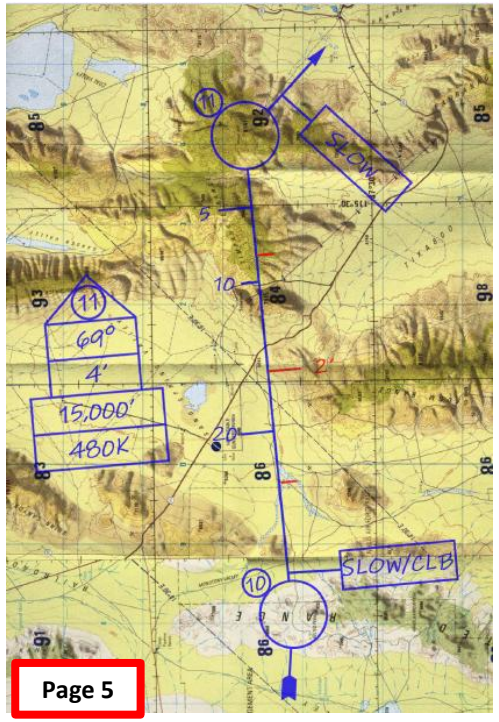
Source: Red Flag 81-2 Campaign by Reflected Simulations

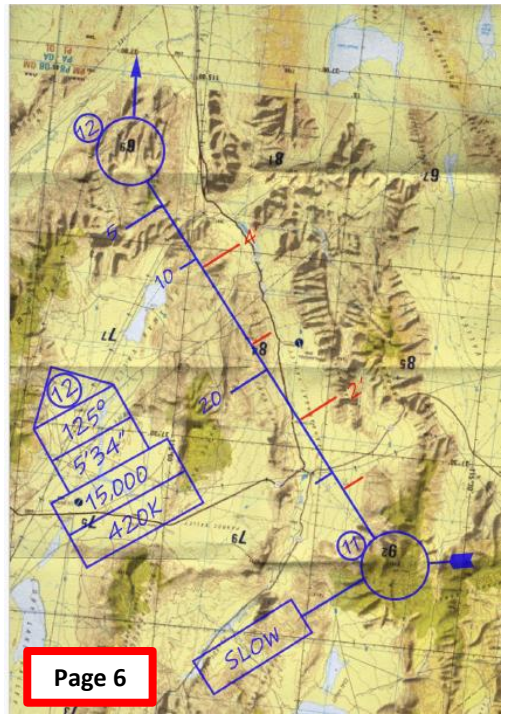












4 – FLIGHT PLAN
4.2 – Flight Plan Preparation

If the mission has assigned the aircraft a series of waypoints through the **mission editor**, this will be available by default as the Primary Flight Plan. Each waypoint in the flight plan can be designated as one of several special types. These designations will influence JESTER's actions and the dialog phrases he uses as you approach the waypoint.

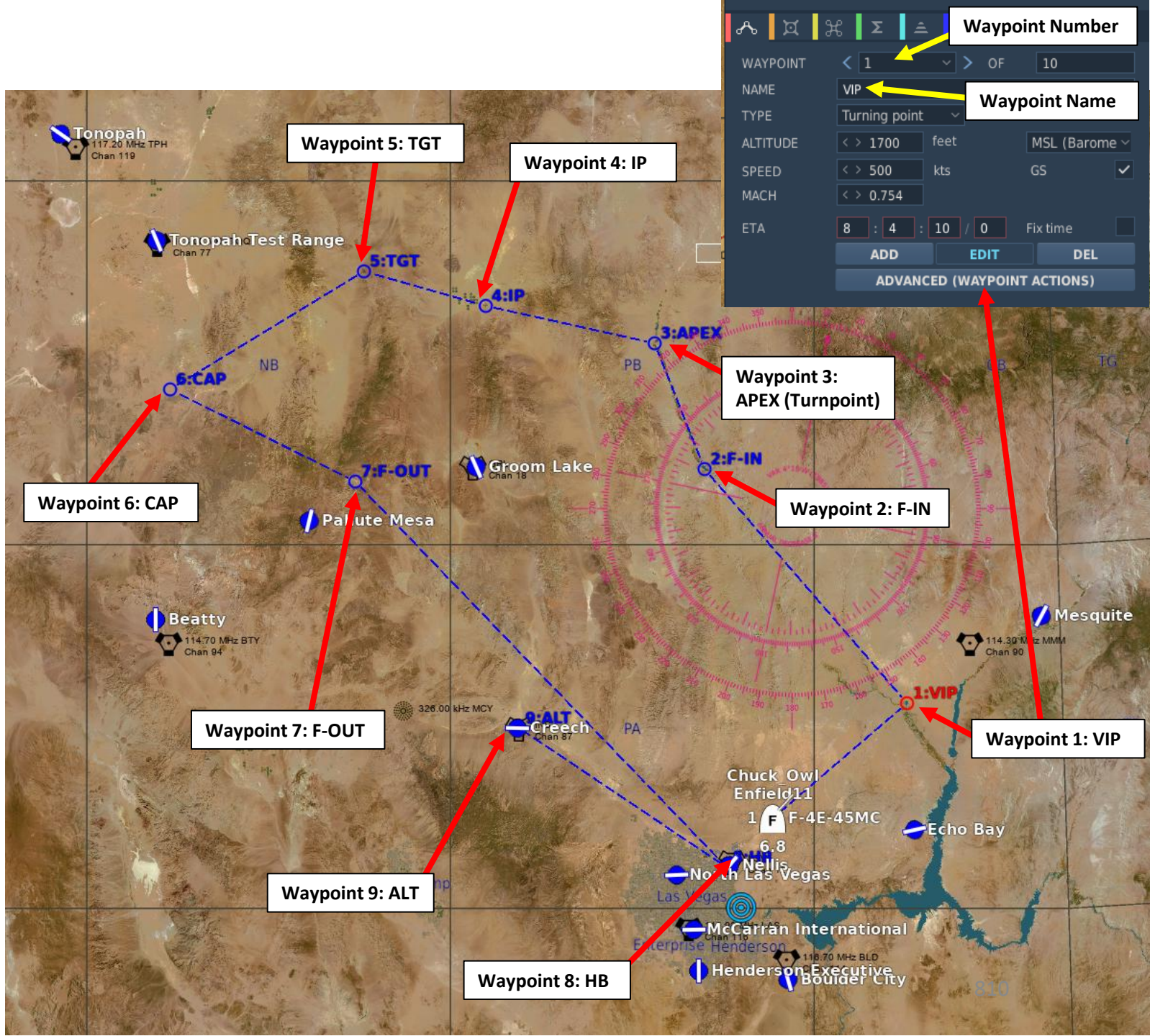
The types are:

Turn Point (default): This is the standard waypoint type.

- JESTER will automatically switch to the next waypoint when the aircraft is within 2 nautical miles (nm) of the turn point, as indicated by his BDHI.

Nav Fix (VIP - Visual Identification Point): This is used to perform an INS (Inertial Navigation System) position update when flying over this point.

- JESTER will perform an INS (Inertial Navigation System) position update when flying over this point. He will report the distance to the VIP 10 nm and 5 nm in advance. Before reaching the VIP, Jester will input the necessary coordinates into the Navigation Computer, set the Navigation Computer Position Update Switch to FIX, and then execute the update when flying over the visual reference point. It is important to note that the pilot must fly over the visual reference, not the INS-indicated point. Jester will adjust the INS coordinates at the VIP, and the success of the fix depends on how accurately the visual flyby matches the reference point. Afterward, Jester will report whether the update was successful or if the aircraft was too far from the point (in which case the flyby must be repeated). Upon a successful fix, Jester will switch to the next waypoint.



4 – FLIGHT PLAN
4.2 – Flight Plan Preparation

Initial Point (IP): The Initial Point is the last navigation waypoint for a strike aircraft before beginning a bomb run.

- JESTER will update the pilot as the aircraft approaches the point (10 nm, 5 nm, and 2 nm in advance), and switch to the next waypoint once past the target.

Target (TGT): Similar to the IP, but with different phrases, suited target area.

- JESTER will update the pilot as the aircraft approaches the point (10 nm, 5 nm, and 2 nm in advance), and switch to the next waypoint once past the target.

Fence In (F-IN) and **Fence Out (F-OUT):** These waypoints function similarly to the IP and Target types. These reference points are used to run "FENCE" checks, which stands for "Firepower, Emitter, Navigation, Chaff/Flare and Electronic Countermeasures". The F-4's crew basically sets up weapons, sensors and everything needed before going into combat.

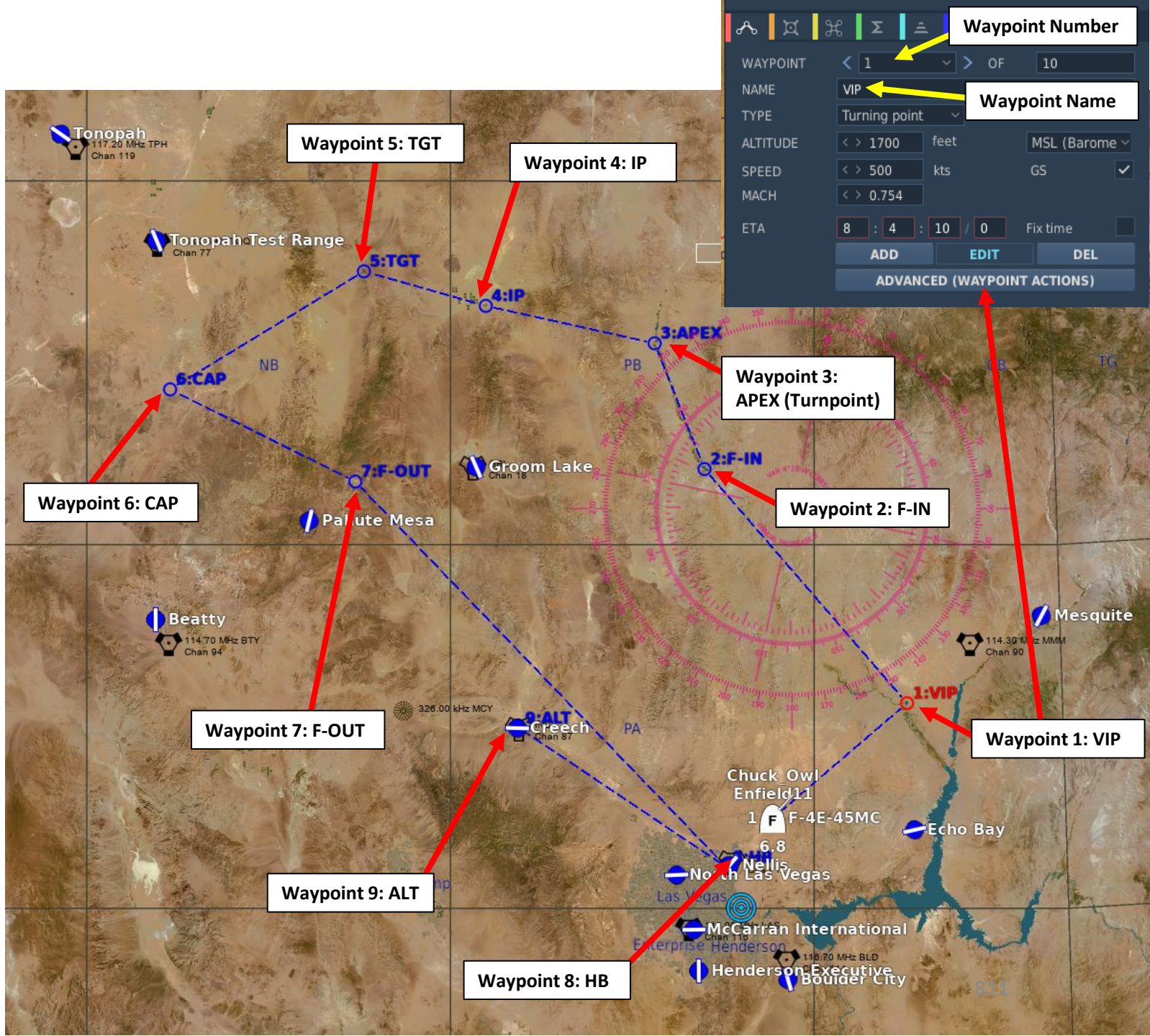
- JESTER will run through fence in and fence out checklists.

Homebase (HB) and **Alternate (ALT):** These are designated landing points.

- JESTER will not automatically switch to the next waypoint at these points, and he will report as the aircraft approaches the Homebase.

Combat Air Patrol (CAP): The first waypoint designated as CAP will be saved as CAP1, and the second will be saved as CAP2, regardless of their positions in the flight plan. CAP points are used for reference when performing, err, combat air patrols… d'uh!

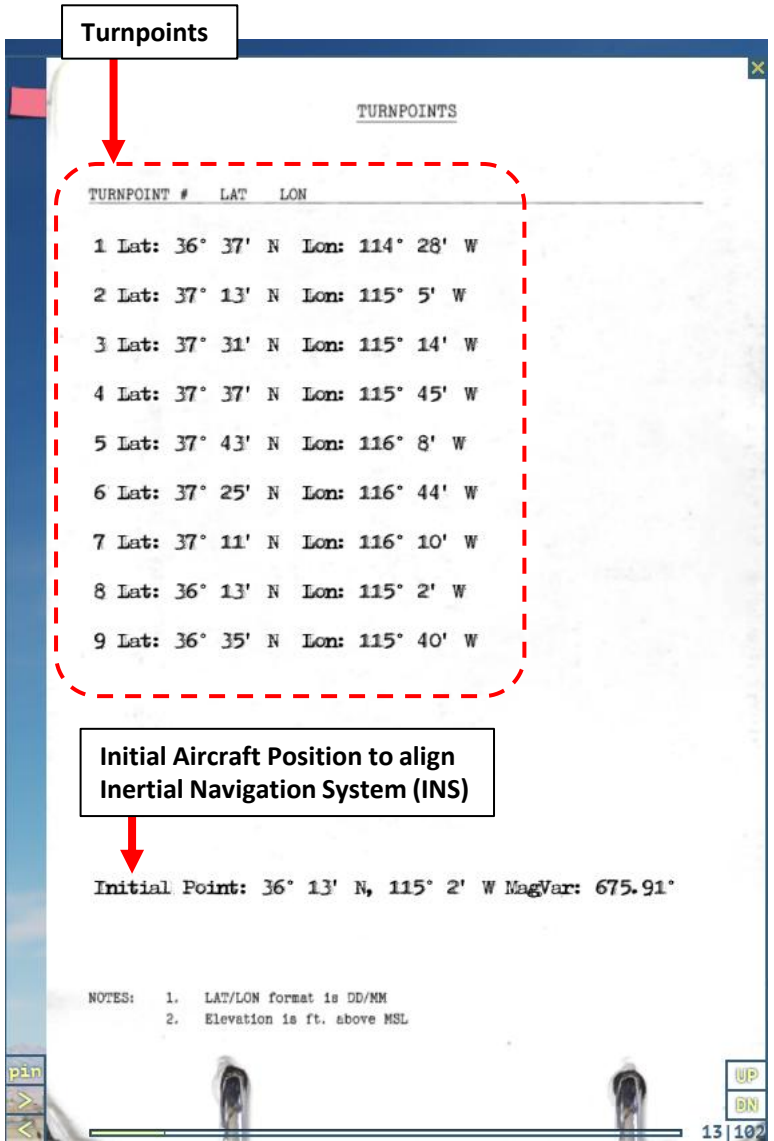
- JESTER will ask how long the pilot intends to remain on station at CAP1. He will then cycle between CAP1 and CAP2 until the designated CAP time expires, after which he will switch to the next waypoint following CAP2 in the flight plan. There can be several CAP1-CAP2 pairs.

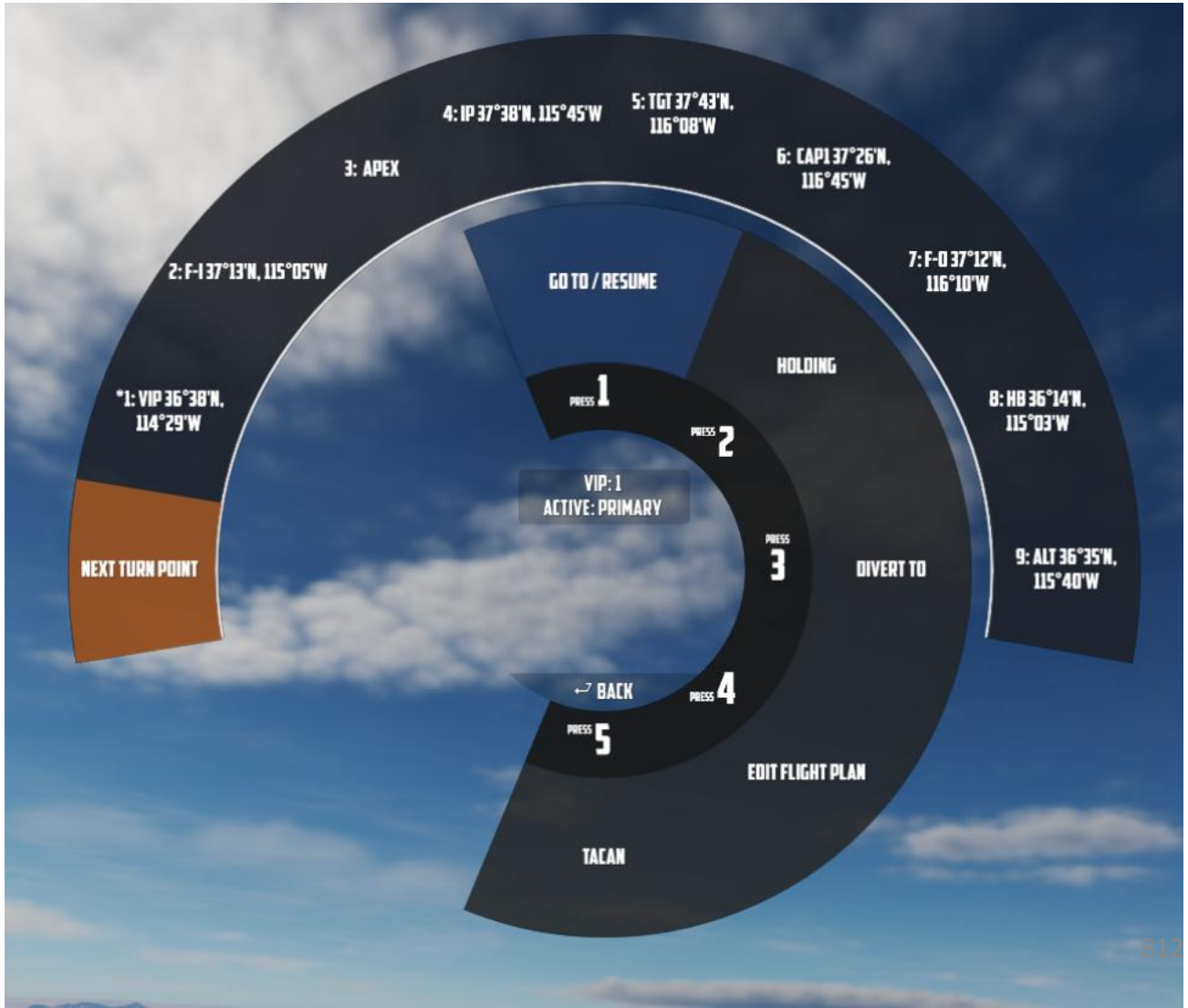


4 – FLIGHT PLAN
4.2 – Flight Plan Preparation

Waypoints are listed on your kneeboard TURNPOINTS page. Use “RSHIFT+K” to access kneeboard, cycle through pages using the “[“ and “]” .

JESTER’s Navigation menu also lists all waypoints in your primary flight plan.

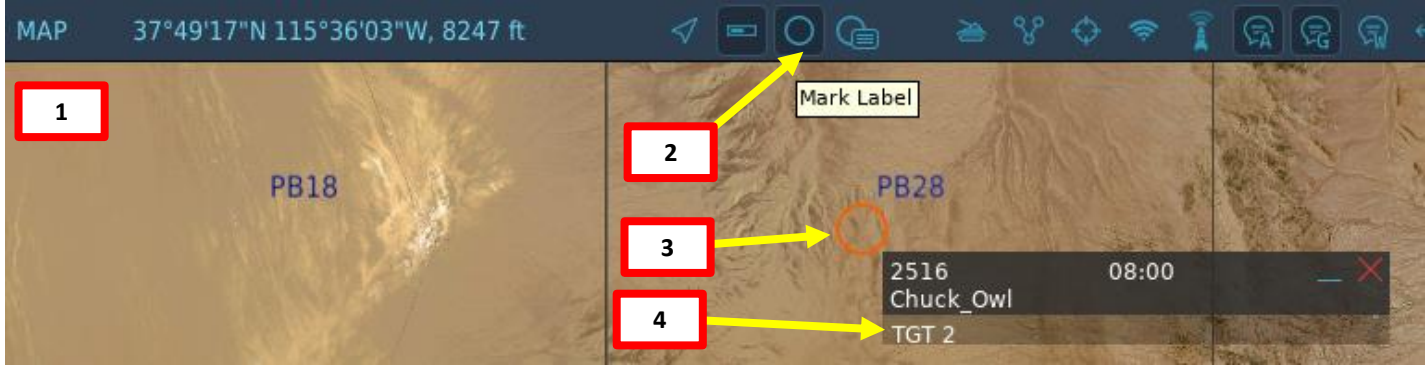


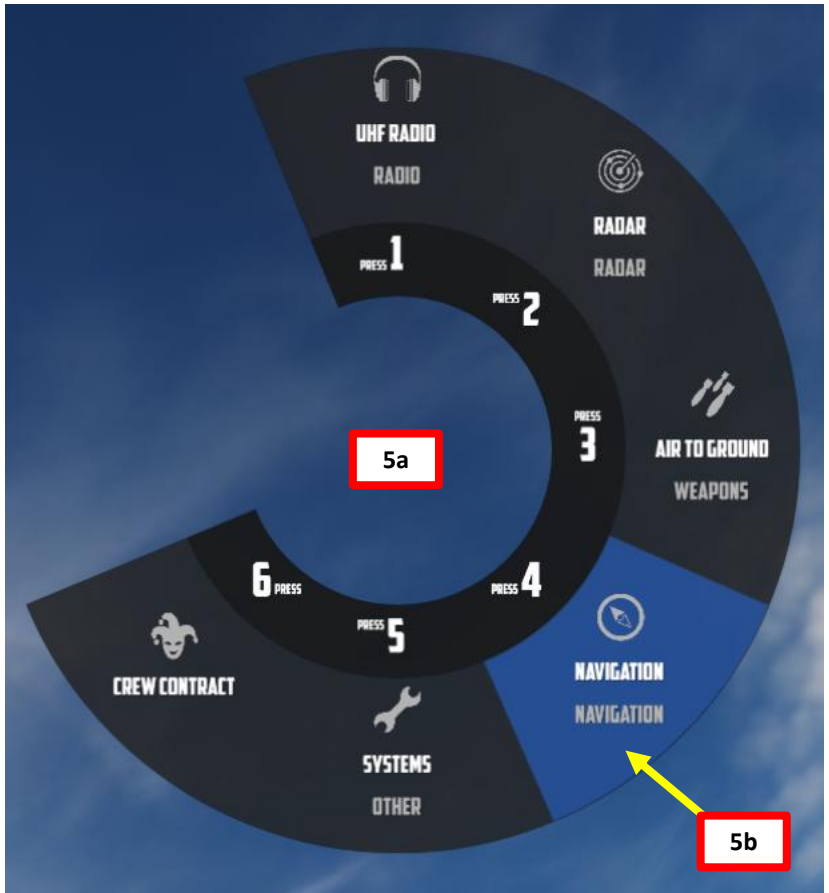


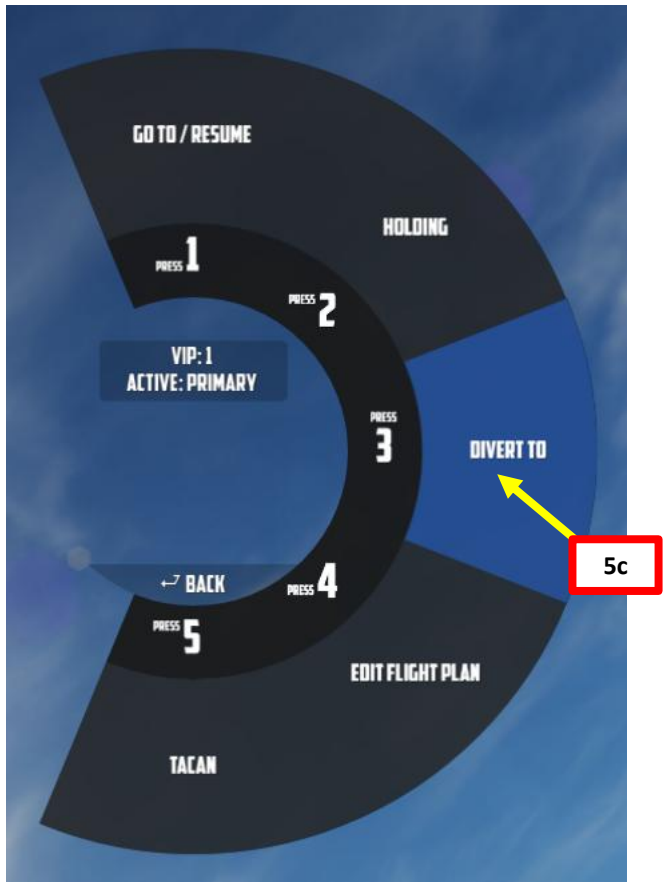
4 – FLIGHT PLAN
4.2 – Flight Plan Preparation

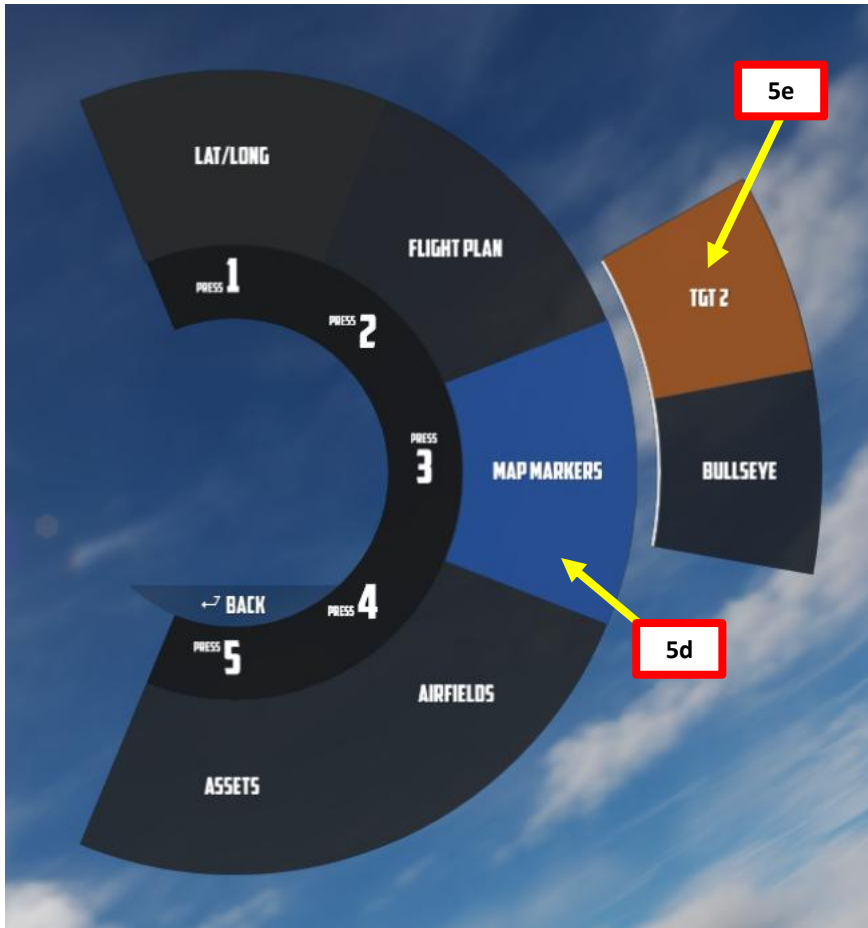
It is possible to **create markers on the F10 map**.

1. Press F10 to access the map
2. Click « Mark Label »
3. Double-click on the desired location on the map
4. Enter the waypoint's name (we set TGT 2 for « Target No. 2 »).
5. Using the JESTER Navigation Menu, it is possible to use this waypoint using various JESTER-related functions like DIVERT TO.





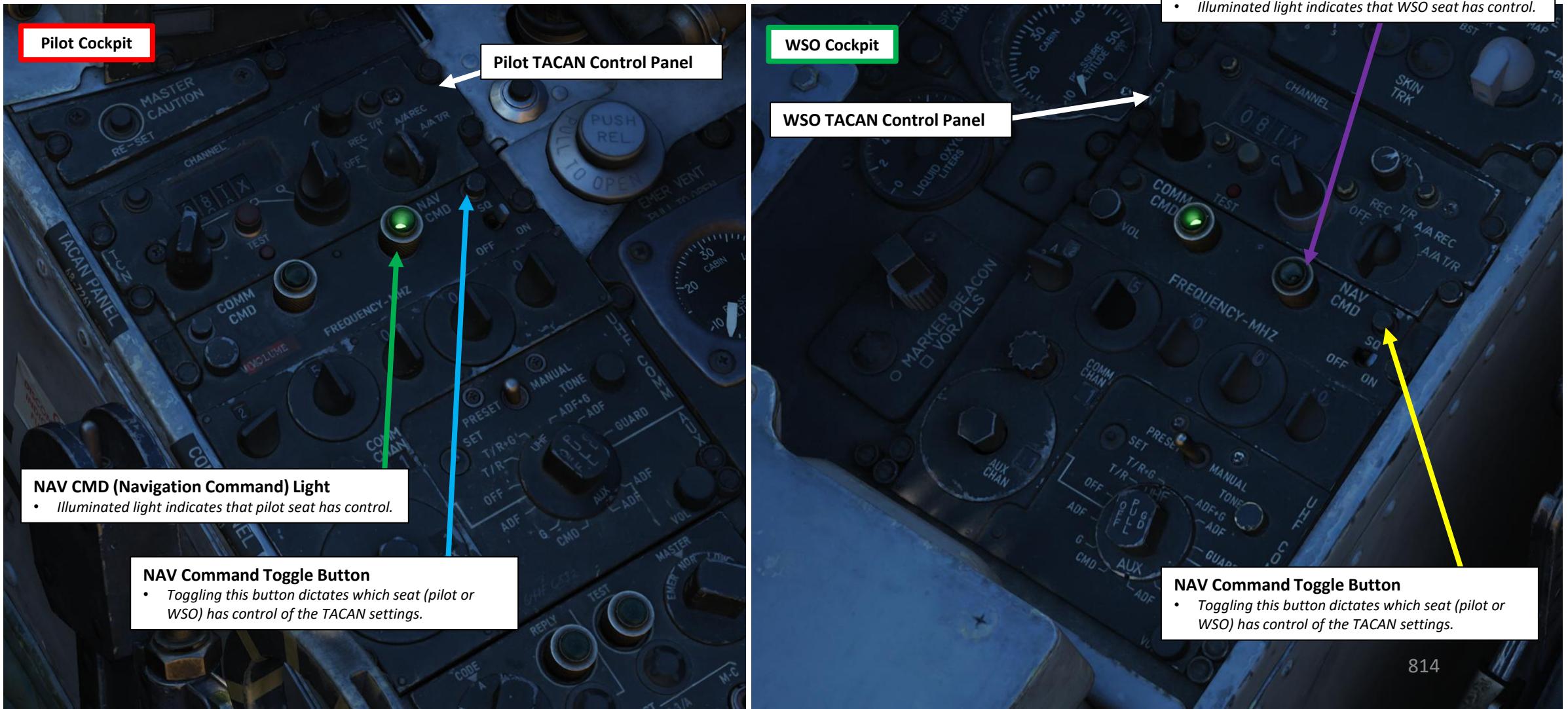




5 – NAVIGATION COMMAND (NAV CMD)

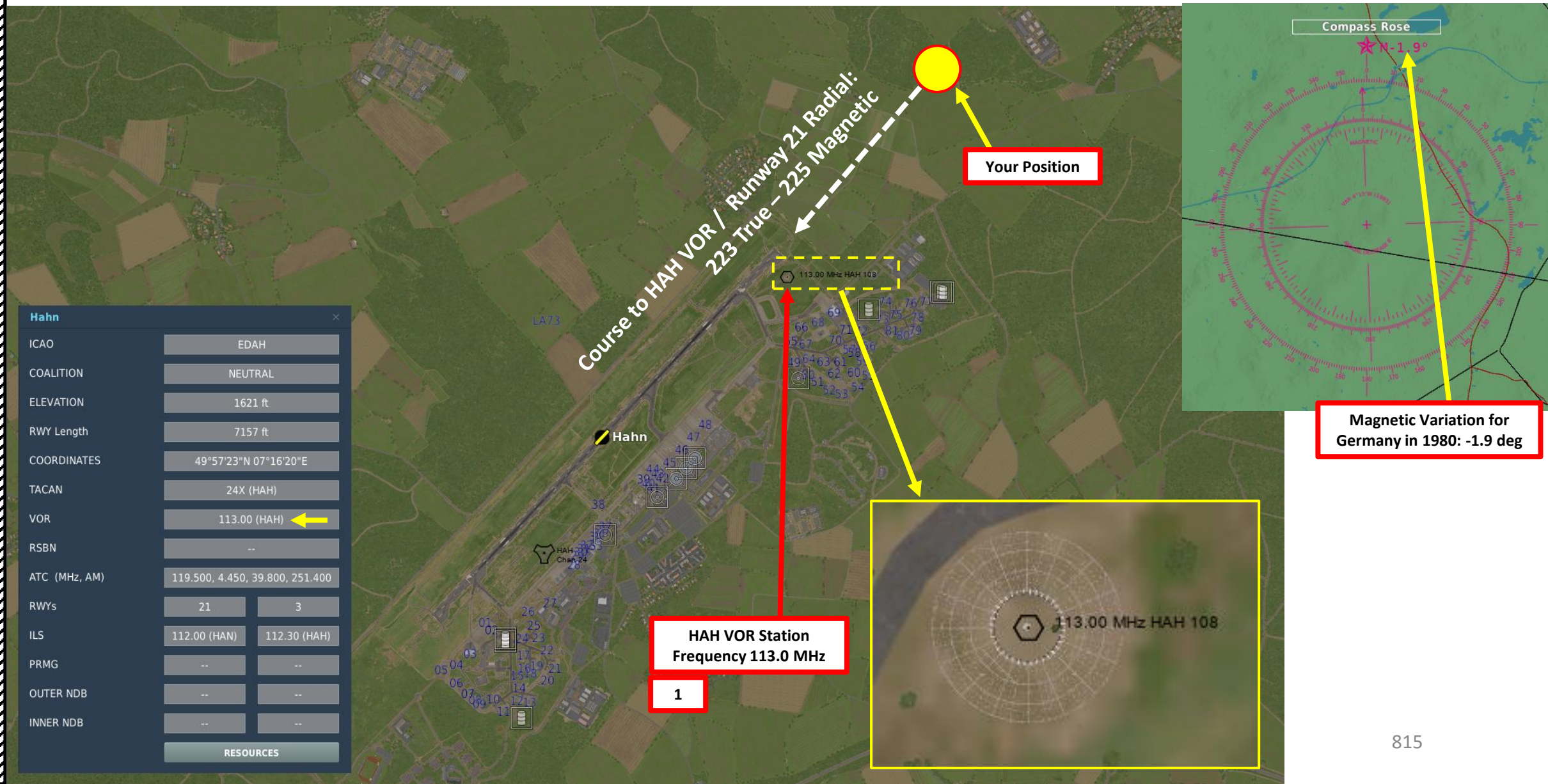
The **Navigation Command Button (NAV CMD)** in each cockpit allows any crew member to take or relinquish command of the TACAN-related navigation system functions. A **green light** to the right of the button illuminates in the cockpit which has command/control of TACAN settings.

In the example below, the pilot has **pressed on the NAV Command Toggle Button**, and the **illuminated green NAV CMD light** indicates that the pilot has control over the TACAN panel. WSO TACAN control will be overridden by whatever TACAN setting the pilot has selected. In the WSO cockpit, the **NAV CMD light is extinguished**, indicating that the WSO does not have command of the TACAN system.



6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

1. In this example, we want to intercept **VOR Station HAH (113.00 MHz)** in order to approach Hanh Air Base with a **radial course** of **225 magnetic**.

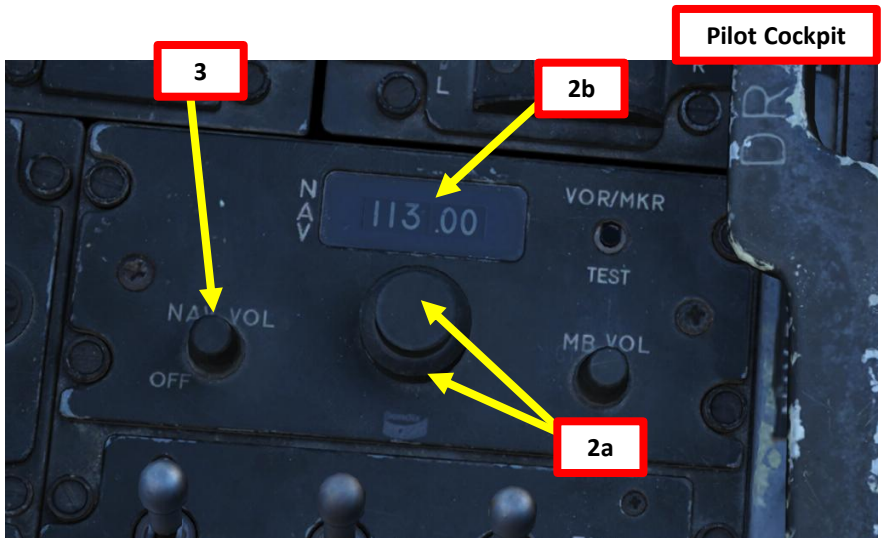


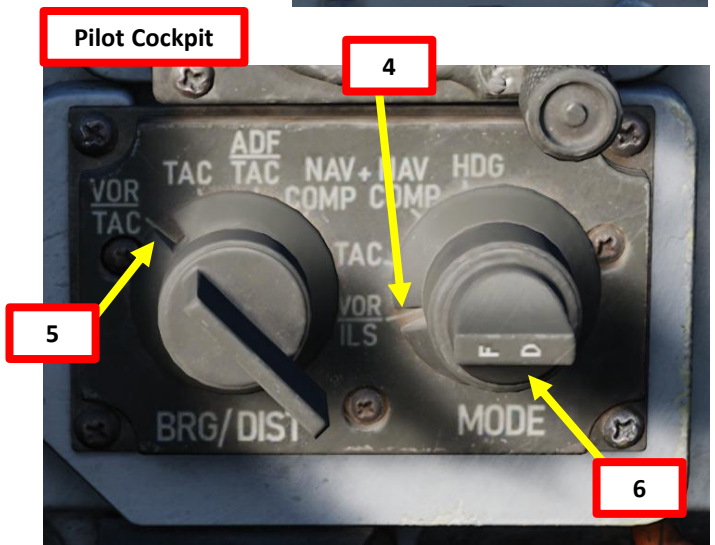
6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

2. *[P]* Tune NAV frequency to **113.00 MHz (HAH VOR Station).**
3. *[P]* Adjust volume of navigation aid tone as desired.
4. *[P]* Set Navigation Mode Selecter (Outer Knob) – VOR/ILS.
    - This provides control over the presentation of various displayed information on the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
5. *[P]* Set Navigation Input (Bearing/Distance) Selector – VOR/TAC.
    - This determines the source of navigation information for the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
6. *[P]* Set Flight Director (FD) Selector (Inner Knob) – Horizontal Position (FD ON).
    - This activates pitch and bank steering bars on the ADI (Attitude Director Indicator).
7. *[P]* Set radial interception course to 225 Magnetic with the Course Set Knob.
8. *[WSO]* Set WSO Navigation Mode Selector Switch – MIDDLE Position (1 VOR / 2 TAC)



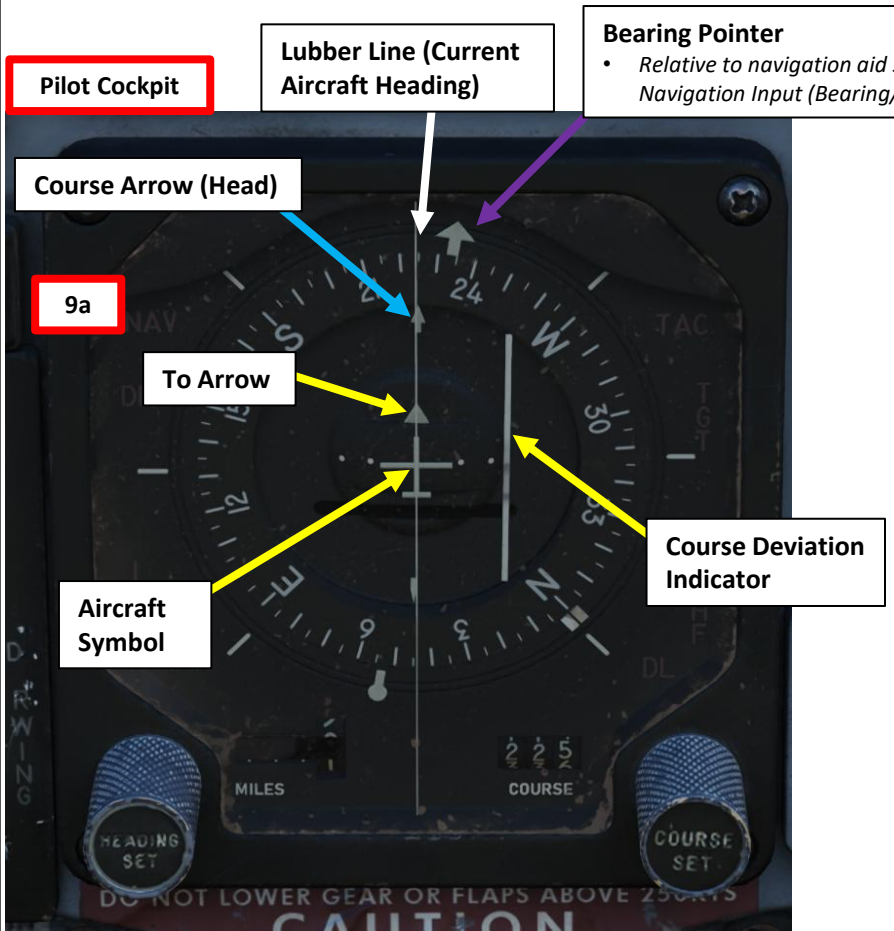


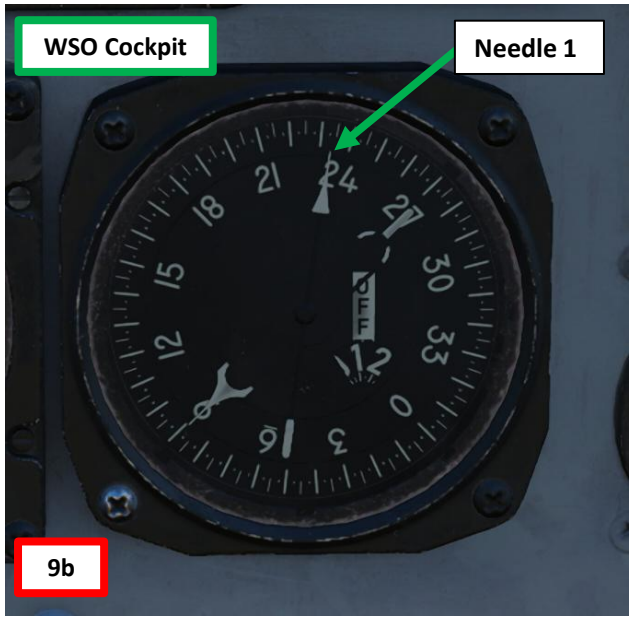




6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

9. Once the VOR station is detected:
   - *a)* *[P]* On the HSI (Horizontal Situation Indicator): Bearing to VOR station is provided by the Bearing Pointer, while the Course Deviation Indicator indicates deviation from the radial course. A morse code signal should be audible.
   - *b)* *[WSO]* On the BDHI (Bearing Distance Heading Indicator): Needle 1 provides bearing to the VOR station. The BDHI is mostly used in a monitoring capacity by the WSO.
   - Note: The VOR station will not provide distance information.
10. *[P]* Steer the aircraft towards the Course Deviation Line. As you approach the radial, the line deviation with the vertical centerline of the ADI will gradually diminish.
11. *[P]* When Course Deviation Line is centered, this means you are on the 225 radial.
12. *[P]* Turn towards the Bearing Pointer to follow the radial to the runway.



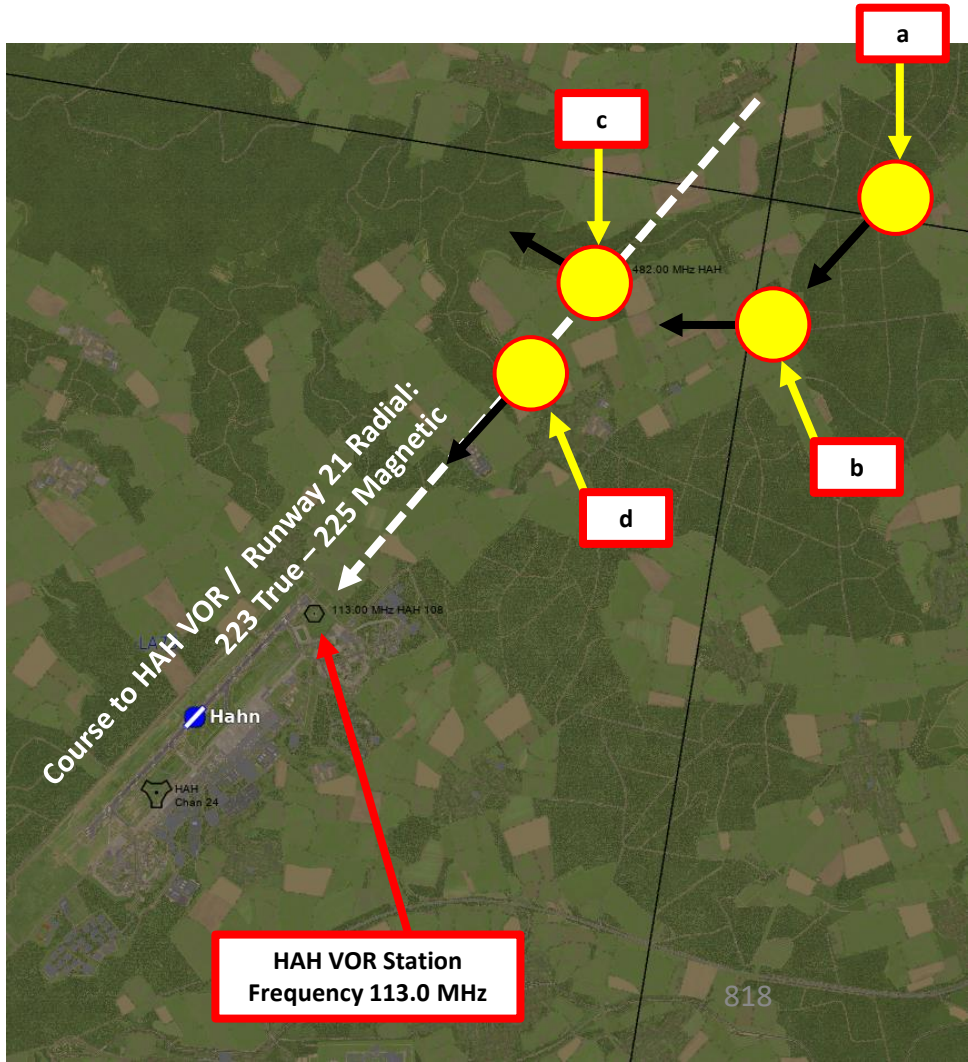




6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

13. *[P]* Here is an example of the radial interception process.

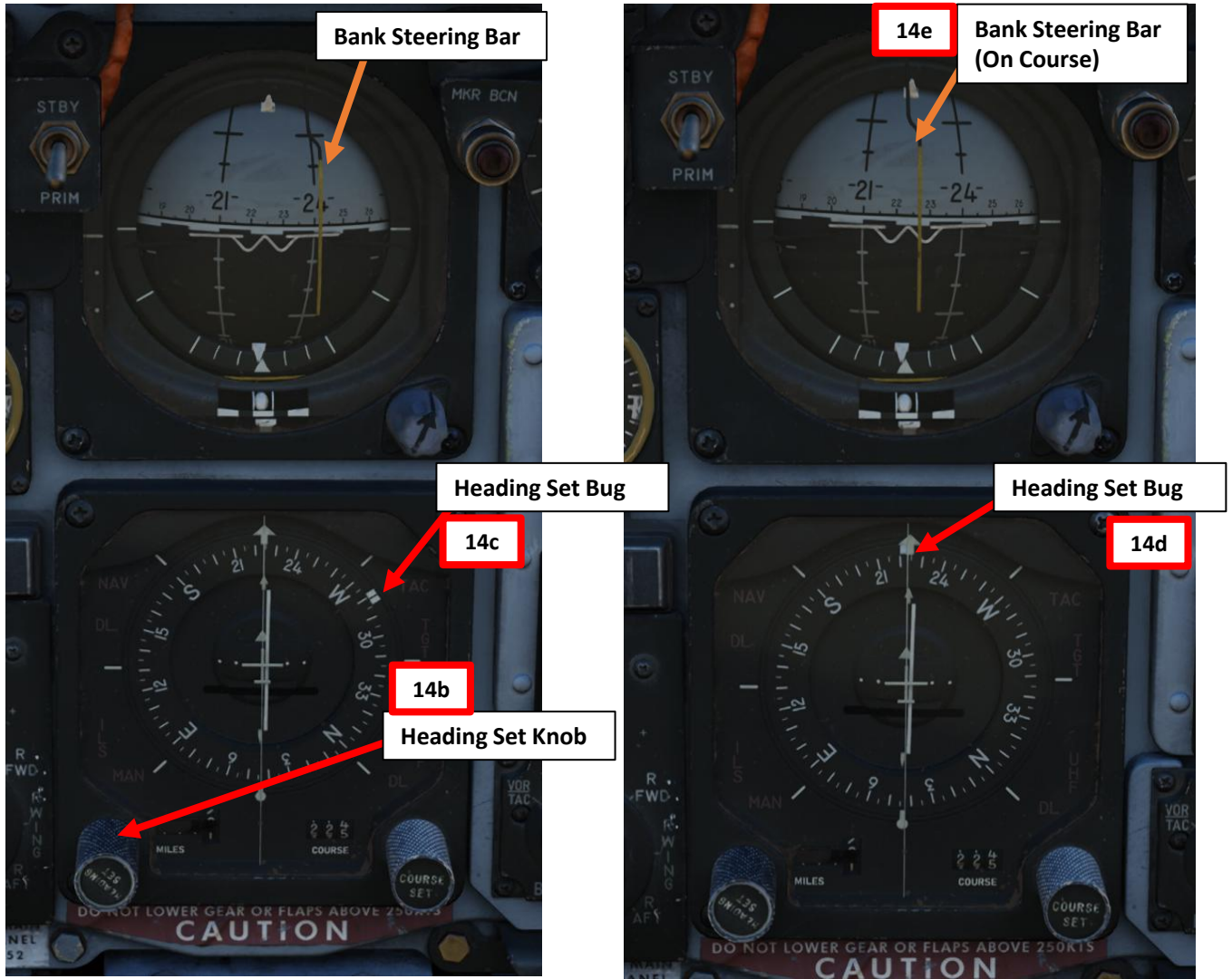


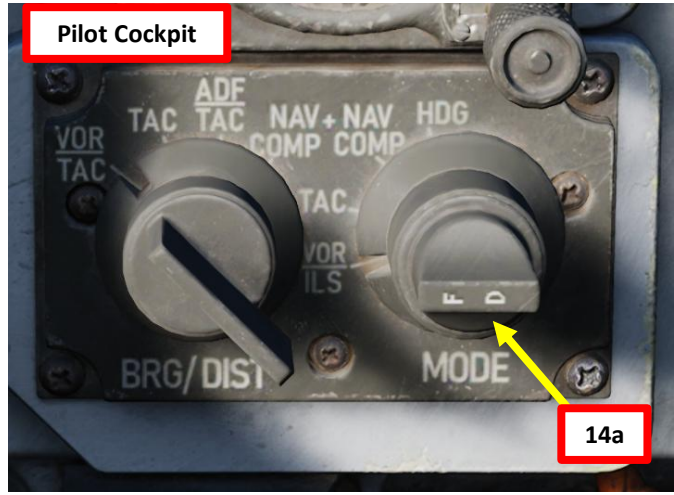


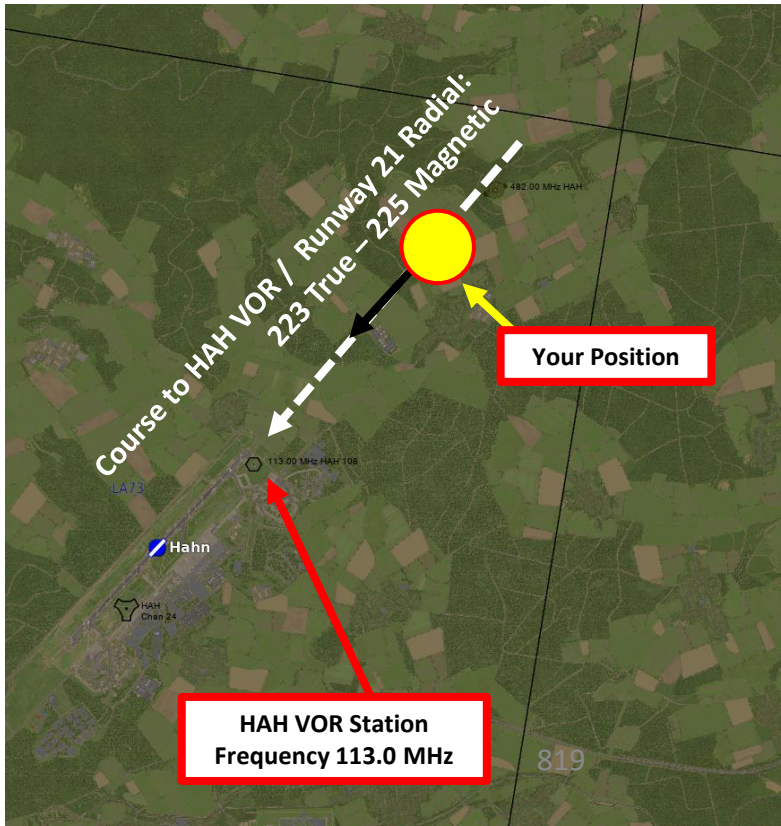
6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

14. *[P] Optional Step:* Once the radial 225 (M) for the VOR station is intercepted, you can set the Heading Bug to the interception course (225 Magnetic) if desired. Provided Flight Director Mode is ON (FD Selector is Horizontal), the ADI (Attitude Director Indicator) will display a yellow bank steering bar, which indicates deviation from the heading/course to the VOR station.

- Note: As the bank steering is based on the heading marker position, if it is not set properly, bank steering on the ADI will not be correct to intercept the desired course. I typically prefer to use the Horizontal Situation Indicator instead of the ADI to perform radial intercepts, but that is just my personal preference.







6 – VOR (VHF OMNIDIRECTIONAL RANGE) NAVIGATION

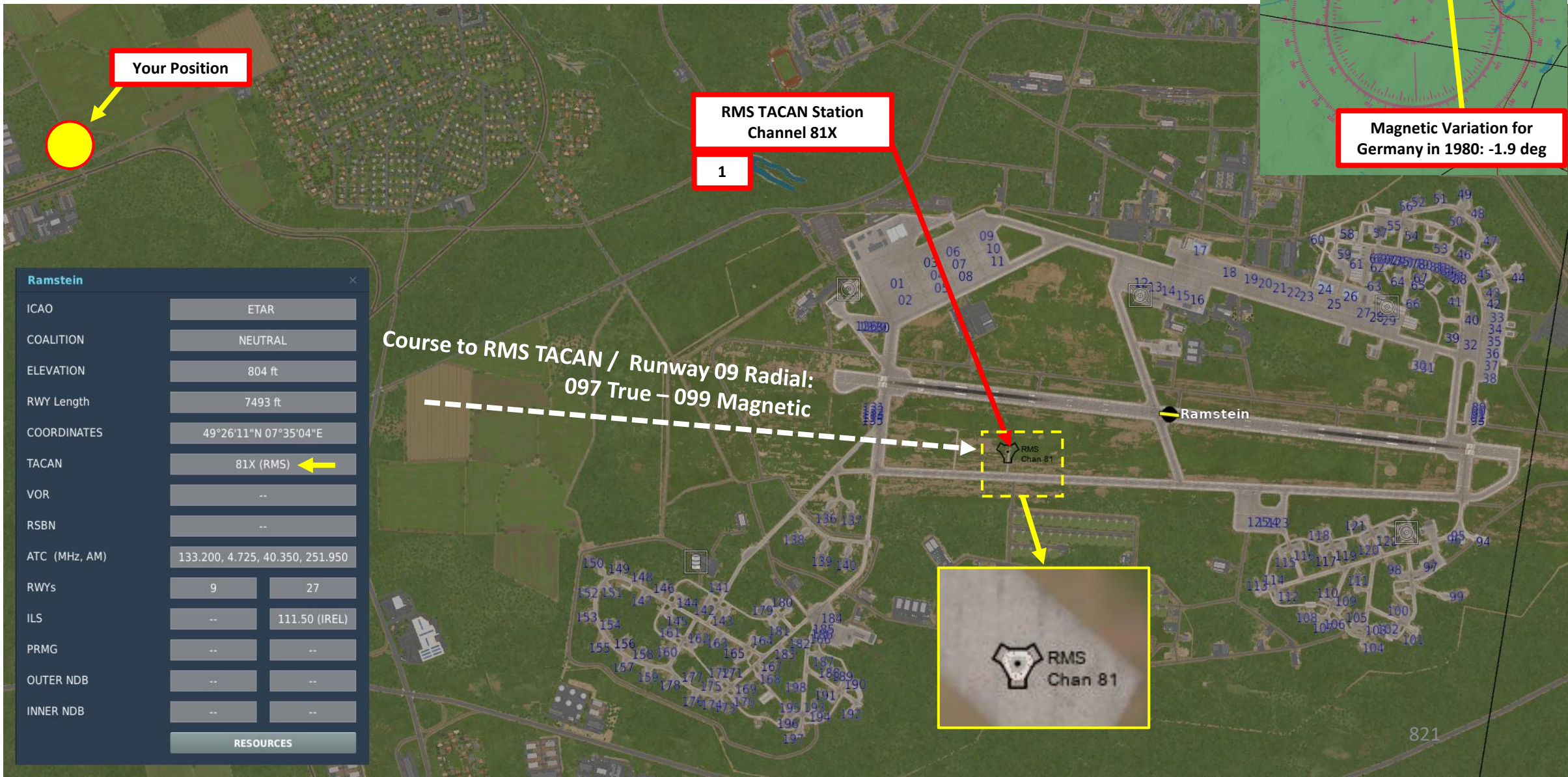
15. We are now aligned with the “HAH” VOR for Hahn Air Base, following a radial course of 225 Magnetic.

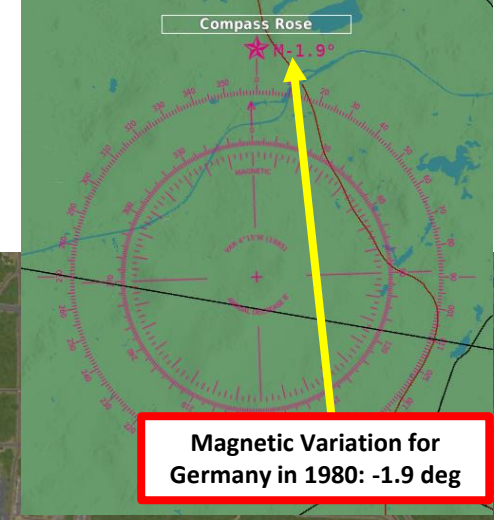




7 – TACAN NAVIGATION

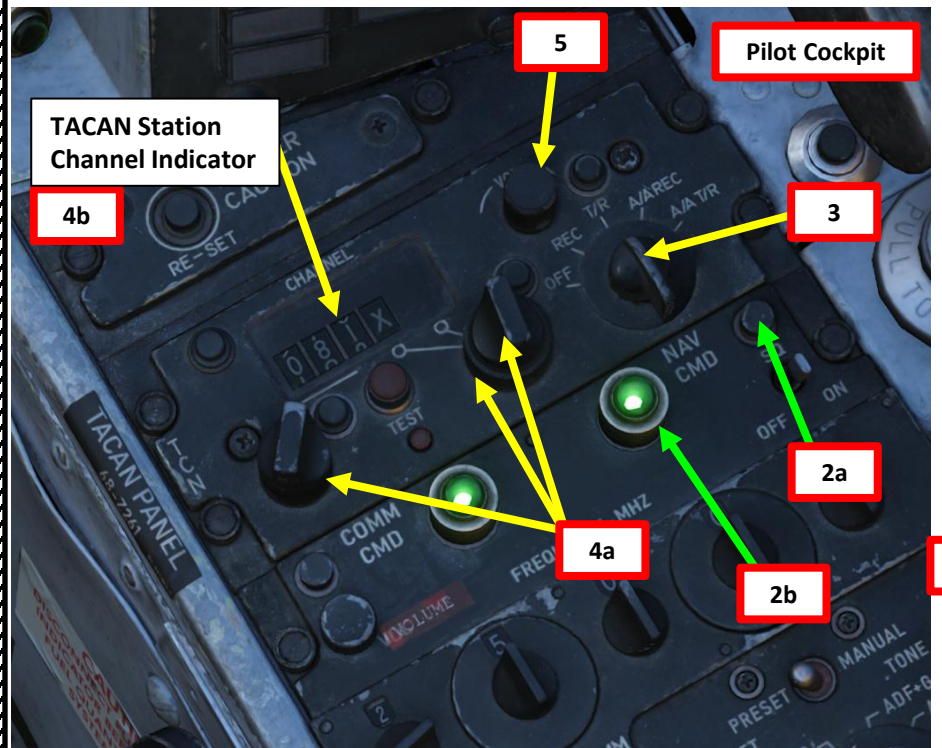
1. In this example, we want to intercept **TACAN Station RMS (Channel 81X)** in order to approach Ramstein Air Base with a **radial course** of **099 magnetic**.



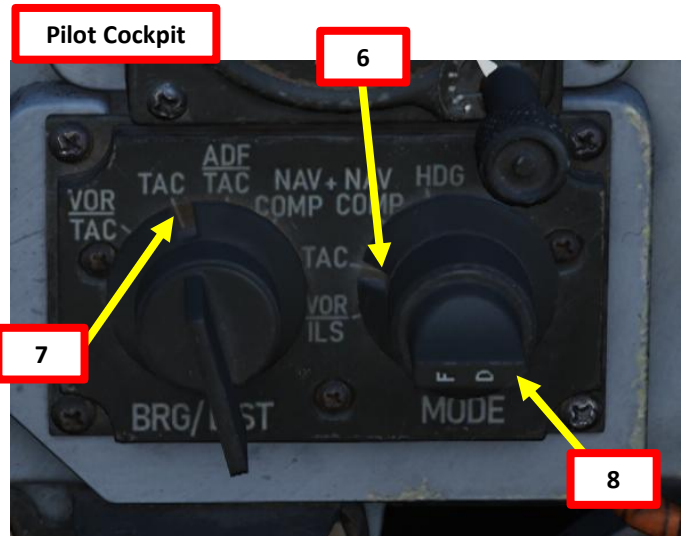


7 – TACAN NAVIGATION

2. *[P]* Check NAV CMD light is illuminated. If not, press the NAV Command Toggle Button. This will give TACAN command to your own cockpit.
3. *[P]* Set TACAN Mode Selector – T/R (Transmit/Receive).
4. *[P]* Tune TACAN Channel to **81X (RMS TACAN Station).**
    - Left Knob for Hundreds, Right Outer Knob for X/Y and Right Inner Knob for Ones
5. *[P]* Adjust volume of TACAN tone as desired.
6. *[P]* Set Navigation Mode Selecter (Outer Knob) – TAC (TACAN).
    - This provides control over the presentation of various displayed information on the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
7. *[P]* Set Navigation Input (Bearing/Distance) Selector – TAC (TACAN).
    - This determines the source of navigation information for the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
8. *[P]* Set Flight Director (FD) Selector (Inner Knob) – Horizontal Position (FD ON).
    - This activates pitch and bank steering bars on the ADI (Attitude Director Indicator).
9. *[P]* Set radial interception course to 99 Magnetic with the Course Set Knob.
10. *[WSO]* Set WSO Navigation Mode Selector Switch – MIDDLE Position (1 VOR / 2 TAC)



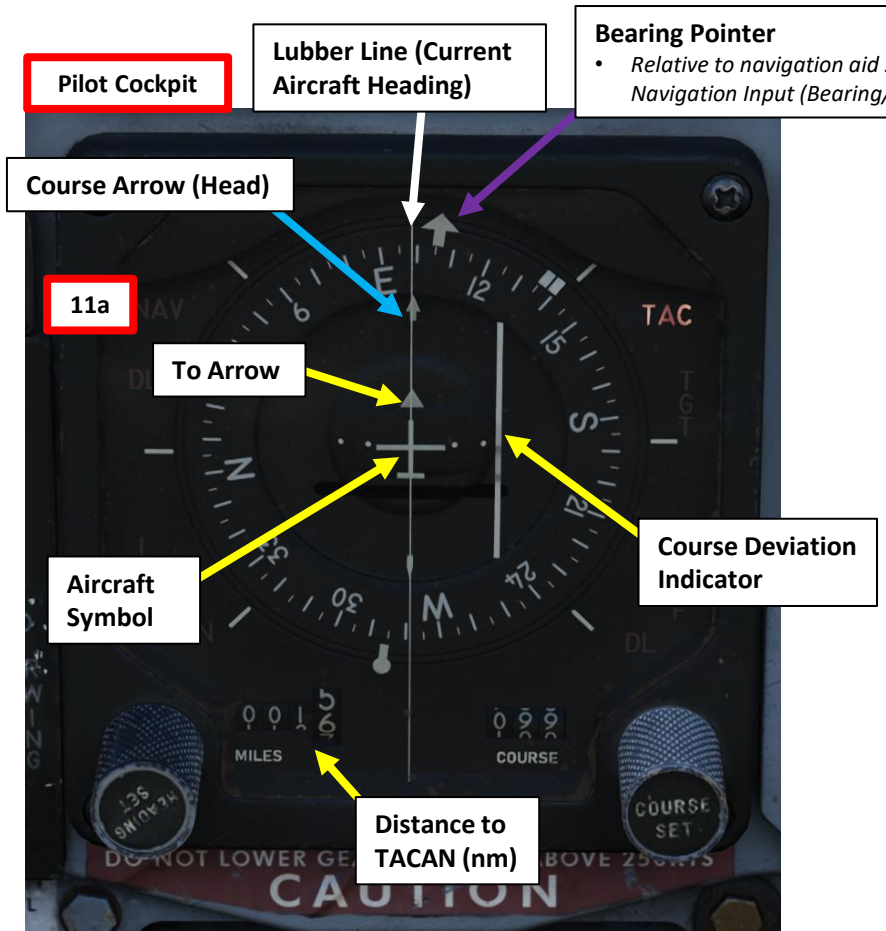


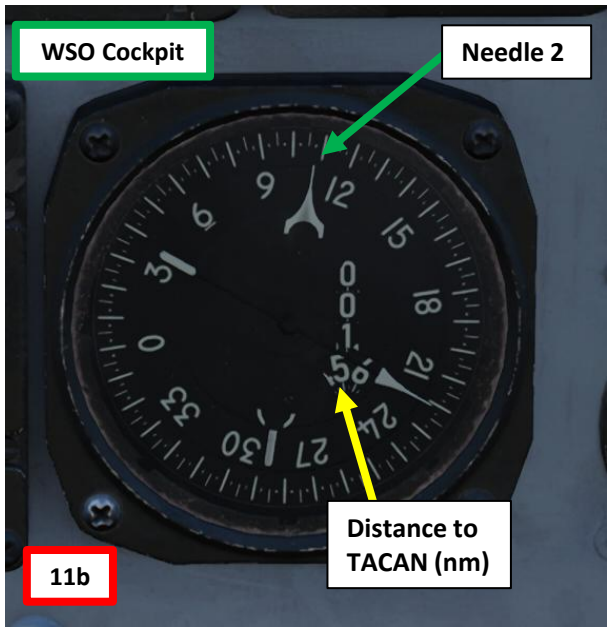


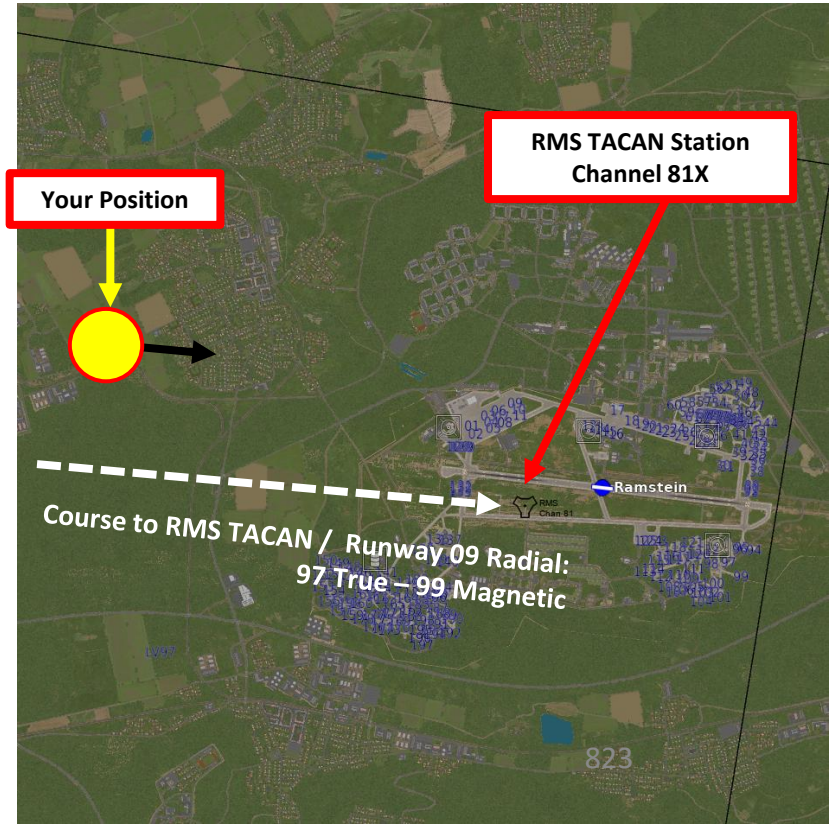


7 – TACAN NAVIGATION

11. Once the TACAN station is detected:
    - *a)* *[P]* On the HSI (Horizontal Situation Indicator): Bearing to TACAN station is provided by the Bearing Pointer, while the Course Deviation Indicator indicates deviation from the radial course. A morse code signal should be audible.
    - *b)* *[WSO]* On the BDHI (Bearing Distance Heading Indicator): Needle 2 provides bearing to the TACAN station. The BDHI is mostly used in a monitoring capacity by the WSO.
    - Note: The TACAN station will provide distance information as well.



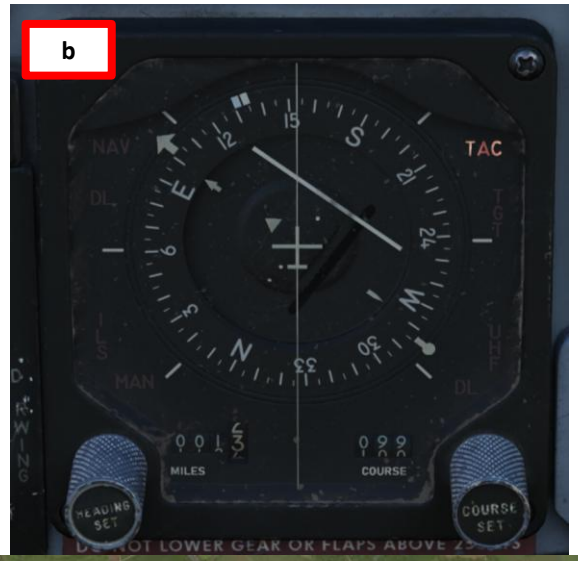




7 – TACAN NAVIGATION

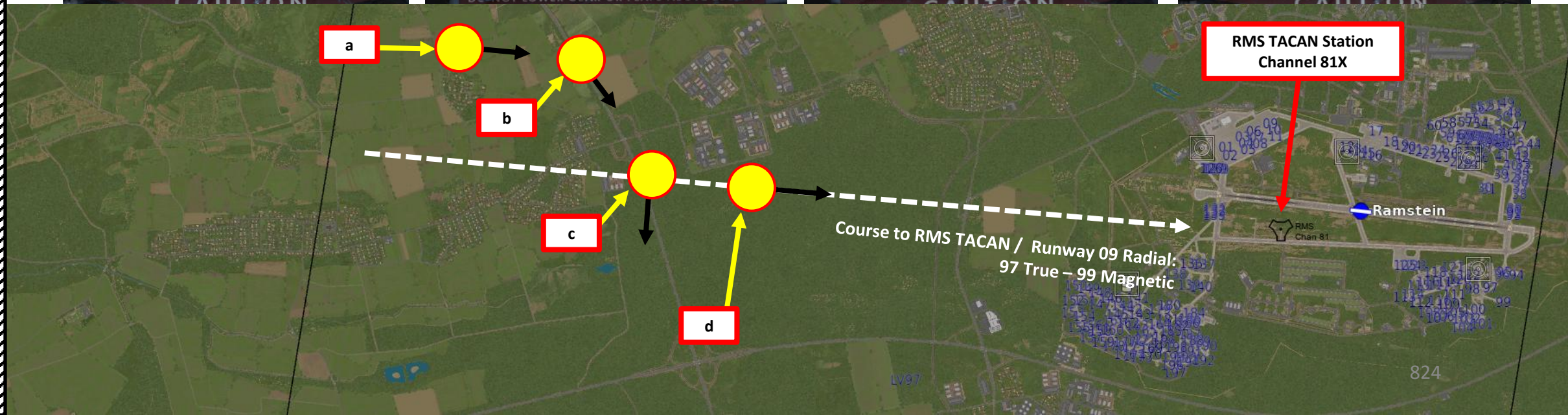
12. *[P]* Here is an example of the radial interception process.
13. *[P]* Steer the aircraft towards the Course Deviation Line.
14. *[P]* When Course Deviation Line is centered, this means you are on the 099 radial.
15. *[P]* Turn towards the Bearing Pointer to follow the radial to the runway.









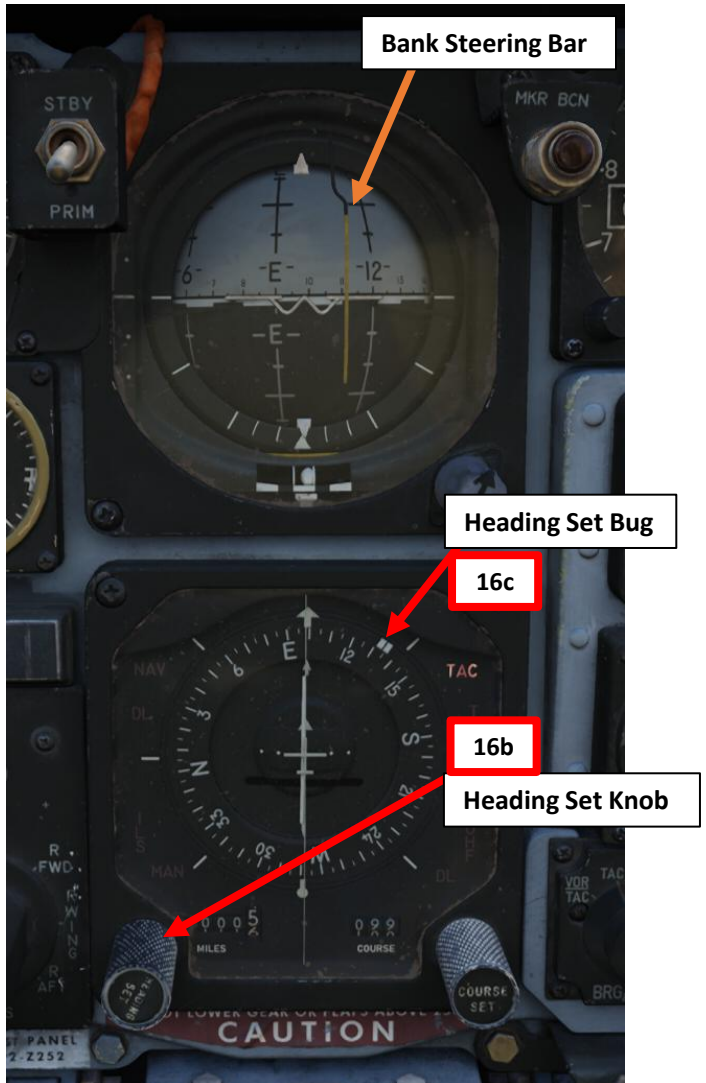


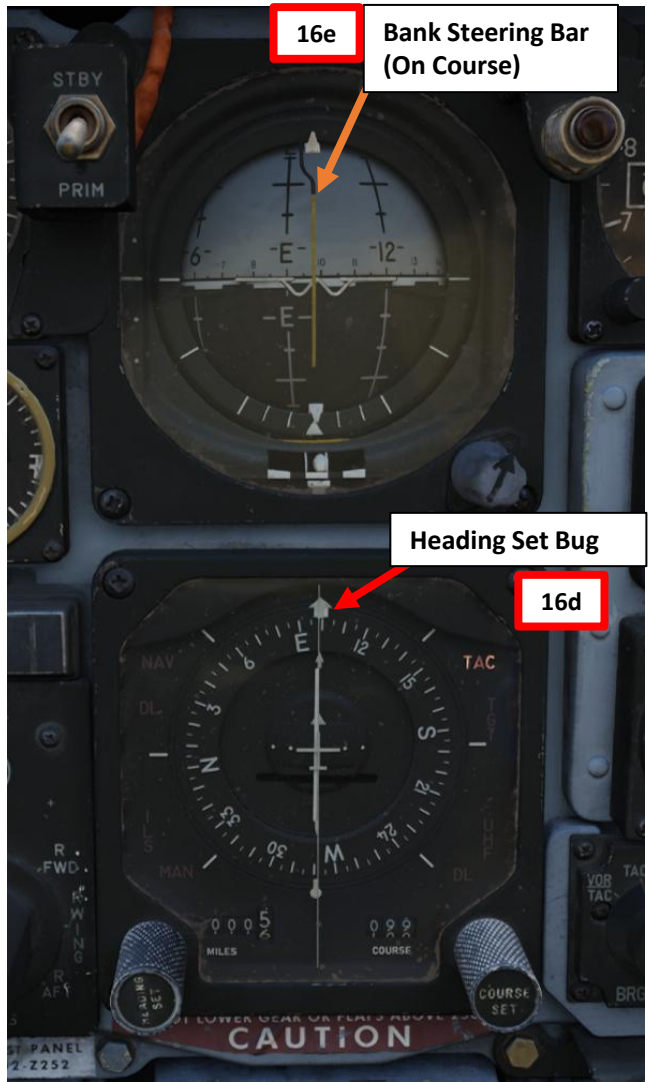
7 – TACAN NAVIGATION

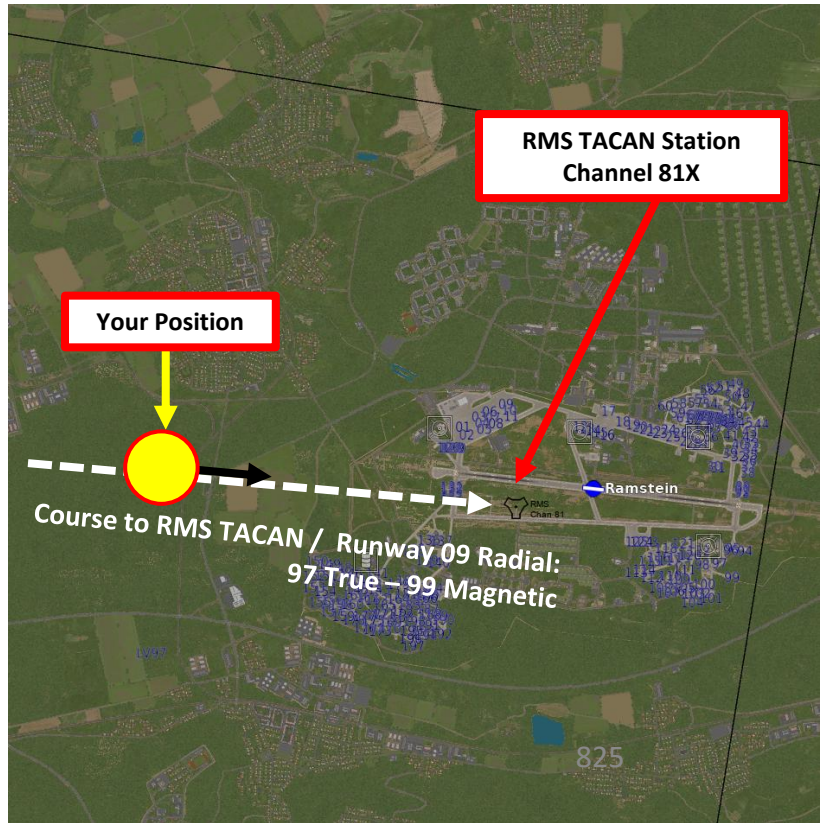
16. *[P] Optional Step:* Once the radial 099 (M) for the TACAN station is intercepted, you can set the Heading Bug to the interception course (099 Magnetic) if desired. Provided Flight Director Mode is ON (FD Selector is Horizontal), the ADI (Attitude Director Indicator) will display a yellow bank steering bar, which indicates deviation from the heading/course to the TACAN station.

- Note: As the bank steering is based on the heading marker position, if it is not set properly, bank steering on the ADI will not be correct to intercept the desired course. I typically prefer to use the Horizontal Situation Indicator instead of the ADI to perform radial intercepts, but that is just my personal preference.









7 – TACAN NAVIGATION

17. We are now aligned with the “RMS” TACAN 81X for Ramstein Air Base, following a radial course of 099 Magnetic.



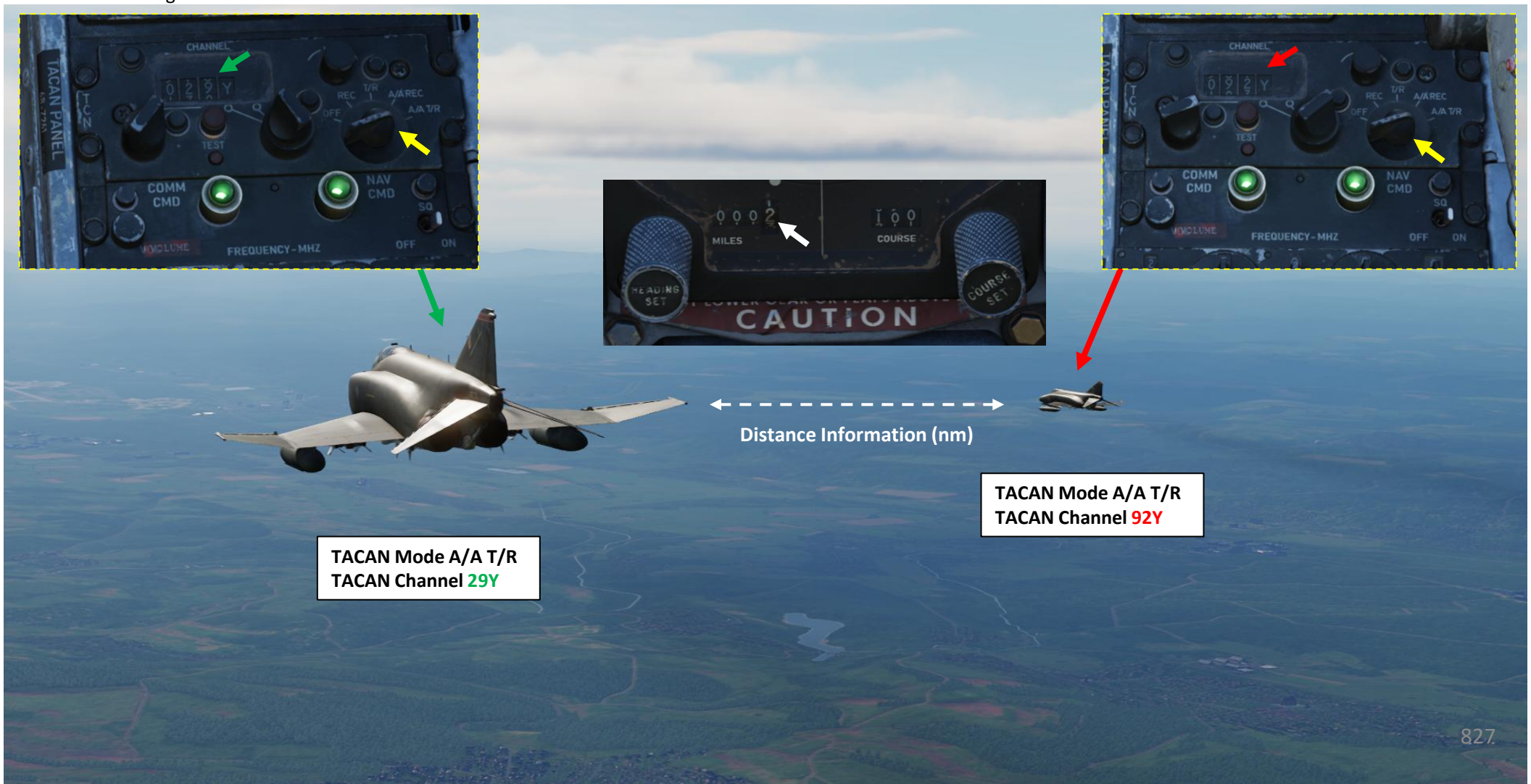


7 – TACAN NAVIGATION

Note about TACAN Yardstick

It is possible for wingmen to use the A/A (Air-to-Air) TACAN Mode, also referred as "TACAN Yardstick", to provide DME (Distance Measuring Equipment) distance between the two jets but without any bearing information.

To do so, fighters set their TACAN to **A/A T/R Mode** on a **Y channel 63 channels apart** (wingman No. 1 can use **29Y** and wingman No. 2 can use **92Y**, but other channel combinations like 30Y/93Y or 10Y/73Y also work). The TACAN distance indicator will show distance information between both fighters, which was very useful back in the days without modern Datalink. This feature could also be used with air-to-air refueling tankers like the KC-135.

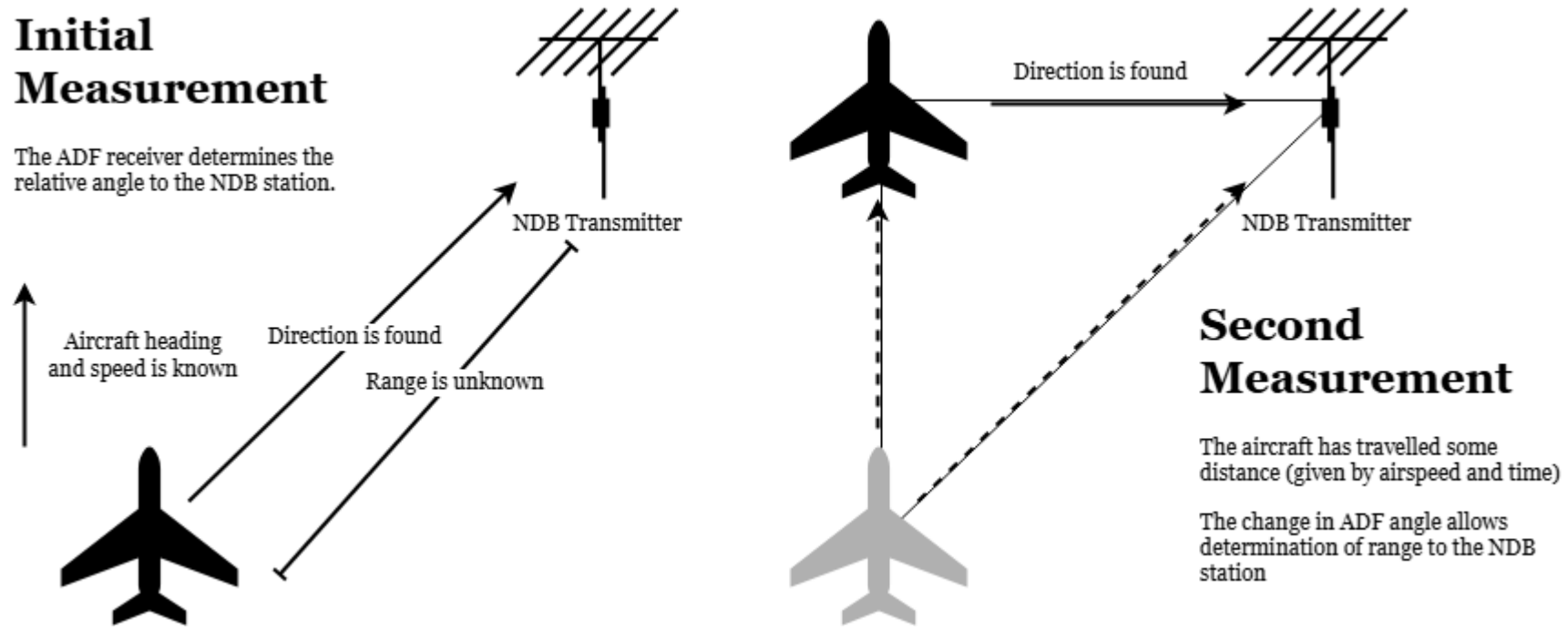


8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION

In the F-4E Phantom, the AN/ARC-164V UHF Radio in the F-4E provides both voice communication (AM) and Automatic Direction Finding (ADF) capabilities. Both the COMM and AUX receivers have the capability to process ADF signals, which can be displayed on the Horizontal Situation Indicator (HSI) or Bearing Distance Heading Indicator (BDHI). In practice, this means that an aircraft transmitting on a valid UHF frequency can be picked up by the automatic direction finder, allowing you to get a bearing to locate the radio transmitter.

In real life, ADF was rarely used for navigation by Phantom crews. This kind of navigation dated back to the 1950's and the Korean war; it was quickly replaced by TACAN, which provided better navigation capabilities and distance information. In practice, ADF was briefed as a backup to rejoin air-to-air refueling tankers in case of radar and A/A TACAN issues. Still, we're flying a simulator, so… what the heck? Let's learn about its theoretical use!

Automatic Direction Finder Concept

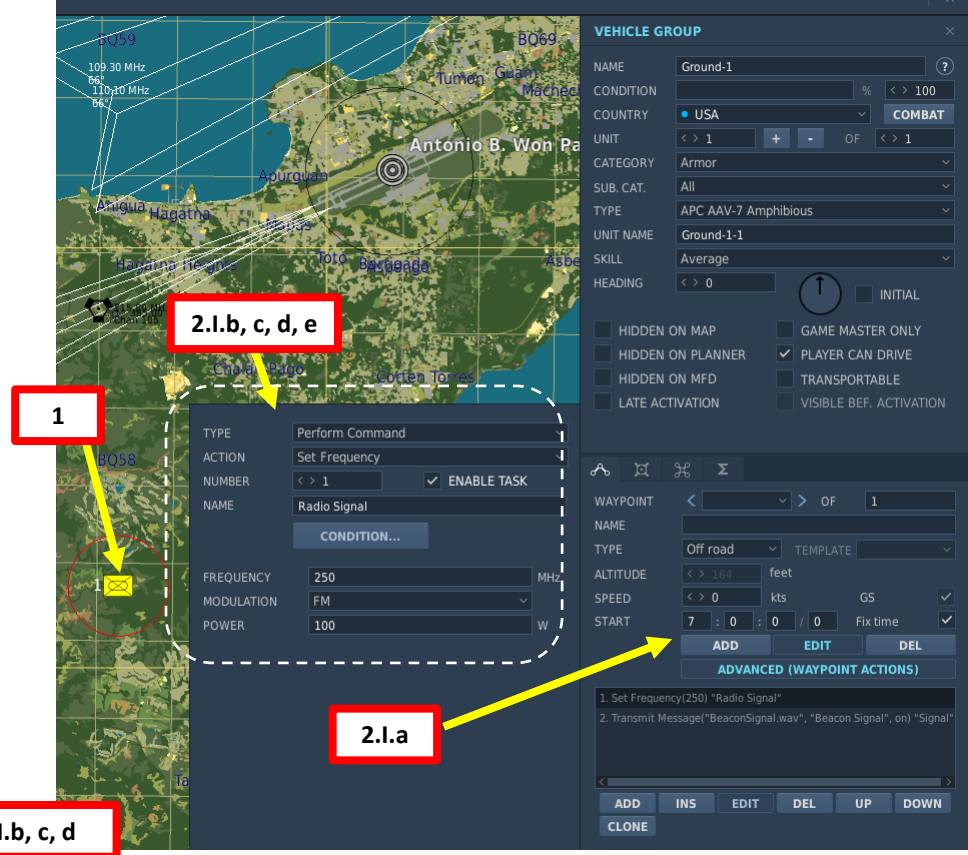


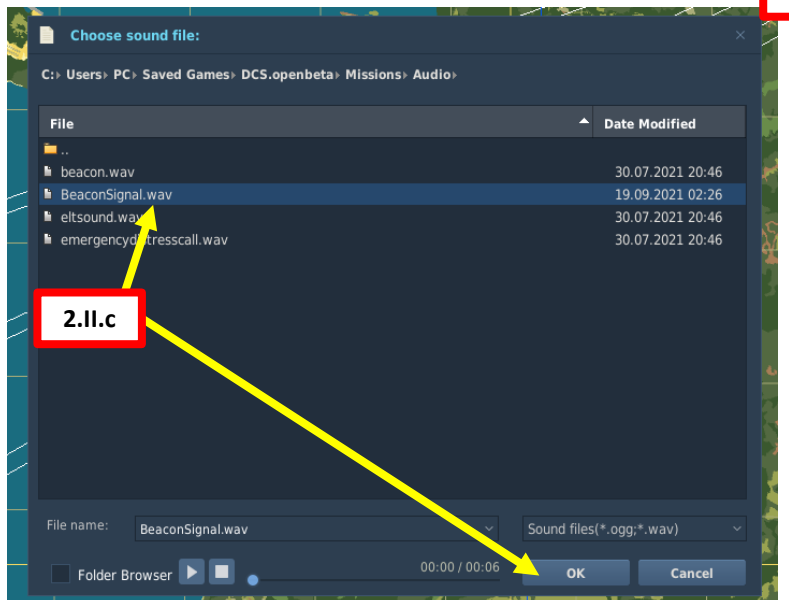
8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION

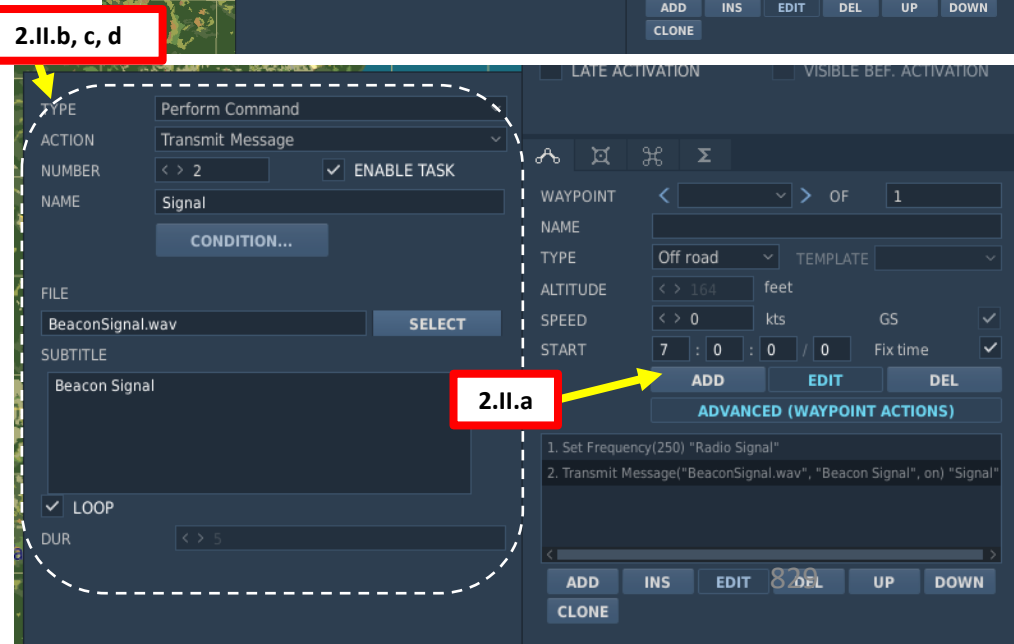
Note: most Non-Directional Beacons in DCS are set in the KHz frequency range, while the F-4E can only track frequencies in the MHz range. Therefore, a way to use ADF is to have a ground or air unit transmitting a radio signal on the MHz frequency range. This can be done with the Mission Editor.

We will first need to set up a mission with a unit that transmits a radio signal on a **UHF FM frequency of 250 MHz**.

1. Create Unit that will transmit the radio signal
2. In ADVANCED (WAYPOINT ACTIONS) of Waypoint 0
    - I. Click on ADD
        - a) Select Type - PERFORM COMMAND
        - b) Select ACTION – SET FREQUENCY
        - c) Set Frequency to a valid frequency (250 MHz)
        - d) Select FM Band
        - e) Select Power (i.e. 100 W)
    - II. Click on ADD
        - a) Select Type - PERFORM COMMAND
        - b) Select ACTION – TRANSMIT MESSAGE
        - c) Select a valid .wav or .ogg audio file with the distress call. Add subtitles if desired.
        - d) Select LOOP



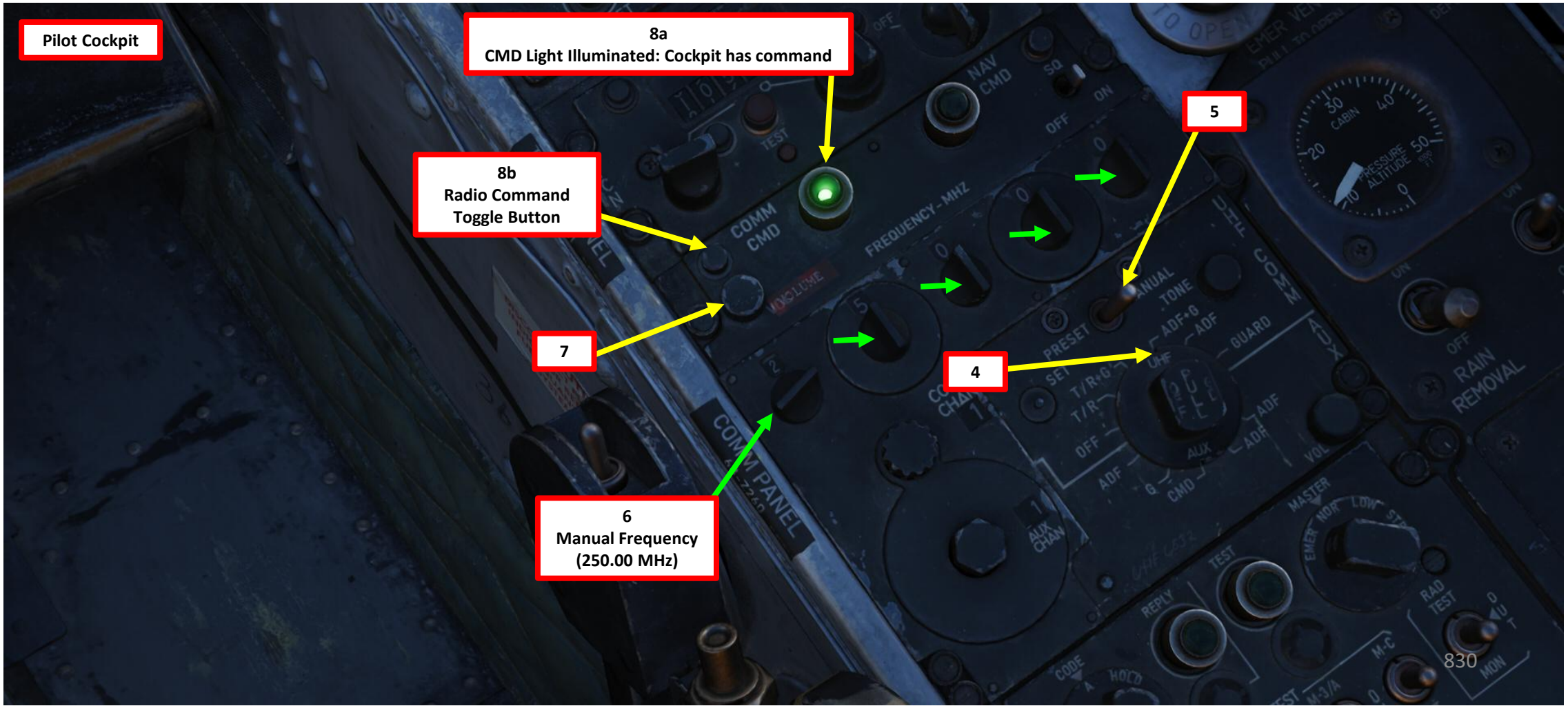




8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION

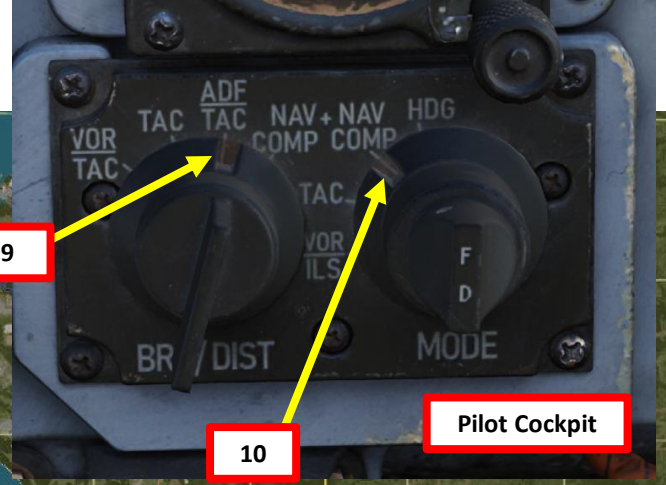
3. *[P]* Read mission briefing to determine on what UHF frequency the vehicle will transmit. In our case, the beacon is located in a vehicle transmitting on a frequency of 250.00 MHz.
4. *[P]* Set UHF Radio Mode Selector – ADF+G (Automatic Direction Finder + Guard Frequency).
5. *[P]* Set UHF Radio Frequency Mode Selector – Manual.
6. *[P]* Set UHF Radio Frequency with Frequency Tuning knobs. We will select 250.00 MHz.
7. *[P]* Set UHF Radio Volume – As desired.
8. *[P]* Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to your own cockpit.

Note: *Alternatively, you could also set the Mode selector to T/R+G, which will in turn set the AUX radio mode to ADF. In that case, you would need to select the AUX COMM channel preset to a frequency of 250.00 MHz.*

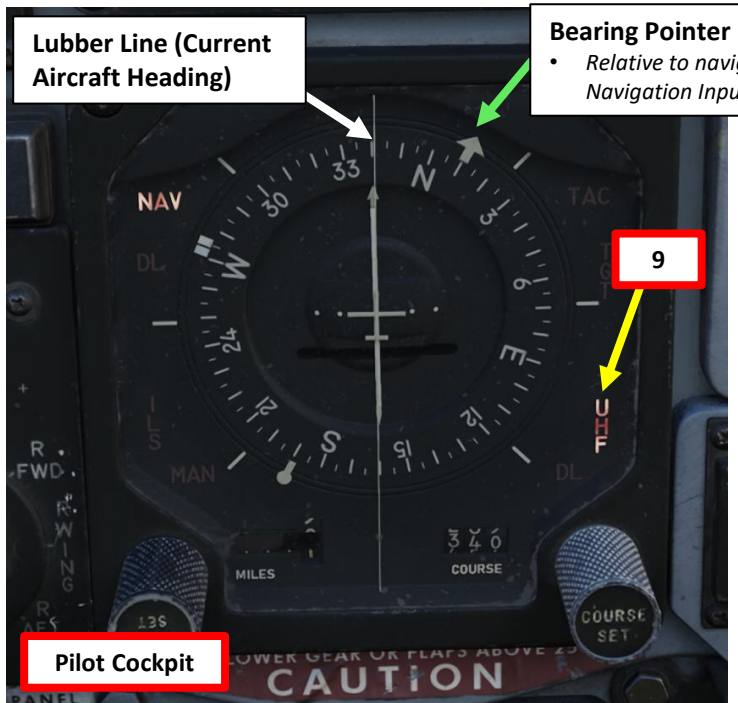


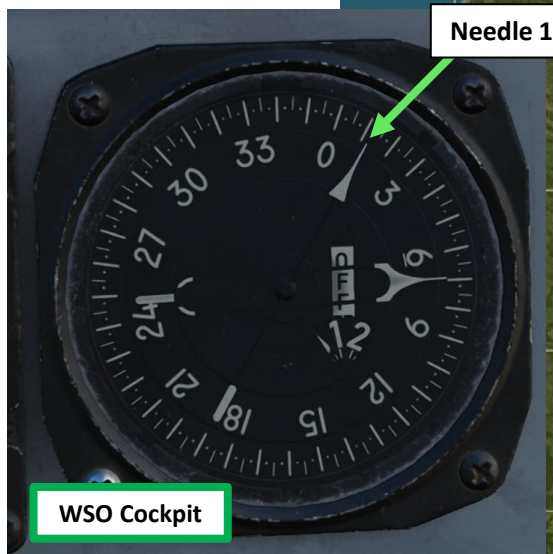
8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION

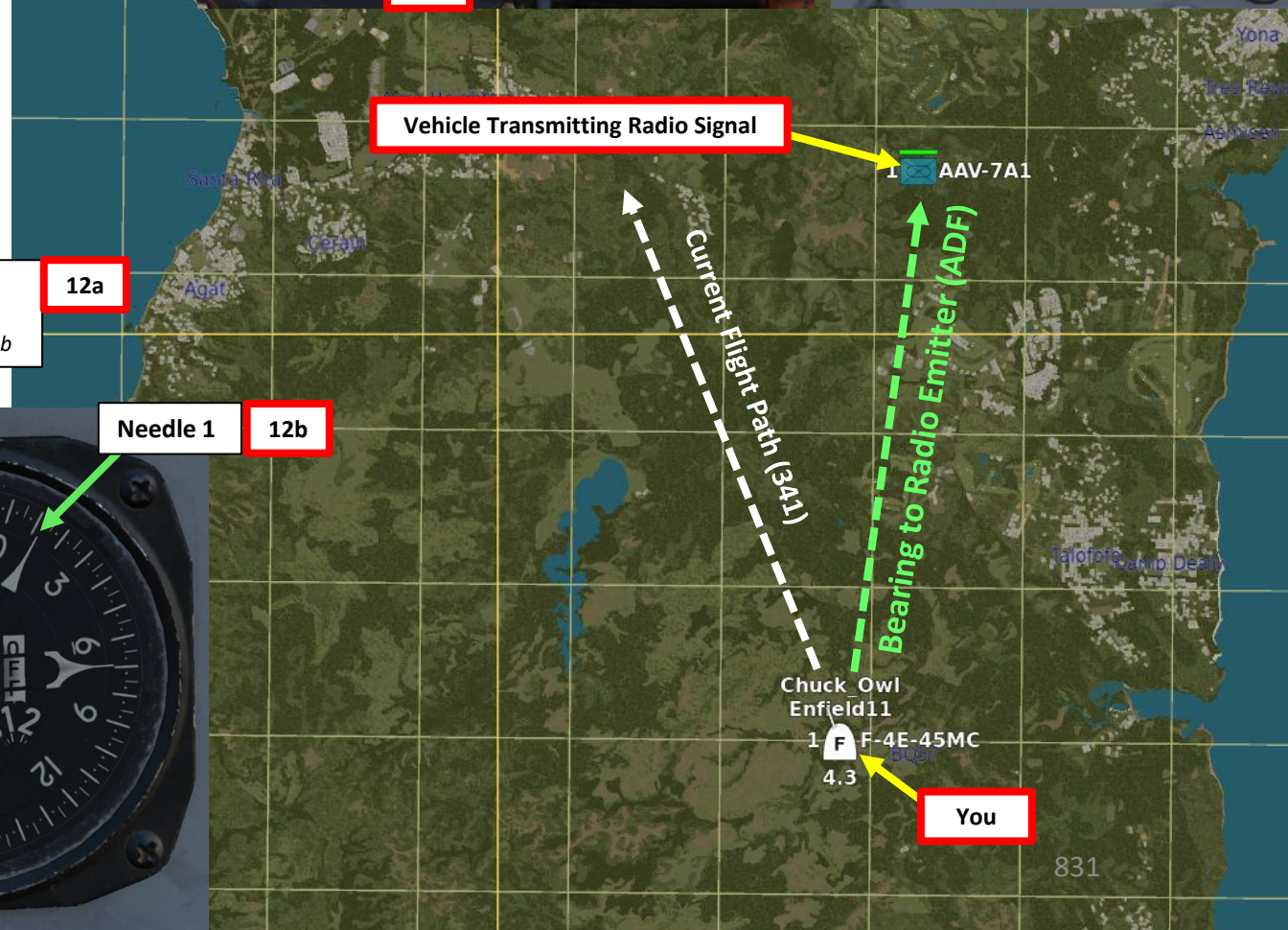
9. *[P]* Set Navigation Input (Bearing/Distance) Selector – ADF/TAC (Automatic Direction Finder/TACAN).
    - This determines the source of navigation information for the HSI (Horizontal Situation Indicator).
    - Make sure no valid TACAN station channel is selected. In real life, UHF ADF was often combined with a TACAN station nearby to get both bearing and distance information. However, in this tutorial we will only use the UHF ADF functionality for simplification purposes.
10. *[P]* Set Navigation Mode Selecter (Outer Knob) – NAV COMP.
    - This provides control over the presentation of various displayed information on the HSI (Horizontal Situation Indicator).
11. *[WSO]* Set WSO Navigation Mode Selector Switch – UP Position (1 UHF/ADF / 2 TAC)
12. Once the UHF radio signal is detected from the emitter:
    a) *[P]* On the HSI (Horizontal Situation Indicator): Bearing to the UHF radio emitter is provided by the Bearing Pointer. Radio signal should be audible.
    b) *[WSO]* On the BDHI (Bearing Distance Heading Indicator): Needle 1 provides bearing to the UHF Radio Emitter. The BDHI is mostly used in a monitoring capacity by the WSO.
    - Note: No distance information is provided.





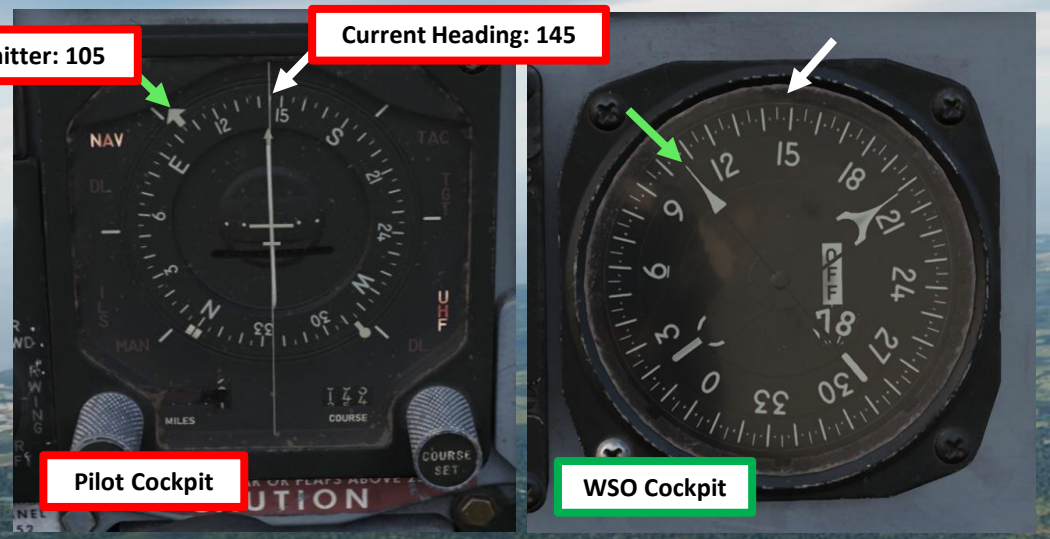






8 – ADF (AUTOMATIC DIRECTION FINDER) NAVIGATION

13. Steer the aircraft towards the UHF radio emitter using the HSI (Horizontal Situation Indicator) Bearing Pointer.



Vehicle Transmitting Radio Signal

9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)

9.1 – INS Introduction

The F-4 predated the era of modern GPS (Global Positioning System) and it needed a system to guide the aircraft on a route to a mission objective hundred miles-long, and then back to the home base. The solution to this problem took the form of an INS (Inertial Navigation System). The INS measures and integrates sensed inertia forces (acceleration) and rotational velocities to calculate aircraft position and linear velocity. The INS used on the F-4 is designated as AN/ASN-63, which provides the F-4E aircrew and integrated weapons delivery system with real time accurate positional, velocity, attitude, and heading information. The INS requires coordinates of its initial position, which means that it must be aligned either on the ground (see Start-Up Procedure – INS Alignment section).

Terminology-wise, the "**LN-12 Inertial Navigation System"** is Litton's **designation for the AN/ASN-63 Inertial Navigation Set**. The "**Nav Computer"** is the **designation for the AN/ASN-46 Navigational Computer Set**.

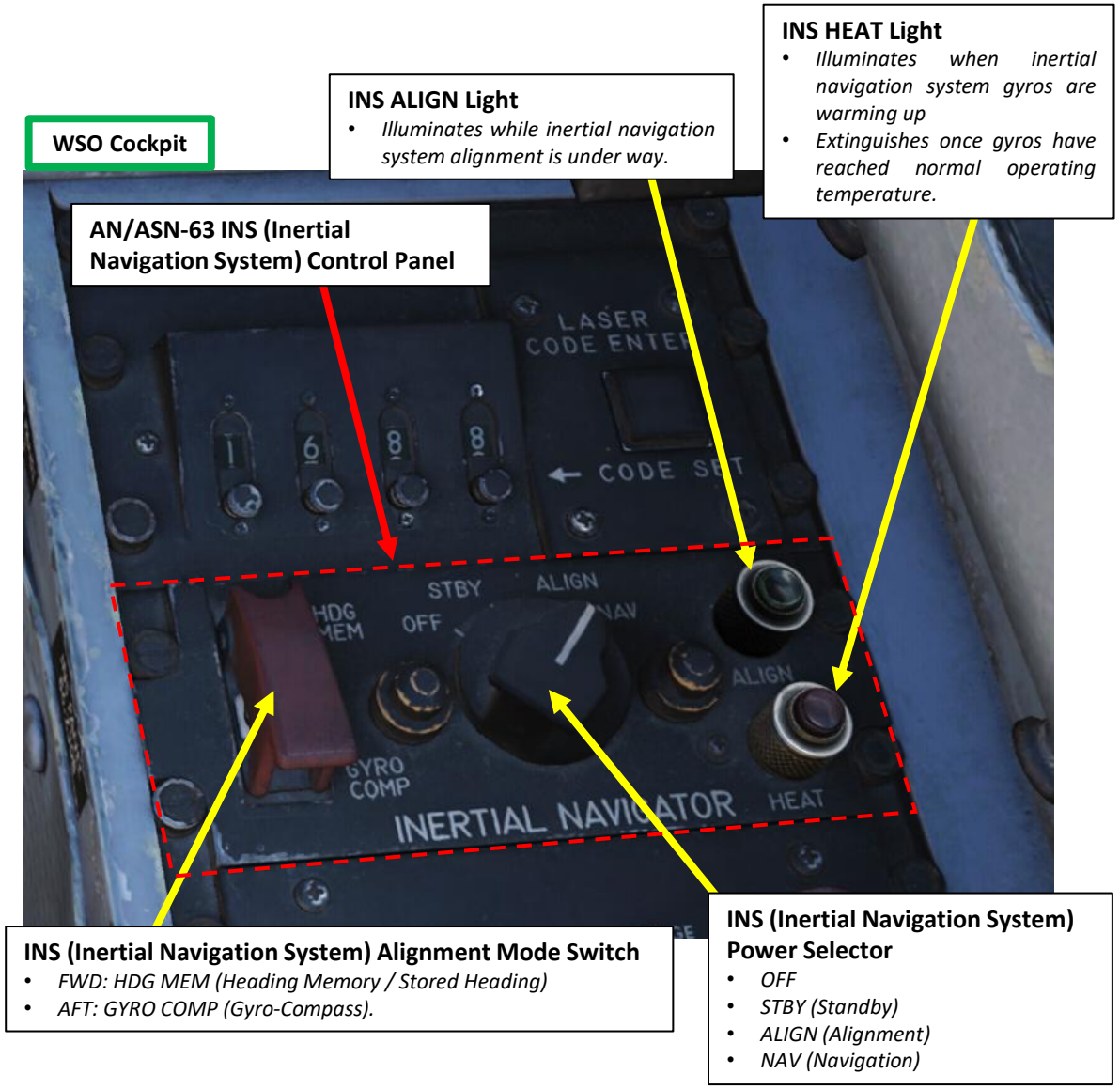
The respective captured motion signals from the gyroscopes and accelerometers are amplified in the navigational computer, which then performs the earth reference integration. The LN-12 compensates for all longitudes and can effectively track as high as 80 degrees latitude, where the mechanical limitations of calculating tangent relative to the equator is too high for the device.

The AN/ASN-63 provides information to other systems in the Phantom from the **OSDU (Output Signal Distribution Unit)**. The OSDU provides ground speed, north-south and east-west velocity, total velocity, inertially stabilized altitude, climb angle, true inertial heading, ground track, and drift angle. The WRCS (Weapon Release Computer Set) receives inertial true heading, ground track, drift correction angle, and drift angle for its ballistics computer. Drift angle is captured for the BDHI (Bearing Distance Heading Indicator), HSI (Horizontal Situation Indicator), and FDC (Flight Director Computer). Drift correction angle is also provided to the radar and LCOSS (Lead Computing Optical Sight System).

The system uses a four gimbal (outer roll, pitch, inner roll, azimuth) inertial navigating platform, with the dual roll gimbals providing redundancy to eliminate a gimbal lock in outer roll/azimuth gimbal alignment. When the system is aligned to its most precise extent in gyrocompass mode, the INS is **accurate to 3 nautical miles per hour of circular error probability (CEP).**

In real life, the limited accuracy of the INS system meant it was simply not used as a primary tool for navigation. Practically, navigation back then was still mostly planned and executed with a compass, maps, and a chronometer.

FlyAndWire has a great video showing INS Basics: https://youtu.be/JVzSWqVzbKk



9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)

9.1 – INS Introduction

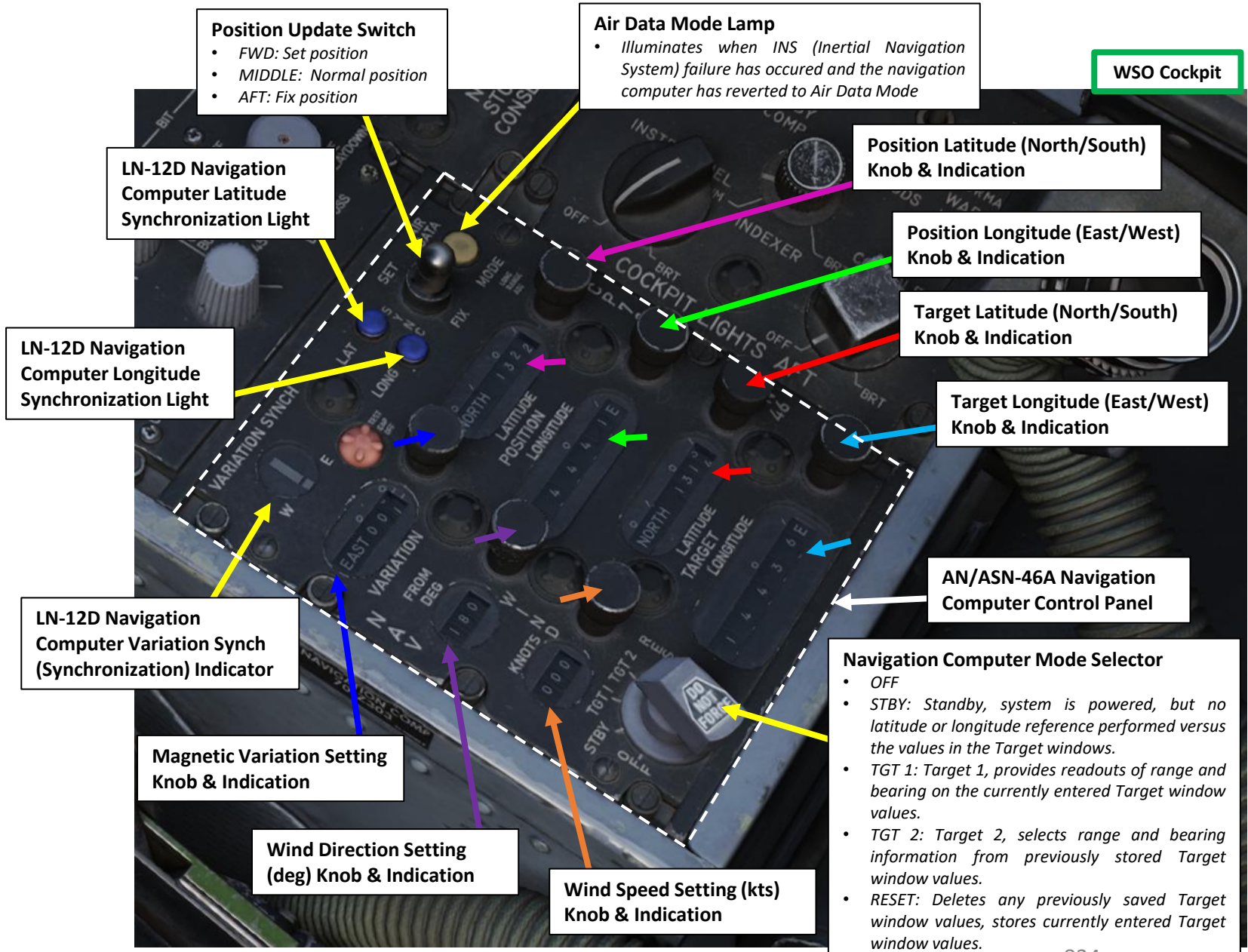
The AN/ASN-46 Navigational Computer

The ASN-46A Nav Computer is used for general navigation and tactical route planning. The system contains both a great circle and rhumb line computational capabilities, with the former being used for larger distance bearing calculations (over 120 miles), and the latter for closer range accuracy. The Nav Computer functions solely using aircraft-based instruments, ergo the INS, Air Data Computer, and the magnetic compass; it can receive no information from the ILS, VOR, or TACAN systems.

The computer also provides confirmation of current LN-12 precision, using a pair of lights marked **LAT** (Latitude) and **LONG** (Longitude), as well as the **Variation Sync Meter (Variation Synchronization Indicator)**. When these lamps are off, the current displayed position coordinates are within 1 1/2 arc minutes precision. Magnetic variation detected by way of the INS gyroscopes is compared against the manual performed prior to INS power-up via the Magnetic Variation Control knob, and displayed on the Variation Sync Meter. This deviation can be corrected on the Magnetic Variation Control Knob to bring the sync to center. Although the magnetic variation control knob has no effect on the meter in air data mode, positive correction prior to INS loss increases the air data mode precision.

The Nav Computer can function in either **Inertial mode** or **Air Data mode**. Both modes provide the same outputs but the inertial mode (default) is more accurate.

In the event of an **INS failure**, the Nav Computer reverts to Air Data mode. In Air Data mode, the rear pilot must continually monitor and adjust true wind direction and speed, magnetic variation, as the only dead reckoning inputs available to the computer is true airspeed (from the air data computer) and magnetic heading from the compass system. When the system reverts to Air Data mode, the **AIR DATA MODE** lamp will illuminate.



9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.1 – Basic Concepts

The INS can only **store/memorize coordinates for a single waypoint**. This might be confusing since your flight plan will typically have many different waypoints. In real life, the WSO keeps a copy of the flight plan on paper with the coordinates for each waypoint. The coordinates will have to be manually updated in the INS every time you want to navigate to another waypoint.

The **Navigation Computer Mode Selector** has the following operating modes:

- **TGT 1**: This mode will navigate towards coordinates currently set on the Nav Computer panel. These coordinates can be changed on the fly and are not memorized.
- **TGT 2**: This mode will navigate towards waypoint coordinates memorized in the nav computer.
- **RESET**: This spring-loaded position loads the coordinates entered on the Nav Computer panel into the waypoint of the INS, resetting existing waypoint coordinates and memorizing the new coordinates in the process. The selector must be set to this position when updating the memorized coordinates used by TGT 2 mode.
- **STANDBY**: System is powered but inactive.

TGT 1 and TGT 2 do not refer to Waypoint/Target No. 1 and Target/Waypoint No. 2; this actually refers to what mode the INS is operating in. There is only one waypoint memorized in the INS database.

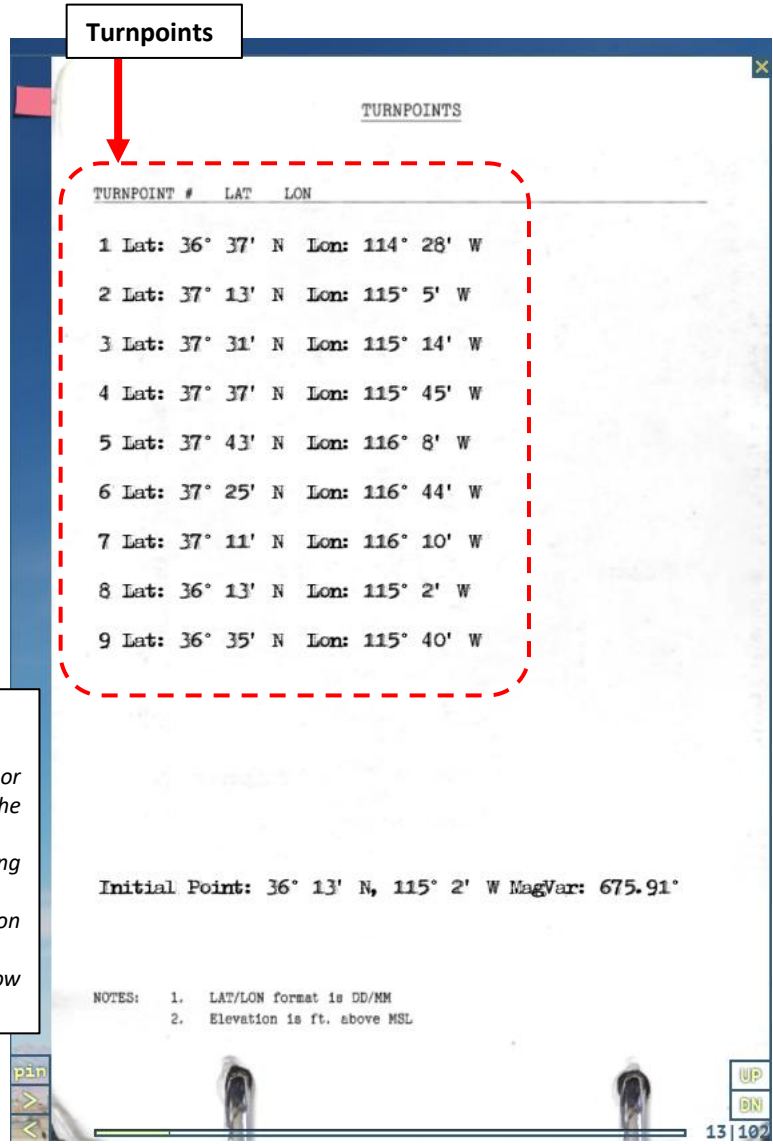
In practice, what JESTER does (and what real Phantom WSOs did) is to use TGT 1 mode (i.e. what coordinates are currently set on the panel) for any quick deviation from the flight plan, or for a reference point like Bullseye. While TGT 2 mode was used to memorize the "next waypoint" in the flight plan. Meaning, when you arrive to your designated waypoint, you have to enter and "load" (RESET position) the next waypoint coordinates into TGT 2. This is referred to as "leapfrogging".

JESTER will abstract from the technical quirks of this panel and provide you with a more modern and understandable UI, where you can simply tell him your flight plan and command him to quickly navigate elsewhere, while he will take care of working his panel to serve your request.



Navigation Computer Mode Selector

- *OFF*
- *STBY: Standby, system is powered, but no latitude or longitude reference performed versus the values in the Target windows.*
- *TGT 1: Target 1, provides readouts of range and bearing on the currently entered Target window values.*
- *TGT 2: Target 2, selects range and bearing information from previously stored Target window values.*
- *RESET: Deletes any previously saved Target window values, stores currently entered Target window values.*



9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.1 – Basic Concepts

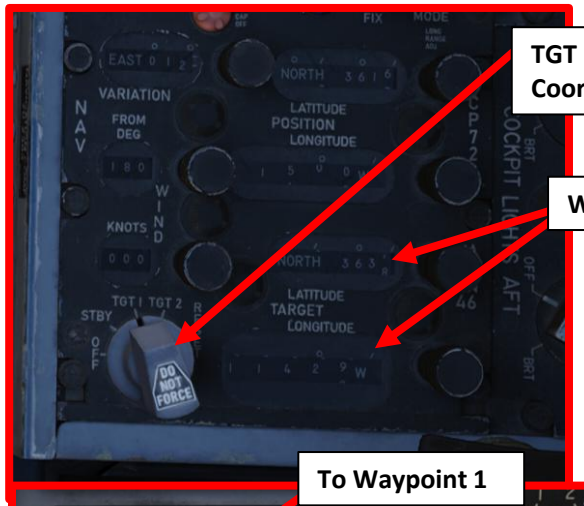
Alternating between TGT 1 and TGT 2 mode can allow you quickly switch between two targets or navigation points. TGT 1 will track what coordinates are currently on the nav computer panel (which can be modified at any time), while TGT 2 will track the last memorized coordinates when the mode selector knob was last set to RESET.

To illustrate the difference between TGT 1 and TGT 2 mode, here is a quick example. Coordinates entered on the Nav Computer panel are for Waypoint 1, while coordinates memorized for TGT 2 mode have already been previously set to Waypoint 5.

Waypoint 1 Coordinates

TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W

Waypoint 5 Coordinates (Memorized in INS)

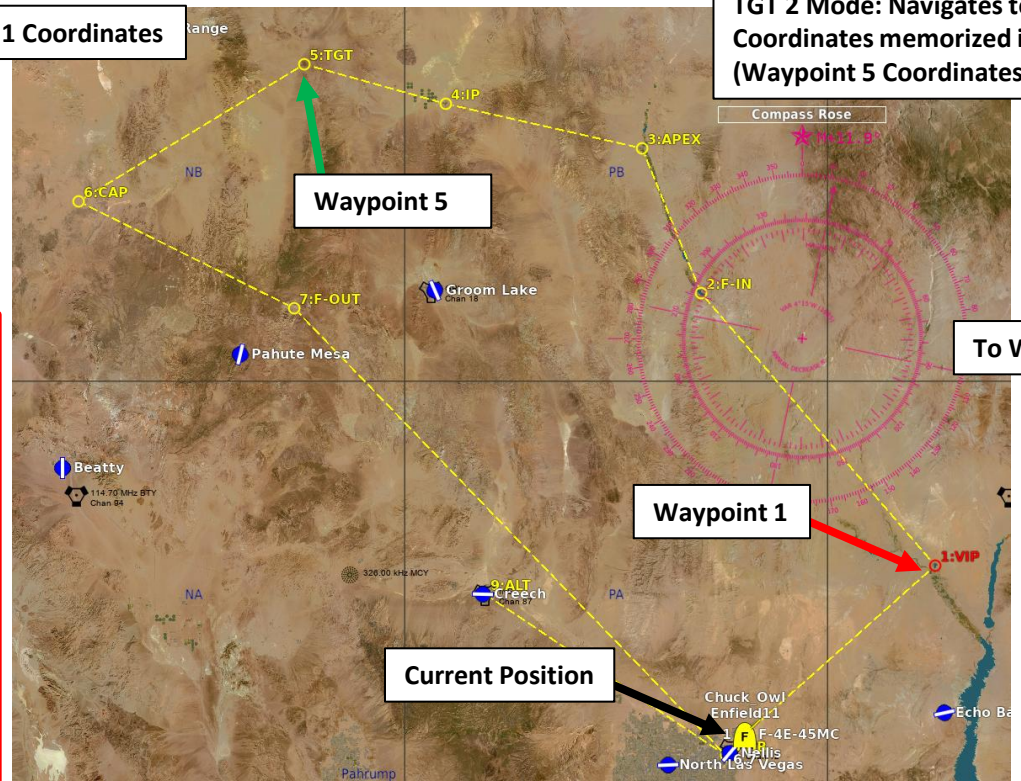


TGT 1 Mode: Navigates to Coordinates on Nav Computer Panel

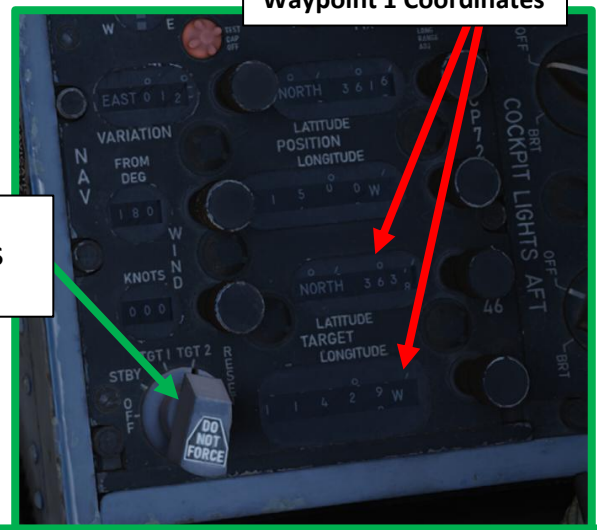
Waypoint 1 Coordinates



To Waypoint 1



TGT 2 Mode: Navigates to Coordinates memorized in the INS (Waypoint 5 Coordinates)



Waypoint 1 Coordinates



To Waypoint 5

9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.2 – Navigation using TGT 1 Mode

In this example, we want to navigate to the coordinates of Waypoint 2.

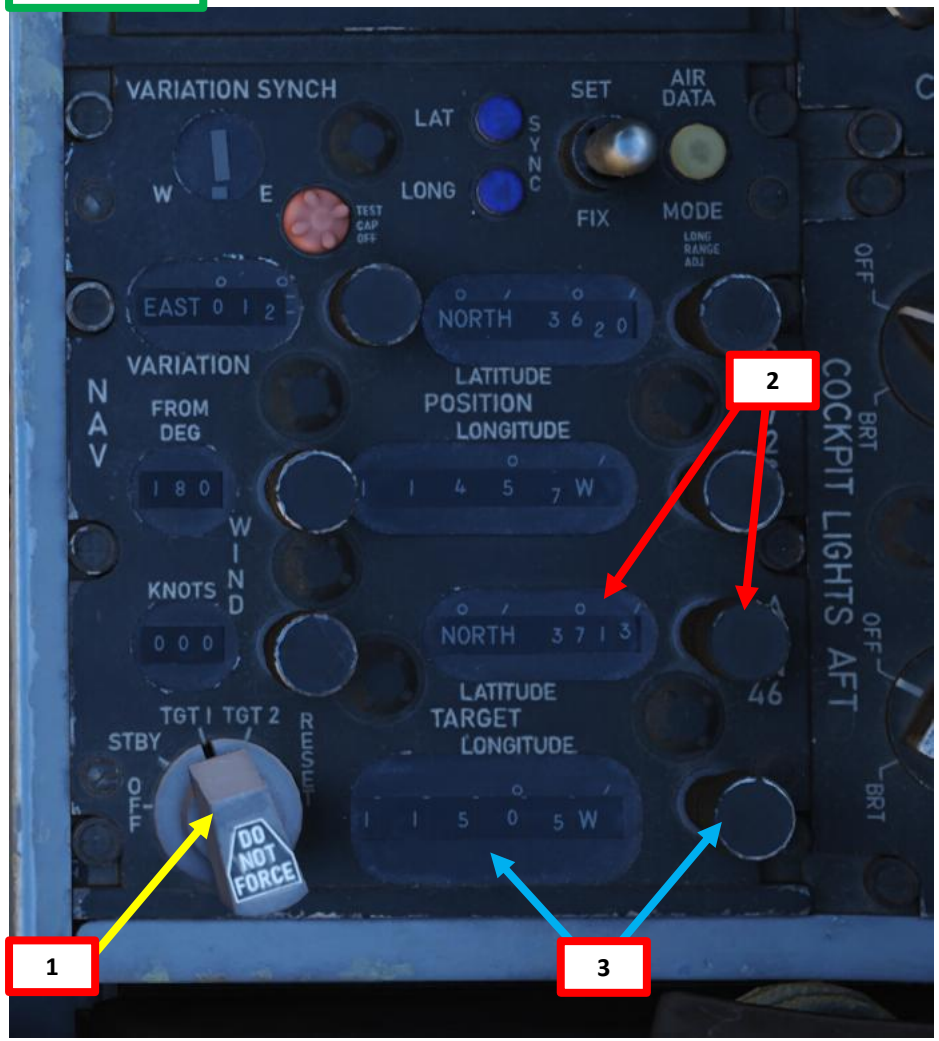
Waypoint 2 Coordinates (degrees, minutes): 37 deg 13 min North / 115 deg 05 min West

1. *[WSO]* Set Navigation Computer Mode Selector – TGT 1 Mode.
2. *[WSO]* Rotate TARGET LATITUDE position knob (scroll mousewheel) to **37 deg 13 min North**
3. *[WSO]* Rotate TARGET LONGITUDE position knob (scroll mousewheel) to **115 deg 05 min West**
4. *[WSO]* TGT 1 Mode uses the coordinates set for the Target Latitude/Longitude entered on the Nav Computer Panel as a reference. These **coordinates are not stored or memorized in the INS**.

Waypoint 2 Coordinates

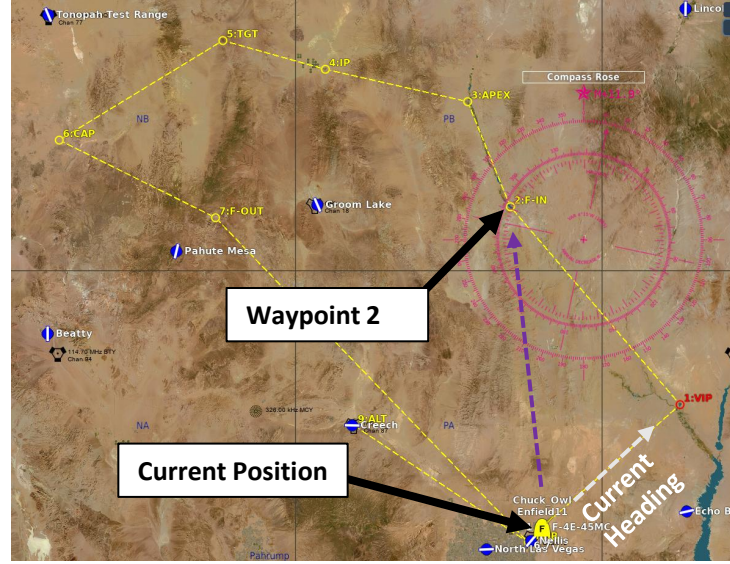
TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W

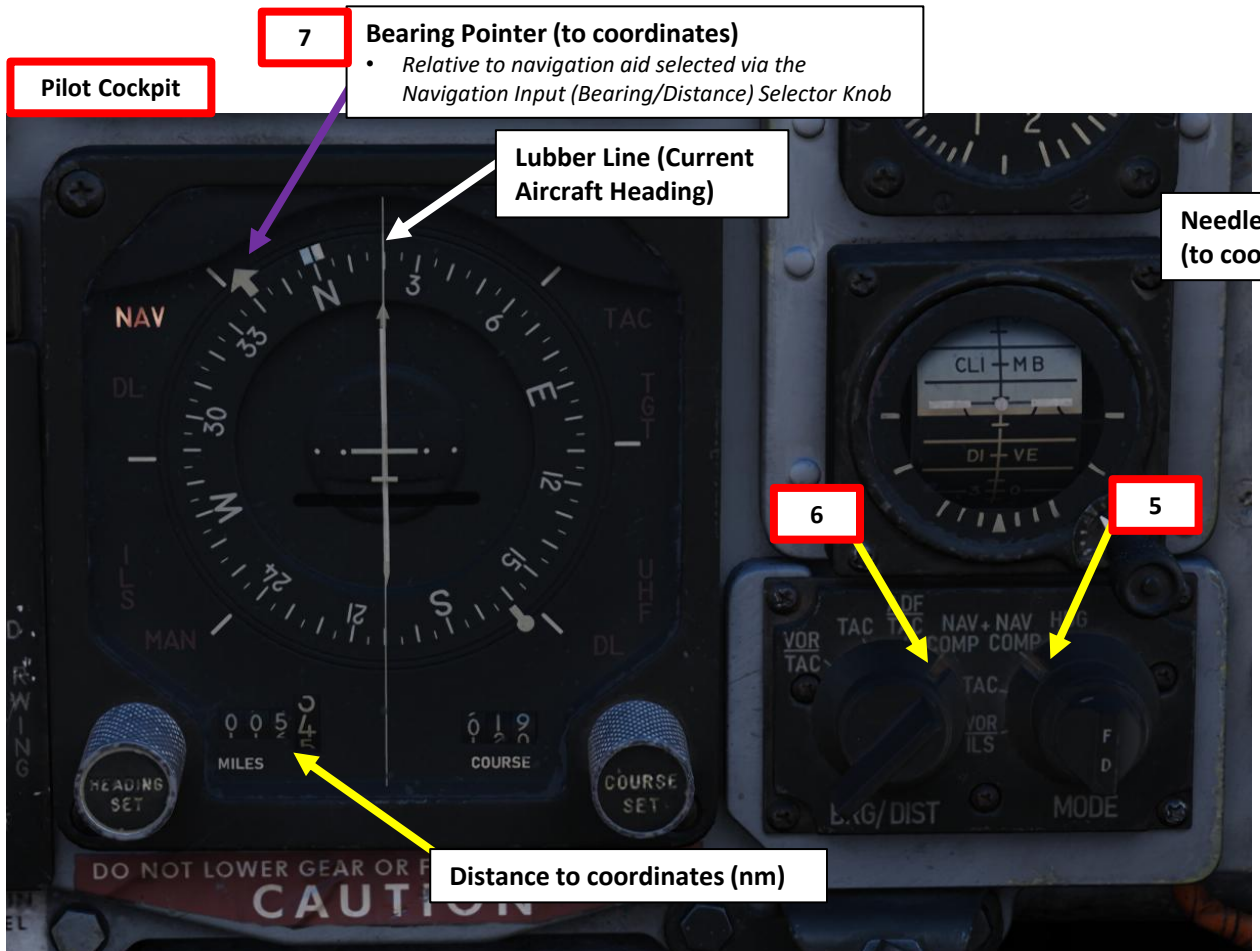
WSO Cockpit

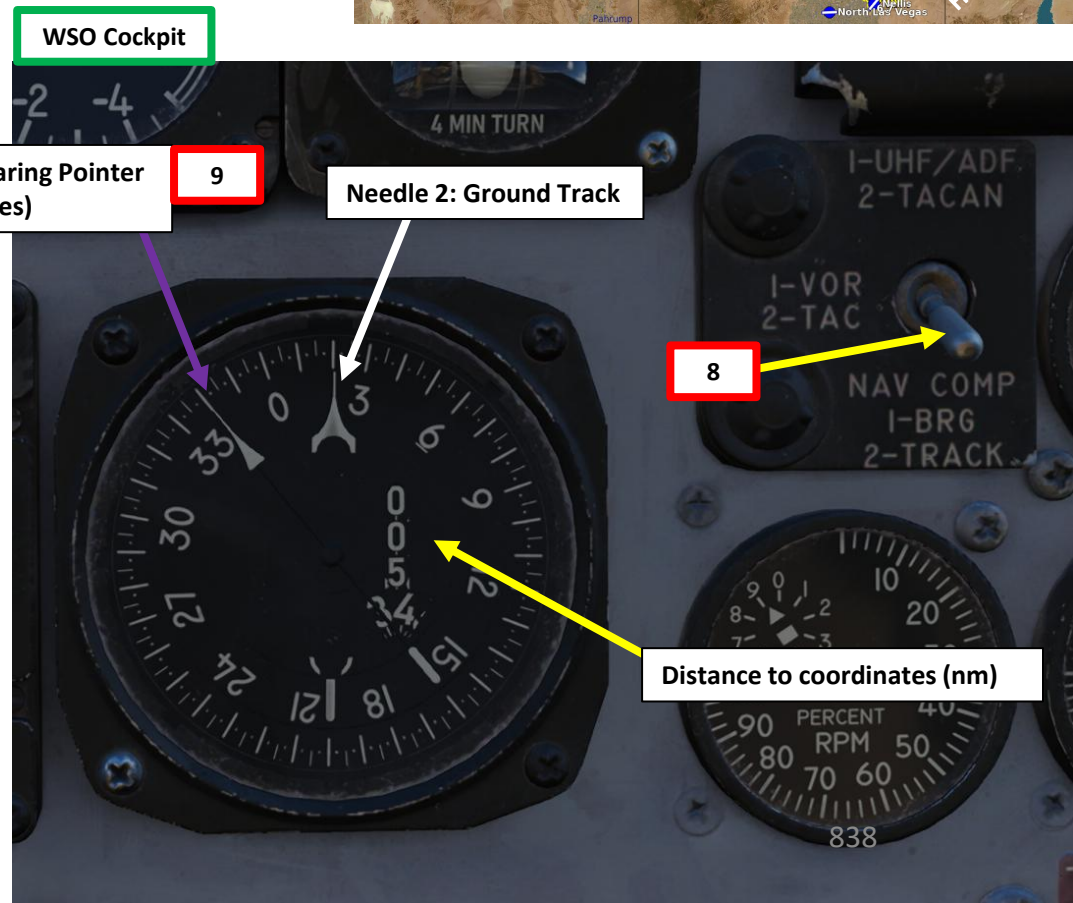


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.2 – Navigation using TGT 1 Mode

5. *[P]* Set Navigation Mode Selector (Outer Knob) – NAV COMP (Navigation Computer)
6. *[P]* Set Navigation Input Selector – NAV COMP (Navigation Computer).
7. *[P]* On HSI (Horizontal Situation Indicator), navigate by following the Bearing Pointer towards the nav computer coordinates.
8. *[WSO]* Set Navigation Input Selector Switch – DOWN position.
    - Needle 1: Navigation Computer Mode: Bearing to nav computer coordinates
    - Needle 2: Navigation Computer Mode: Ground Track
9. *[WSO]* On BDHI (Bearing Distance Heading Indicator), Needle 1 is used to navigate towards the nav computer coordinates.

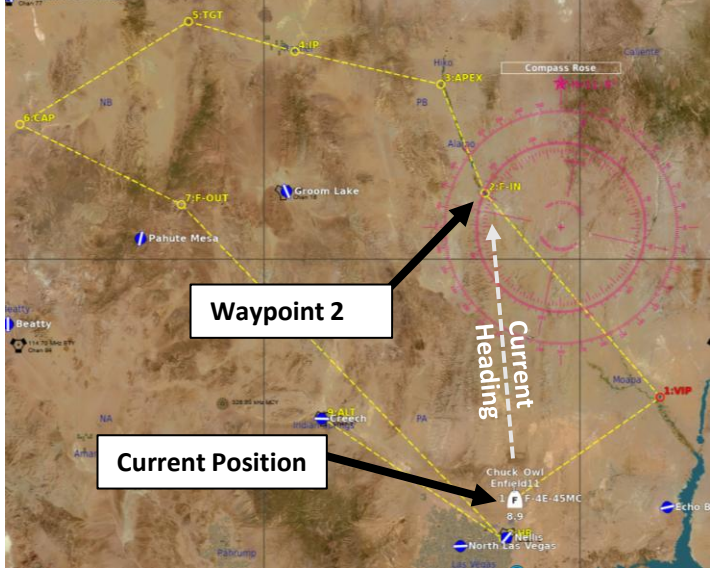






9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.2 – Navigation using TGT 1 Mode







9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.3 – Navigation using TGT 2 Mode (Stored Coordinates)

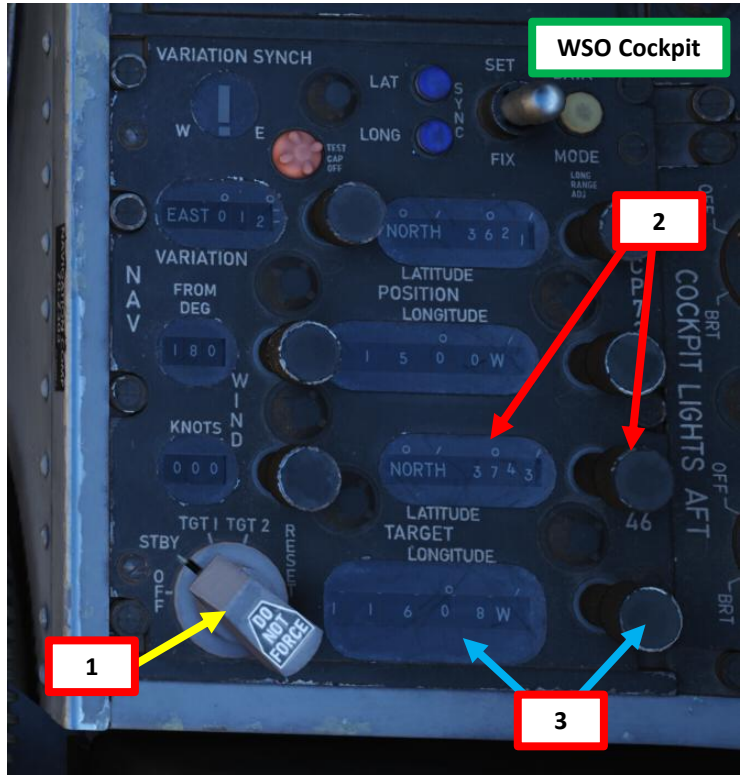
In this example, we want to navigate to Waypoint 5. We will first store the waypoint's coordinates in the INS, then select TGT 2 Mode to steer the aircraft towards these stored coordinates.

Waypoint 5 Coordinates (degrees, minutes): 37 deg 43 min North / 116 deg 08 min West

1. *[WSO]* Set Navigation Computer Mode Selector – STBY (Standby).
2. *[WSO]* Rotate TARGET LATITUDE position knob (scroll mousewheel) to **37 deg 43 min North**
3. *[WSO]* Rotate TARGET LONGITUDE position knob (scroll mousewheel) to **116 deg 08 min West**
4. *[WSO]* Set Navigation Computer Mode Selector – RESET position. This stores the coordinates from the Nav Computer panel into the Inertial Navigation System's only waypoint.
5. *[WSO]* Set Navigation Computer Mode Selector – TGT 2 position. This mode will guide the aircraft towards the coordinates stored in the previous step.
6. *[WSO]* Waypoint 5 Coordinates are now memorized/stored in the Inertial Navigation System. Keep in mind that the INS can only store a single waypoint at a time.

TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W

Waypoint 5 Coordinates

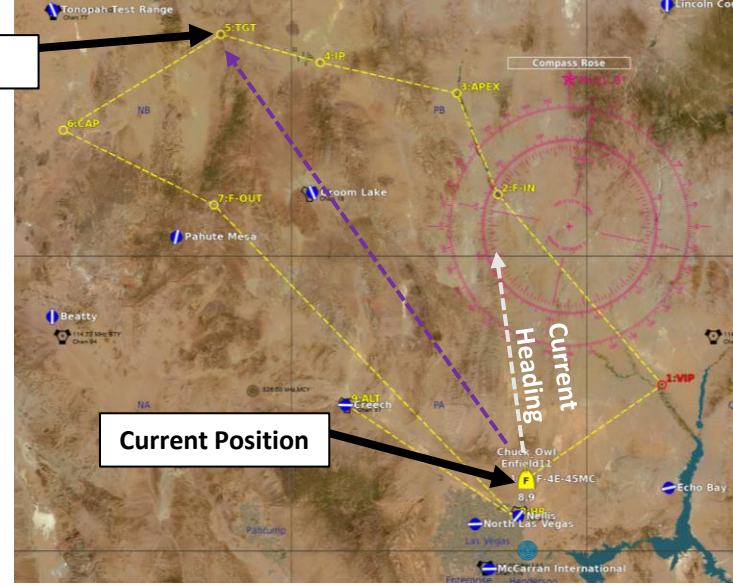






9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.3 – Navigation using TGT 2 Mode (Stored Coordinates)

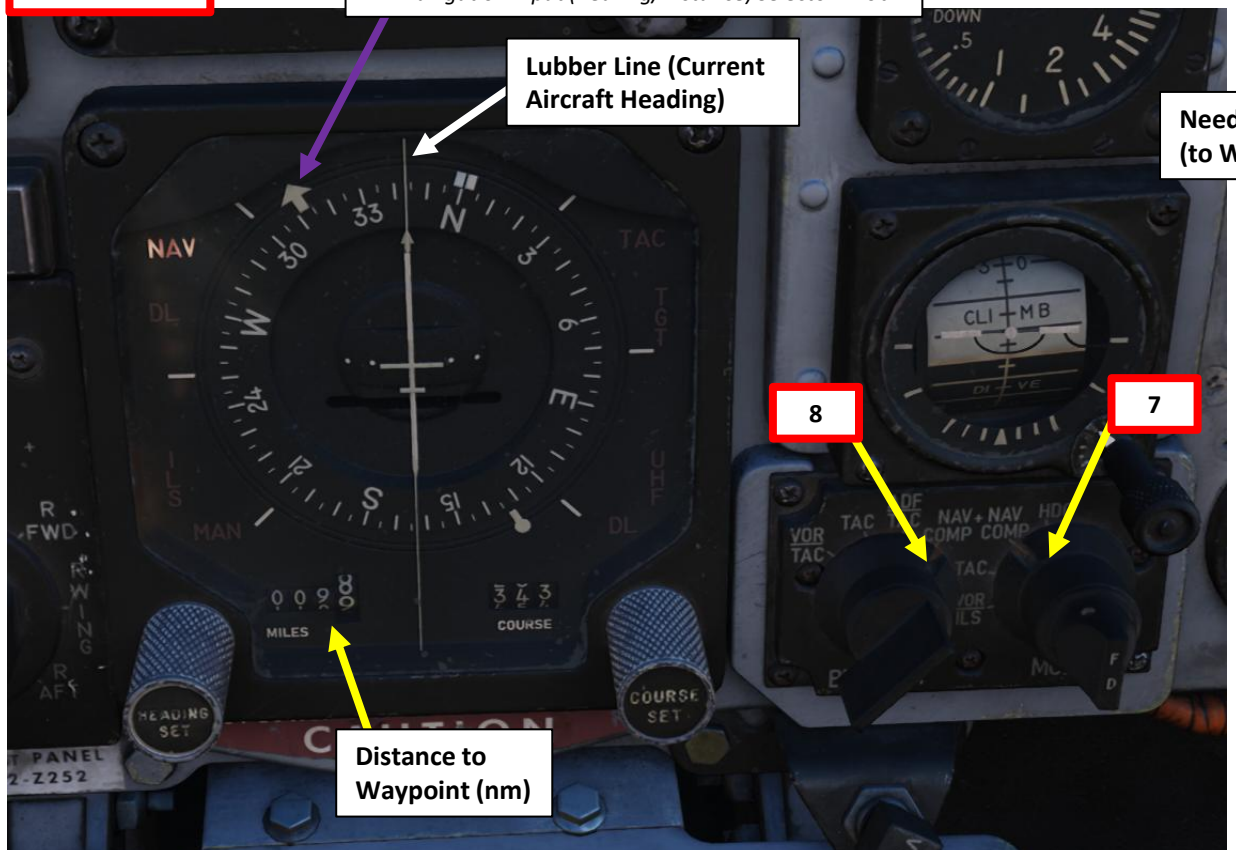
7. *[P]* Set Navigation Mode Selector (Outer Knob) – NAV COMP (Navigation Computer)
8. *[P]* Set Navigation Input Selector – NAV COMP (Navigation Computer).
9. *[P]* On HSI (Horizontal Situation Indicator), navigate by following the Bearing Pointer towards the waypoint.
10. *[WSO]* Set Navigation Input Selector Switch – DOWN position.
    - Needle 1: Navigation Computer Mode: Bearing to Waypoint
    - Needle 2: Navigation Computer Mode: Ground Track
11. *[WSO]* On BDHI (Bearing Distance Heading Indicator), Needle 1 is used to navigate towards the waypoint.



Pilot Cockpit

9 **Bearing Pointer (to Waypoint)**
- *Relative to navigation aid selected via the Navigation Input (Bearing/Distance) Selector Knob*

Lubber Line (Current Aircraft Heading)

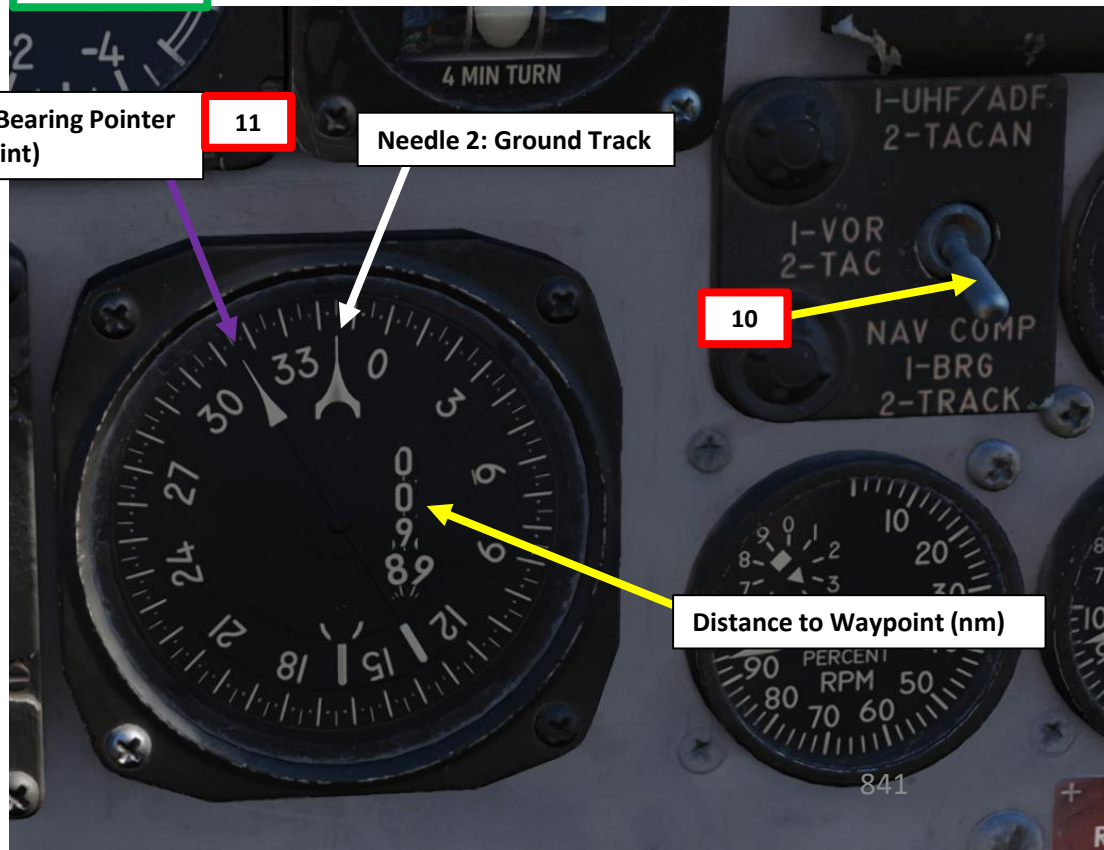


Distance to Waypoint (nm)

WSO Cockpit

Needle 1: Bearing Pointer (to Waypoint) 11

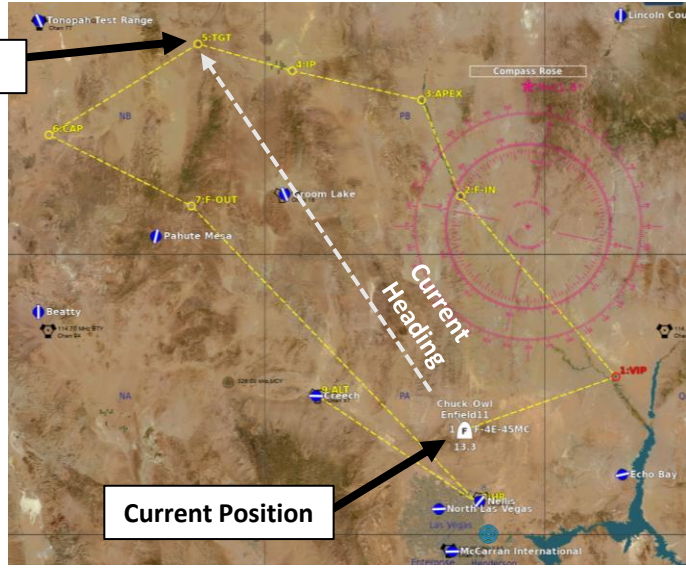
Needle 2: Ground Track

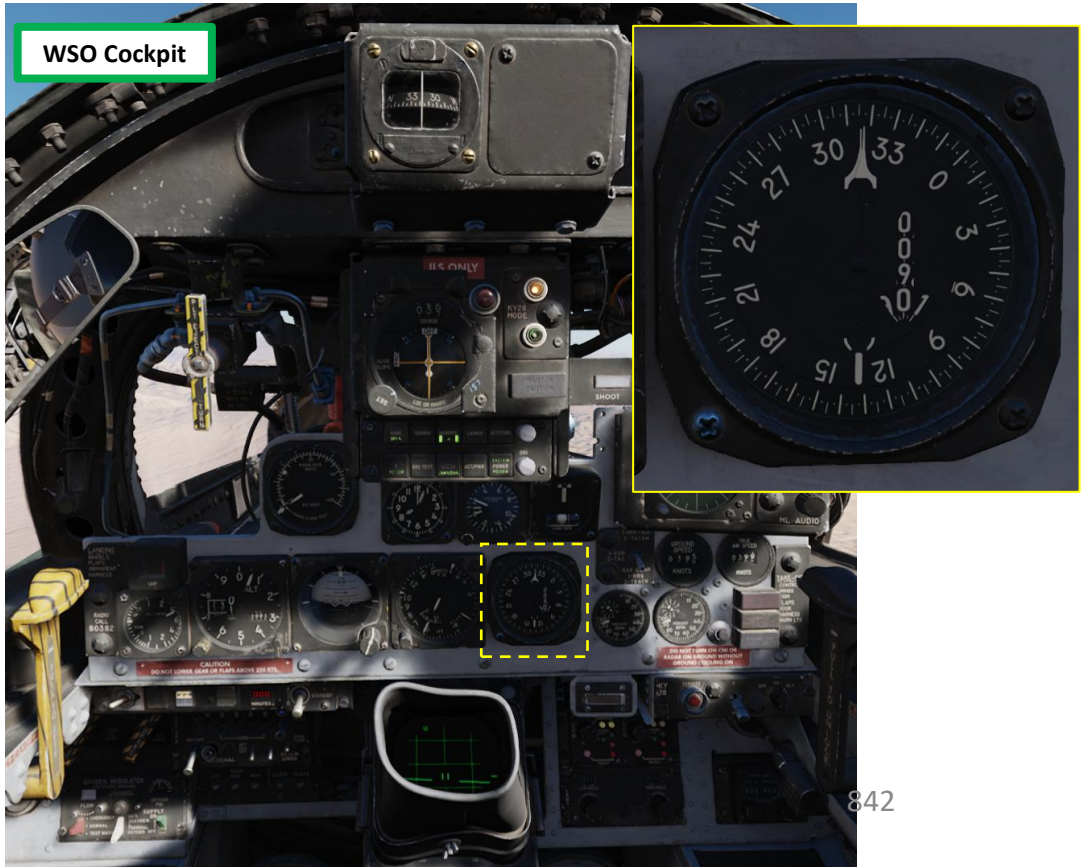


Distance to Waypoint (nm)

9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.3 – Navigation using TGT 2 Mode (Stored Coordinates)





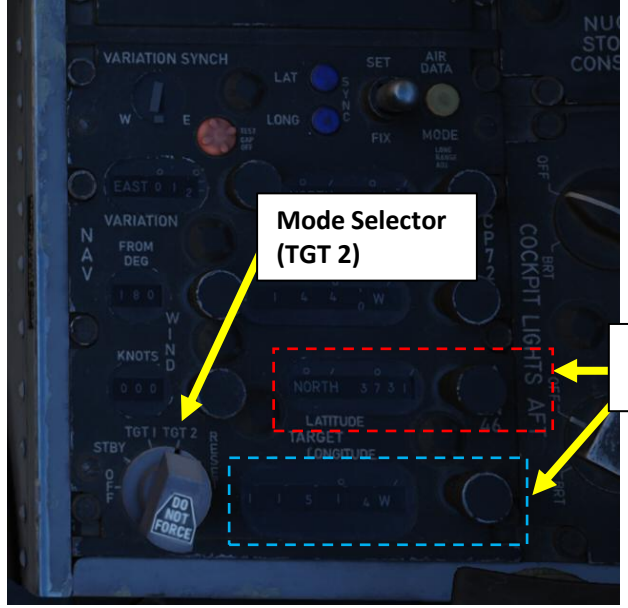


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.4 – Leapfrogging Technique

Since the INS database memory is limited to a single waypoint, a technique called "leapfrogging" is used when navigating through a flight plan with multiple waypoints. The concept is rather simple: find a way to switch between waypoints quickly by setting in advance the coordinates of the next waypoint on the Nav Computer panel while navigating to the coordinates stored for the current waypoint. This enables the pilot to follow the entire route of the flight plan by selecting NAV COMP on the Navigation Function Selector panel and following the corresponding indication on the HSI (Horizontal Situation Indicator) and BDHI (Bearing Distance Heading Indicator). This technique is used by JESTER AI automatically, but this section aims to show a real WSO how to do it.

Remember: TGT 2 Mode memorizes waypoint coordinates. When leapfrogging, TGT 2 mode always indicates the next turn point of the current active flight plan. As the aircraft approaches this turn point (+/- 2 nm), the WSO updates TGT 2 to the next turn point in the sequence (JESTER will automatically do this).

- **FlyAndWire Video on Leapfrogging**: https://youtu.be/qLsjU9eWUuU
- **FlyAndWire Article**: https://flyandwire.com/2025/01/30/f-4e-leap-frog-operations/

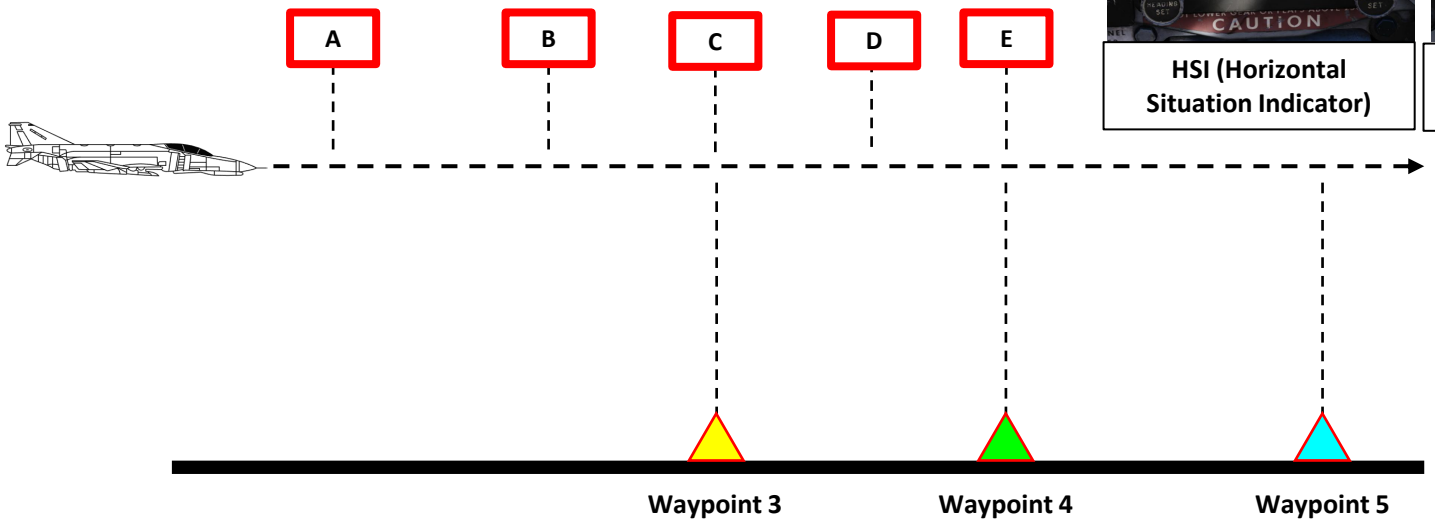




HSI (Horizontal Situation Indicator)



BDHI (Bearing Distance Heading Indicator)



Time: Phase A
- *TGT 2 Mode Selected*
- *Nav Computer Panel Input: Waypoint 3 Coordinates*
- *Stored Coordinates (INS): Waypoint 3*
- *HSI/BDHI Steer To: Waypoint 3*

Time: Phase B
- *TGT 2 Mode Selected*
- *Nav Computer Panel Input: Waypoint 4 Coordinates*
- *Stored Coordinates (INS): Waypoint 3*
- *HSI/BDHI Steer To: Waypoint 3*

Time: Phase C
- *RESET Mode Selected, then return to TGT 2 Mode*
- *Nav Computer Panel Input: Waypoint 4 Coordinates*
- *Stored Coordinates (INS): Waypoint 4*
- *HSI/BDHI Steer To: Waypoint 4*

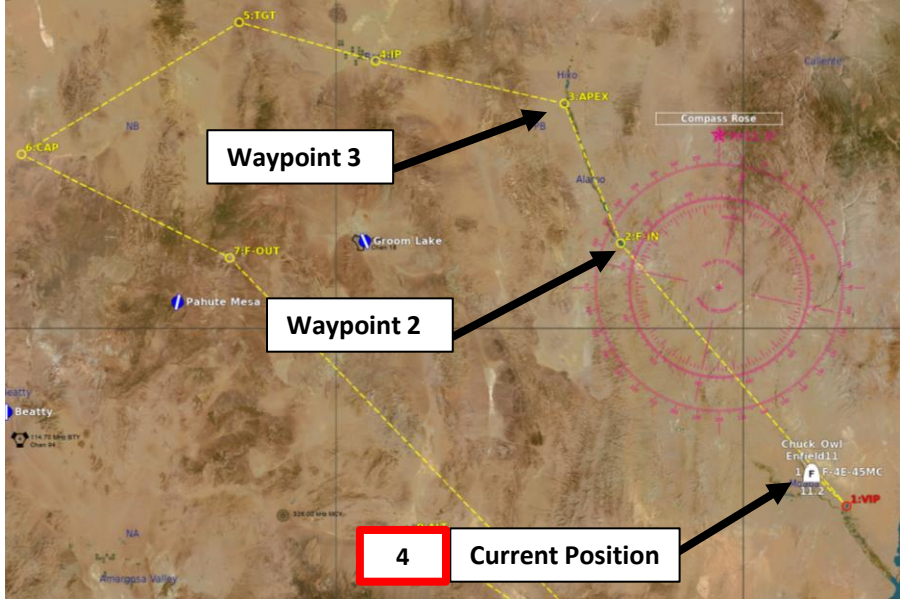
Time: Phase D
- *TGT 2 Mode Selected*
- *Nav Computer Panel Input: Waypoint 5 Coordinates*
- *Stored Coordinates (INS): Waypoint 4*
- *HSI/BDHI Steer To: Waypoint 4*

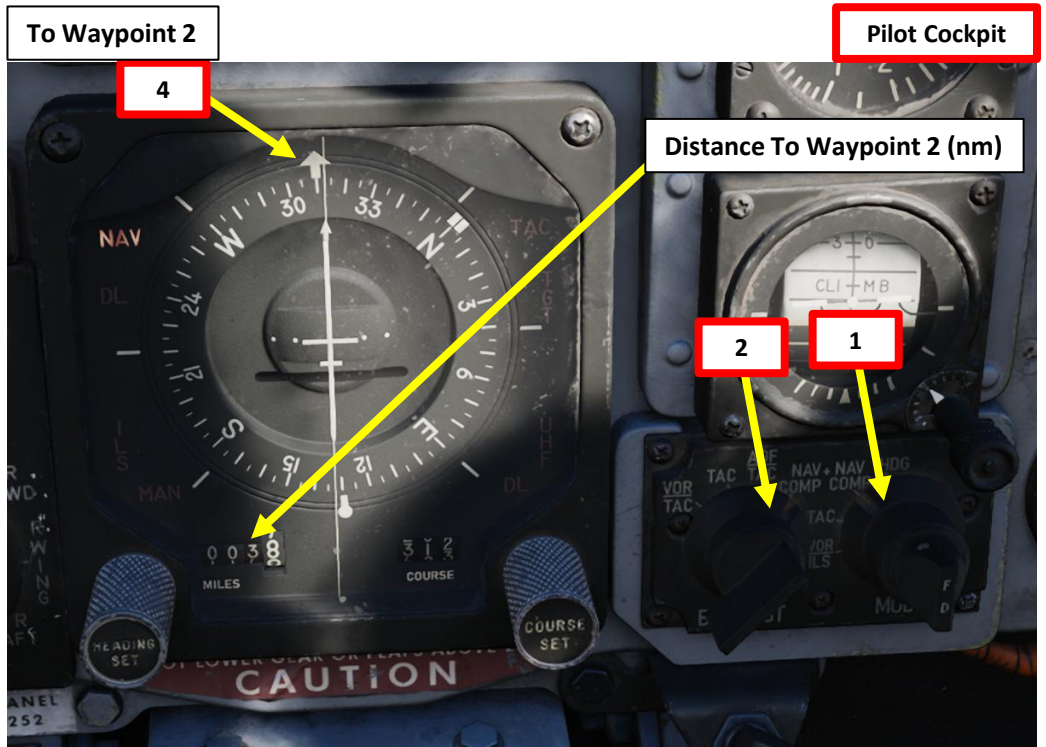
Time: Phase E
- *RESET Mode Selected, then return to TGT 2 Mode*
- *Nav Computer Panel Input: Waypoint 5 Coordinates*
- *Stored Coordinates (INS): Waypoint 5*
- *HSI/BDHI Steer To: Waypoint 5*

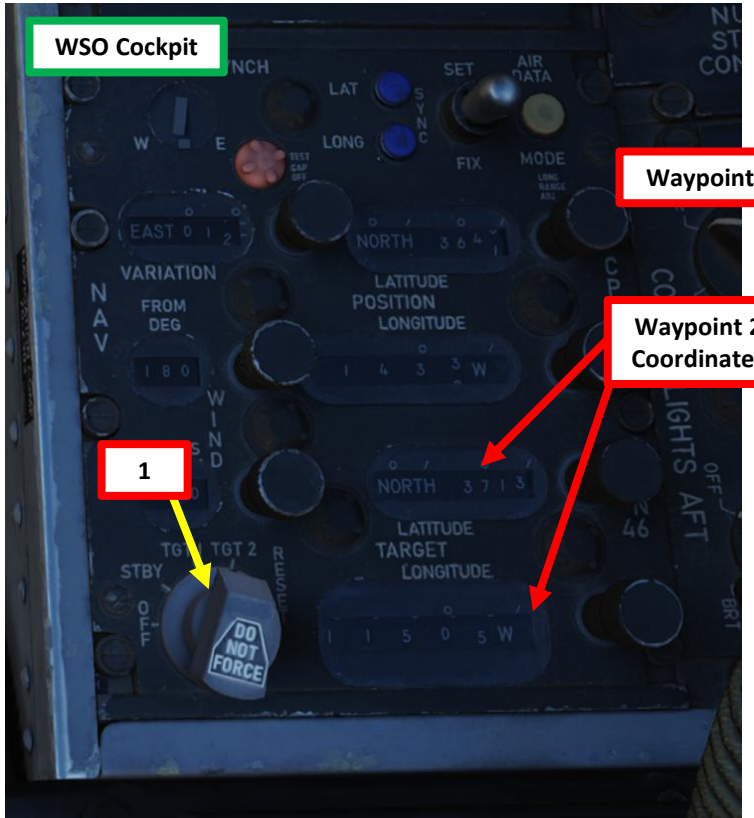
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.4 – Leapfrogging Technique

How is it used in practice, though? Here is an example.

1. *[P]* Set Navigation Mode Selector (Outer Knob) – NAV COMP (Navigation Computer)
2. *[P]* Set Navigation Input Selector – NAV COMP (Navigation Computer).
3. *[WSO]* Set Navigation Computer Mode Selector – TGT 2.
4. *[P]* On HSI (Horizontal Situation Indicator), navigate by following the Bearing Pointer, which points towards the last stored/memorized coordinates in the INS, which are the coordinates of Waypoint 2 in this example.







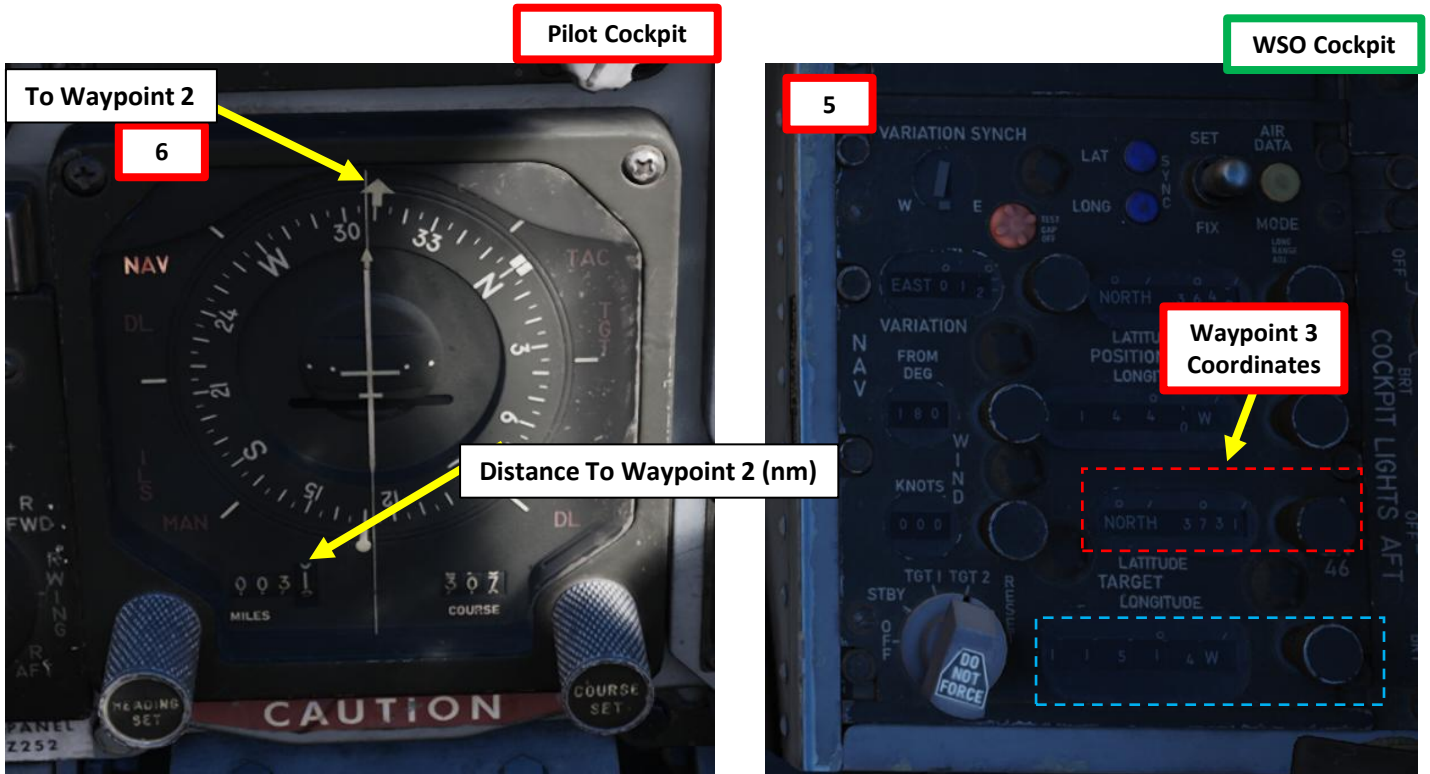
TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W

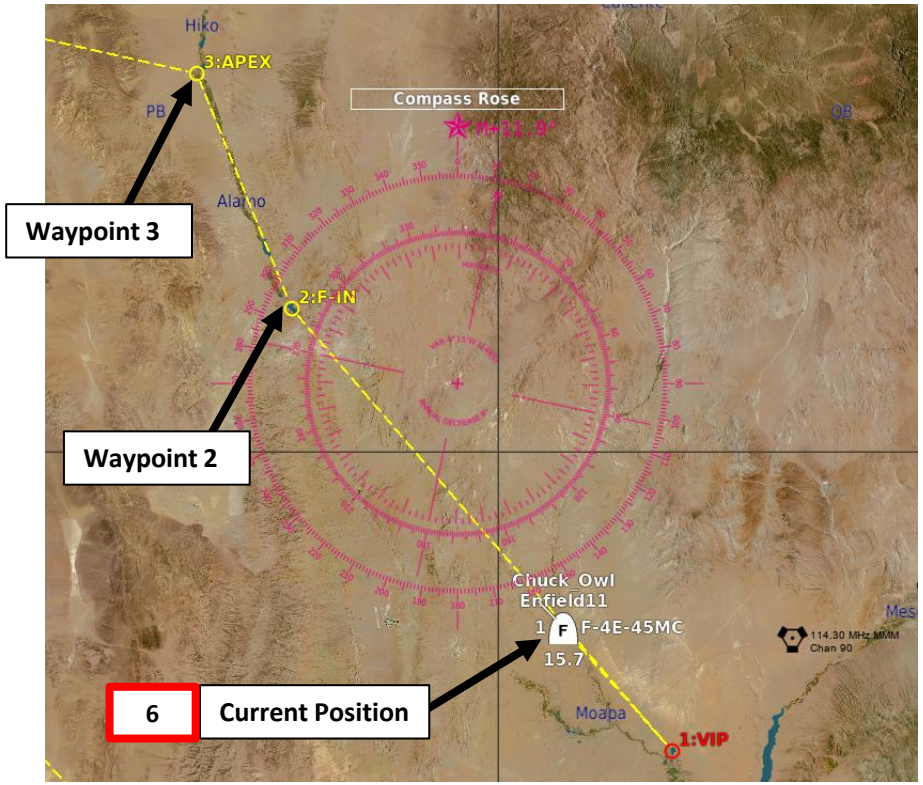
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.4 – Leapfrogging Technique

5. *[WSO]* On Navigation Computer Panel, set Target Latitude and Target Longitude for the next Waypoint (No. 3).
   - Rotate TARGET LATITUDE position knob (scroll mousewheel) to **37 deg 31 min North**
   - Rotate TARGET LONGITUDE position knob (scroll mousewheel) to **115 deg 14 min West**
6. Even if Waypoint 3 coordinates are entered on the Navigation Computer Panel, having TGT 2 Mode selected means that the navigation system will keep tracking the last memorized coordinates, which are still the coordinates of Waypoint 2.

TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W

Waypoint 3



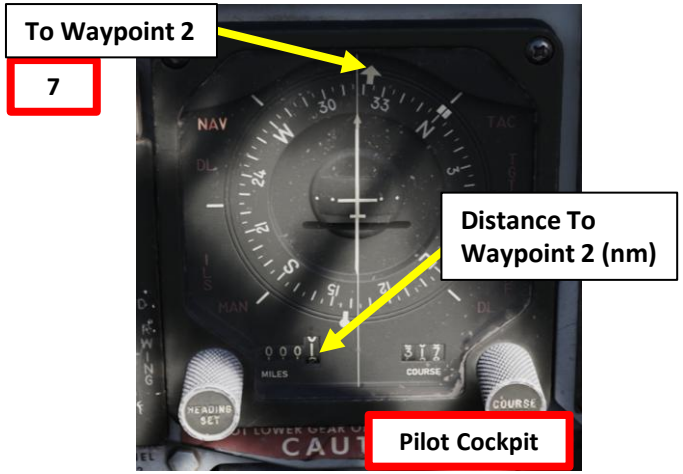


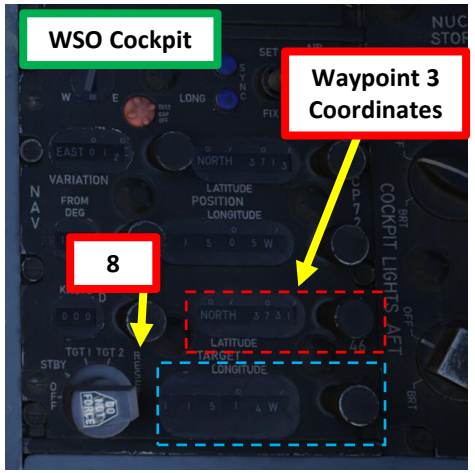
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.2 – Waypoints
9.2.4 – Leapfrogging Technique

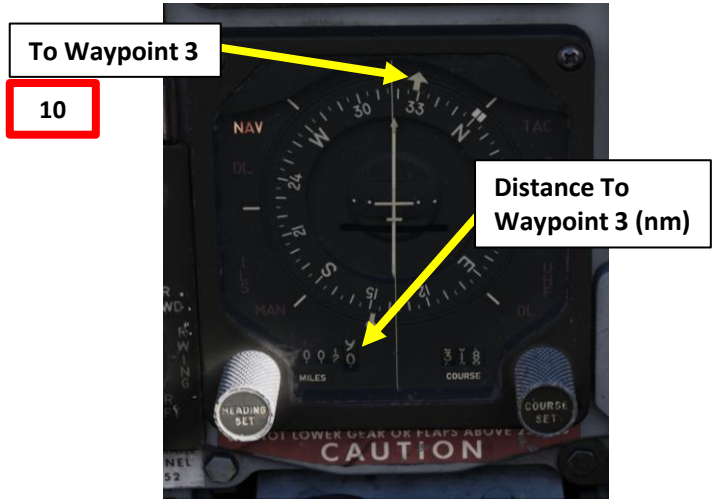
7. *[WSO]* When you are near Waypoint 2 (+/- 2 nm), the crew should get ready to navigate towards the next waypoint (Waypoint 3).
8. *[WSO]* Set Navigation Computer Mode Selector – RESET. This stores the coordinates from the Nav Computer panel (Waypoint 3) into the Inertial Navigation System's only waypoint.
9. *[WSO]* Set Navigation Computer Mode Selector – TGT 2.
10. *[P]* And voila! On HSI (Horizontal Situation Indicator), navigate by following the Bearing Pointer, which now points towards the last stored/memorized coordinates in the INS, which are the coordinates of Waypoint 3. Your WSO can then start preparing the coordinates for the next waypoint on the Nav Computer panel as shown in step 5.

TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W

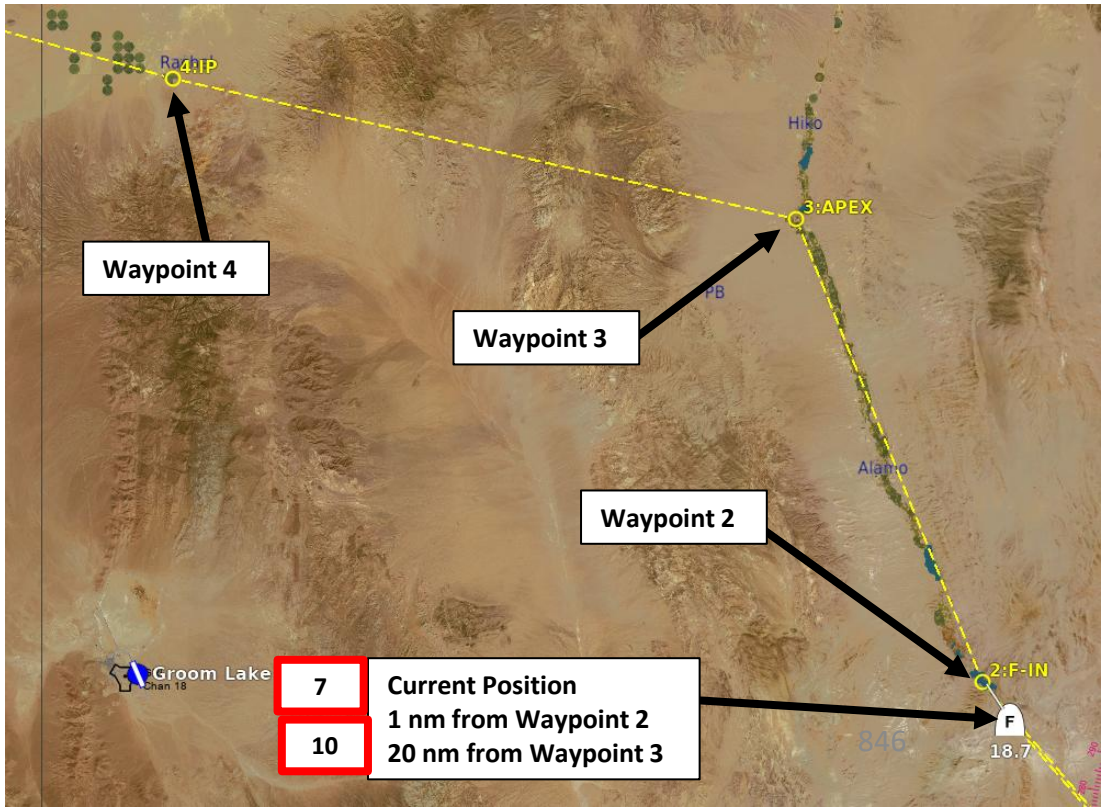
Waypoint 3









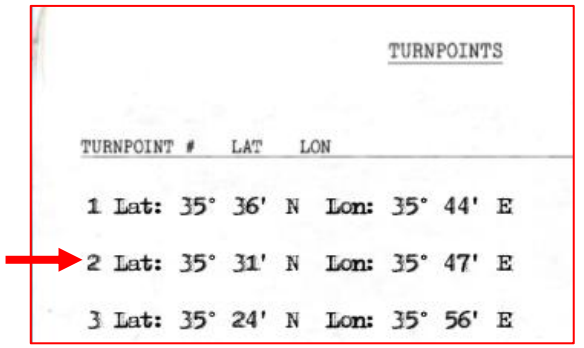


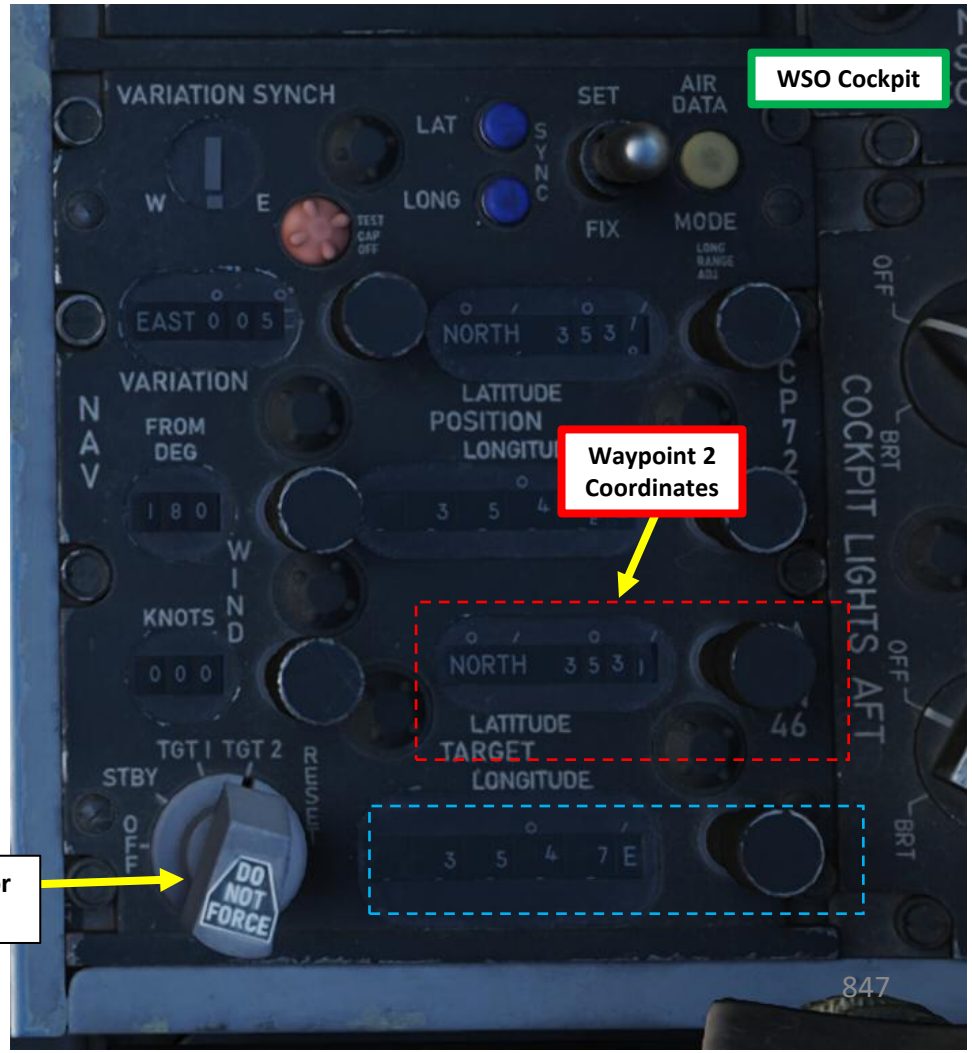
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.1 – INS Drift

The INS suffers drift due to measurement errors that accumulate with time. due to imprecise sensors (gyroscopes and accelerometers) and due to the limitations of calculation methods. A cumulative error in coordinate calculations can be up to a few nautical miles after 1 hour of flight. Errors in coordinate calculations will affect flight path and determination of target locations, especially if the pilot uses waypoints to navigate. To compensate for these errors, they need to be corrected. You will start noticing inertial drift once the coordinates of your waypoints do not seem to match what you see outside the cockpit.

The F-4's INS generates a drift error of about 3 miles of circular error probability (CEP) for every hour of flight. This can add up quickly, especially since dogfighting and manoeuvering increases the error even more!

In order to update/re-align the INS position in-flight, a pilot uses reference points such as known landmark, TACAN station or something easy to spot visually. These reference points are called **fixed points (or "fix")**, Fixed points, which are similar in nature to waypoints (basically, a set of coordinates for a navigation point), are used to re-align your INS. Typically, you want to have these fixed points set up before entering a combat zone.





Navigation Computer Mode Selector (TGT 2 Mode)

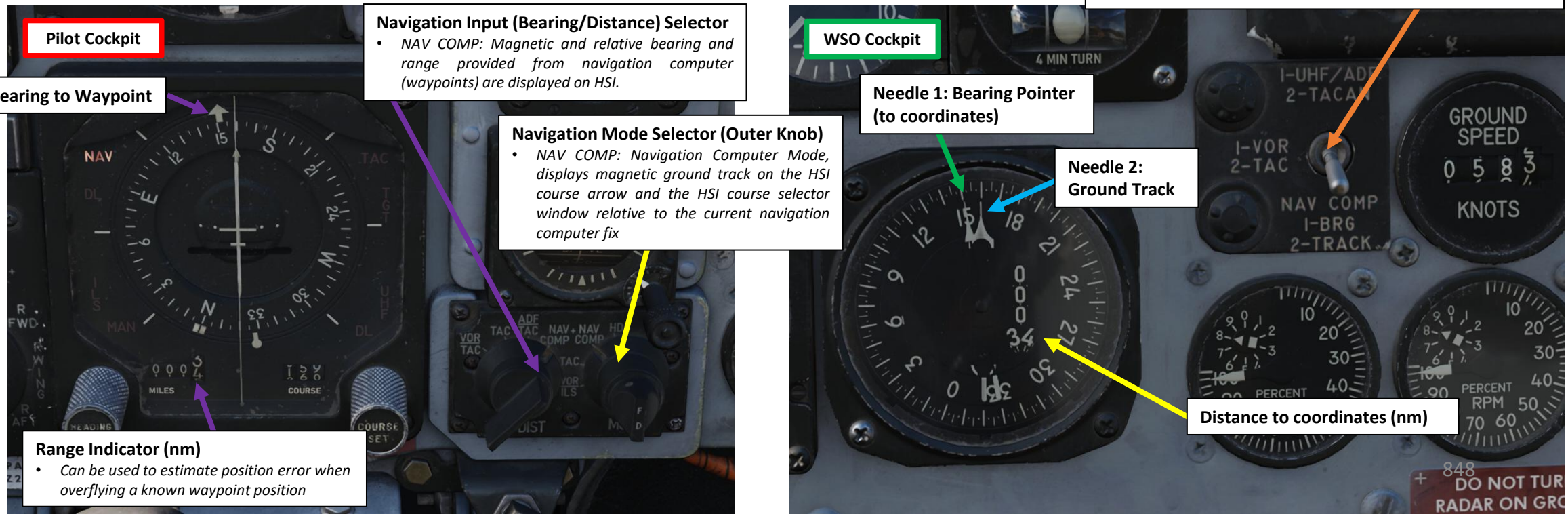
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.1 – INS Drift

How do you know when to re-align, though? Well, one quick way is to select an existing waypoint as a navigation fix point; its coordinates should set on a visual landmark. When overflying this landmark, setting both **the Navigation Input (Bearing/Distance) Selector** and **the Navigation Mode Selector (Outer Knob) to NAV COMP** indicates the INS-computed distance between the aircraft and selected waypoint.

- If the INS drift is minimal (high accuracy), overflying the expected position of this waypoint should result in a small distance reading, meaning that the geographic coordinates match the INS coordinates.
- If the INS drift is high (low accuracy), overflying the expected position of this waypoint should result in a significantly greater distance reading, meaning that the geographic coordinates do not match the INS coordinates.

Another method of estimating INS drift this is to use a TACAN station as a reference point and compare the TACAN distance displayed with the distance value computed for a waypoint set on the TACAN station.

WSO Navigation Mode Selector Switch
- *UP Position*
  - *Needle 1: UHF/Automatic Direction Finder*
  - *Needle 2: TACAN Station*
- *MIDDLE Position*
  - *Needle 1: VOR Station*
  - *Needle 2: TACAN Station*
- *DOWN Position*
  - *Needle 1: Navigation Computer Mode: Bearing*
  - *Needle 2: Navigation Computer Mode: Ground Track*



9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.1 – INS Drift



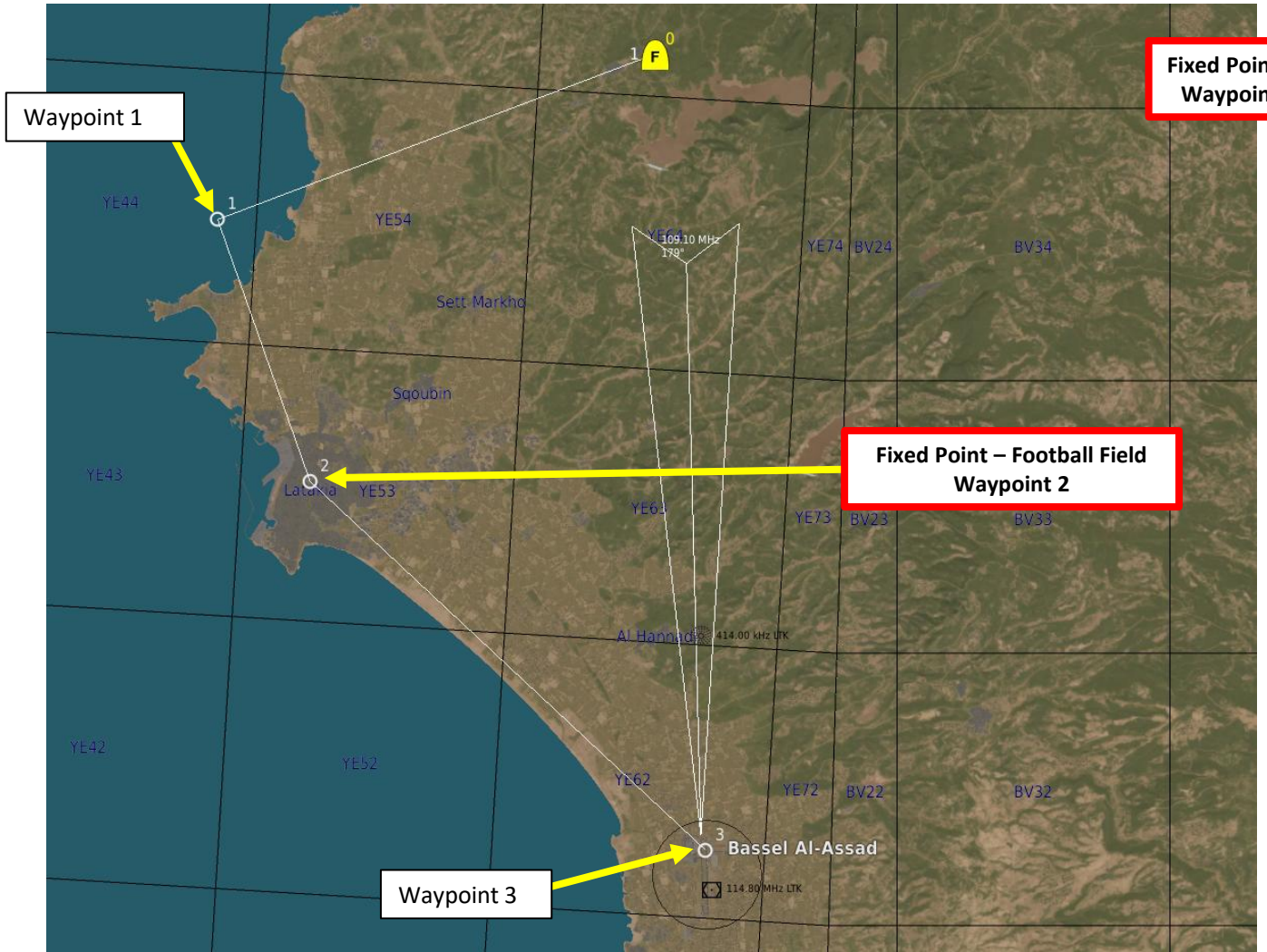
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.2 – Coordinate Correction using Overfly Fix

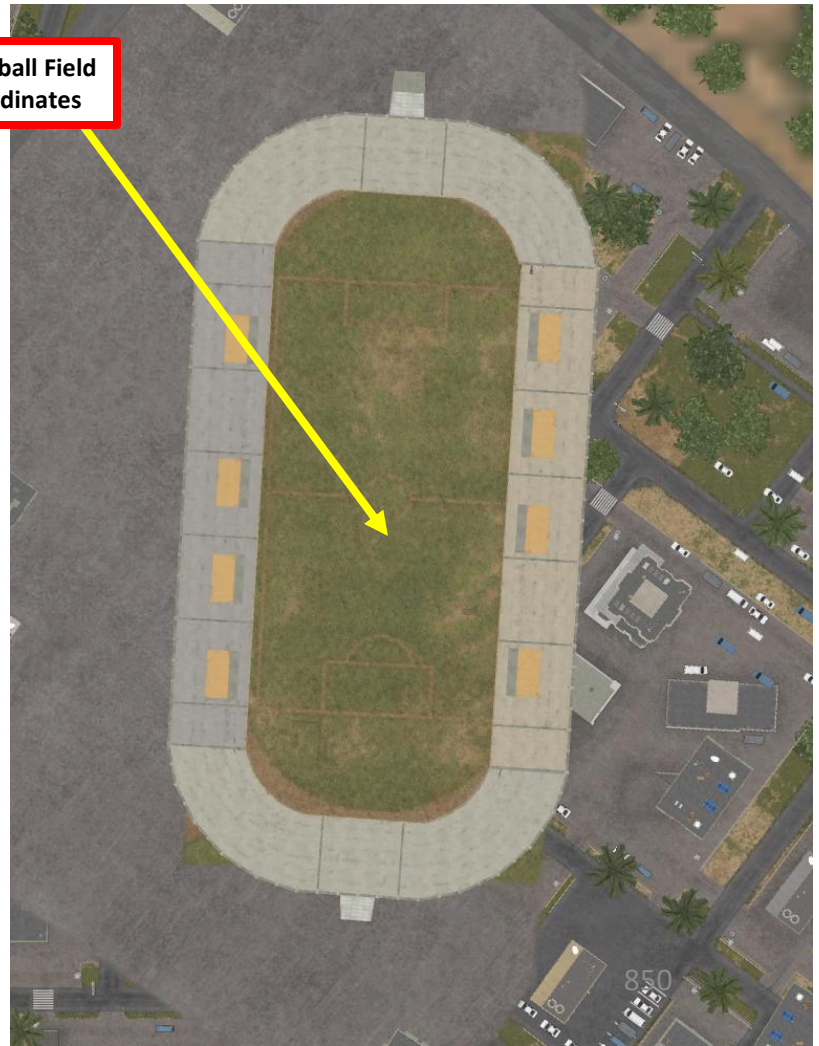
For fixed points, it is recommended to use locations that stand out in the terrain – buildings, towers, bridges, road crossings, and river merge points that are easily located along the route. In this example, our Fix Point coordinates are already entered in Waypoint 2, which is set over a visual landmark (football field). We need the actual coordinates for Waypoint 2, which are listed on the kneeboard's TURNPOINTS page.

TURNPOINTS

TURNPOINT #	LAT	LON
1	Lat: 35° 36' N	Lon: 35° 44' E
2	Lat: 35° 31' N	Lon: 35° 47' E
3	Lat: 35° 24' N	Lon: 35° 56' E

Waypoint 2 Coordinates (used for Fixed Point)





9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.2 – Coordinate Correction using Position Update (Overfly) Fix

In this example, we will use a waypoint 2 and its known coordinates. Use “RSHIFT+K” to access kneeboard, cycle through pages using the “[“ and “]”.

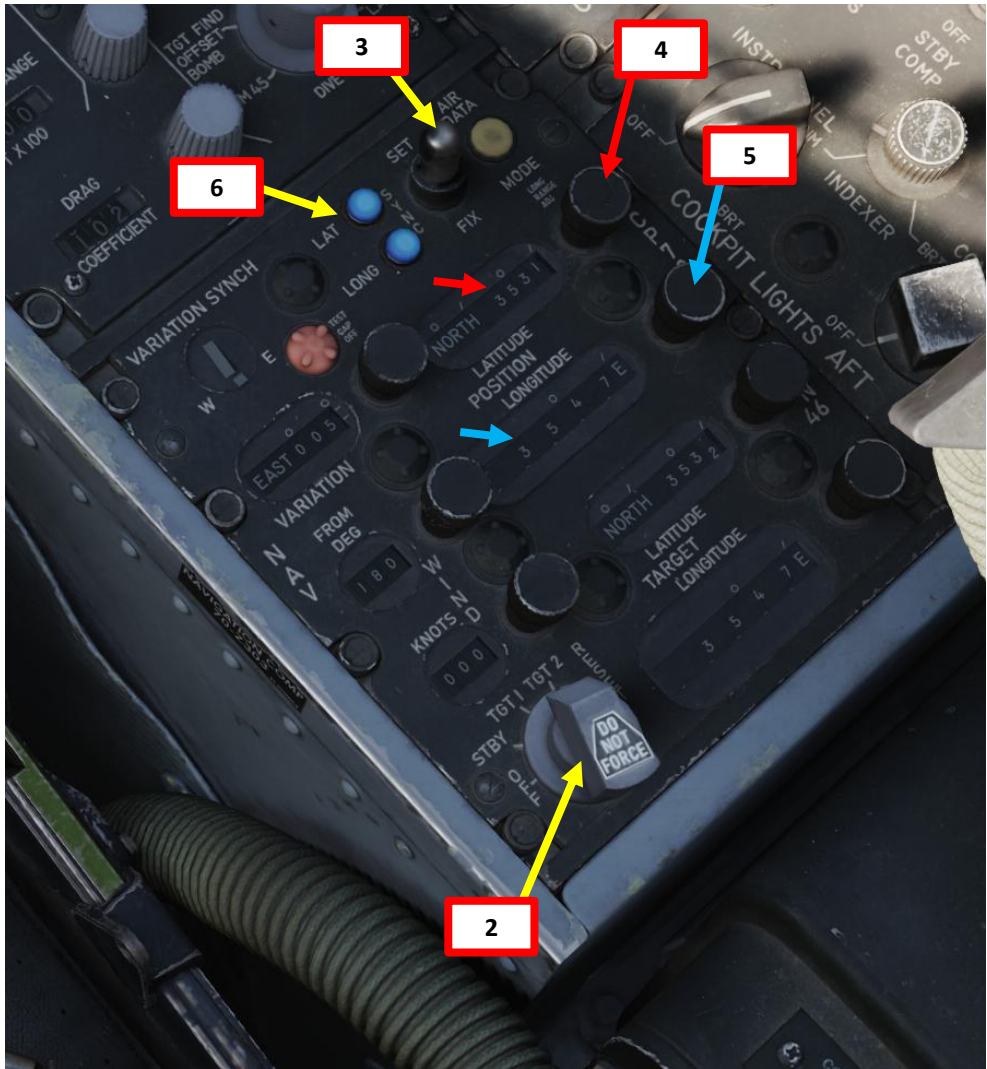
Waypoint 2 (Fixed Point) coordinates: **35 deg 31 min North 035 deg 47 min East**

1. We will use the Fixed Point coordinates (Waypoint 2) as a reference for the position update of the aircraft.
2. *[WSO]* Set Navigation Computer Mode Selector to either STBY, TGT 1 or TGT 2 mode.
3. *[WSO]* Prior to arrival at the fix point, set the Position Update Switch to SET position (FWD) by right-clicking. Doing so disengages the longitude and latitude position counters.
4. *[WSO]* Press and hold **LATITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Latitude to **35 deg 31 minutes North**. Release knob (OUT) when correct value is set.
5. *[WSO]* Press and hold **LONGITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Longitude to **035 deg 47 minutes East**. Release knob (OUT) when correct value is set.
6. *[WSO]* The LAT and LONG Synchronization lights will illuminate if the position counters for latitude or longitude do not match the coordinates provided by the INS (difference above 1.5 arc minutes). In this case, we expect them to illuminate since the INS has accumulated a significant amount of positional drift error.

Waypoint 2 Coordinates (used for Fixed Point)

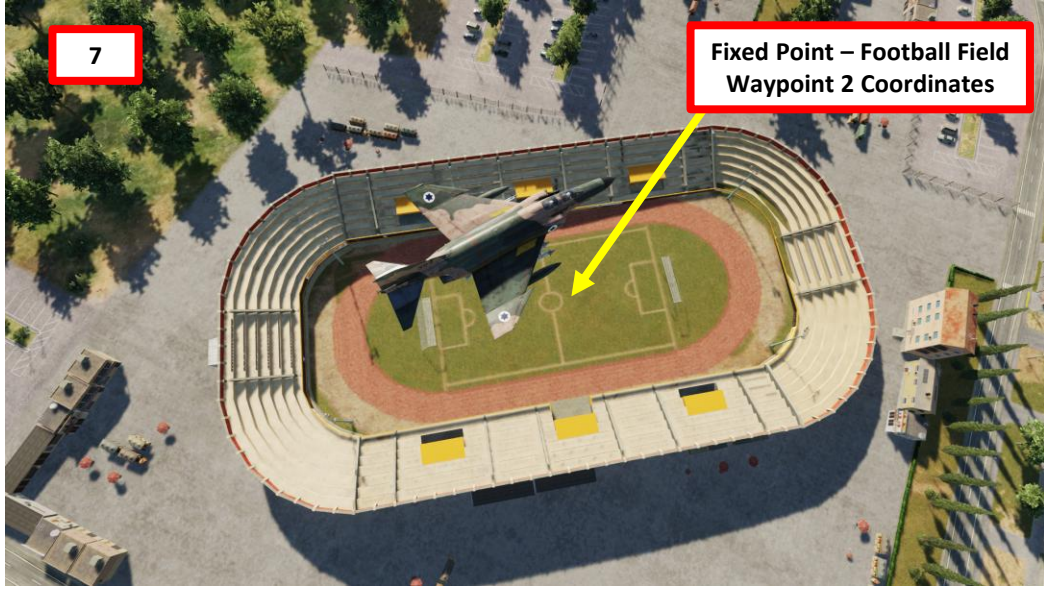
TURNPOINTS

TURNPOINT #	LAT	LON
1	Lat: 35° 36' N	Lon: 35° 44' E
2	Lat: 35° 31' N	Lon: 35° 47' E
3	Lat: 35° 24' N	Lon: 35° 56' E



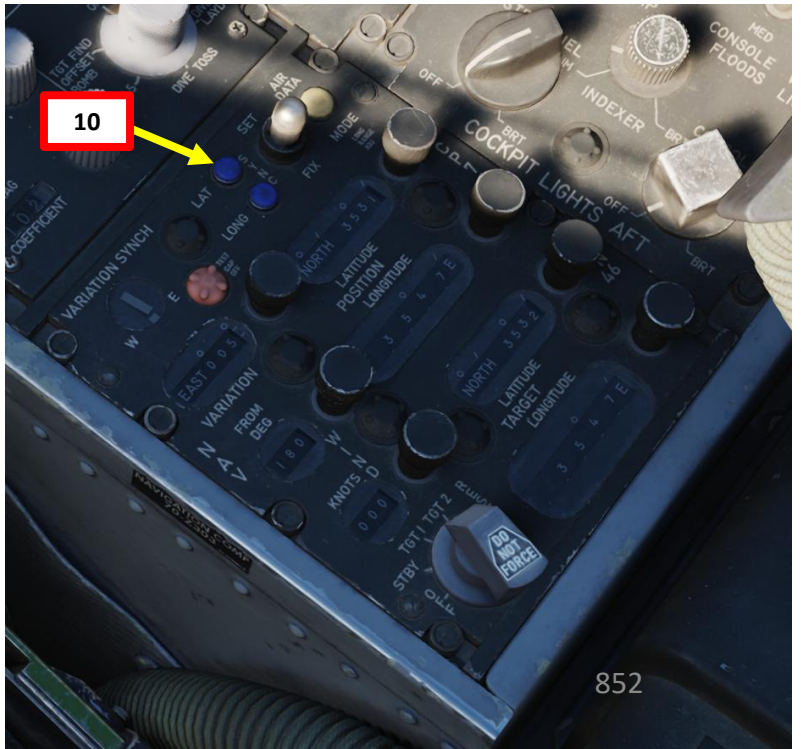
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.2 – Coordinate Correction using Position Update (Overfly) Fix

7. *[P]* Fly directly towards the fixed point's geographic position (football field).
8. *[WSO]* A few seconds before overflying the fix point, **set and hold** Position Update Switch to FIX (AFT) position by clicking and holding the left mouse button.
    - The correction rate of the Nav Computer is roughly 3 minutes latitude or longitude per second, and the Update Switch must be held in FIX long enough to account for the largest value. As an example, if the deviation is 9 minutes in latitude and 4 in longitude, the FIX position must be held at least 3 seconds prior to the aircraft directly passing the fix location.
9. *[WSO]* Half a second before the aircraft is over the fixed point, release Position Update Switch to NORMAL (MIDDLE) position. This will synchronize the aircraft's coordinates with the coordinates of the reference point.
    - The switch actuation from SET to FIX must be smooth and direct, as there is a half second time delay in the computer in the pass-through of NORMAL.
10. *[WSO]* The LAT and LONG Synchronization lights will illuminate since the aircraft's position is now synced.







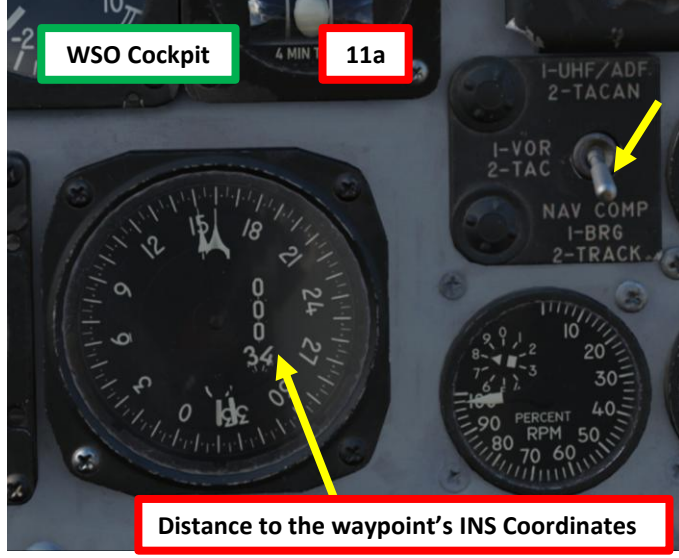


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.2 – Coordinate Correction using Position Update (Overfly) Fix

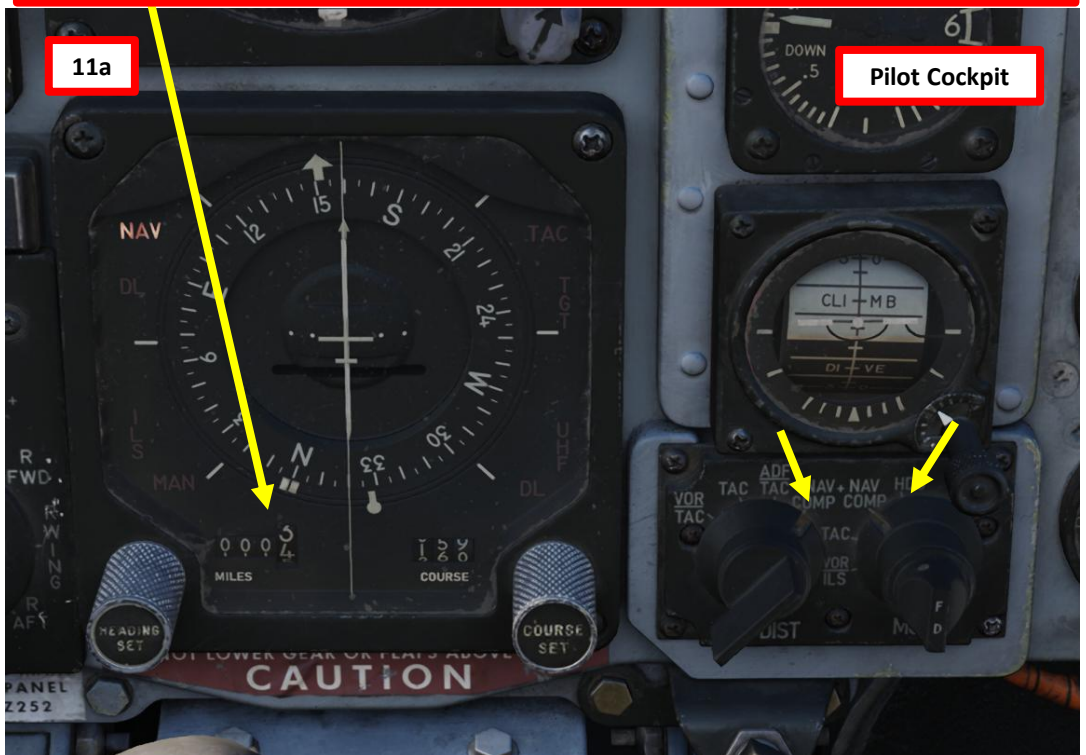
11. That's it, you have corrected the INS drift! You can check the distance to the waypoint on the pilot's Horizontal Situation Indicator or WSO's Bearing Distance Heading Indicator… provided the NAV COMP mode is selected and navigation system is set up correctly to track the waypoint's coordinates (see section 9.2 – Waypoints).

Important Note:

A blind validation over the wrong position can screw up your whole INS position easily since it will modify the aircraft position. It will also affect INS bias calculations, which will degrade the quality of the INS over multiple flights.



Distance to the waypoint's INS Coordinates
- *Position Update has not been performed yet*
- *In this case, we are flying directly over the fixed point, therefore an INS with minimal position error should display a distance value close to 0 nm.*
- *In this example, we see that the INS position has drifted by about 3 nm.*



Distance to the waypoint's INS Coordinates
- *INS position is updated to correct accumulated position error.*
- *We see that the INS position drift is close to 1 nm.*

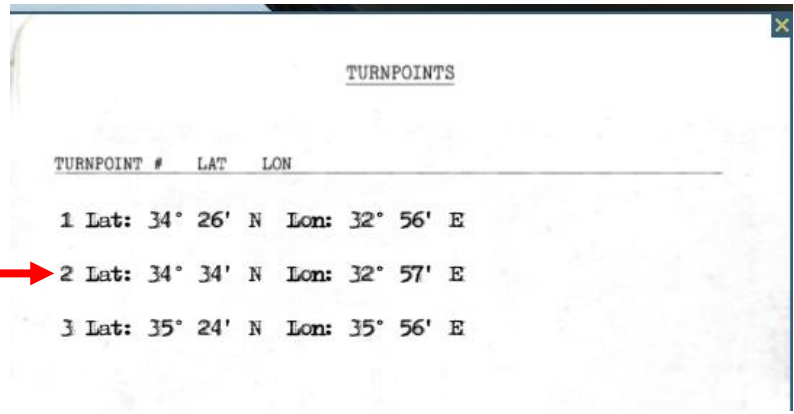


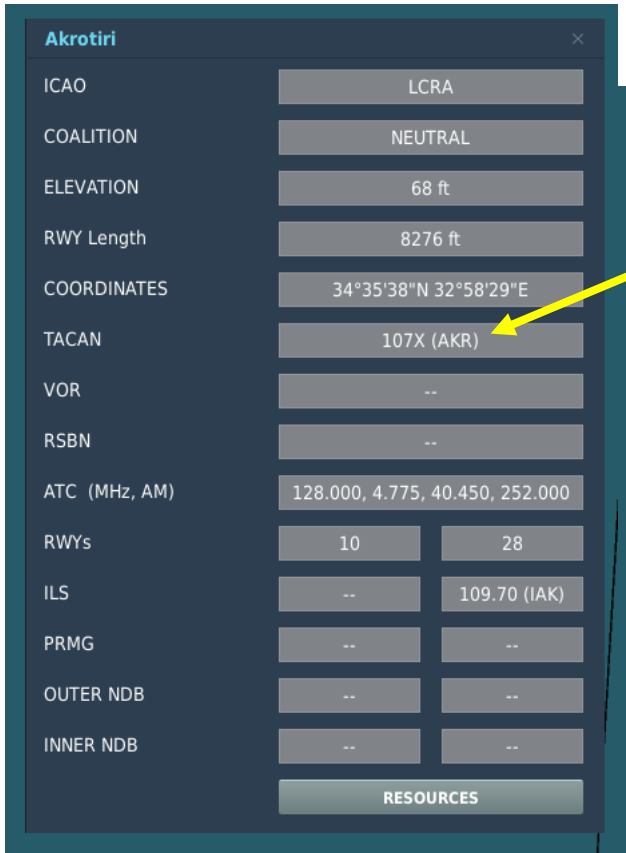
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.3 – Coordinate Correction using TACAN

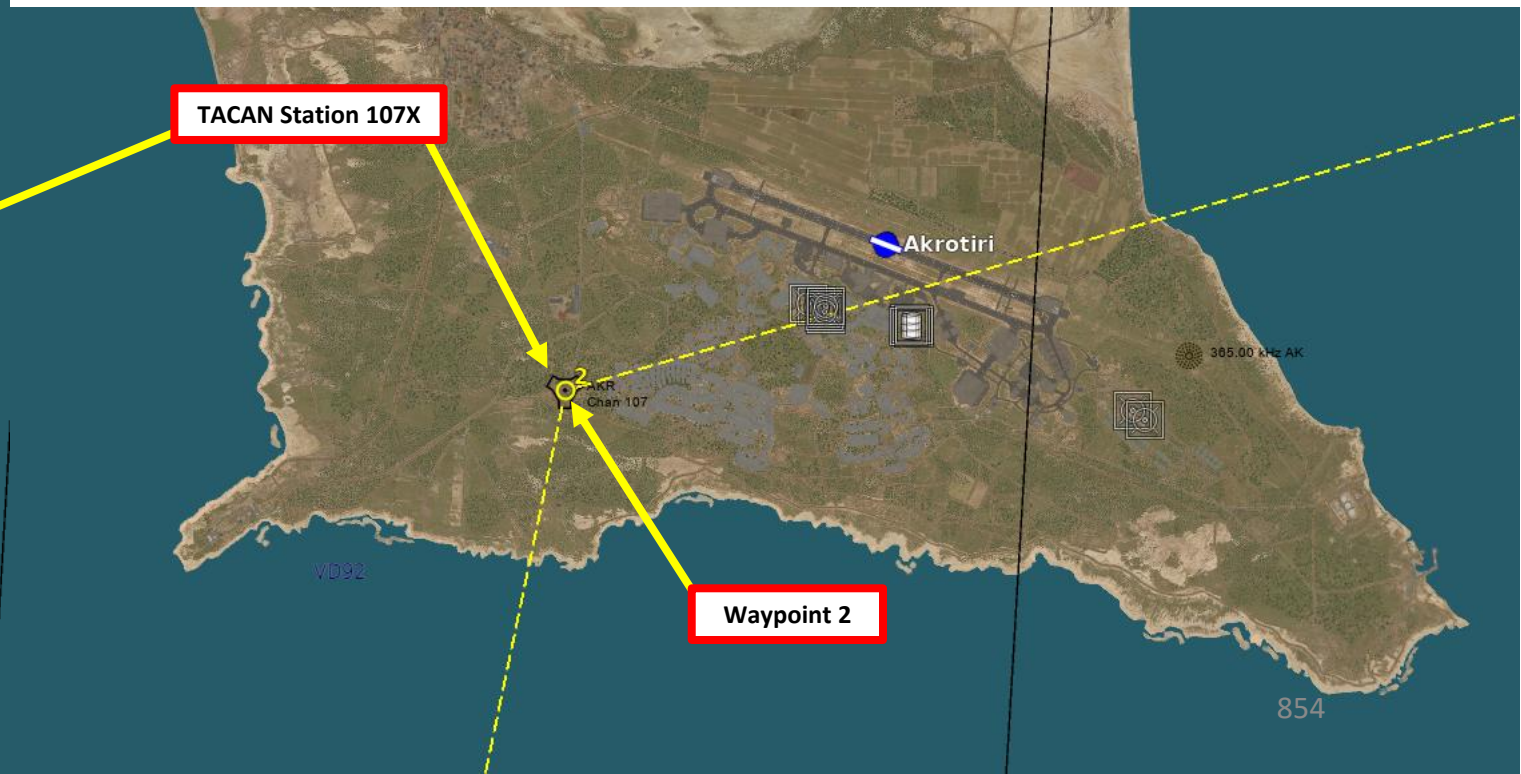
TACAN Fix Example by FlyAndWire
https://youtu.be/4oOJh40dv0k

In theory, it is possible to use a TACAN station as a reference instead of a visual landmark when updating the aircraft position. In practice, this process is impractical at best. You need a valid station (**TACAN Station 107X for Akrotiri**, as an example) and a waypoint aligned on the location of the station with its associated coordinates.

Waypoint 2 (over TACAN) coordinates: **34 deg 34 min North 032 deg 57 min East**







9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.3 – Coordinate Correction using TACAN

1. *[WSO]* Tune TACAN Station to 107X.
2. *[WSO]* Set INS to Waypoint 2 coordinates using TGT 2 Mode (see section 9.2 – Waypoints).

2

Waypoint 2 Coordinates

TURNPOINTS

TURNPOINT #	LAT	LON
1	Lat: 34° 26' N	Lon: 32° 56' E
2	Lat: 34° 34' N	Lon: 32° 57' E
3	Lat: 35° 24' N	Lon: 35° 56' E

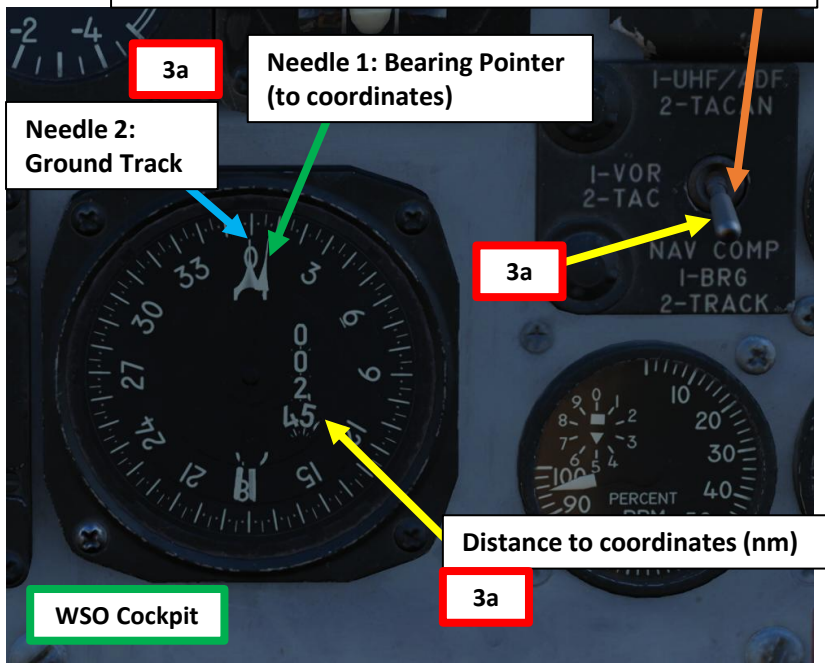


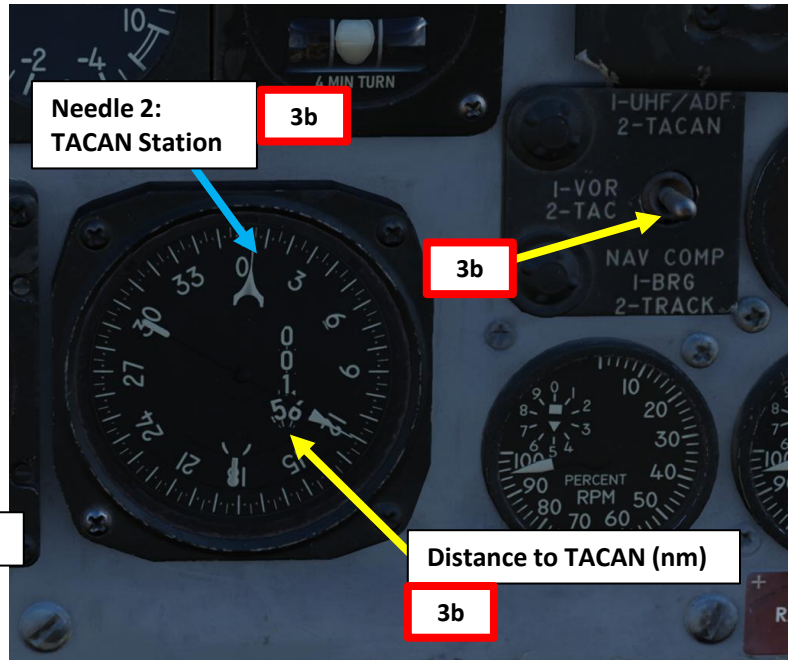


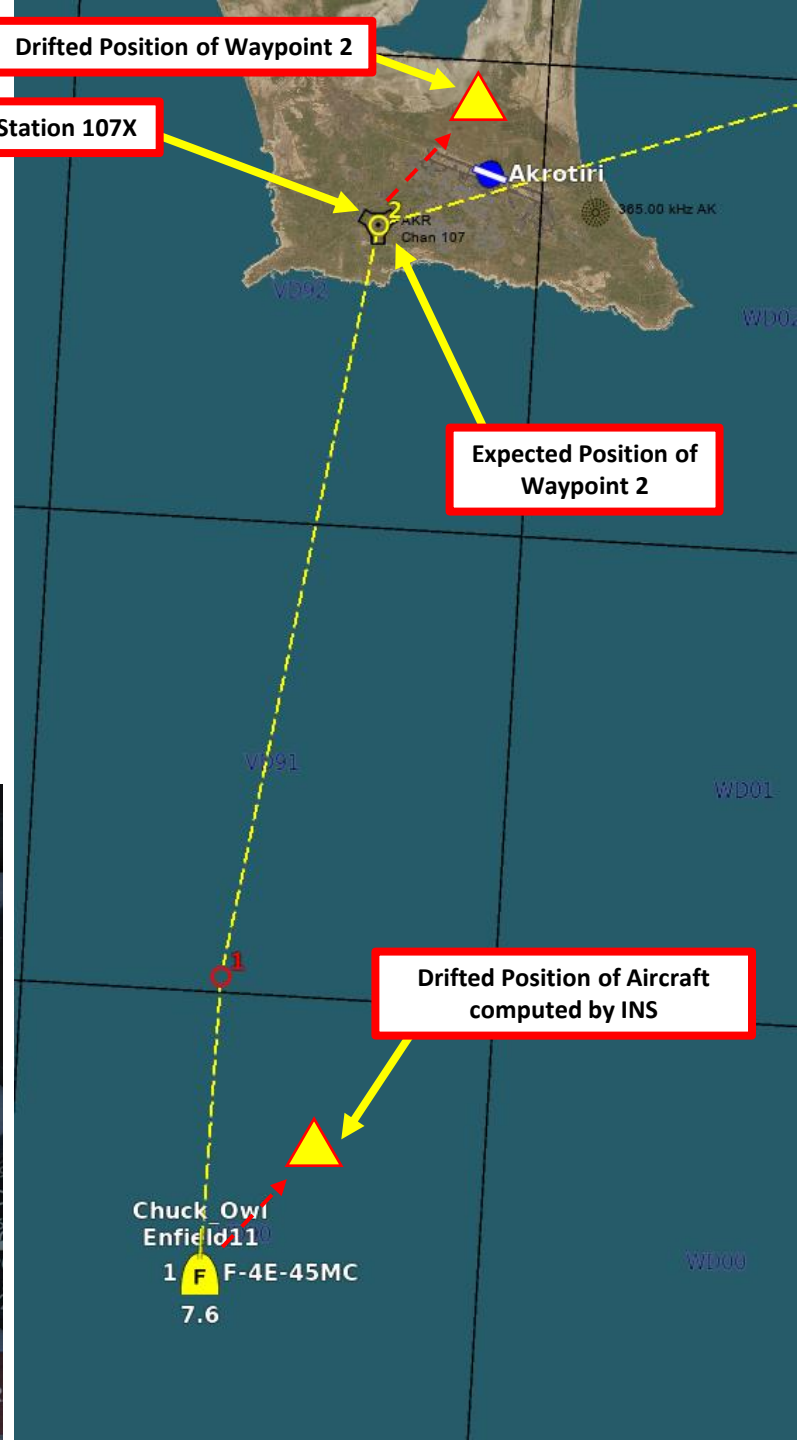
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.3 – Coordinate Correction using TACAN

3. *[WSO]* Compare distance and bearing between the TACAN station and Waypoint 2. Toggle the Navigation Mode Selector between DOWN and MIDDLE position and compare distance and bearing. If the distance information and bearing do not match, it means INS error drift has accumulated and a position update is required.
    a) **For TACAN (Reference):** Set WSO Navigation Mode Selector Switch – MIDDLE. Needle 2 points towards the TACAN station.
    b) **For Waypoint/NAV COMP (affected by INS drift):** Set WSO Navigation Mode Selector Switch – DOWN. This is used for the Waypoint coordinates. Needle 1 points towards the Waypoint, while Needle 2 points towards Ground Track.

WSO Navigation Mode Selector Switch
- *UP Position*
    - *Needle 1: UHF/Automatic Direction Finder*
    - *Needle 2: TACAN Station*
- *MIDDLE Position*
    - *Needle 1: VOR Station*
    - *Needle 2: TACAN Station*
- *DOWN Position*
    - *Needle 1: Navigation Computer Mode: Bearing*
    - *Needle 2: Navigation Computer Mode: Ground Track*

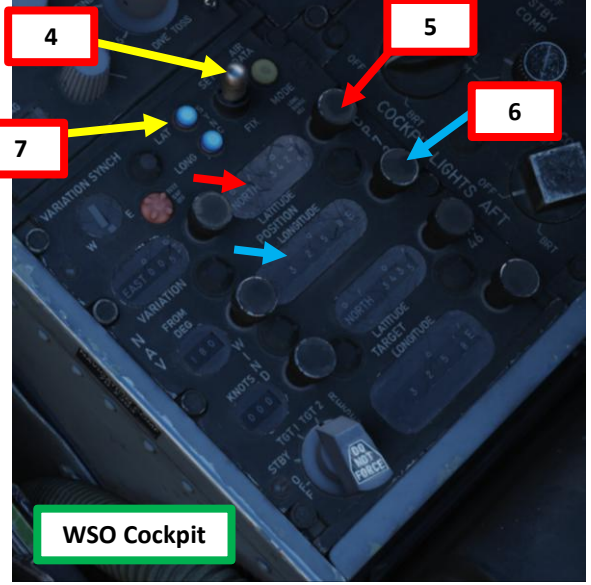


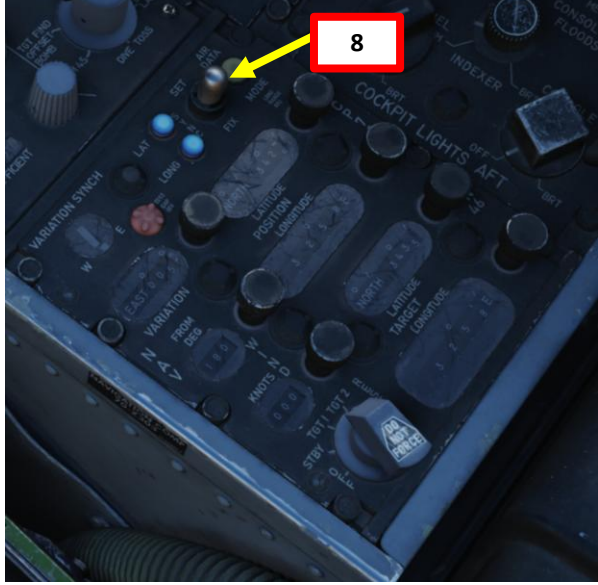


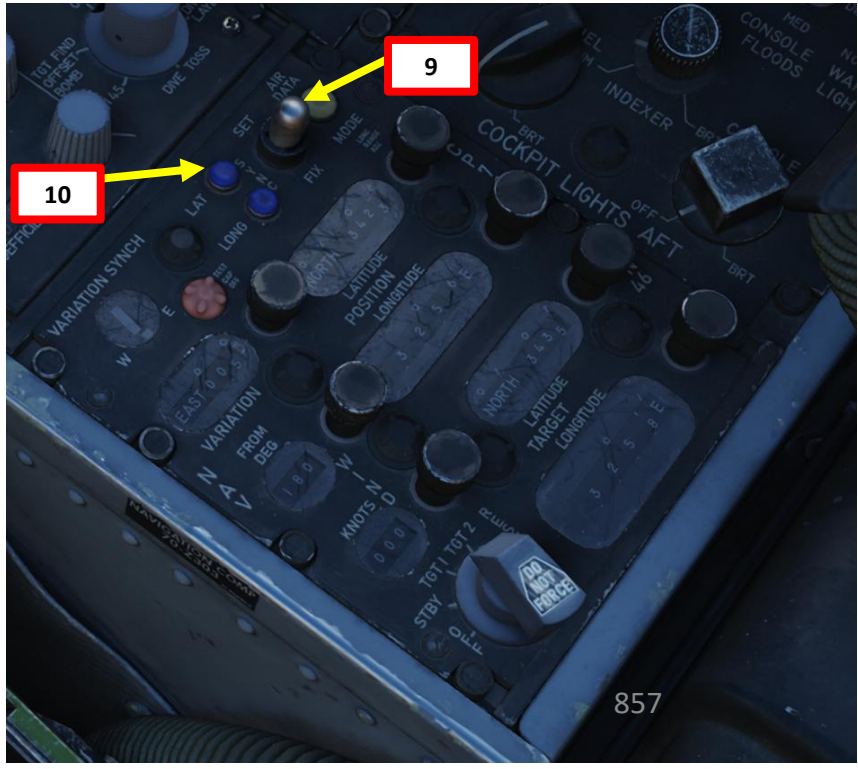


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.3 – Coordinate Correction using TACAN

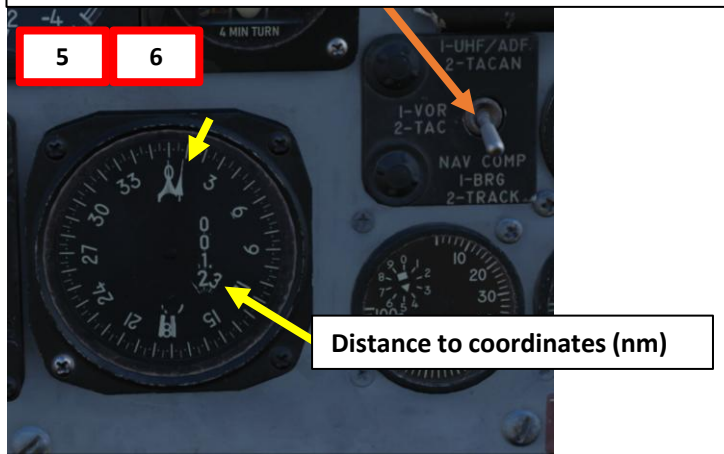
4. *[WSO]* Set the Position Update Switch to SET position (FWD) by right-clicking. Doing so disengages the longitude and latitude position counters.
5. *[WSO]* Press and hold **LATITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to **adjust aircraft Latitude position in order to match waypoint position and TACAN station position (bearing and distance)**. Release knob (OUT) when correct value is set.
6. *[WSO]* Press and hold **LONGITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to **adjust aircraft Longitude position in order to match waypoint position and TACAN station position (bearing and distance).** Release knob (OUT) when correct value is set.
7. *[WSO]* The LAT and LONG Synchronization lights will illuminate if the position counters for latitude or longitude do not match the coordinates provided by the INS (difference above 1.5 arc minutes). In this case, we expect them to illuminate since the INS has accumulated a significant amount of positional drift error.
8. *[WSO]* Once you have shifted the INS aircraft position to make the selected TACAN and waypoint distance and bearing match, quickly s**et and hold** Position Update Switch to FIX (AFT) position by clicking and holding the left mouse button.
9. *[WSO]* Release Position Update Switch to NORMAL (MIDDLE) position. This will synchronize the aircraft's coordinates.
    - The switch actuation from SET to FIX must be smooth and direct, as there is a half second time delay in the computer in the pass-through of NORMAL.
10. *[WSO]* The LAT and LONG Synchronization lights will illuminate since the aircraft's position is now synced.



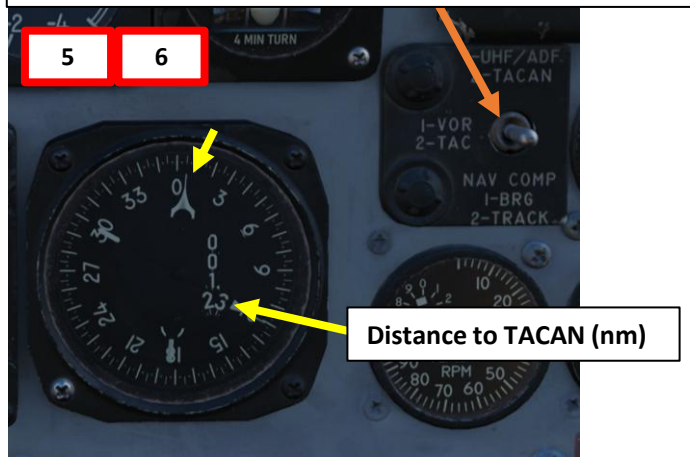




WSO Navigation Mode Selector Switch – NAV COMP (DOWN)

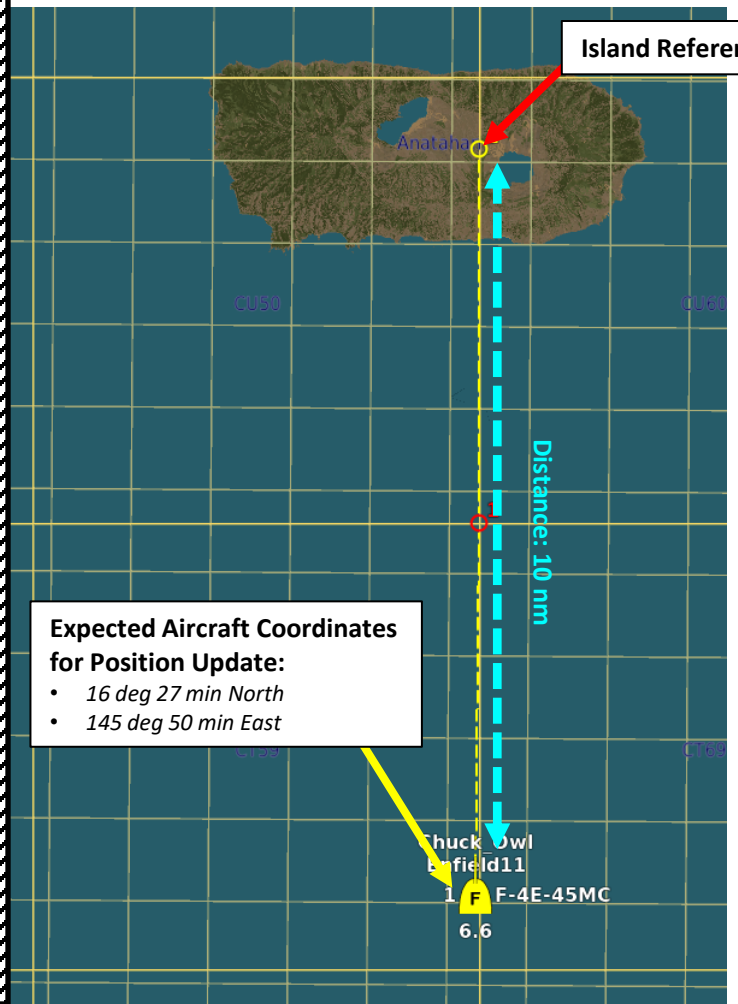


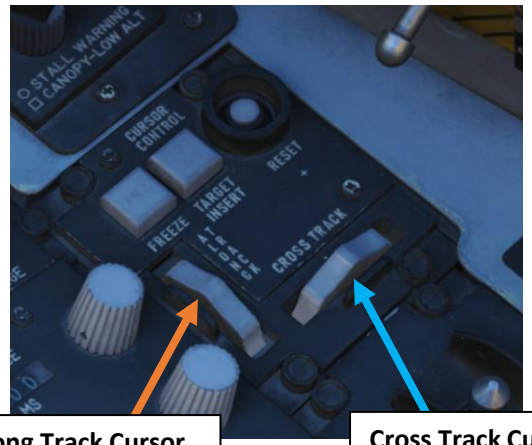
WSO Navigation Mode Selector Switch – TACAN (MIDDLE)

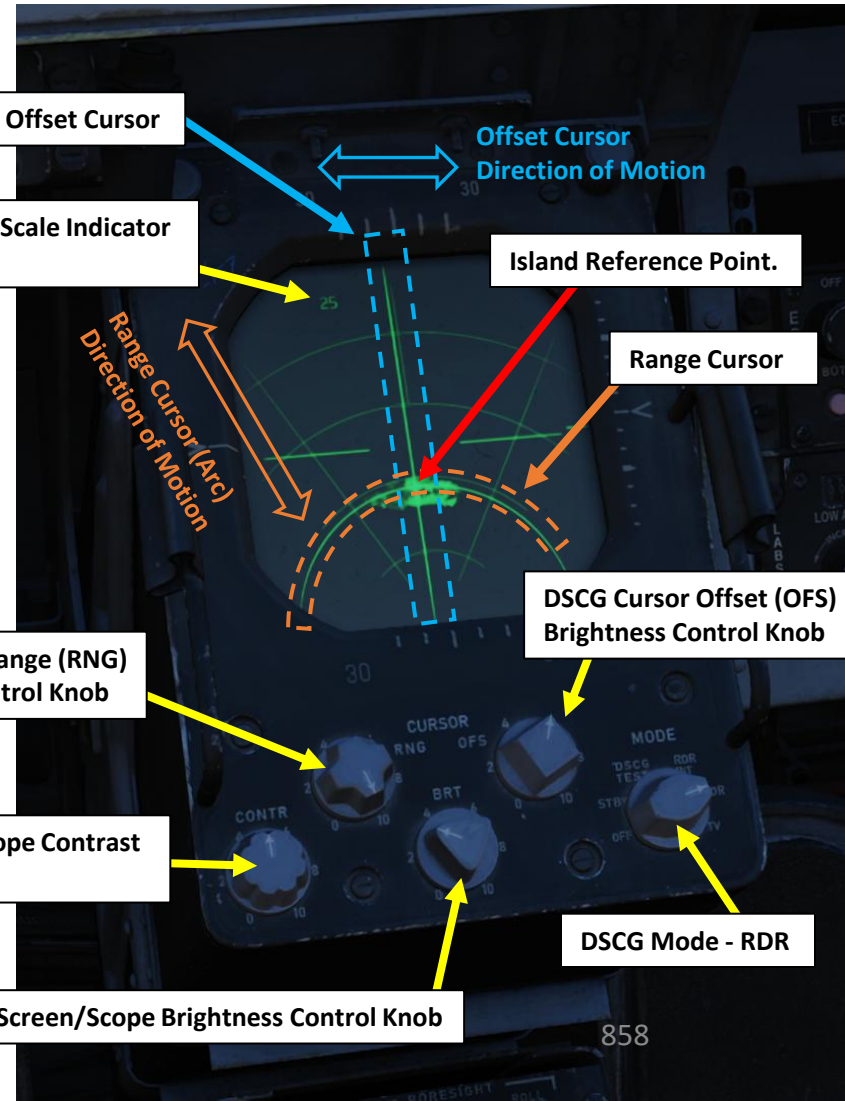


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.4 – Coordinate Correction using Radar Fix

Another **theoretical but highly impractical** use of the radar is to perform a radar fix. This requires a lot of planning. The concept is that you use the radar's ground mapping capability to determine the position of the aircraft in relationship to a reference point that is easy to see (like an Island in the middle of the ocean). When the aircraft is at an expected position (as an example, 10 nm South of the Anatahan Island), a position update is performed with the coordinates expected as a reference. The radar is used in Map PPI (Plan-Position Indicator) mode to determine if you are at the correct position geographically.



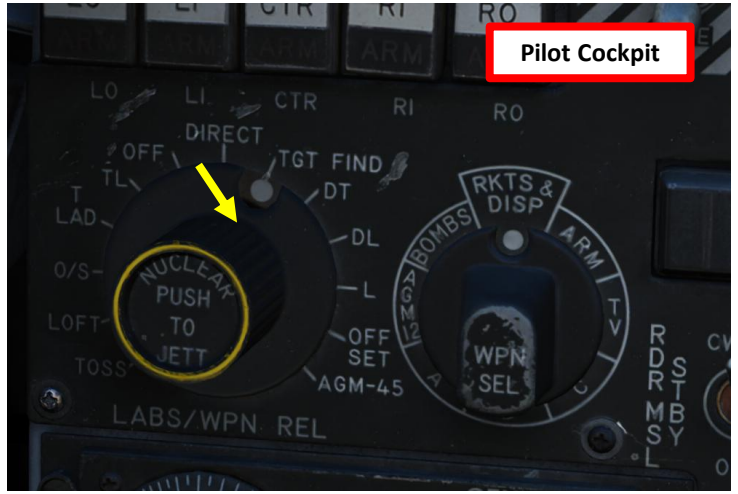


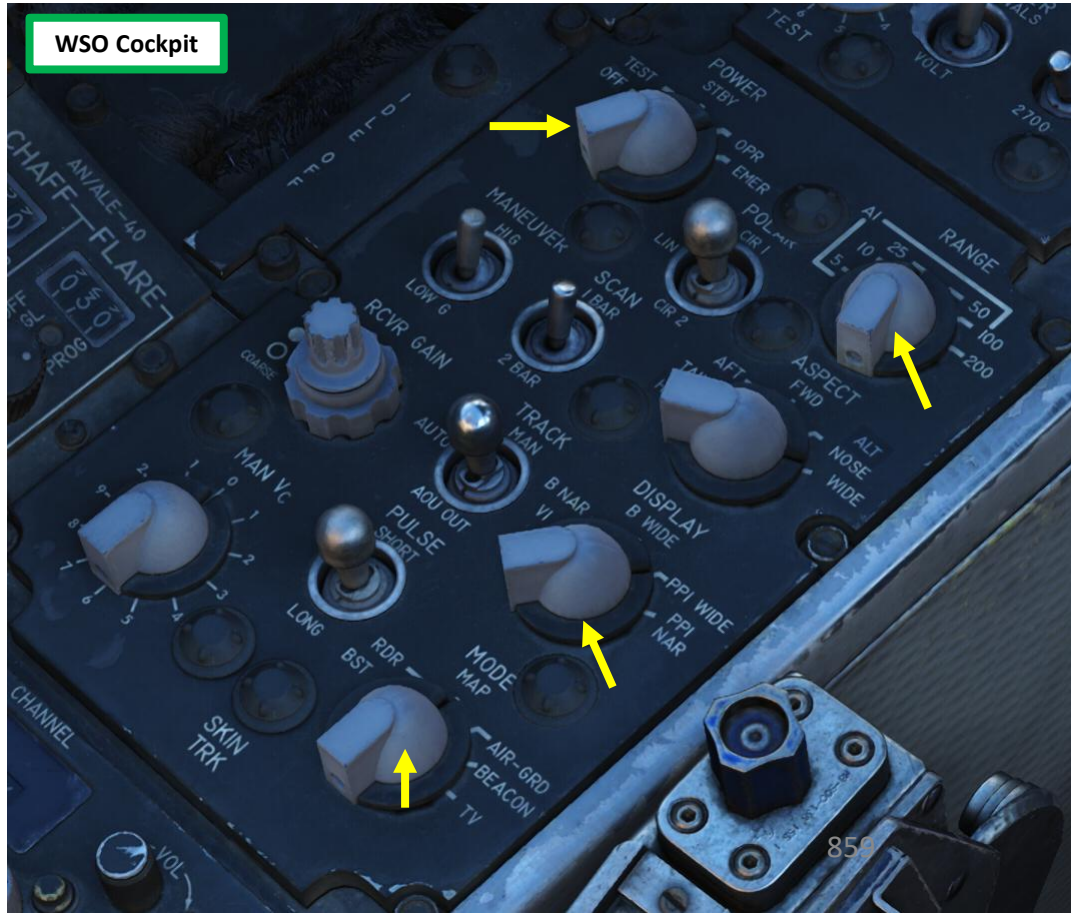


9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.4 – Coordinate Correction using Radar Fix

Consult Part 10 – Radar & Sensors to see how to operate the radar in Map PPI (Plan-Position Indicator) mode.

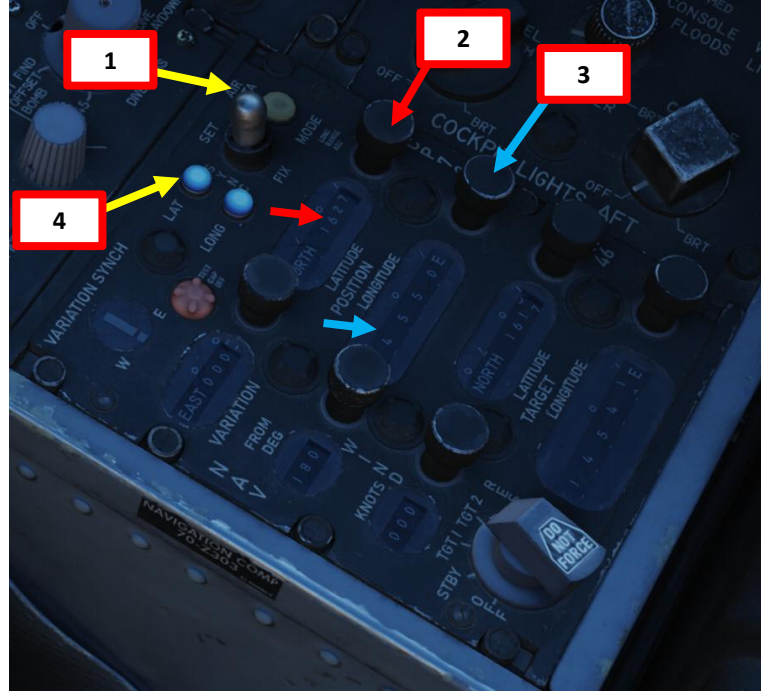


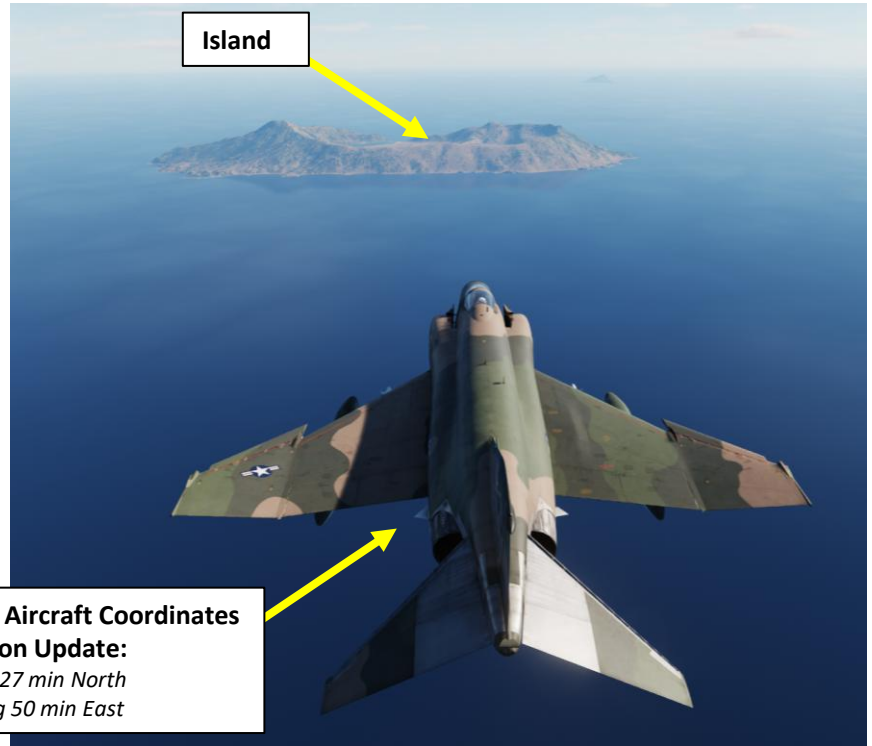


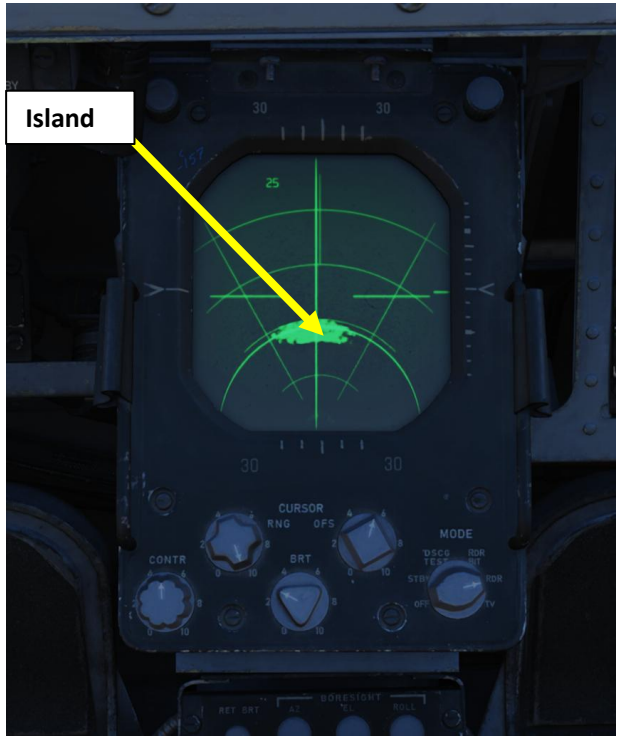


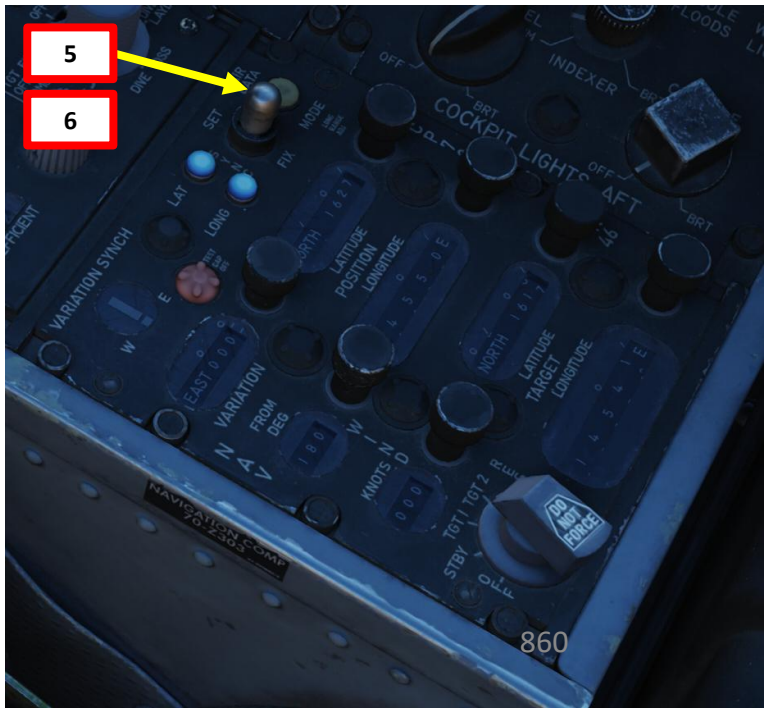
9 – AN/ASN-63 INS (INERTIAL NAVIGATION SYSTEM)
9.3 – INS Drift & Navigation Fix
9.3.4 – Coordinate Correction using Radar Fix

1. *[WSO]* Set the Position Update Switch to SET position (FWD) by right-clicking. Doing so disengages the longitude and latitude position counters. We will use coordinates **16 deg 27 min North** **145 deg 50 min East** as a reference point.
2. *[WSO]* Press and hold **LATITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Latitude as per reference point to **16 deg 27 min North** . Release knob (OUT) when correct value is set.
3. *[WSO]* Press and hold **LONGITUDE** position knob IN (left click and hold), then rotate (scroll mousewheel) to set Longitude to **145 deg 50 min East** . Release knob (OUT) when correct value is set.
4. *[WSO]* The LAT and LONG Synchronization lights will illuminate if the position counters for latitude or longitude do not match the coordinates provided by the INS (difference above 1.5 arc minutes). In this case, we expect them to illuminate since the INS has accumulated a significant amount of positional drift error.
5. *[WSO]* **Once you are over the reference point (determined by radar)** set and hold Position Update Switch to FIX (AFT) position by clicking and holding the left mouse button.
6. *[WSO]* Release Position Update Switch to NORMAL (MIDDLE) position. This will synchronize the aircraft's coordinates.
    - The switch actuation from SET to FIX must be smooth and direct, as there is a half second time delay in the computer in the pass-through of NORMAL.
7. *[WSO]* The LAT and LONG Synchronization lights will illuminate since the aircraft's position is now synced.









10 – ILS (INSTRUMENT LANDING SYSTEM)



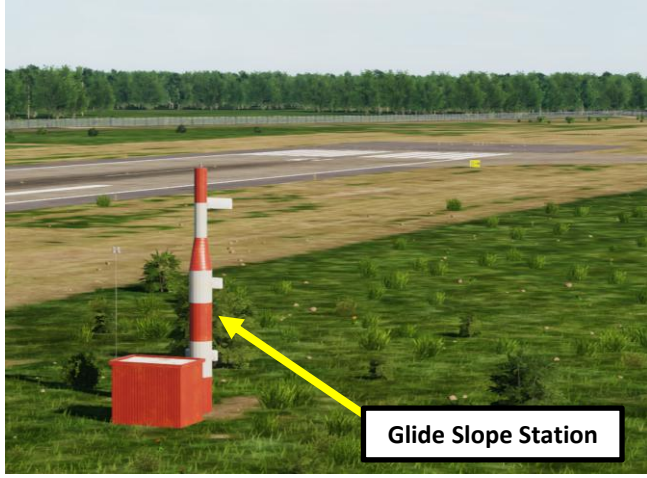
10 – ILS (INSTRUMENT LANDING SYSTEM)

The ILS (Instrument Landing System) exists to guide you during your approach in low-visibility conditions.

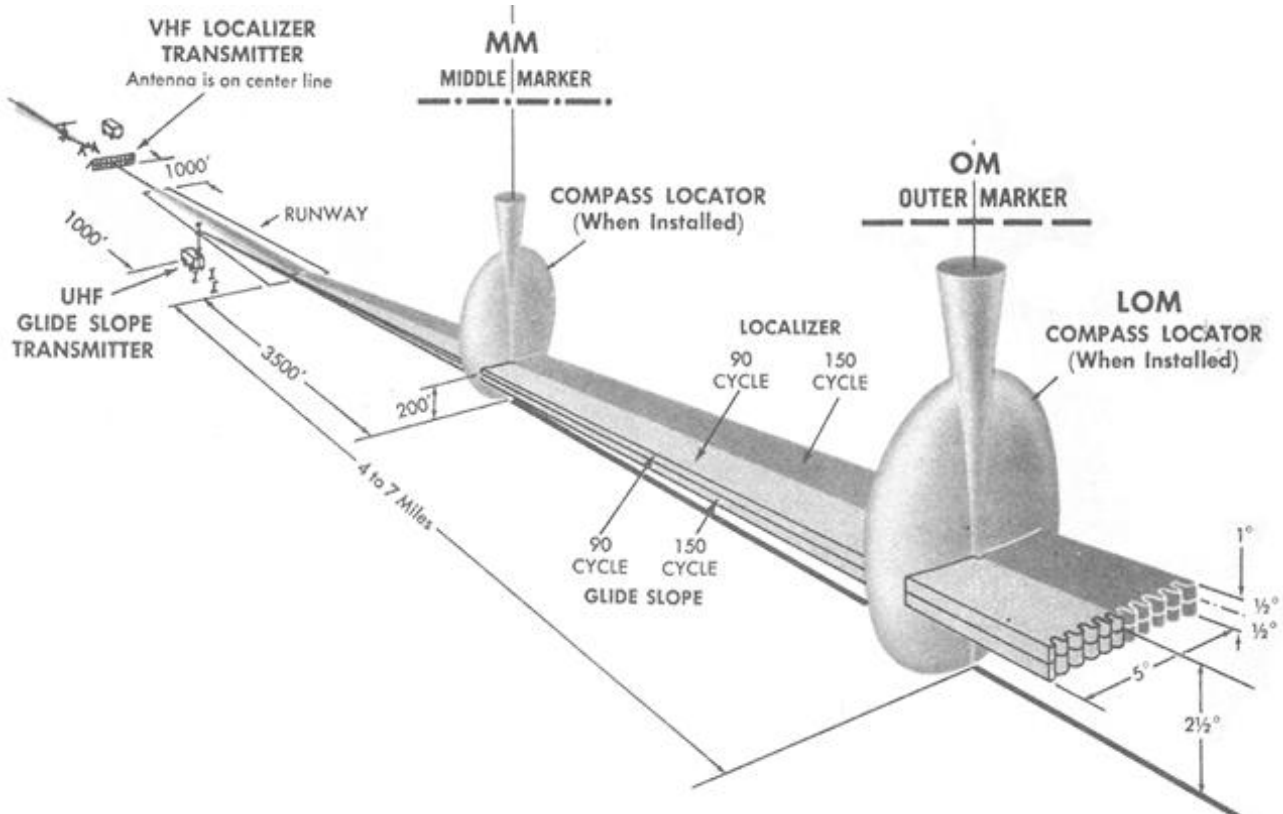
- The **Localizer** is generally an array of antennas that will give you a lateral reference to the center of the runway.
- The **Glide Slope** station will help you determine the descent speed you need in order to not smack the runway in a smoldering ball of fire.

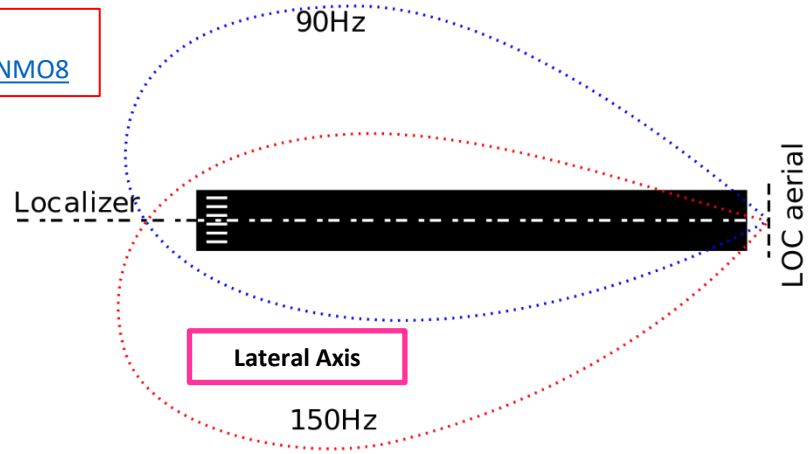
Some runways have markers, but others do not.

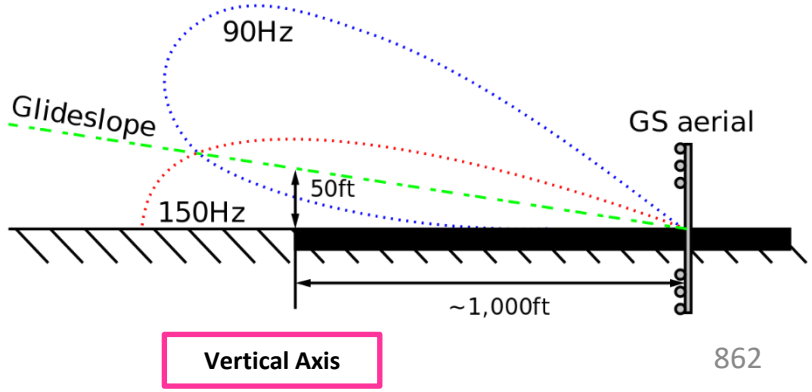




Great video explanation of ILS
https://www.youtube.com/watch?v=KVtEfDcNMO8





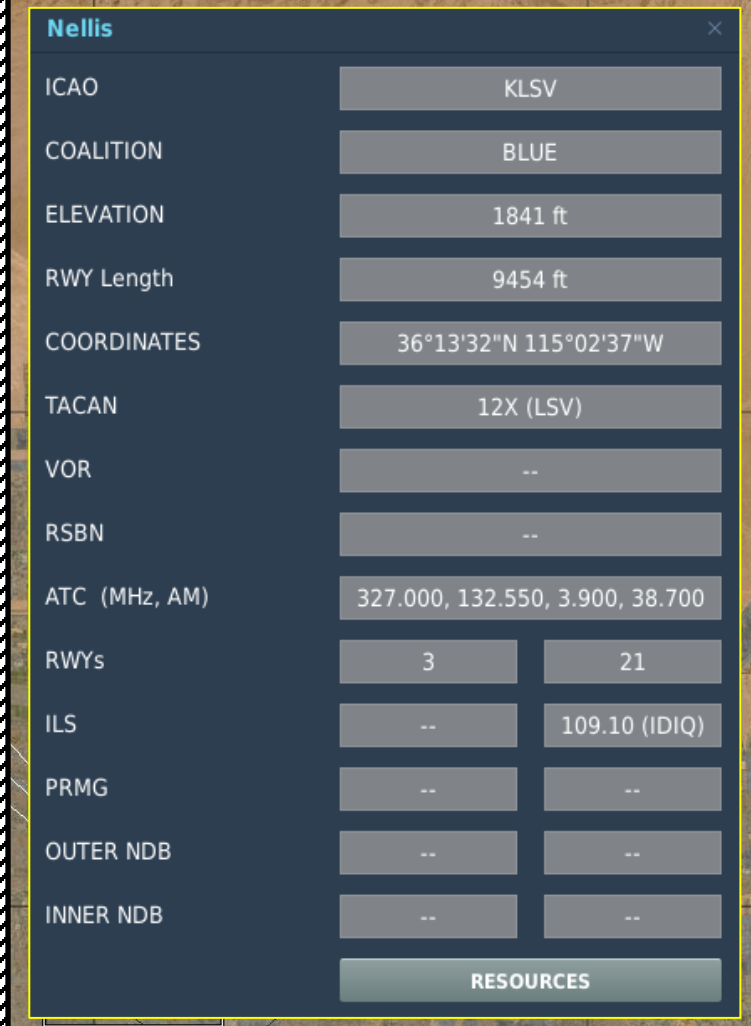


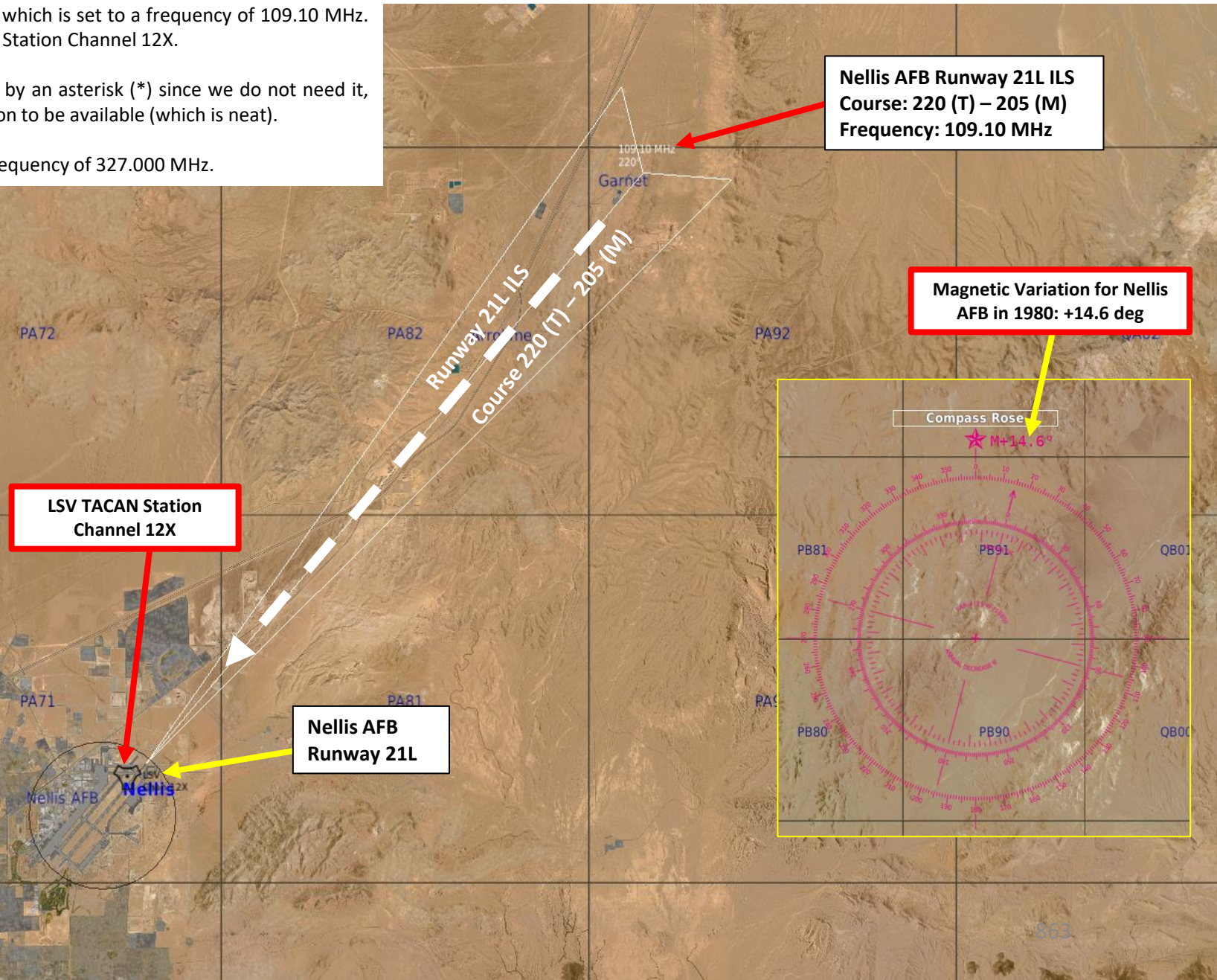
10 – ILS (INSTRUMENT LANDING SYSTEM)

In this tutorial, we will use the ILS for Nellis AFB Runway 21L, which is set to a frequency of 109.10 MHz. We will use a course of 205 Magnetic and also use LSV TACAN Station Channel 12X.

Steps involving the TACAN are optional and will be preceded by an asterisk (*) since we do not need it, but combining the ILS with a TACAN allows distance information to be available (which is neat).

Communications with the tower will be done with a manual frequency of 327.000 MHz.

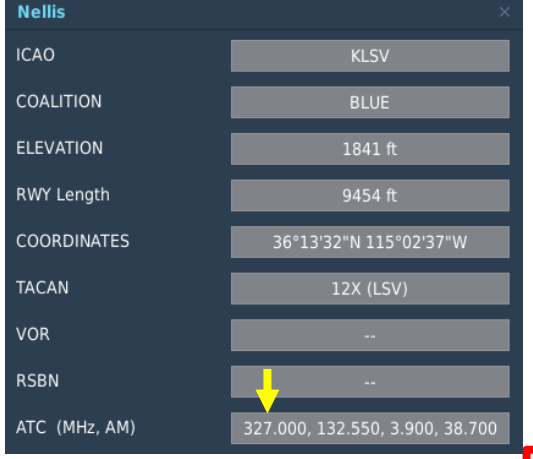


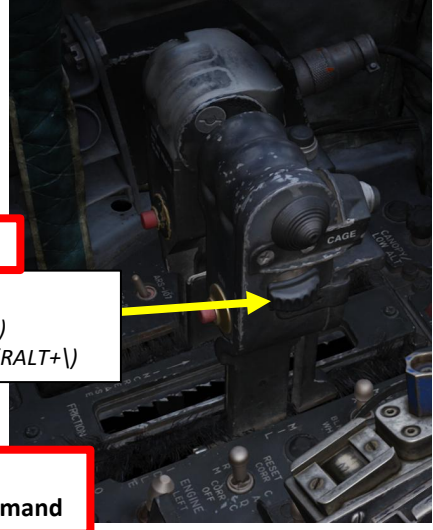


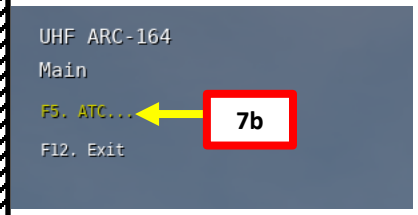
10 – ILS (INSTRUMENT LANDING SYSTEM)

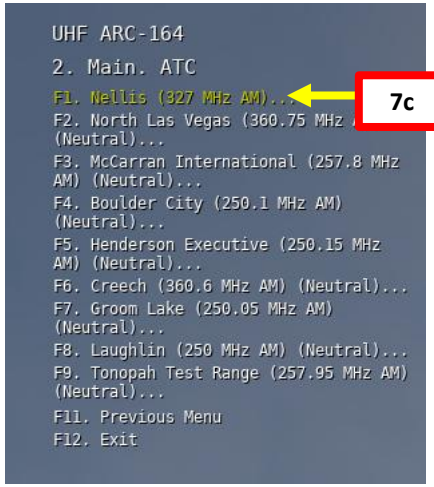
A – Contact Tower & Request Approach Clearance

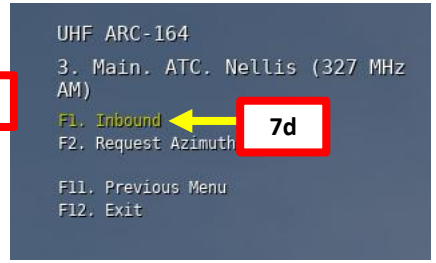
1. Set UHF Radio Mode Selector – T/R+G (Transmit/Receive + Guard Frequency).
2. Set UHF Radio Frequency Mode Selector – Manual.
3. Set UHF Radio Frequency with Frequency Tuning knobs. We will select **327.00 MHz**, which is the Nellis AFB Tower frequency.
4. Set Radio Squelch Switch – ON (OUTBOARD).
5. Set UHF Radio Volume – As desired.
6. Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to your own cockpit.
7. Call the tower to request inbound clearance. Transmit by pressing Mic Switch – FWD (UHF).
   Binding: RSHIFT+\

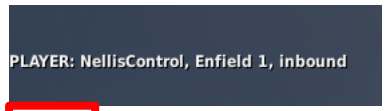


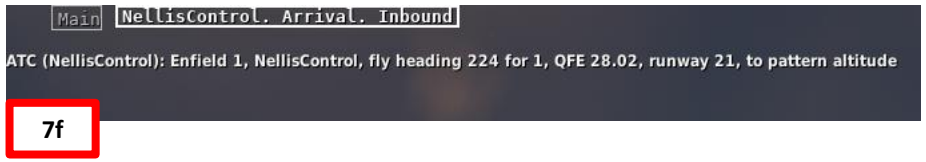


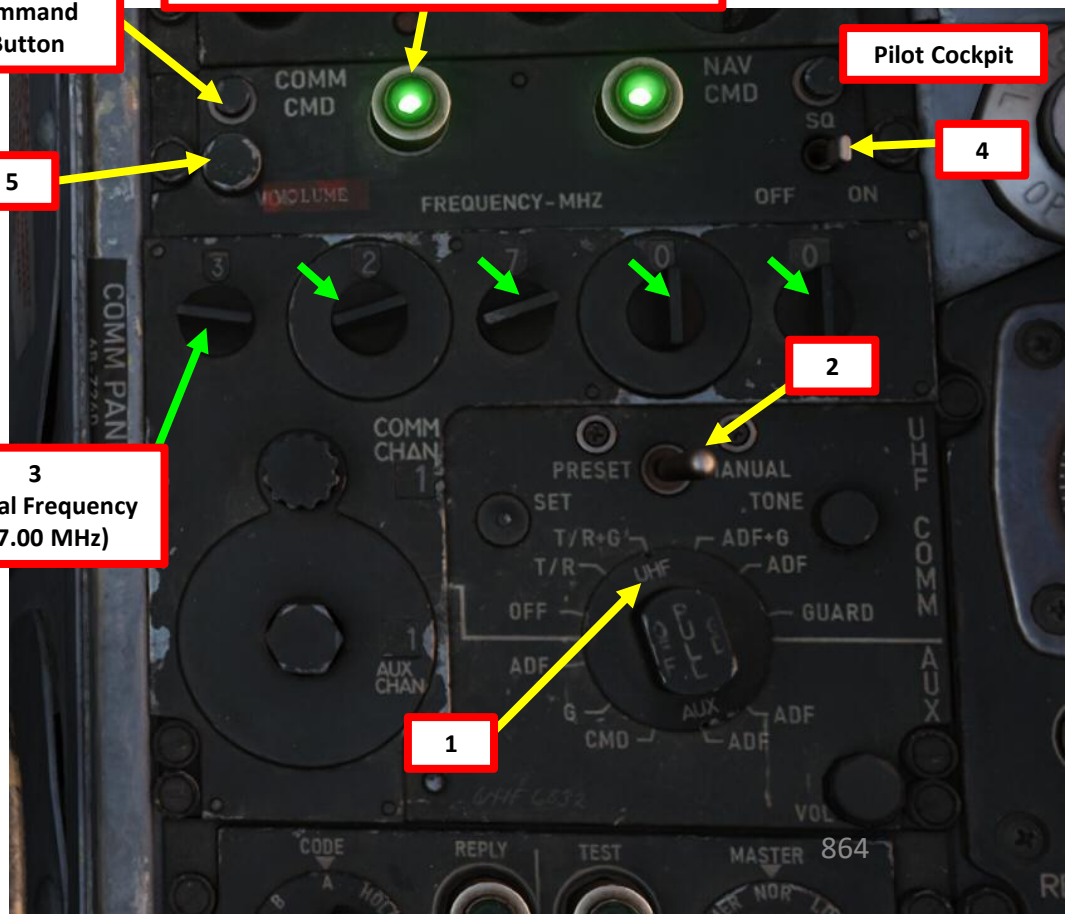












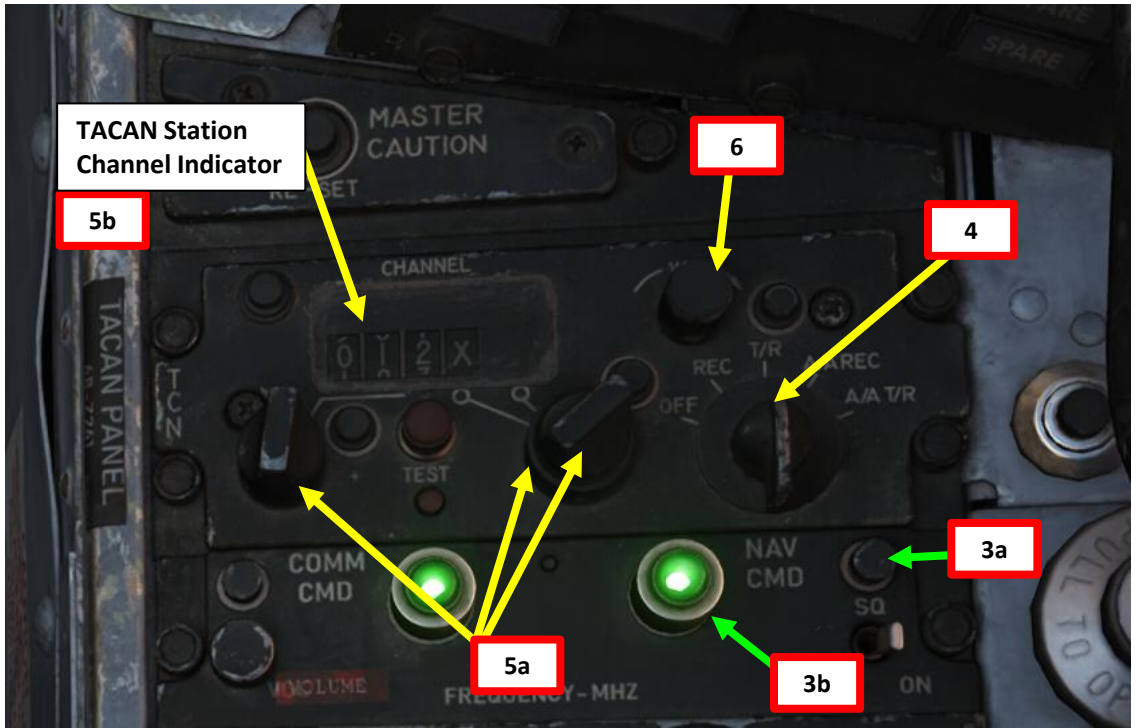
10 – ILS (INSTRUMENT LANDING SYSTEM)

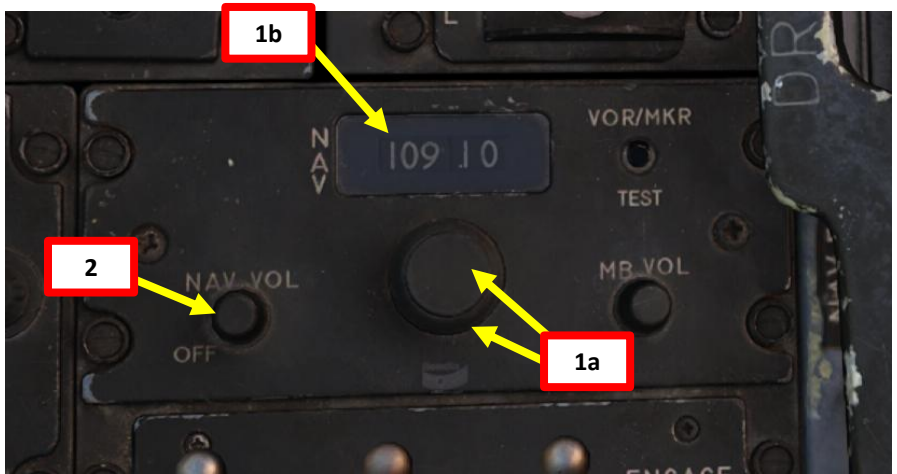
B – Set Up Navigation Systems

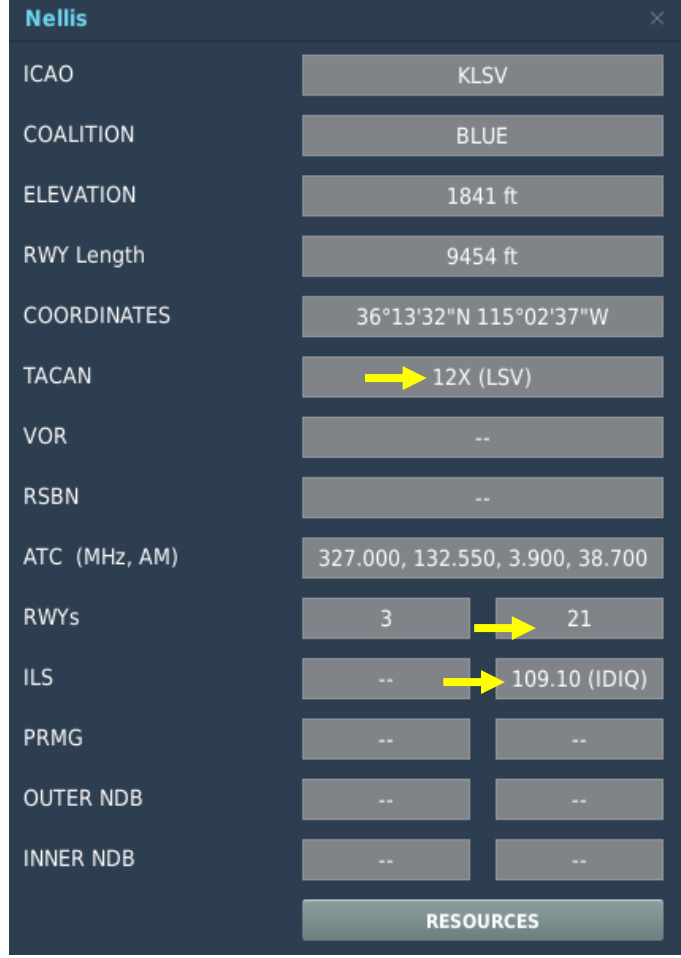
1. *[P]* Tune NAV frequency to **109.10 MHz (Nellis AFB ILS Frequency for Runway 21L).**
2. *[P]* Adjust volume of navigation aid tone as desired.

Note: Setting up the TACAN is optional, but the distance information provided is quite useful.

3. **[P]* Check NAV CMD light is illuminated. If not, press the NAV Command Toggle Button. This will give TACAN command to your own cockpit.
4. **[P]* Set TACAN Mode Selector – T/R (Transmit/Receive).
5. **[P]* Tune TACAN Channel to **12X (LSV TACAN Station).**
   - Left Knob for Hundreds, Right Outer Knob for X/Y and Right Inner Knob for Ones
6. **[P]* Adjust volume of TACAN tone as desired.



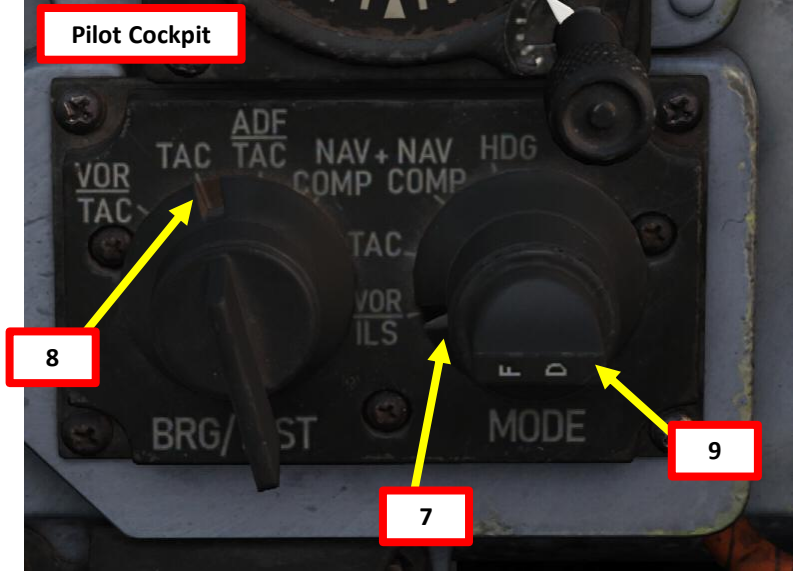


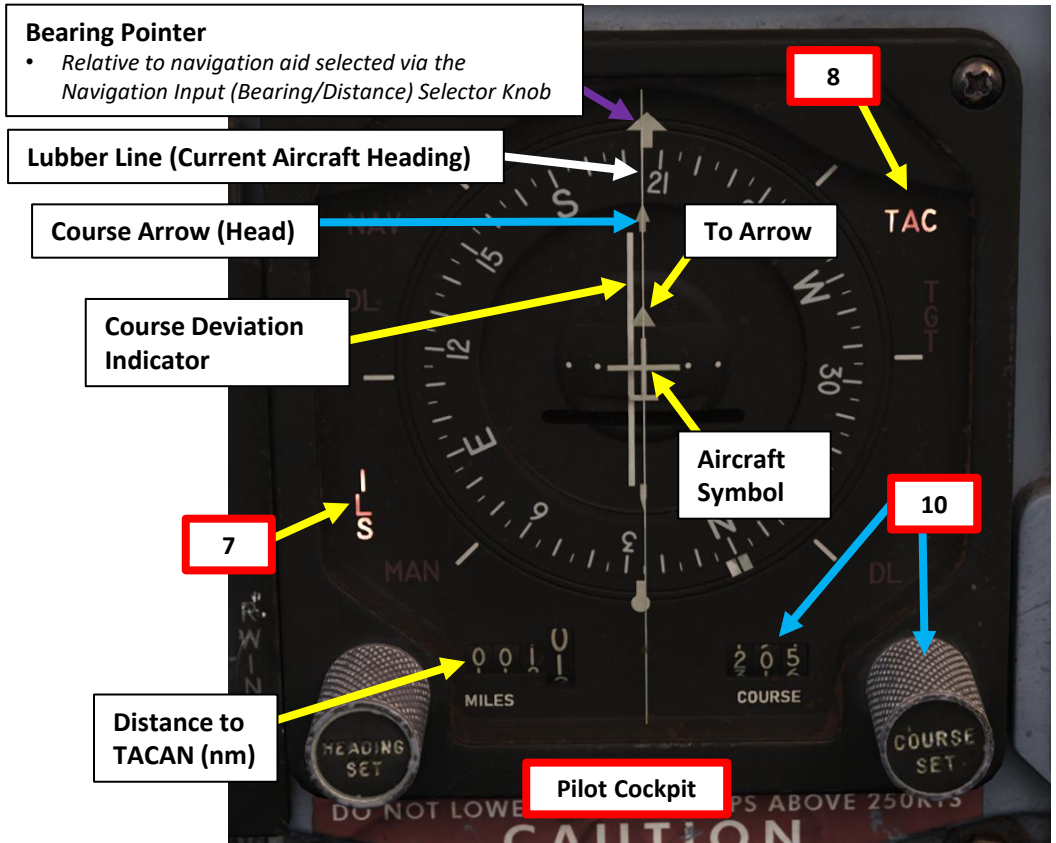


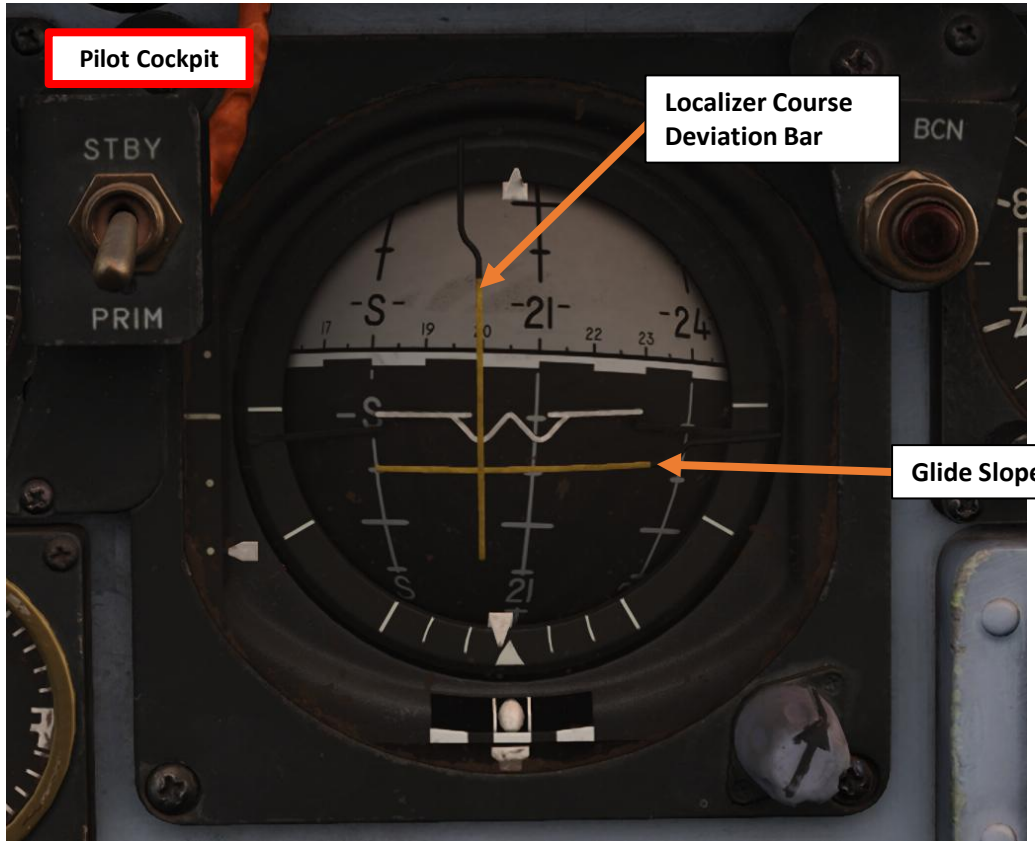
10 – ILS (INSTRUMENT LANDING SYSTEM)

B – Set Up Navigation Systems

7. *[P]* Set Navigation Mode Selecter (Outer Knob) – VOR/ILS.
   - This provides control over the presentation of various displayed information on the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
8. **[P]* Set Navigation Input (Bearing/Distance) Selector – TAC (TACAN).
   - This determines the source of navigation information for the HSI (Horizontal Situation Indicator) and ADI (Attitude Director Indicator).
9. *[P]* Set Flight Director (FD) Selector (Inner Knob) – Horizontal Position (FD ON)
   - This activates pitch and bank steering bars on the ADI (Attitude Director Indicator).
10. *[P]* Set radial interception course to 205 Magnetic with the Course Set Knob. This is the magnetic heading of the runway.
    - Note: In ILS mode, the HSI displays deviation from the localizer signal. This indication is more precise, as the needle is more sensitive to deviations in that mode. Notably, this reading is independent of the selected course, providing direct feedback on the aircraft's alignment with the ILS approach path.



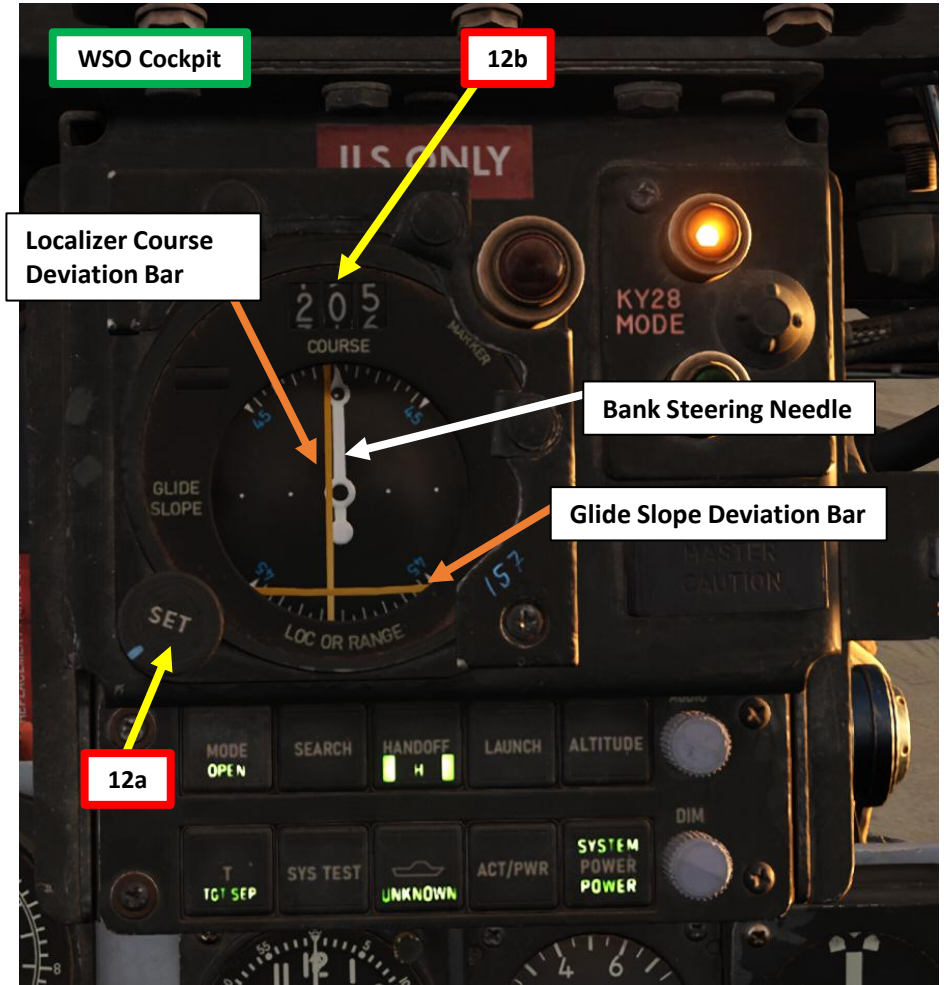




10 – ILS (INSTRUMENT LANDING SYSTEM)

B – Set Up Navigation Systems

*11. *[WSO] Set WSO Navigation Mode Selector Switch – MIDDLE Position (1 VOR / 2 TAC)*
12. [WSO] Set radial interception course to 205 Magnetic with the Course Set Knob. This is the magnetic heading of the runway.





10 – ILS (INSTRUMENT LANDING SYSTEM)

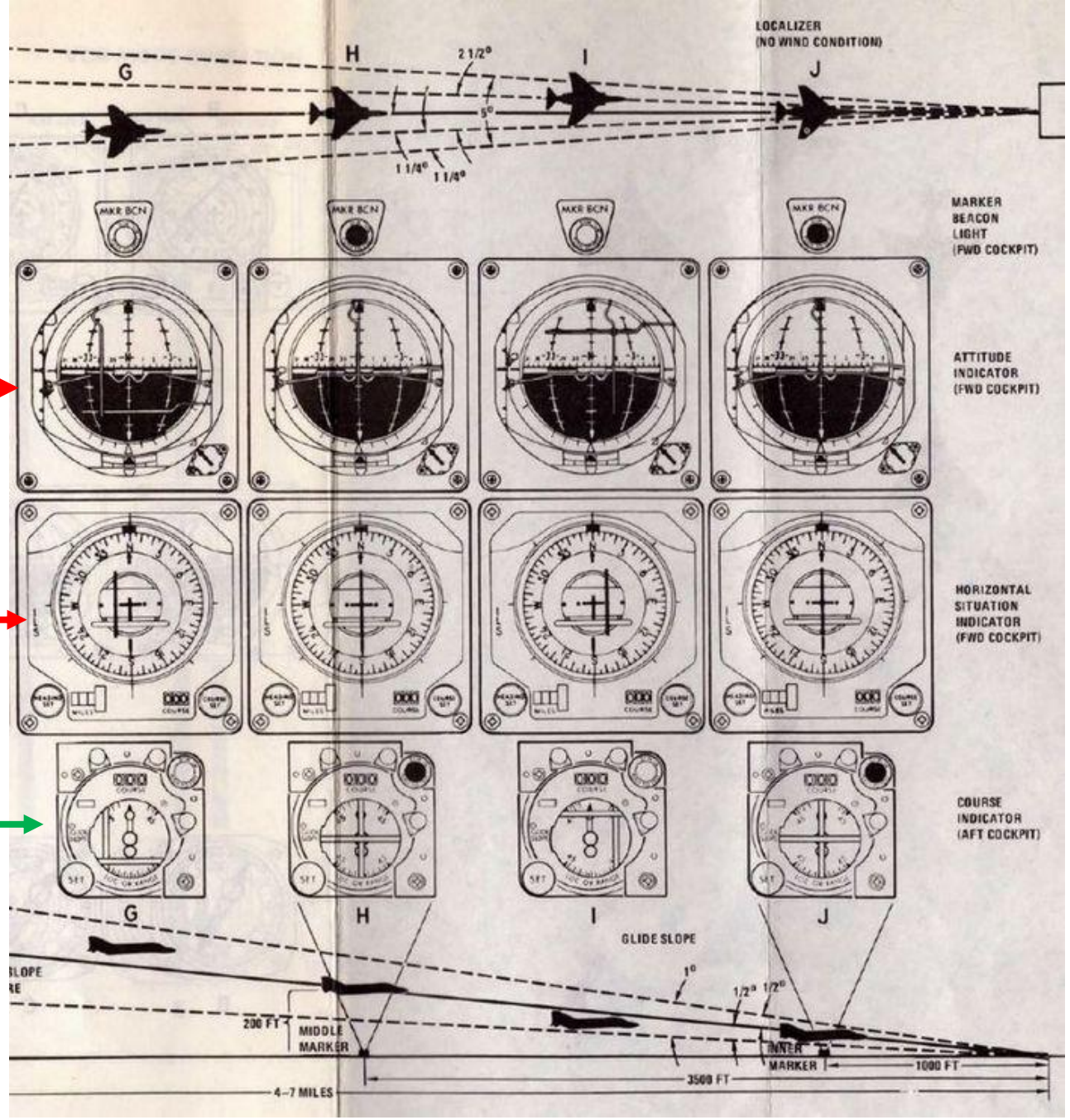
C – Approach

1. *[P]* Once the ILS localizer is detected (about 15 nm from Nellis), start your approach. Using the ADI (Attitude Director Indicator) and HSI (Horizontal Situation Indicator), steer the aircraft to align it with the localizer (lateral deviation from runway centerline) and descend to the runway on a 3 degree glide slope.

ADI (Attitude Director Indicator) (Pilot Cockpit)

HSI (Horizontal Situation Indicator) (Pilot Cockpit)

Course Indicator (WSO Cockpit)



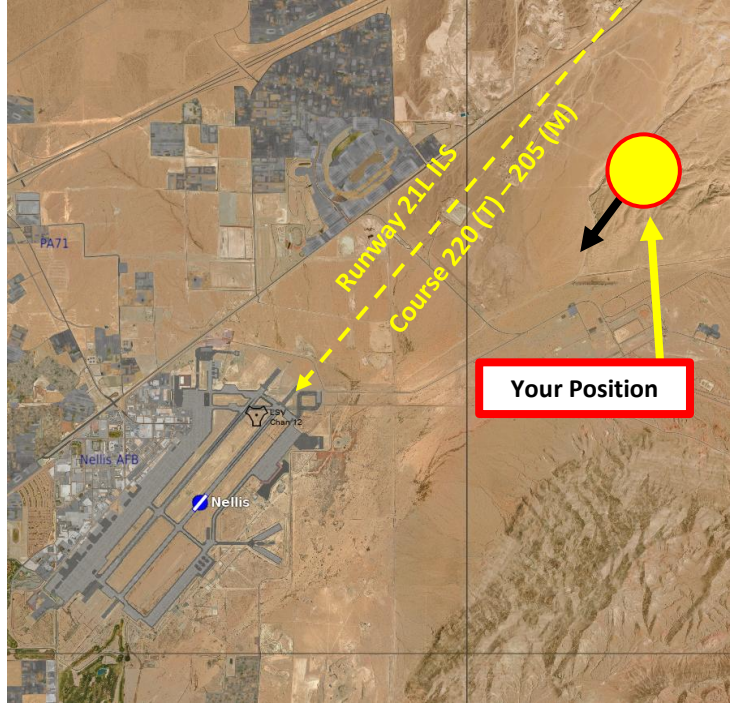
Source: Heatblur Simulations Wiki

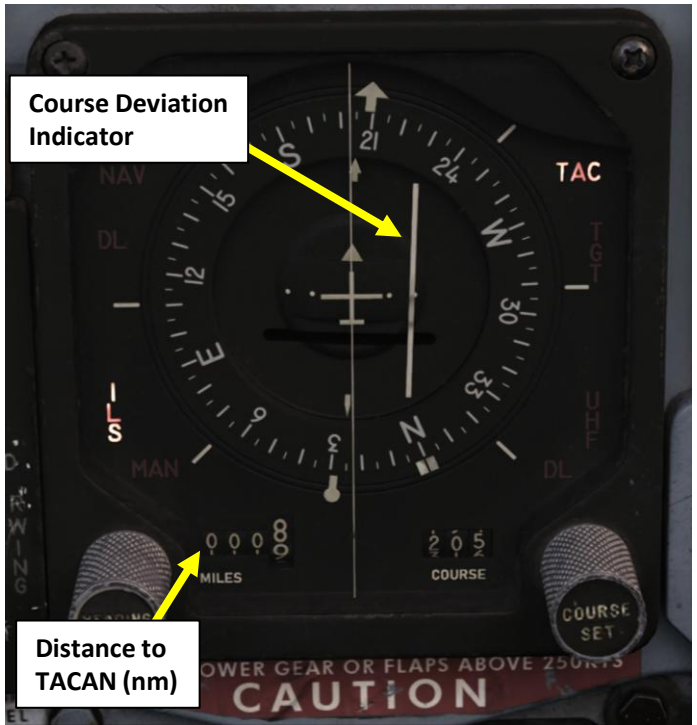
10 – ILS (INSTRUMENT LANDING SYSTEM)

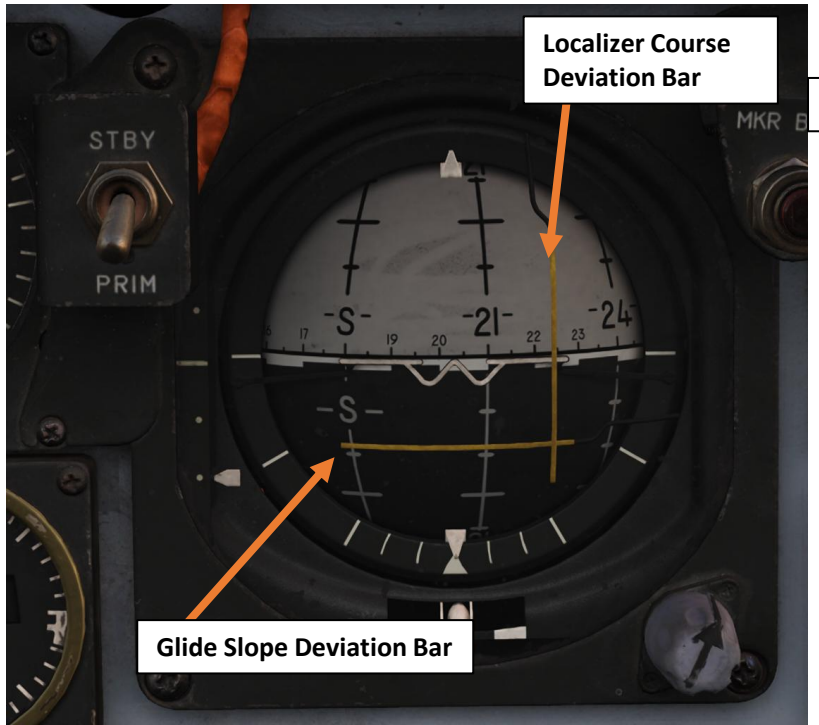
C – Approach

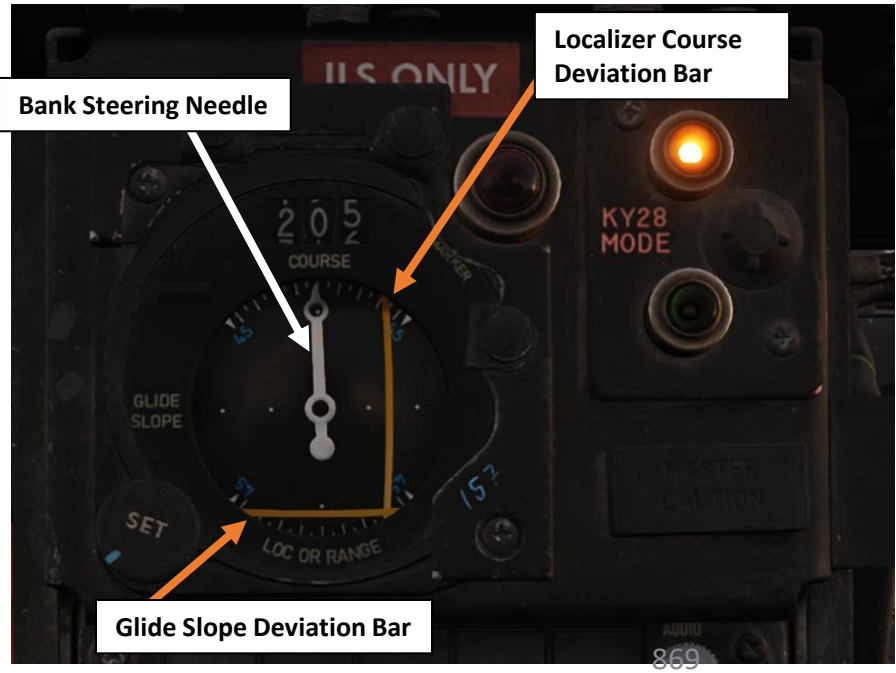
2. *[P]* Steer the aircraft laterally to capture the localizer. When localizer is captured (you are lined up with the runway axis), the course deviation bar will be centered. In the example below, the runway is to our right.
3. *[P]* Fly the aircraft to capture the glide slope by using the glide slope deviation bar (vertical deviation), which should be centered. The glide slope bar should come alive when you are about 10 nm from Nellis. In the example below, we are above the 3 deg glide slope.









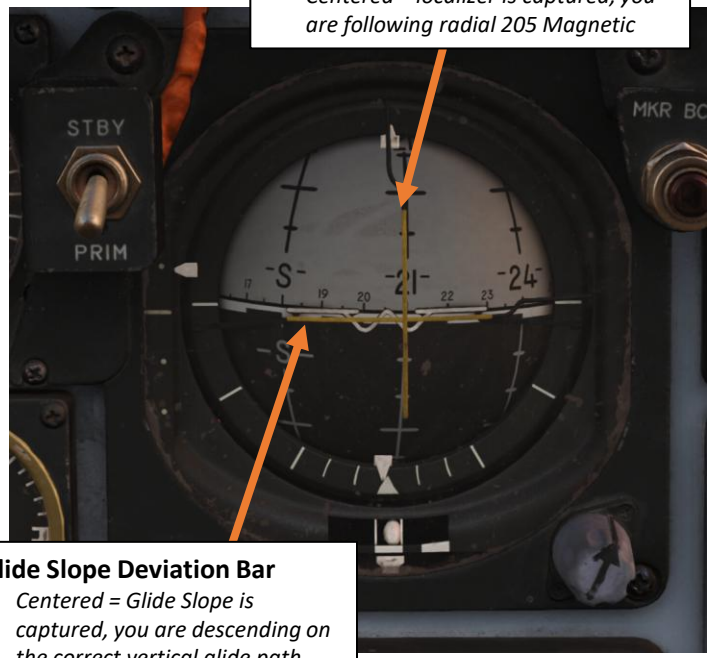


10 – ILS (INSTRUMENT LANDING SYSTEM)

C – Approach

4. *[P]* When you are approaching the airport, the ATC (Air Traffic Controller) will contact you. You can now request landing clearance.
5. *[P]* Once localizer (lateral deviation) and glide slope (vertical deviation) are both captured, fly the aircraft to keep both deviation bars centered. This will ensure that you are on the correct flight path towards the runway.

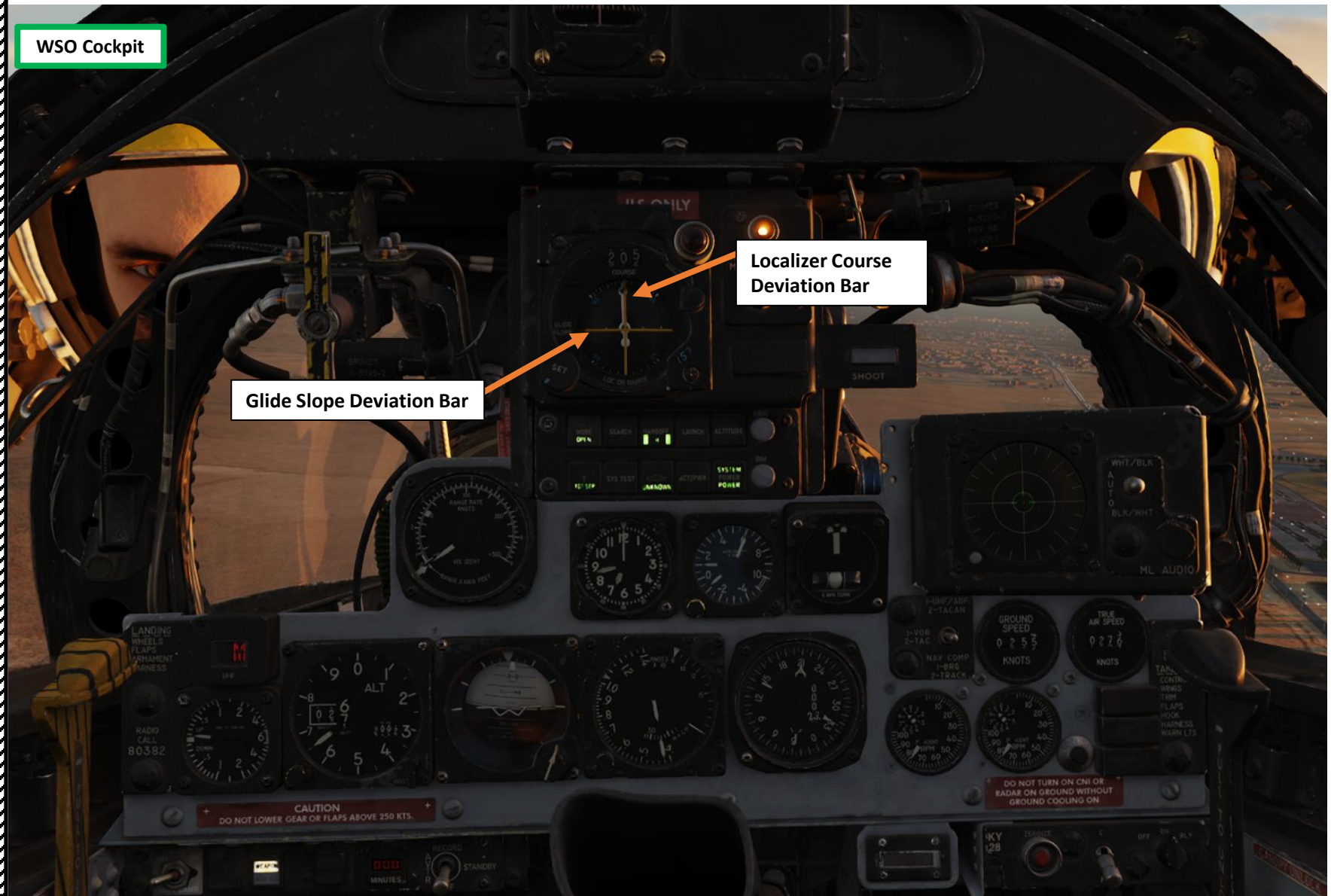




10 – ILS (INSTRUMENT LANDING SYSTEM)

C – Approach

6. *[WSO]* The WSO can monitor the Course Indicator as well, but landing the aircraft is ultimately the responsibility of the pilot.



Localizer Course Deviation Bar
- *Centered = localizer is captured, you are following radial 205 Magnetic*

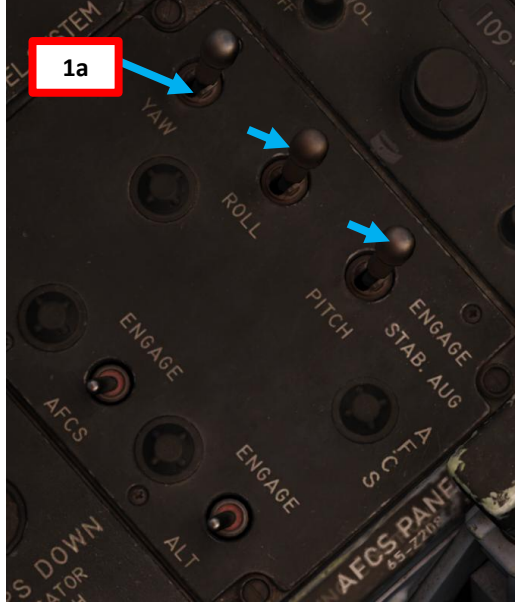


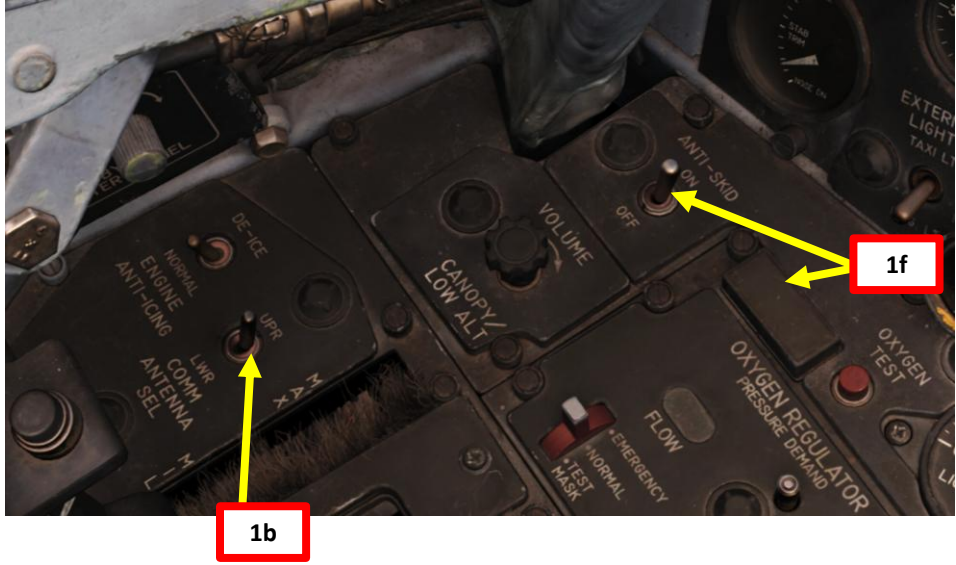
Glide Slope Deviation Bar
- *Centered = Glide Slope is captured, you are descending on the correct vertical glide path.*

10 – ILS (INSTRUMENT LANDING SYSTEM)

D – Landing

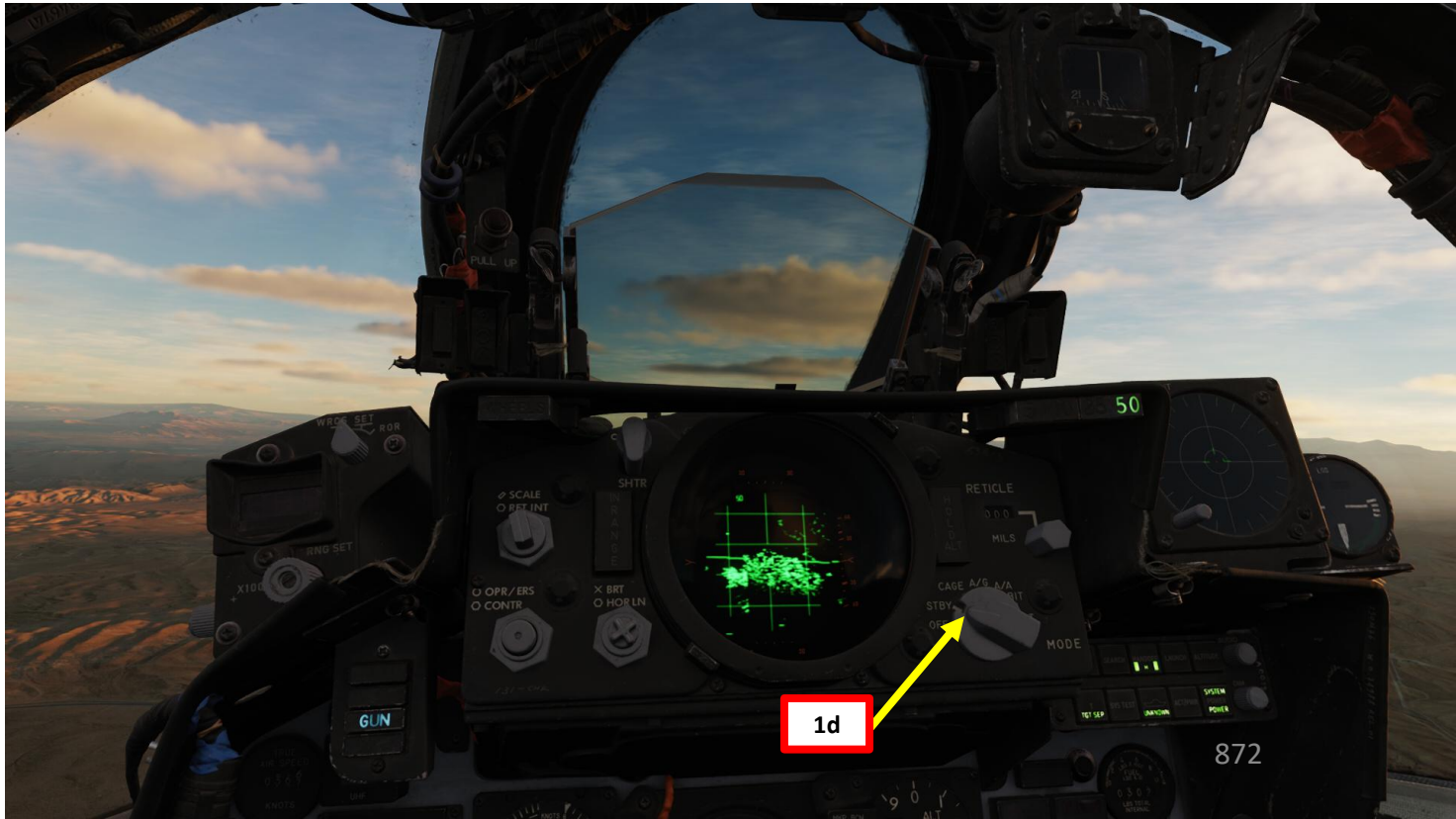
1. *[P]* During initial approach:
   a) On AFCS (Automatic Flight Control System) panel, check Yaw, Roll & Pitch Stability Augmentation System Switches are ON (FWD). Confirm PITCH AUG OFF light is extinguished.
   b) Set Communication Antenna Select Switch – UPR.
      - *Note: Anti-Skid and nosewheel steering may malfunction while transmitting on the lower antenna due to electromagnetic interference.*
   c) Set Taxi/Landing Light Switch – LDG LT (DOWN)
   d) Set Optical Sight Mode – STANDBY (or CAGE).
   e) Set Radar Altimeter Low Altitude Warning Setting – As desired.
   f) Check Anti-Skid Switch is ON (FWD) and confirm ANTI-SKID INOPERATIVE light is extinguished
   g) Align your aircraft with the landing runway at 1500 ft above ground level (or according to local procedures) and maintain 300 kts.











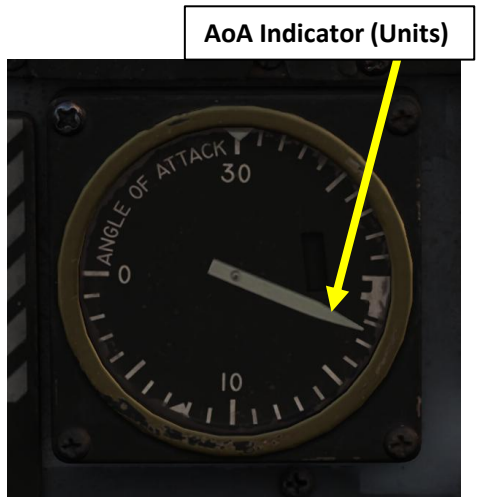
10 – ILS (INSTRUMENT LANDING SYSTEM)

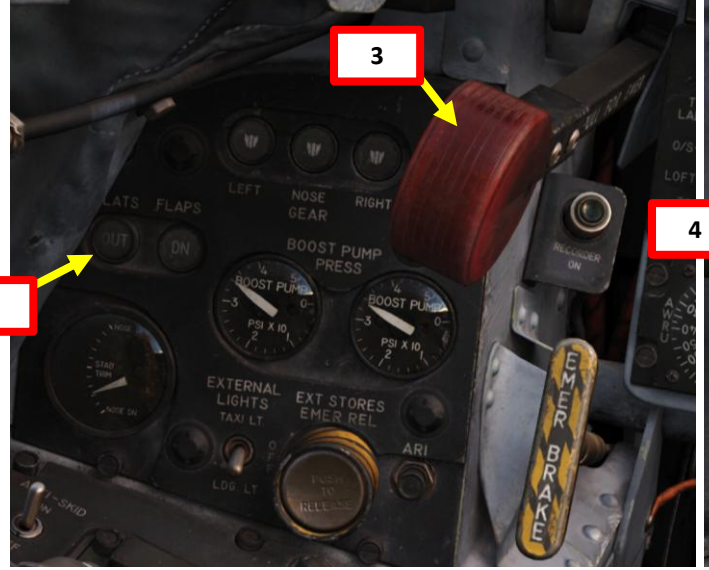
D – Landing

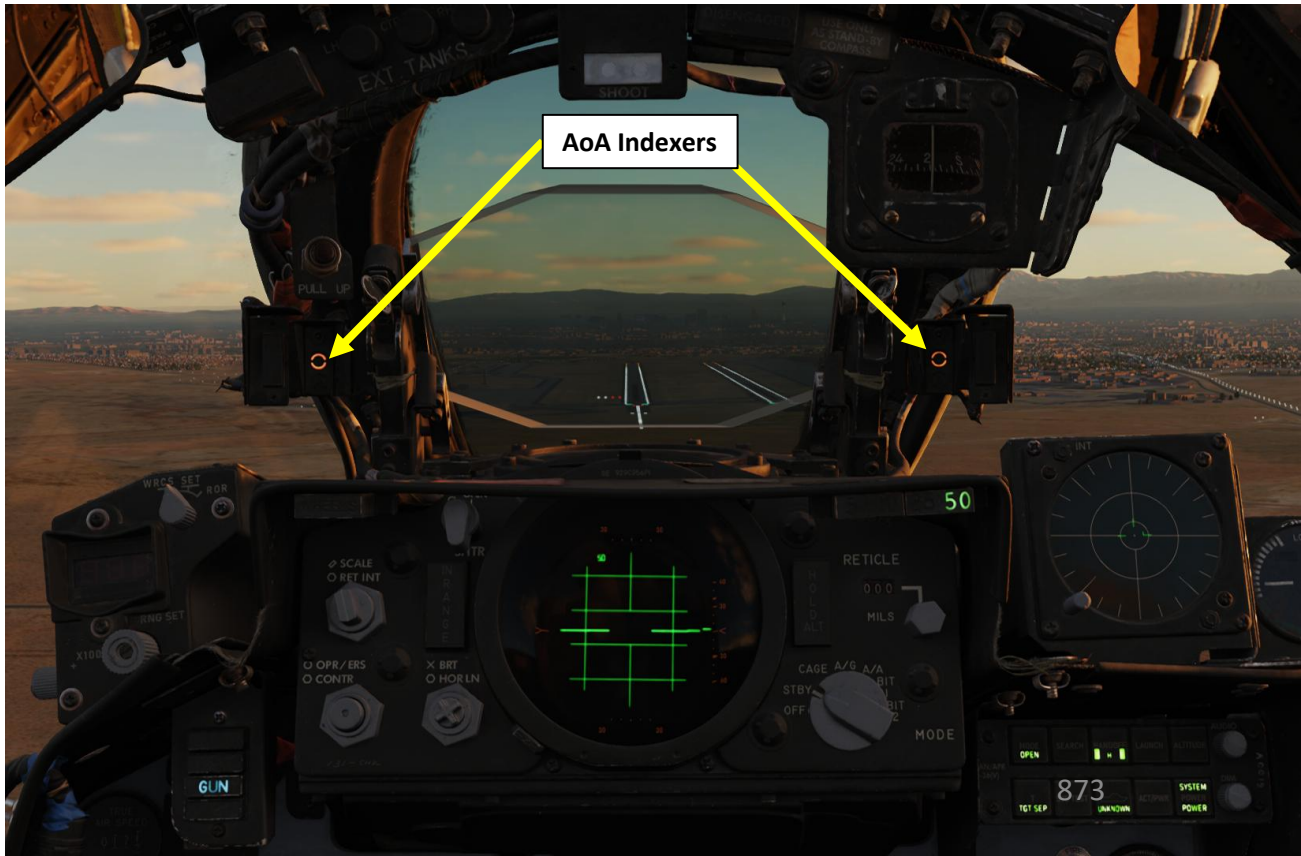
2. *[P]* Adjust power as necessary to attain allowable gear lowering airspeed (below 250 kts).
3. *[P]* Extend landing gear.
4. *[P]* Set Flaps/Slats Control Lever – OUT & DOWN (FULLY DOWN).
5. *[P]* Check SLATS indication displays OUT and FLAPS indication displays DN (Down).

   Note: Actual flap extension may not occur until slowing to 210 knots.
6. *[P]* Reduce speed **(180 kts minimum)** as required to prevent excessive airspeed buildup
7. *[P]* Trim aircraft pitch to set a ON SPEED Angle of Attack (AoA), which is 19.2 units. Use the following to determine ON SPEED AOA:
   - AoA Indexer (doughnut = On Speed)
   - AoA Indicator (angle of attack in units)
   - AoA aural tone system indicates an on-speed approach with steady tone played at medium pitch.







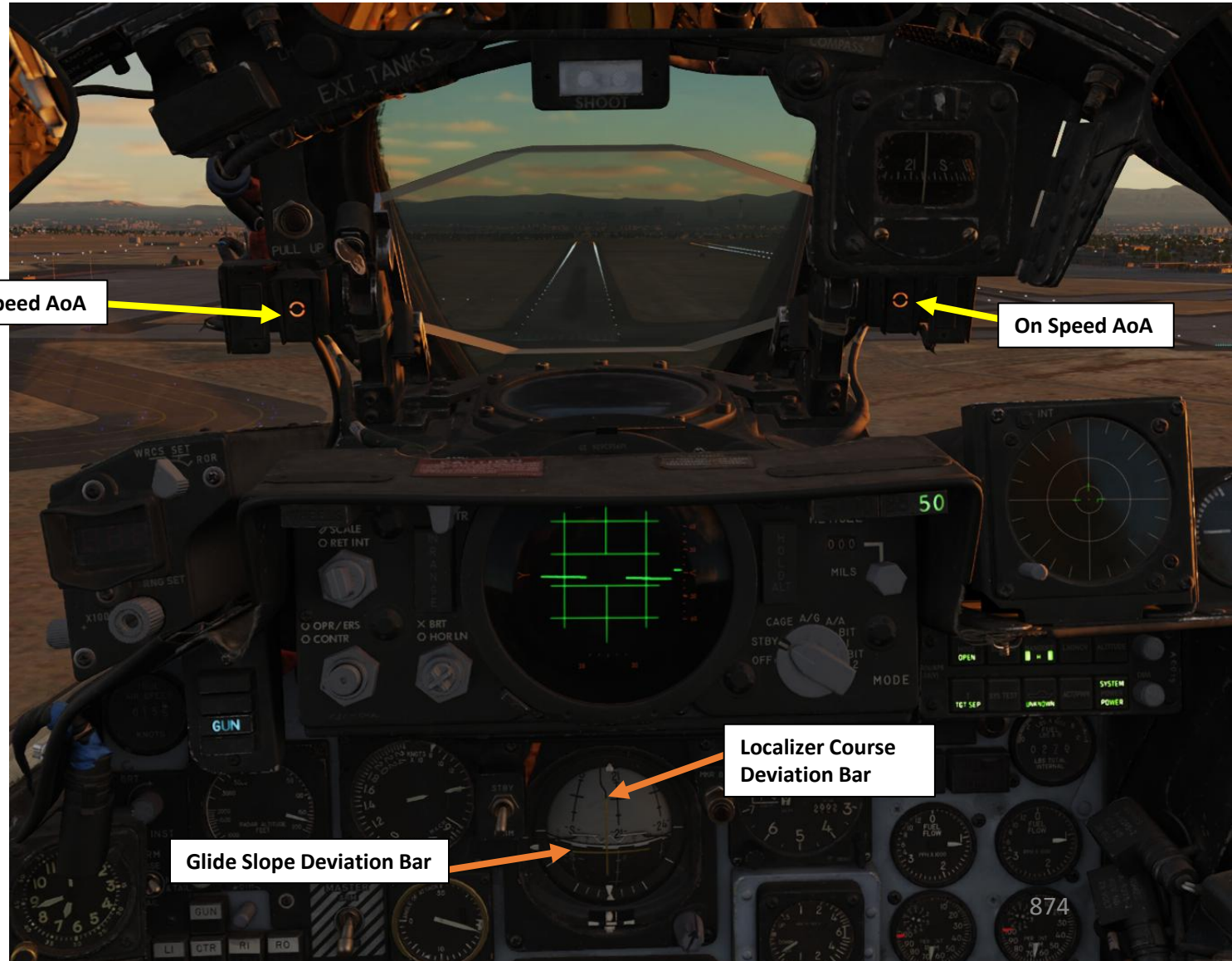


10 – ILS (INSTRUMENT LANDING SYSTEM)

Approach Speed Formula: Final approach airspeed is approximately 142 kts at a gross weight of 33000 lbs + 2 knots for each 1000 lbs above 33000 lbs

D – Landing

8. *[P]* When on final, fly the aircraft to keep both deviation bars centered on the ADI (Attitude Director Indicator). This will ensure proper glidepath (3 deg glide slope) while maintaining 19.2 deg AoA.
9. *[P]* Use throttle to control rate of descent and glide slope while using the stick to maintain a 19.2 units AoA.
10. *[P]* If too high on glide slope, reduce power, establish a new glide slope, then add power to maintain glide slope when captured.
11. *[P]* If too low on glide slope, add power, hold on speed and reduce power to maintain glide slope when captured.



10 – ILS (INSTRUMENT LANDING SYSTEM)

D – Landing

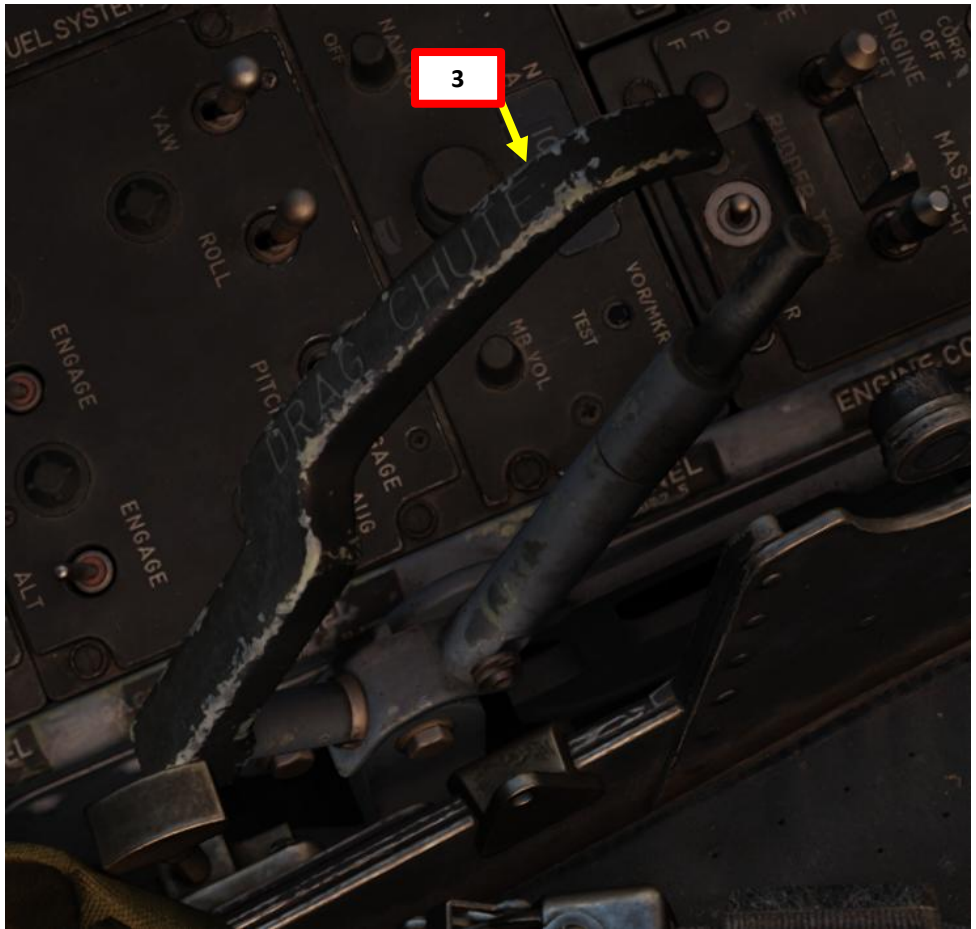
12. *[P]* Maintain final approach angle of attack all the way to touchdown. The F-4 is flown down final approach at touchdown speed, therefore the power is held relatively constant to touchdown.



10 – ILS (INSTRUMENT LANDING SYSTEM)

E – Roll-Out

1. *[P]* Flare at 20 ft by gently pulling the stick aft and let the aircraft touchdown.
    - Note: When the aircraft is 20 ft above the runway, ground effect will tend to pitch the aircraft nose down. Pitch attitude should be maintained by increasing aft stick pressure during touchdown. If you were high above glide path, the rate of descent will be high, and as a result some additional power will be necessary to decrease the excessive rate of descent.
2. *[P]* At touchdown, reduce power to IDLE.
3. *[P]* Pull Drag Chute Lever to deploy drag chute (“P” binding).







10 – ILS (INSTRUMENT LANDING SYSTEM)

E – Roll-Out

4. *[P]* Use full aft stick to help decelerate.
5. *[P]* Use rudder and ailerons for directional control down to 70 knots, then use differential braking. Nose gear steering should not be required for directional control in light crosswind conditions. However, if rudder, aileron, and/or differential braking are not effective in maintaining directional control, use nose gear steering as required. Engage nose gear steering only with the rudder at or near neutral.
6. *[P]* Gently tap wheel brakes when below 70 kts until you come to a full stop.

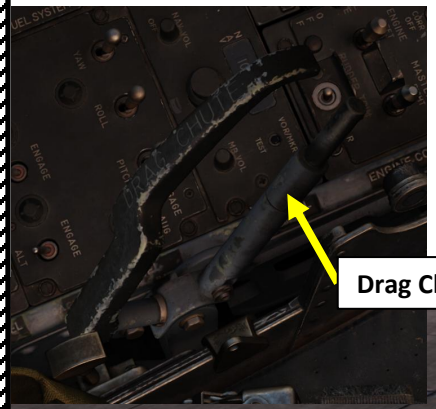


10 – ILS (INSTRUMENT LANDING SYSTEM)

E – Roll-Out

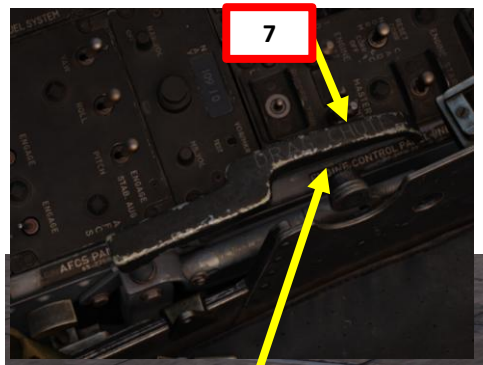
7. *[P]* When able, push Drag Chute Lever back IN to jettison drag chute.

- *Note: Drag chute should not be jettisoned on the runway or a taxiway. A popular technique is to leave it on the side of a taxiway by appropriately orienting the aircraft, inflating the chute with the engines and then releasing it in the desired direction.*



Drag Chute Deployed

Drag Chute Deployed
(High Engine Power)



7

Drag Chute Jettisoned

10 – ILS (INSTRUMENT LANDING SYSTEM)

E – Roll-Out

8. *[P]* Taxi to the parking area and shutdown aircraft.

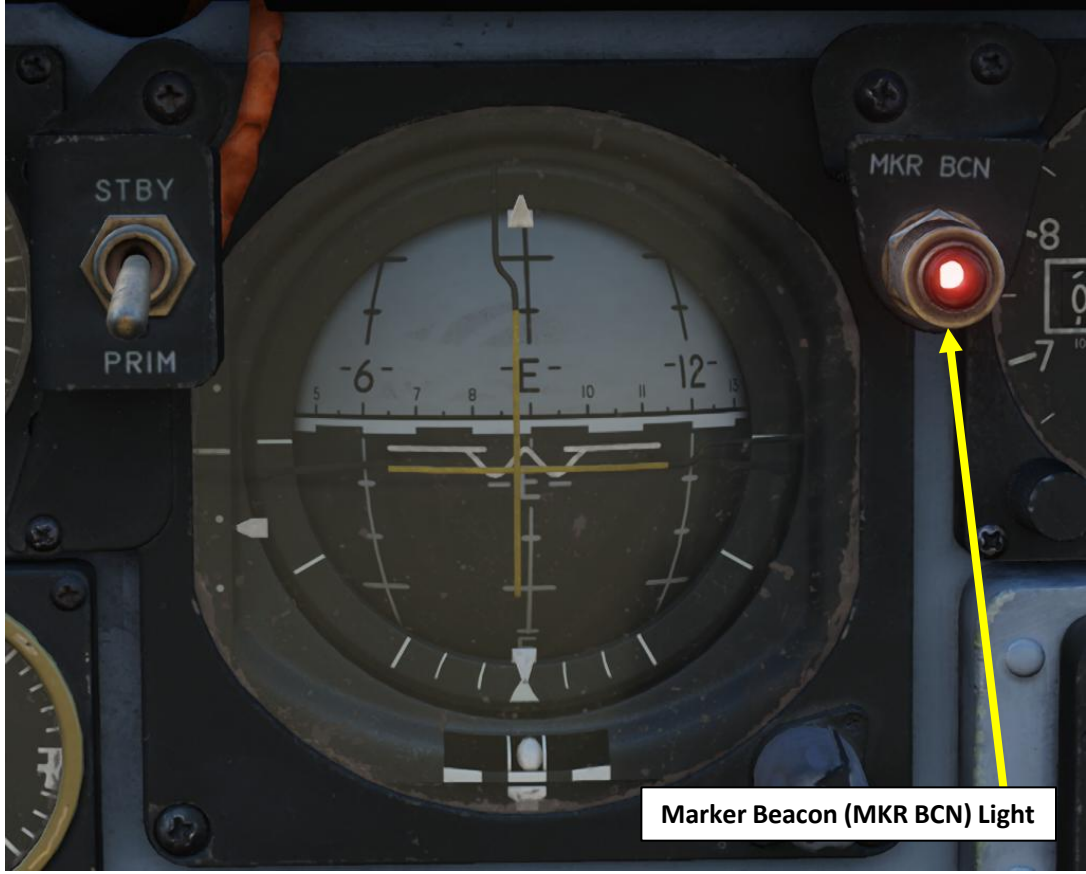


10 – ILS (INSTRUMENT LANDING SYSTEM)

Additional Notes: Markers

If Marker Beacons are positioned along the approach path, the aircraft's system will audibly signal and illuminate the corresponding Marker Beacon light as it passes over each one. Depending on the specific setup at an airport, there can be three kinds of markers:

- **Outer Marker**: Identified by a low-pitched, continuous tone. This marker normally identifies the final approach fix (FAF).
- **Middle Marker**: Recognized by a higher-pitched, alternating audio tone. This marker indicates a closer proximity to the runway, usually at the decision altitude for landing. It is normally positioned 0.5 to 0.8 nautical miles (1 km) before the runway threshold.
- **Inner Marker**: Characterized by a very high-pitched tone or a series of high-pitched dots. This marker is not always present but, when it is, signifies an even closer position to the runway end. It is typically located at the beginning (threshold) of the runway on some ILS approach systems (usually Category II and III) having decision heights of less than 200 feet (60 m) AGL.





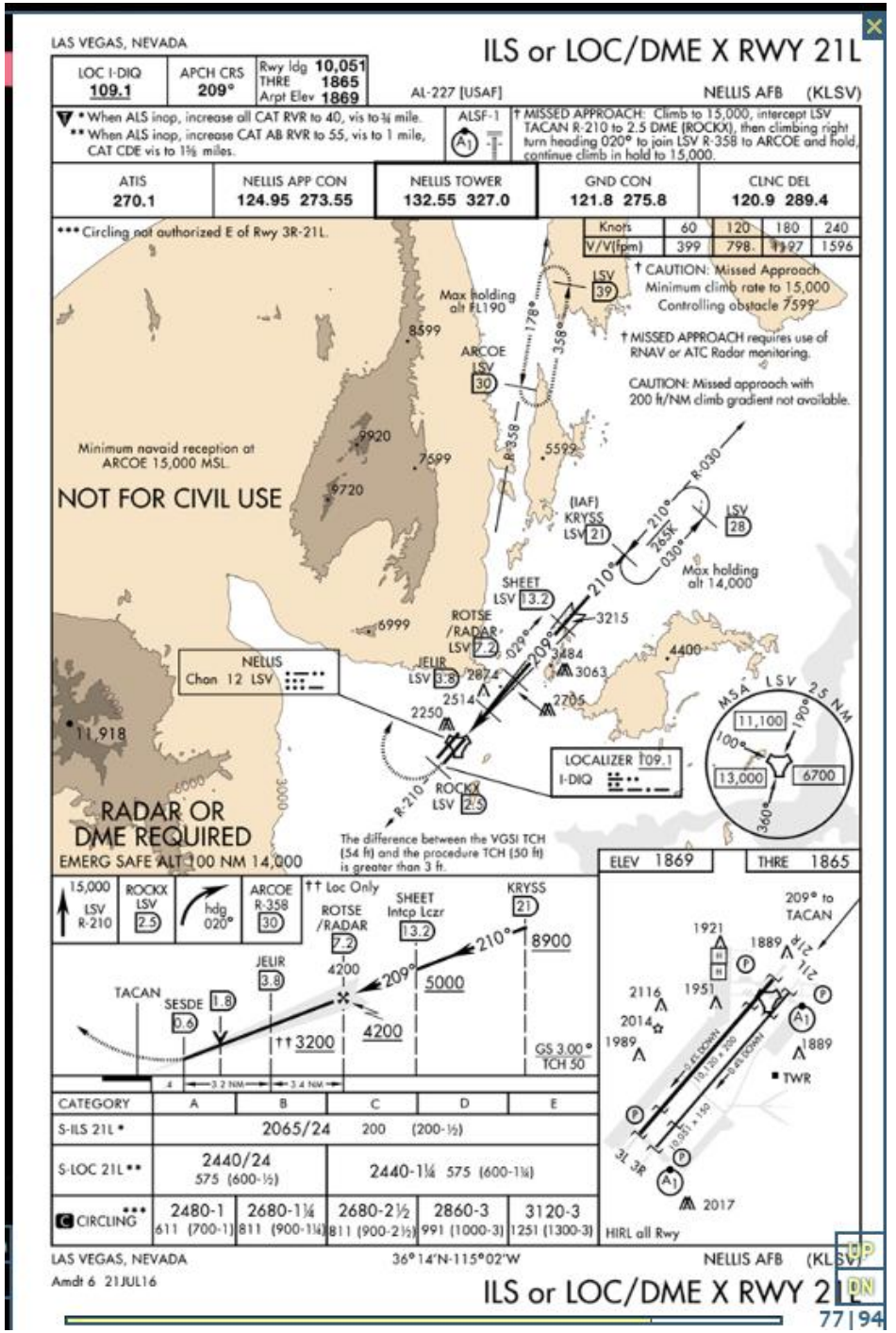
10 – ILS (INSTRUMENT LANDING SYSTEM)

Additional Notes: Reading Approach Charts

There is an interesting online resource that is a great help to learn how to read IFR (Instrument Flight Rules) approach charts, which are used for low-visibility conditions. They are officially called IAP (Instrument Approach Procedure) charts, but pilots often casually call them “approach plates”.

IAP charts explain what procedures, altitude restrictions, navigation aids and missed approach instructions are required for a precise descent to a specific runway for a given airport.

Pilot Institute Website Link:
https://pilotinstitute.com/reading-an-ifr-chart/



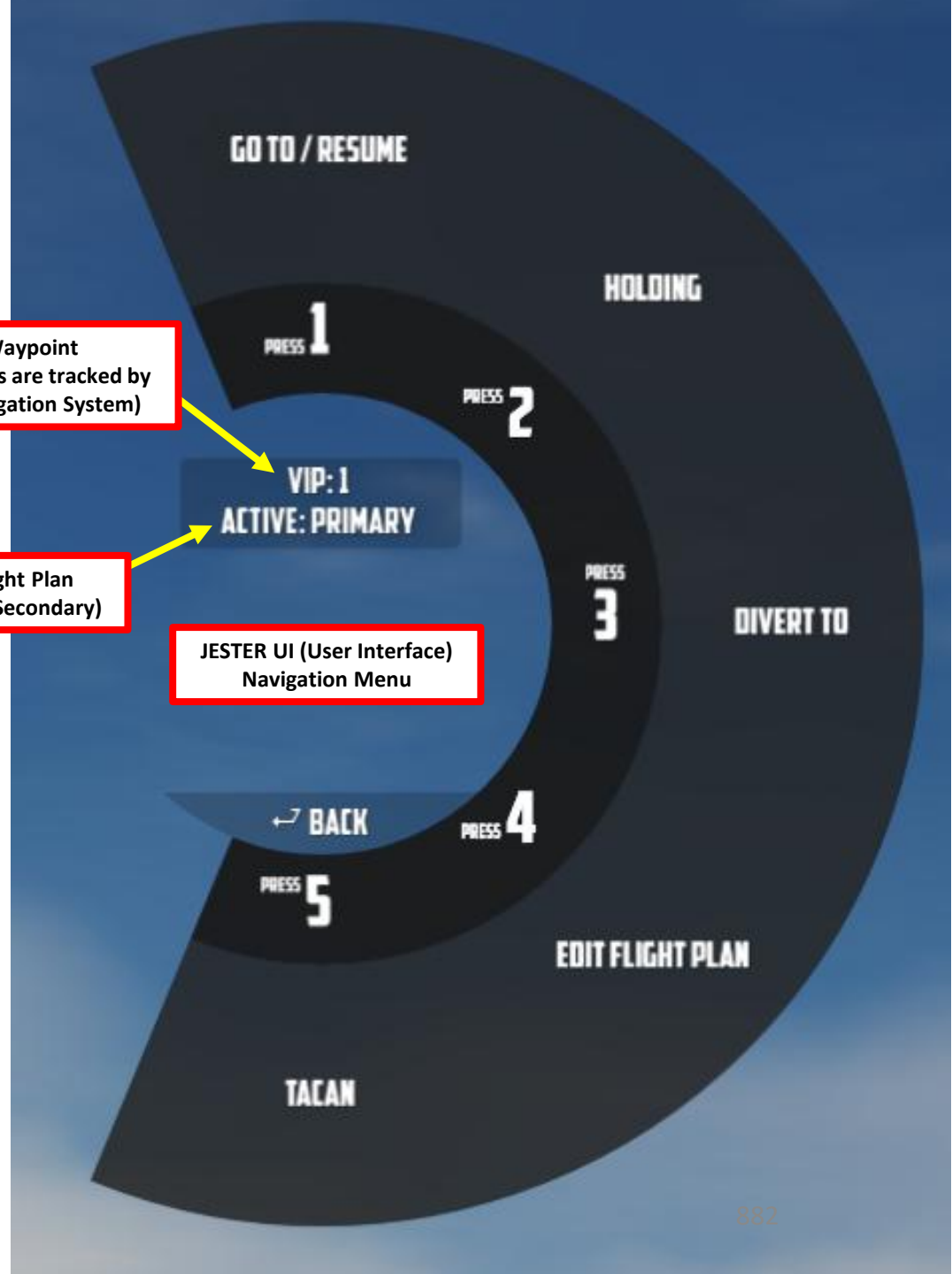
11 – JESTER AI NAVIGATION
11.1 – Navigation Menu

When you are flying in the pilot position and the JESTER AI takes over WSO tasks, JESTER will perform various navigation-related tasks by himself. Navigation with Jester revolves around managing turn points for two flight plans: the Primary Flight Plan and the Secondary Flight Plan. Both can be edited and followed by Jester in the same manner, although Primary Flight Plan is considered the main one and the Secondary Flight Plan serves as a backup.

Simply put, JESTER will set the INS (Inertial Navigation System) to track the coordinates of the first waypoint in your flight plan after takeoff. Once you cross over that waypoint, JESTER will then select coordinates for the next waypoint automatically. You can always use JESTER to select another waypoint of navigation aid as required.

The designation for each waypoint in the flight plan will influence Jester's actions and the dialog phrases he uses as you approach the waypoint. See section 4.2 – Flight Plan Preparation for more information about the nature of these points.

- **Turn Point (default):** JESTER will automatically switch to the next waypoint when the aircraft is within 2 nautical miles (nm) of the turn point, as indicated by his BDHI.
- **Nav Fix (VIP - Visual Identification Point):** JESTER will perform an INS (Inertial Navigation System) position update when flying over this point. Upon a successful fix, Jester will switch to the next waypoint.
- **Initial Point (IP):** JESTER will update the pilot as the aircraft approaches the point (10 nm, 5 nm, and 2 nm in advance), and switch to the next waypoint once past the target.
- **Target (TGT):** JESTER will update the pilot as the aircraft approaches the point (10 nm, 5 nm, and 2 nm in advance), and switch to the next waypoint once past the target.
- **Fence In (F-IN)** and **Fence Out (F-OUT):** JESTER will run through fence in and fence out checklists.
- **Homebase (HB)** and **Alternate (ALT):** JESTER will not automatically switch to the next waypoint at these points, and he will report as the aircraft approaches the Homebase.
- **Combat Air Patrol (CAP):** JESTER will ask how long the pilot intends to remain on station at CAP1. He will then cycle between CAP1 and CAP2 until the designated CAP time expires, after which he will switch to the next waypoint following CAP2 in the flight plan. There can be several CAP1-CAP2 pairs.

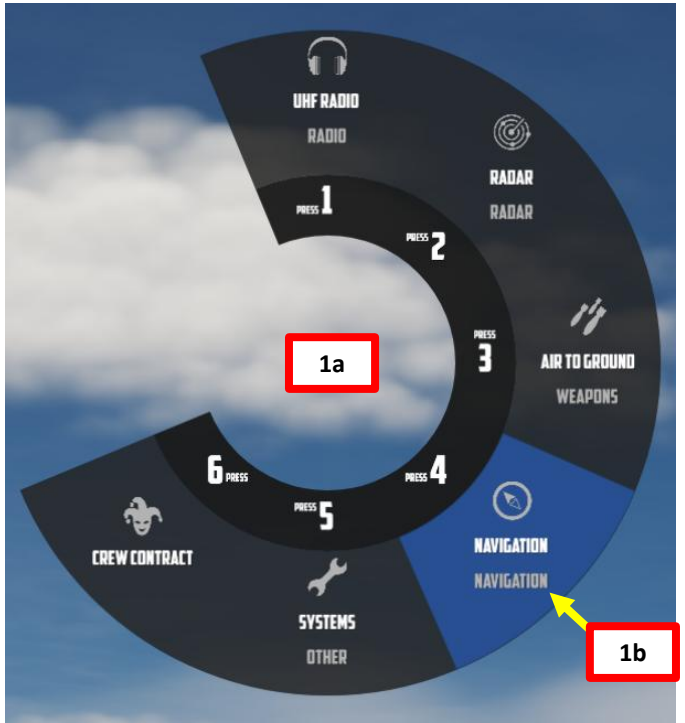


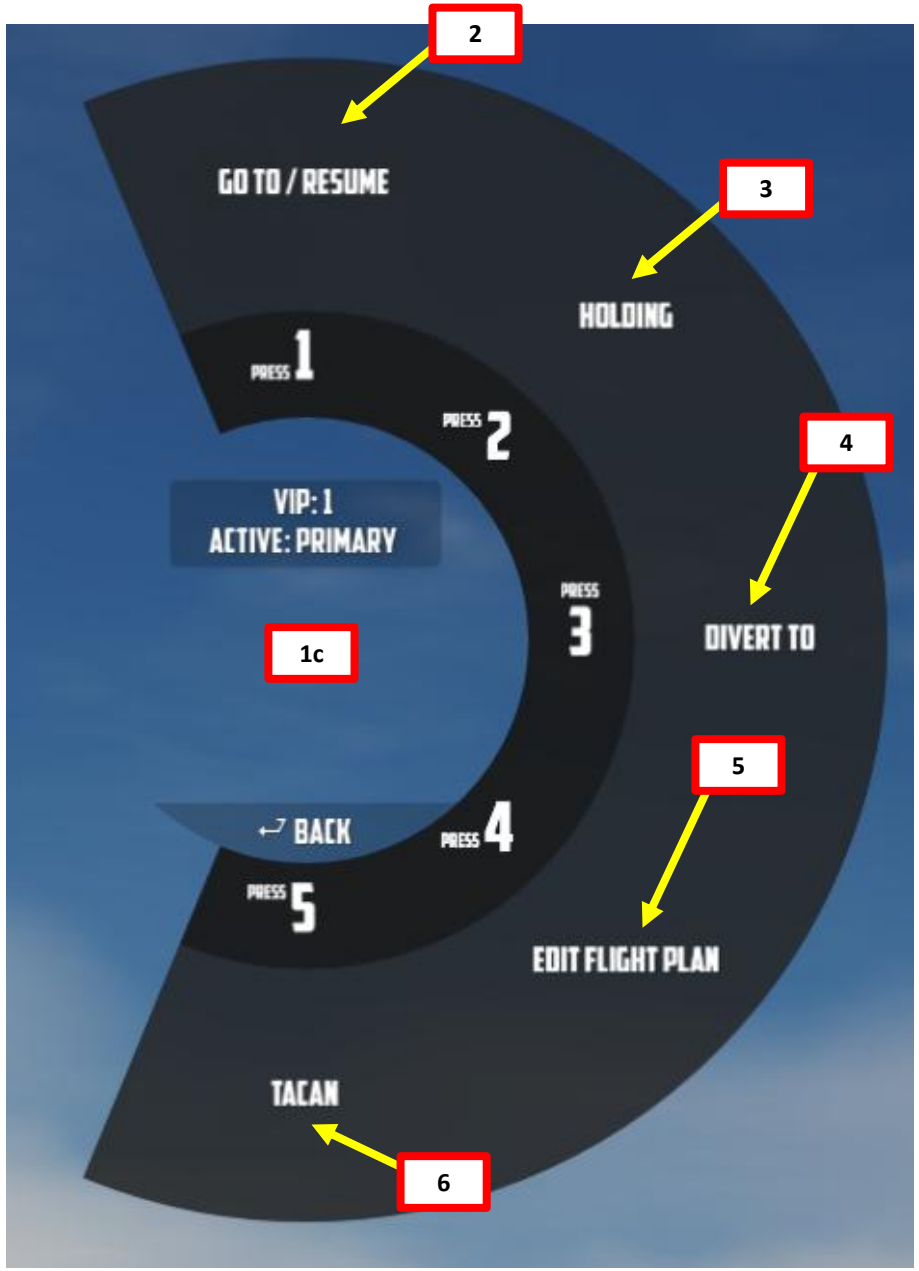
11 – JESTER AI NAVIGATION
11.1 – Navigation Menu

JESTER User Interface (UI) Functions Summary

To open JESTER AI wheel, short-press "A" (JESTER UI Action binding). Consult the Heatblur Simulations wiki for more information.

1. From the **NAVIGATION** menu, you will access all navigation-related JESTER commands.
2. From the **GO TO/RESUME** menu, you can select which waypoint JESTER is tracking from the selected flight plan (primary or secondary).
3. From the **HOLDING** menu, automatic turn point switching can be temporarily disabled per turn point, allowing you to hold position at a designated point. Turn points designated for holding are marked with a "h".
4. From the **DIVERT TO** menu, JESTER can divert to a different unplanned turn point (not necessarily from the primary or secondary flight plan) using TGT 1 mode.
5. From the **EDIT FLIGHT PLAN** menu, you can edit the sequence of waypoints within the primary or secondary flight plan.
6. From the **TACAN** menu, you can select which TACAN station JESTER is tracking.





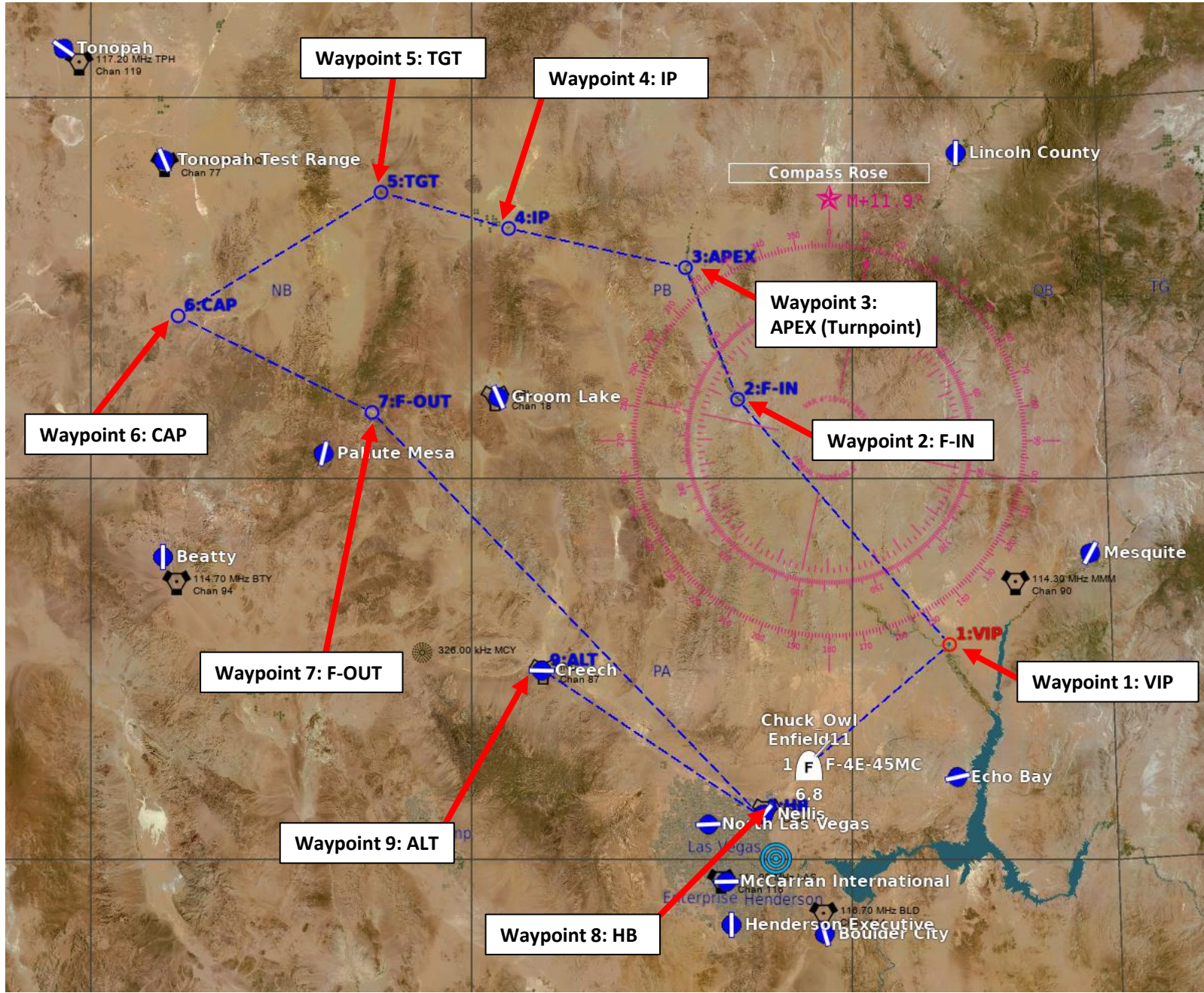
11 – JESTER AI NAVIGATION
11.2 – JESTER Functions

For this section, this flight plan is what we will use as a reference.

Turnpoints

TURNPOINTS

TURNPOINT #	LAT	LON
1	Lat: 36° 37' N	Lon: 114° 28' W
2	Lat: 37° 13' N	Lon: 115° 5' W
3	Lat: 37° 31' N	Lon: 115° 14' W
4	Lat: 37° 37' N	Lon: 115° 45' W
5	Lat: 37° 43' N	Lon: 116° 8' W
6	Lat: 37° 25' N	Lon: 116° 44' W
7	Lat: 37° 11' N	Lon: 116° 10' W
8	Lat: 36° 13' N	Lon: 115° 2' W
9	Lat: 36° 35' N	Lon: 115° 40' W



11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.1 – Go To / Resume

The Go To / Resume option is used to select which turnpoint is being tracked. The active flight plan is indicated by the UI using an asterisk (*) next to the current turn point.

To select a waypoint, click on the desired waypoint from the list within the active flight plan.

Automatic turn point switching can be temporarily disabled per turn point using the Holding option. Turn points designated for holding are marked with a “h”.

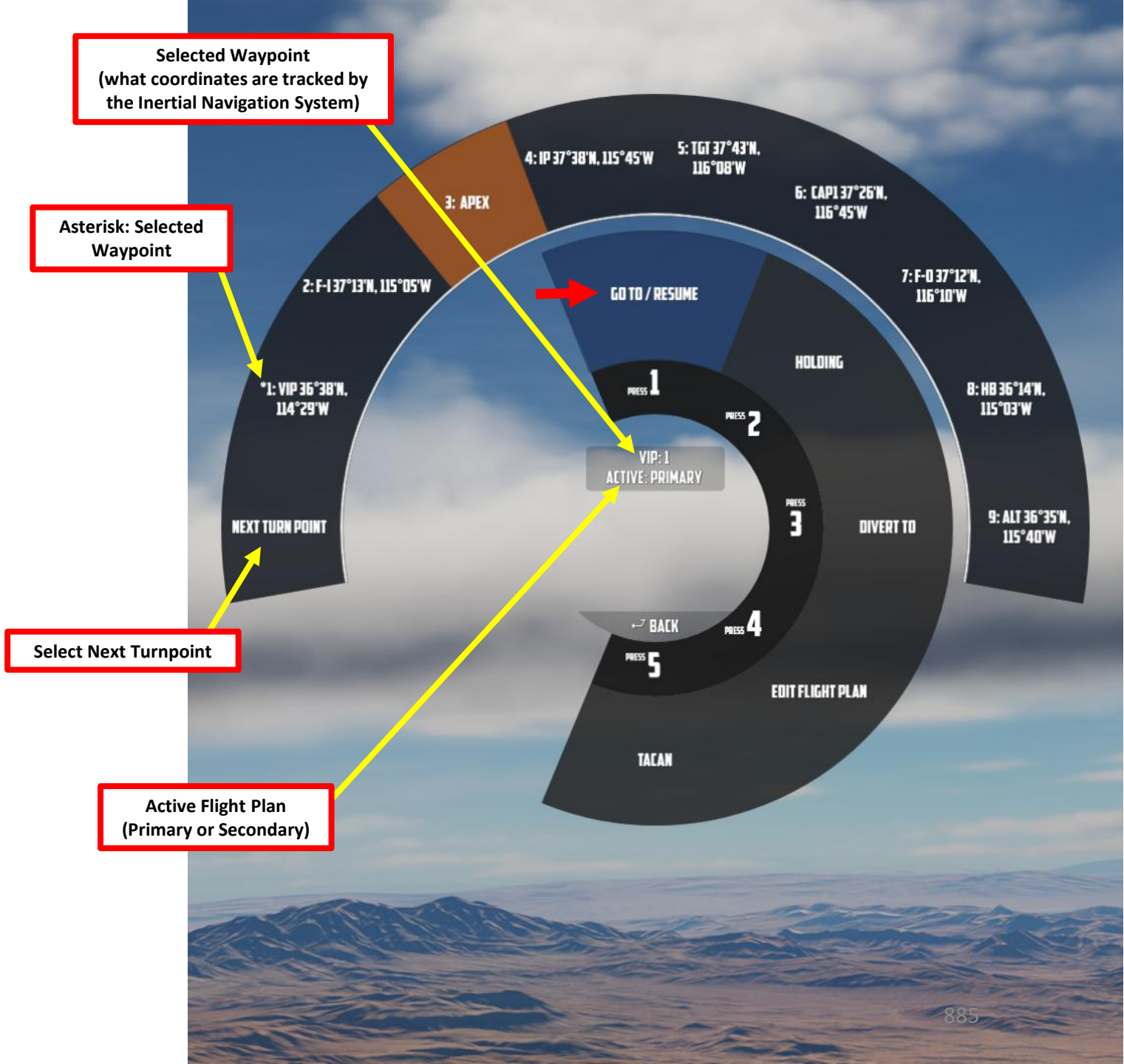
When a flight plan has been paused, for example, because the pilot diverted to a different point (using TGT 1), it can be reactivated through the UI again from the Go To/Resume menu.

This also offers the possibility to skip turn points by jumping directly to any turn point in its sequence, as well as returning to previous points or resuming from a point designated for holding.

Additional Note:

Jester **navigates by utilizing a technique called leapfrogging**. The aircraft only provides a single slot to memorize a waypoint (called TGT 2). When leapfrogging, TGT 2 always indicates the next turn point of the current active flight plan. As the aircraft approaches this turn point (±2 nautical miles), Jester will automatically update TGT 2 to the next turn point in the sequence.

This enables the pilot to follow the entire route of the flight plan by selecting NAV COMP on the Navigation Function Selector Panel and following the corresponding indication on the HSI.



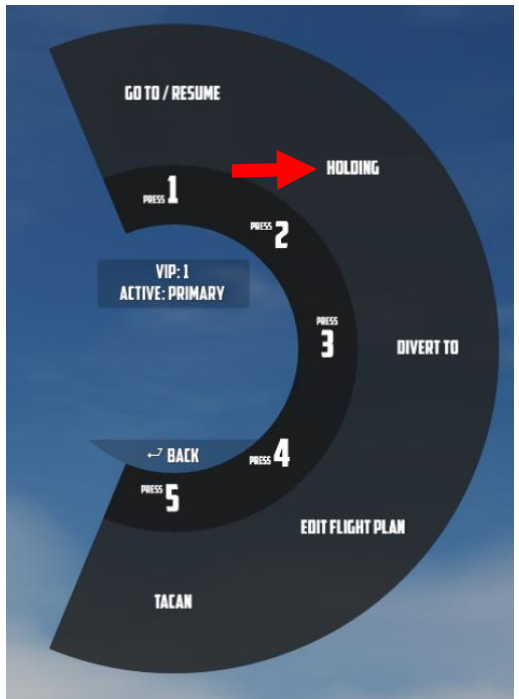
11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.2 – Holding

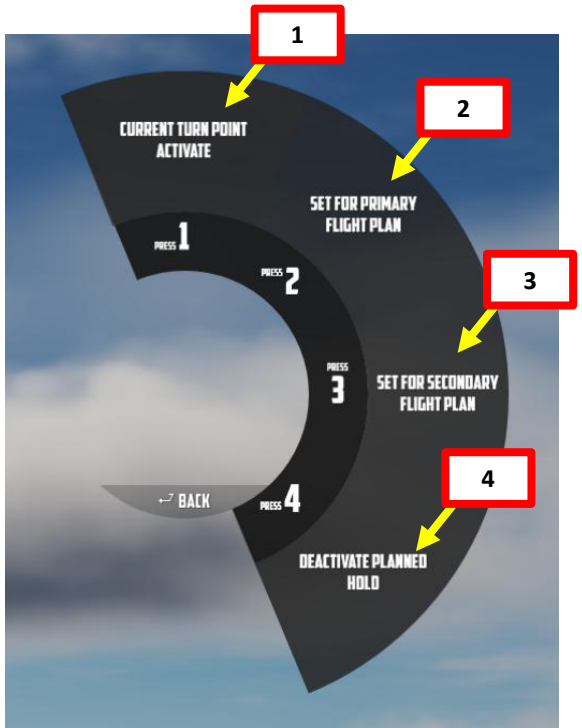
The Holding option allows you to select any waypoint from the existing flight plan and designate it as a "holding point". This means that **JESTER will not switch to the next waypoint when reaching this holding point**. In other words, automatic turn point switching is temporarily disabled per turn point using the Holding option.

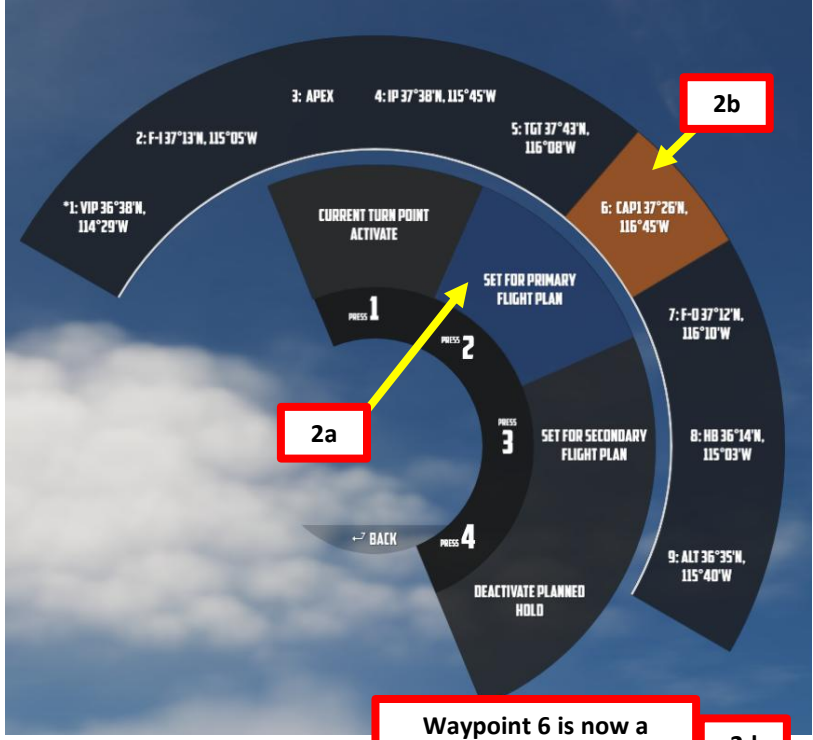
The Holding option allows you to:

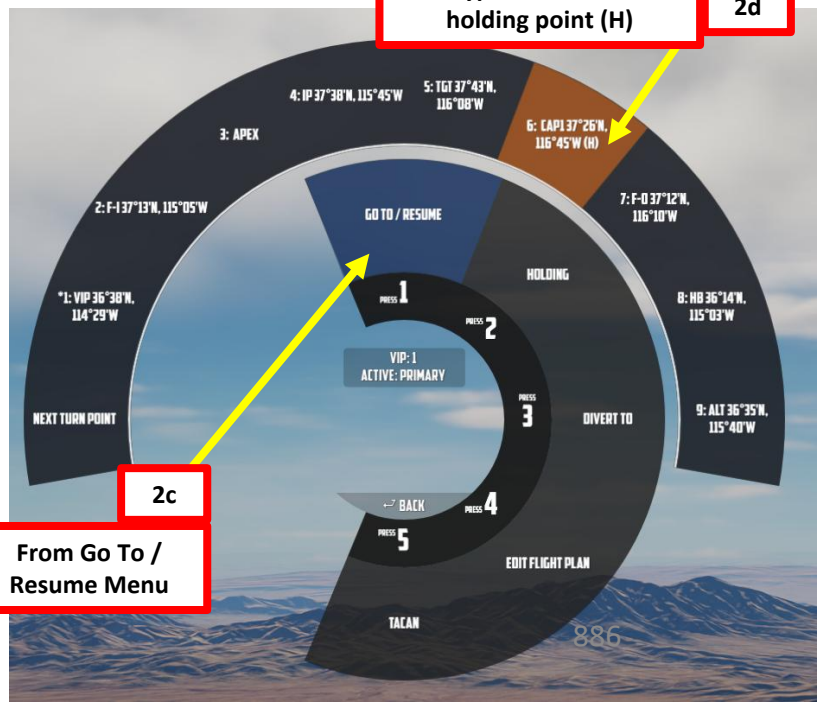
1. Activate the currently selected turn point as a holding point.
2. Set a specific waypoint of your primary flight plan as a holding point.
3. Set a specific waypoint of your secondary flight plan as a holding point.
4. Deactivate a specific waypoint currently set as a holding point.

Turn points designated for holding are marked with "H".





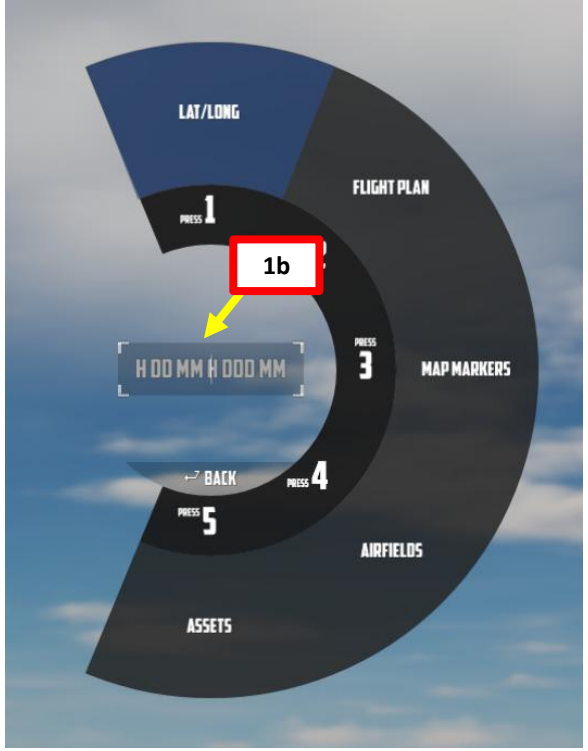


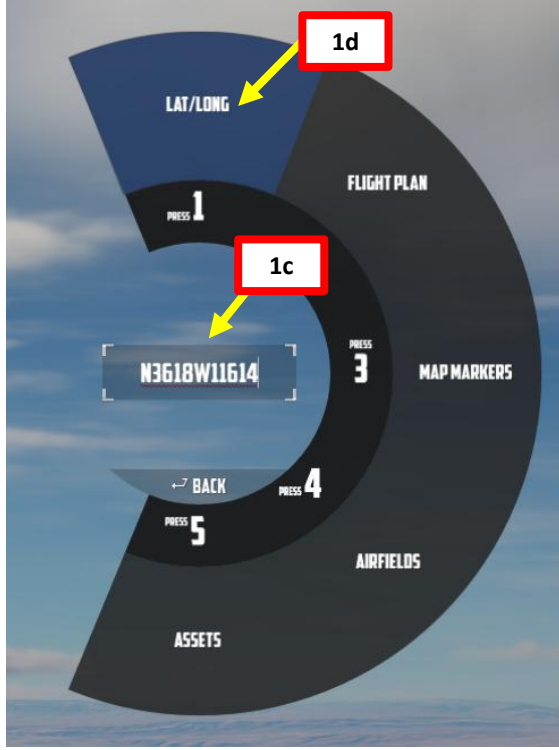


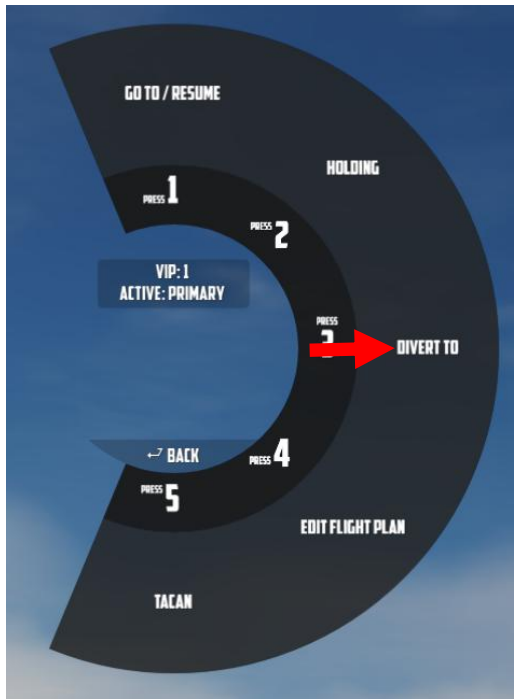
11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.3 – Divert To

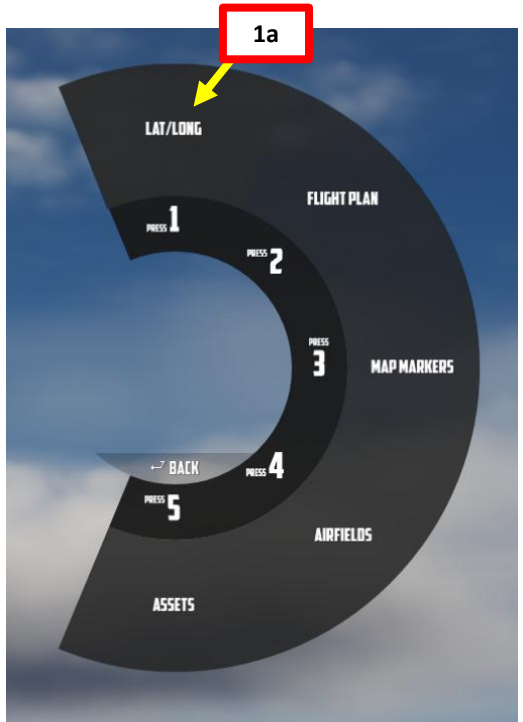
The Divert To option is used to navigate to a different unplanned waypoint using TGT 1 mode. Through the UI, players can switch between the diversion (TGT 1) and flight plan (TGT 2) at any time.

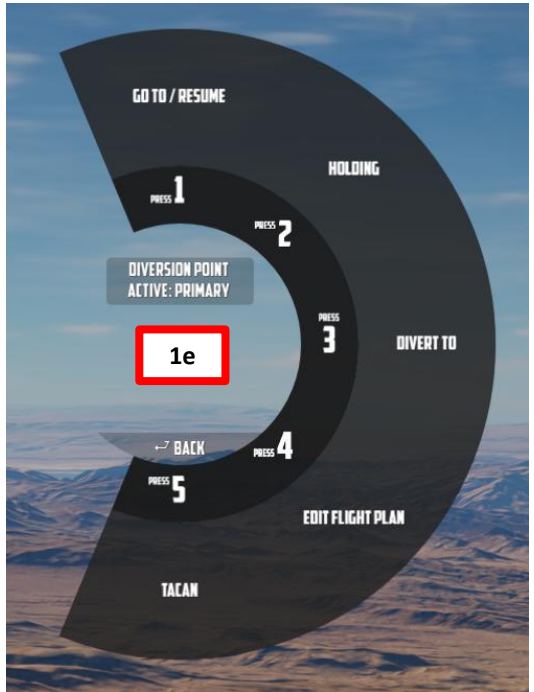
1. **LAT/LONG** option allows you to navigate with TGT 1 mode towards specific latitude / longitude coordinates.
    a) From NAVIGATION – DIVERT TO menu, select LAT/LONG
    b) The coordinate is H DD MM H DDD MM, where "H" represents the hemisphere (N or S for **latitude**, E or W for **longitude**), "D" stands for Degrees and "M" stands for Minutes. As an example, we will enter coordinates **North 36 deg 18 minutes** / **West 116 deg 14 minutes**.
    c) Type **N3618W11614** to enter the desired **latitude** and **longitude** coordinates
    d) Click on LAT/LONG
    e) JESTER will then enter these coordinates in TGT 1 mode and select them for navigation.





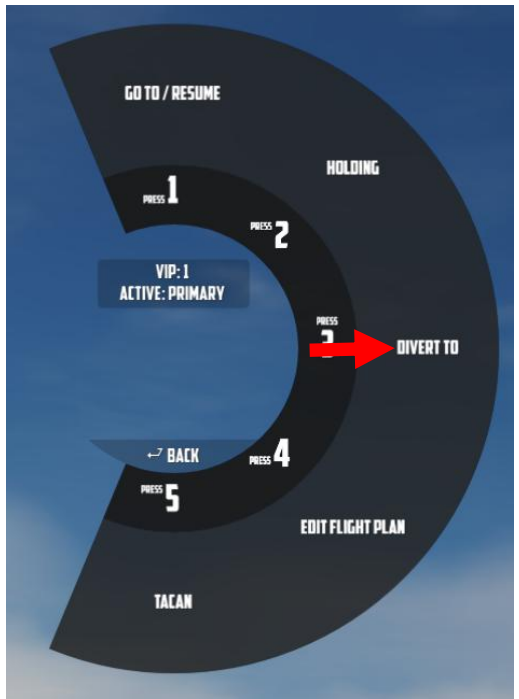


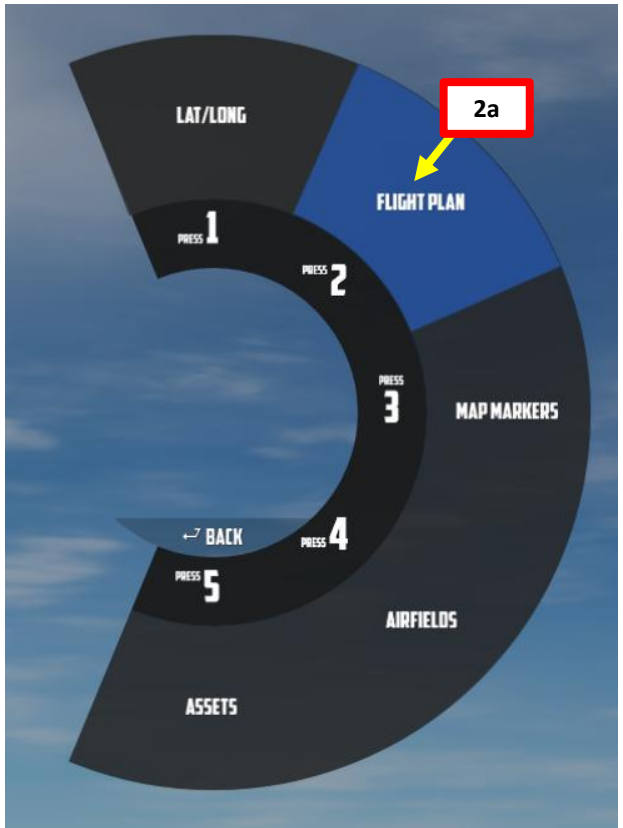




11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.3 – Divert To

2. **FLIGHT PLAN** option allows you to navigate towards an existing waypoint of your primary or secondary flight plan.
    a) From NAVIGATION – DIVERT TO menu, select FLIGHT PLAN
    b) Select either PRIMARY or SECONDARY FLIGHT PLAN
    c) Select desired waypoint.
    d) JESTER will then select this waypoint's coordinates for navigation.

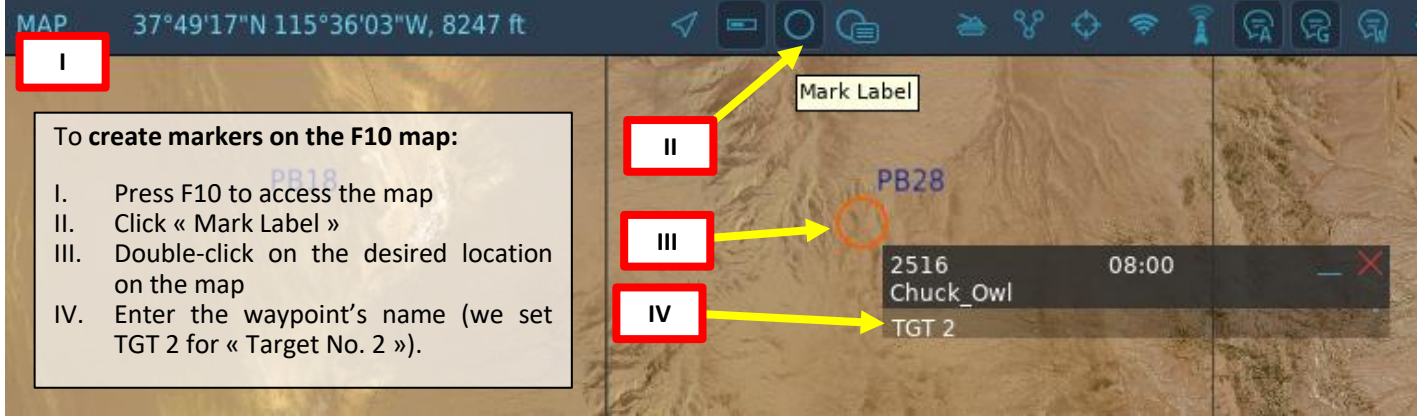


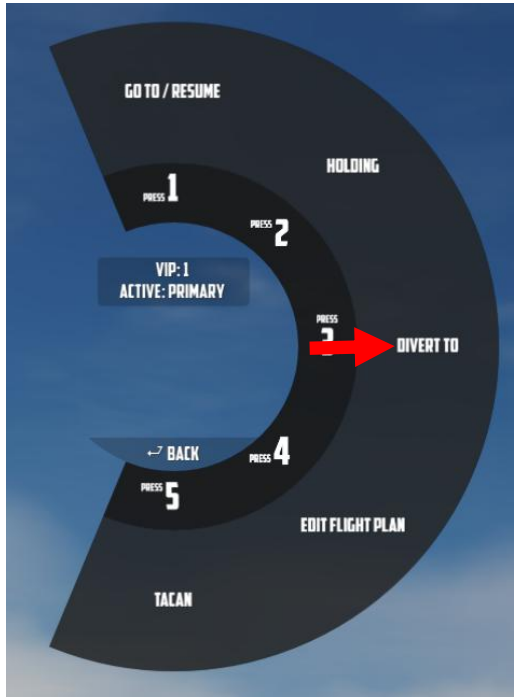


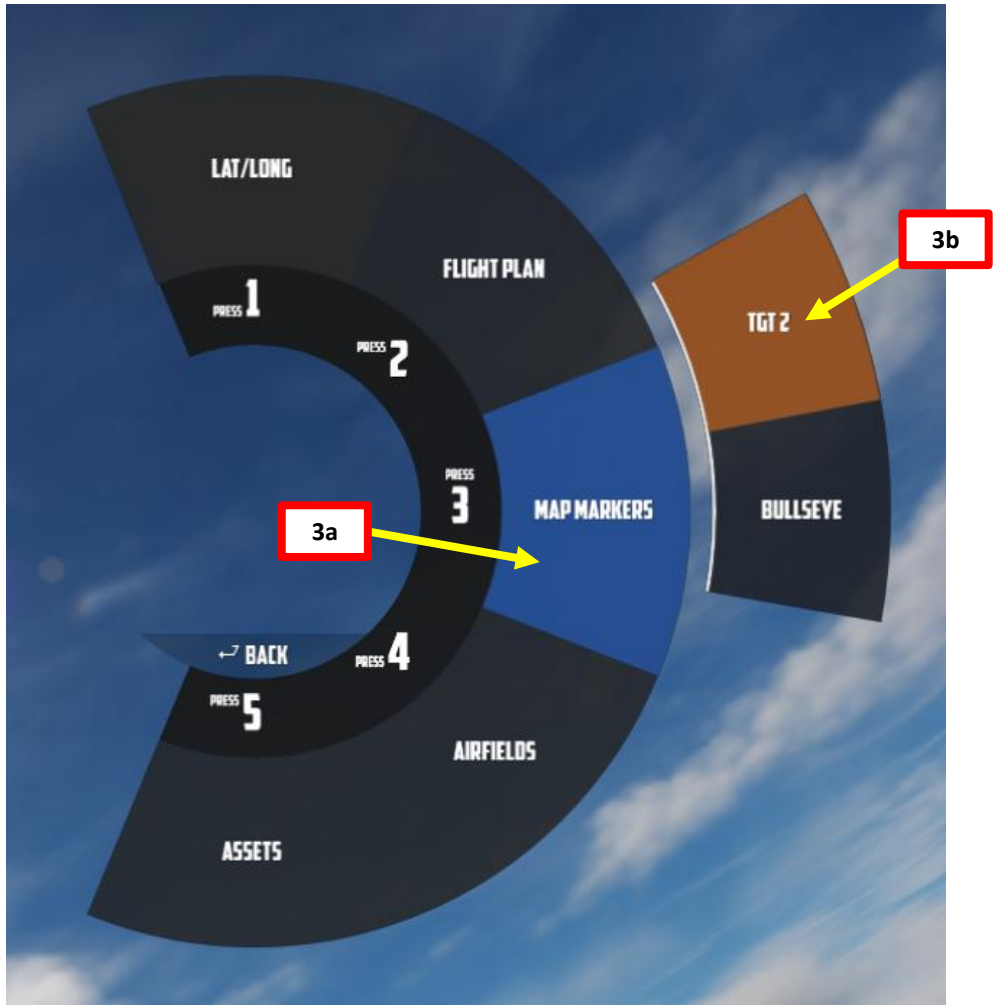


11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.3 – Divert To

3. **MAP MARKERS** option allows you to navigate towards an existing F10 Map marker.
    a) From NAVIGATION – DIVERT TO menu, select MAP MARKERS
    b) Select desired map marker.
    c) JESTER will then select this map marker's coordinates for navigation.

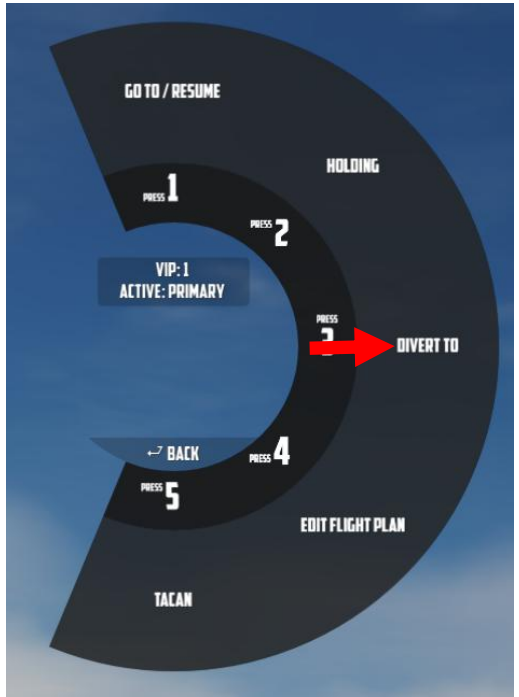


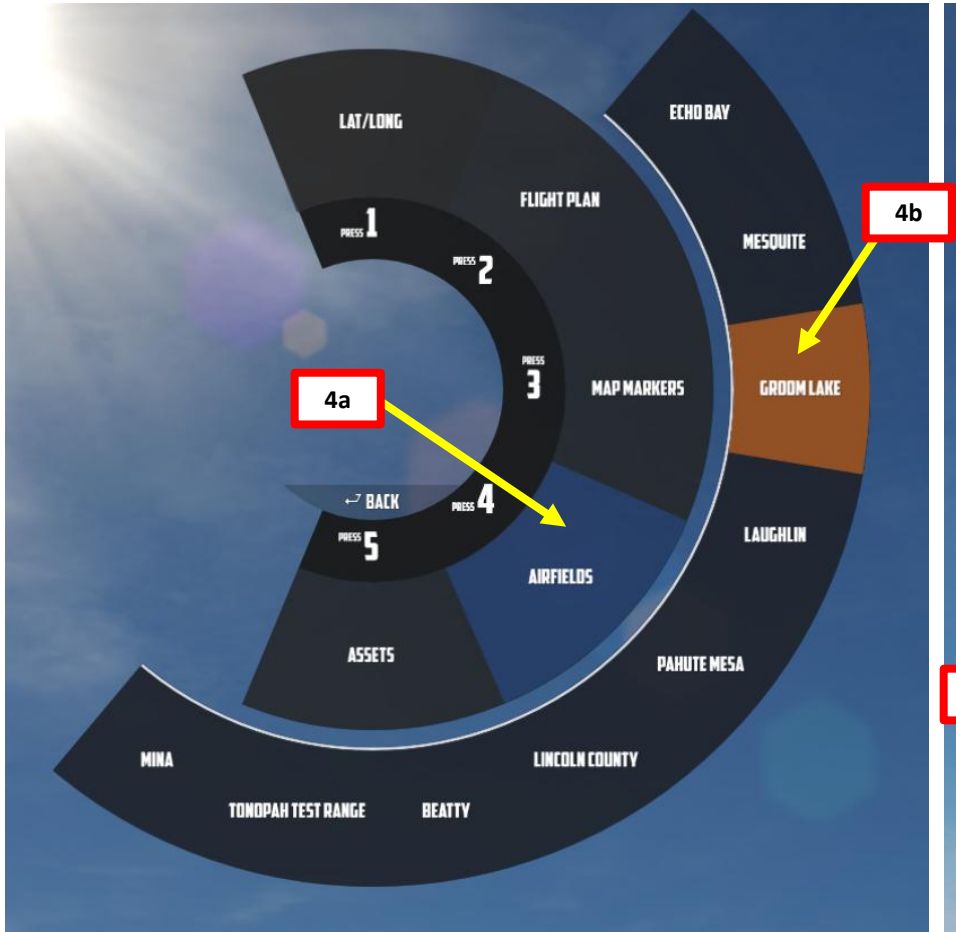


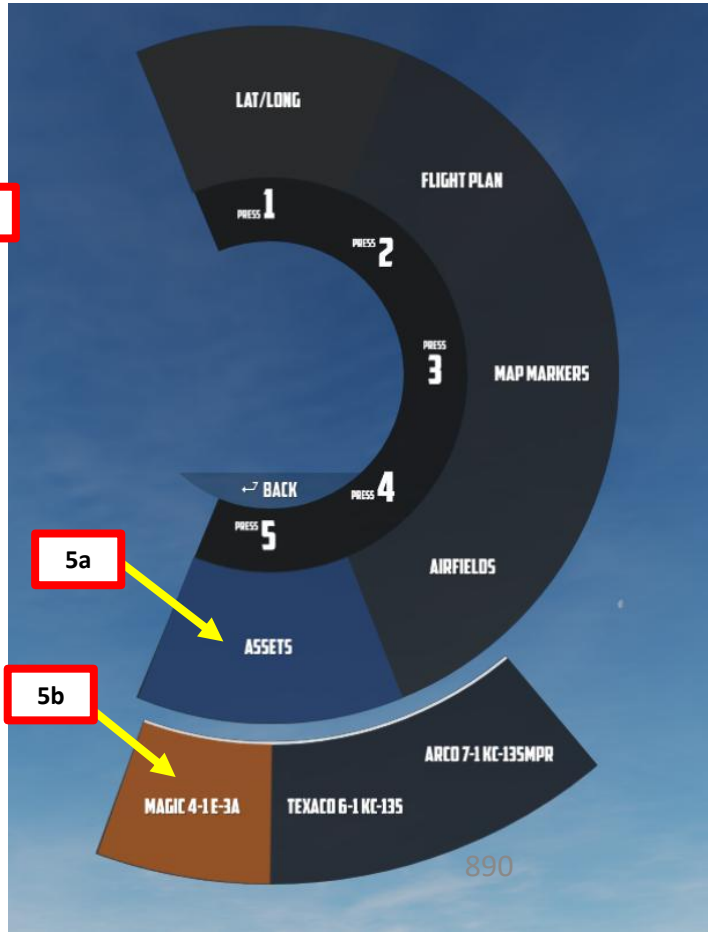


11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.3 – Divert To

4. **AIRFIELDS** option allows you to navigate towards an existing airfield.
    a) From NAVIGATION – DIVERT TO menu, select AIRFIELDS
    b) Select desired airfield.
    c) JESTER will then select this airfield's coordinates for navigation.
5. **ASSETS** option allows you to navigate towards a nearby asset such as ships, tankers or ground stations. For moving assets like refueling tankers, their actual position might vary from the planned coordinates. Use of TACAN or ADF for precise navigation is recommended instead.
    a) From NAVIGATION – DIVERT TO menu, select ASSETS
    b) Select desired asset.
    c) JESTER will then select this asset's last known coordinates for navigation. In this example, we are tracking Magic 4-1 (E-3A AWACS).



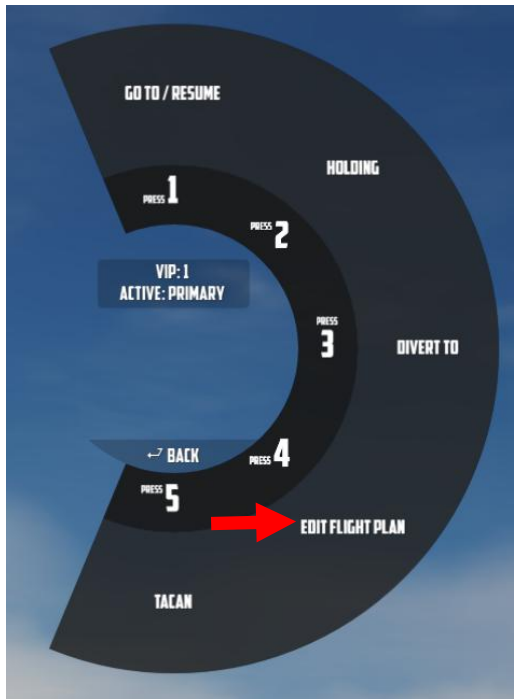


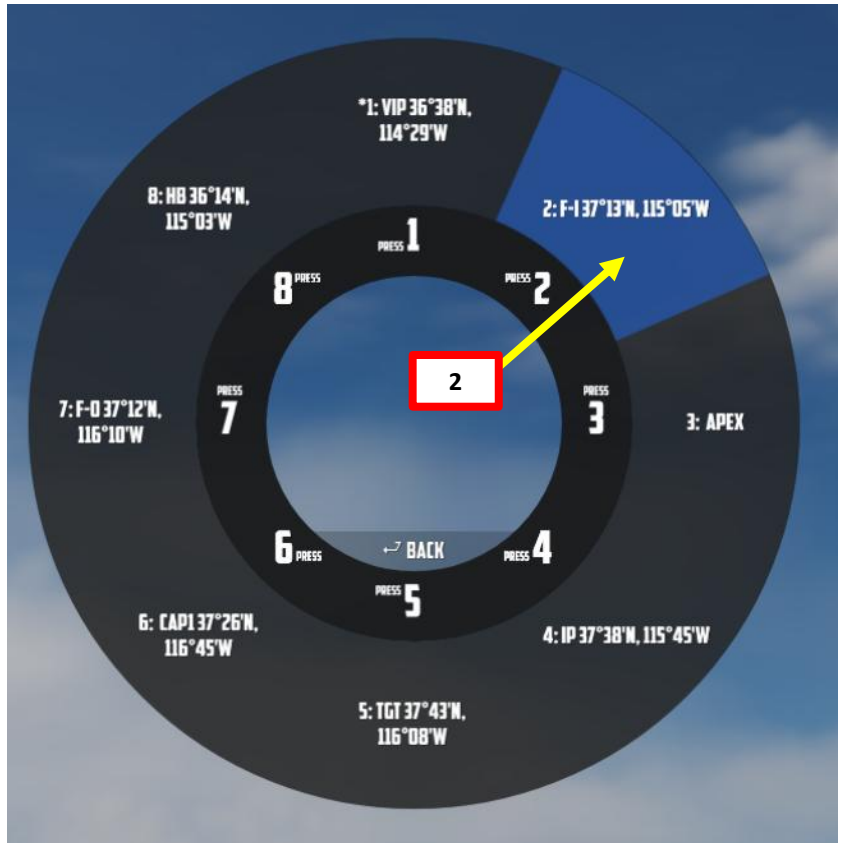


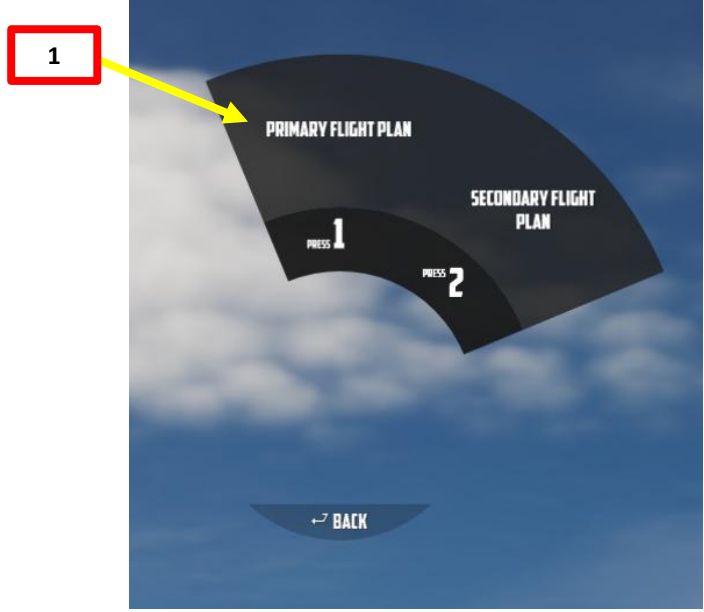
11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.4 – Edit Flight Plan

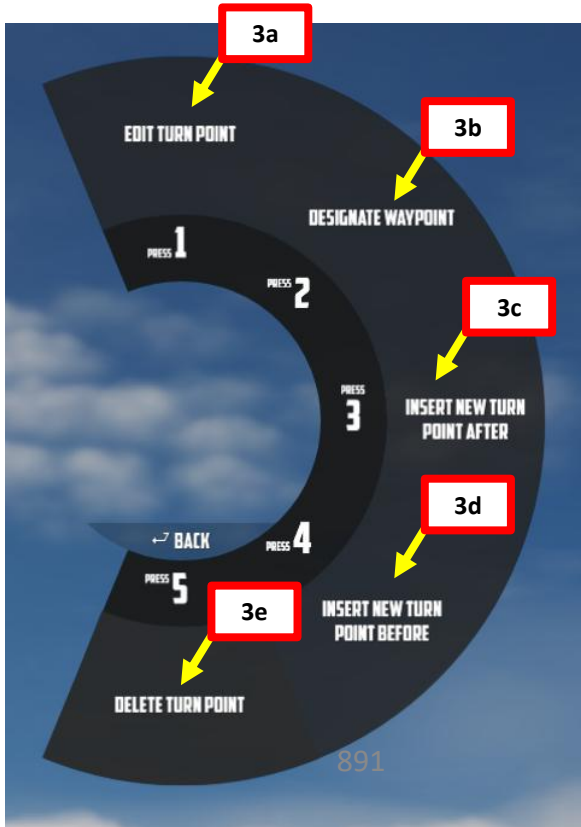
The EDIT FLIGHT PLAN option is used to modify the waypoint type or sequence order of your flight plan's waypoints.

1. Select Primary or Secondary Flight Plan from NAVIGATION – EDIT FLIGHT PLAN menu.
2. Select which waypoint you want to modify from the selected flight plan.
3. Select what you want to modify for this point:
    a) **Edit Turn Point**: Change waypoint coordinates
    b) **Designate Waypoint**: Change waypoint type
    c) **Insert New Turn Point After**: Add a new waypoint after the selected waypoint)
    d) **Insert New Turn Point Before**: Add a new waypoint before the selected waypoint
    e) **Delete Turn Point**



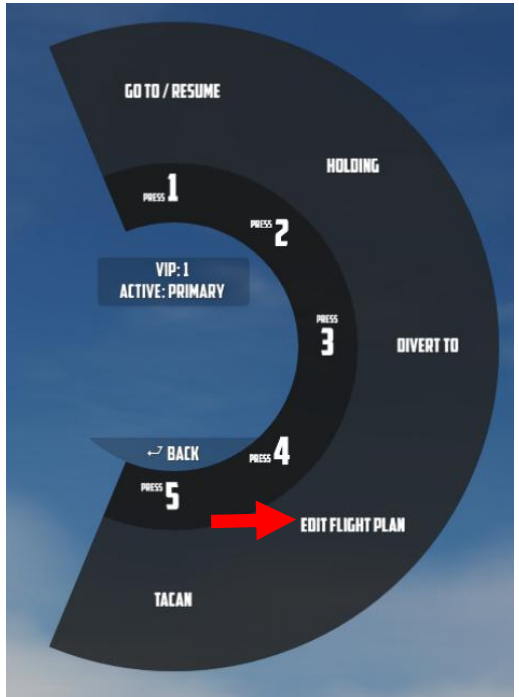


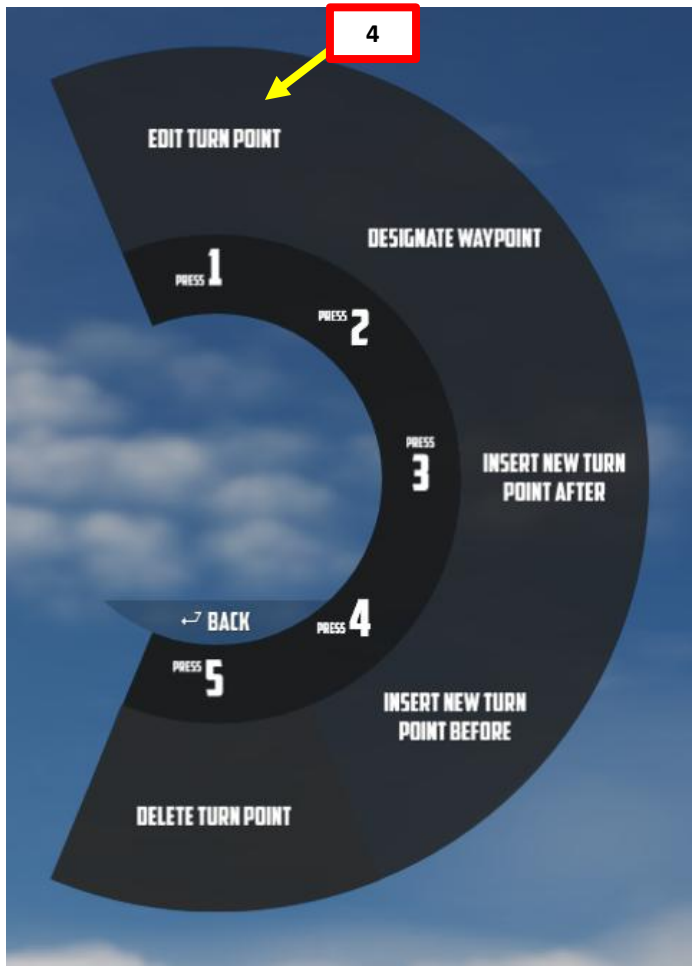


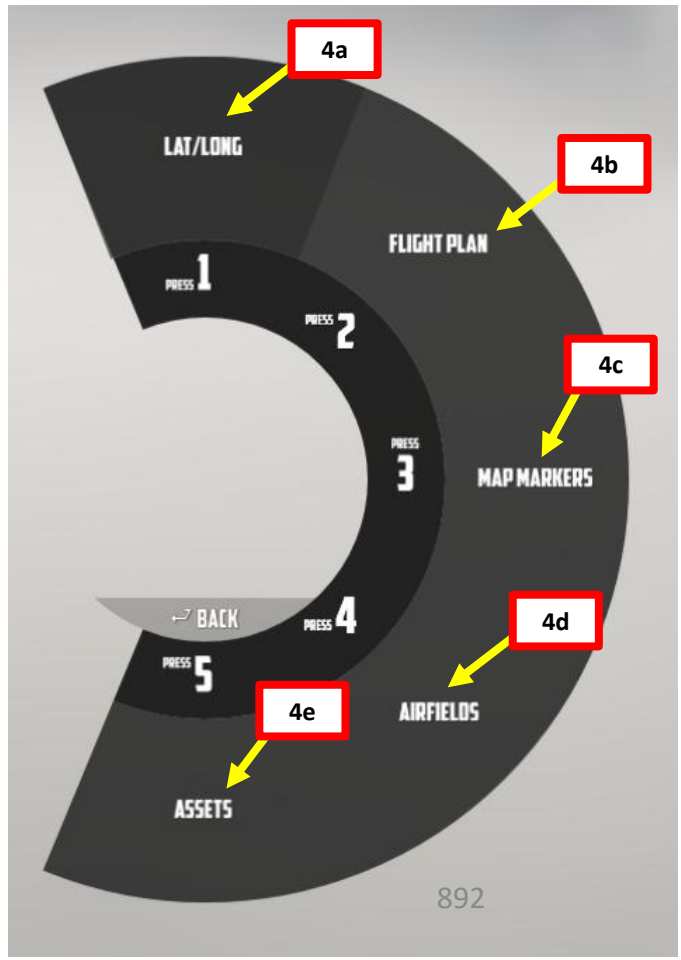


11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.4 – Edit Flight Plan

4. As an example, if selecting EDIT TURN POINT, you will be able to modify the selected waypoint coordinates to:
    a) New **LAT/LONG** (Latitude/Longitude Coordinates)
    b) An existing waypoint from your **Flight Plan**
    c) An existing F10 **Map Marker**
    d) An existing **Airfield**
    e) An existing **Asset** (ship, ground station, refueling tanker)



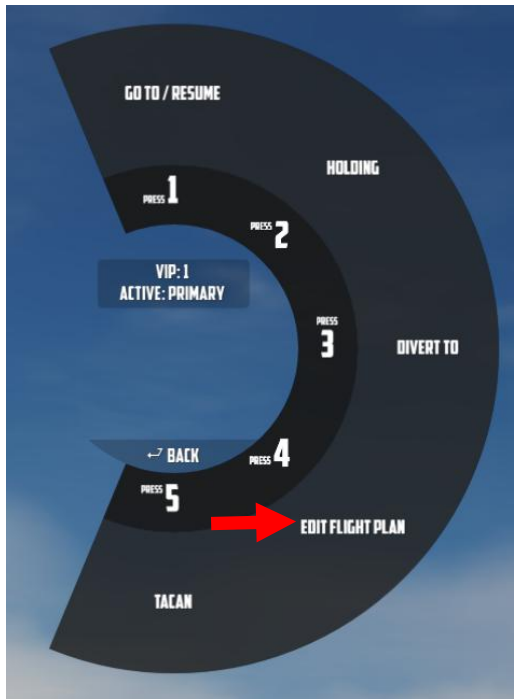


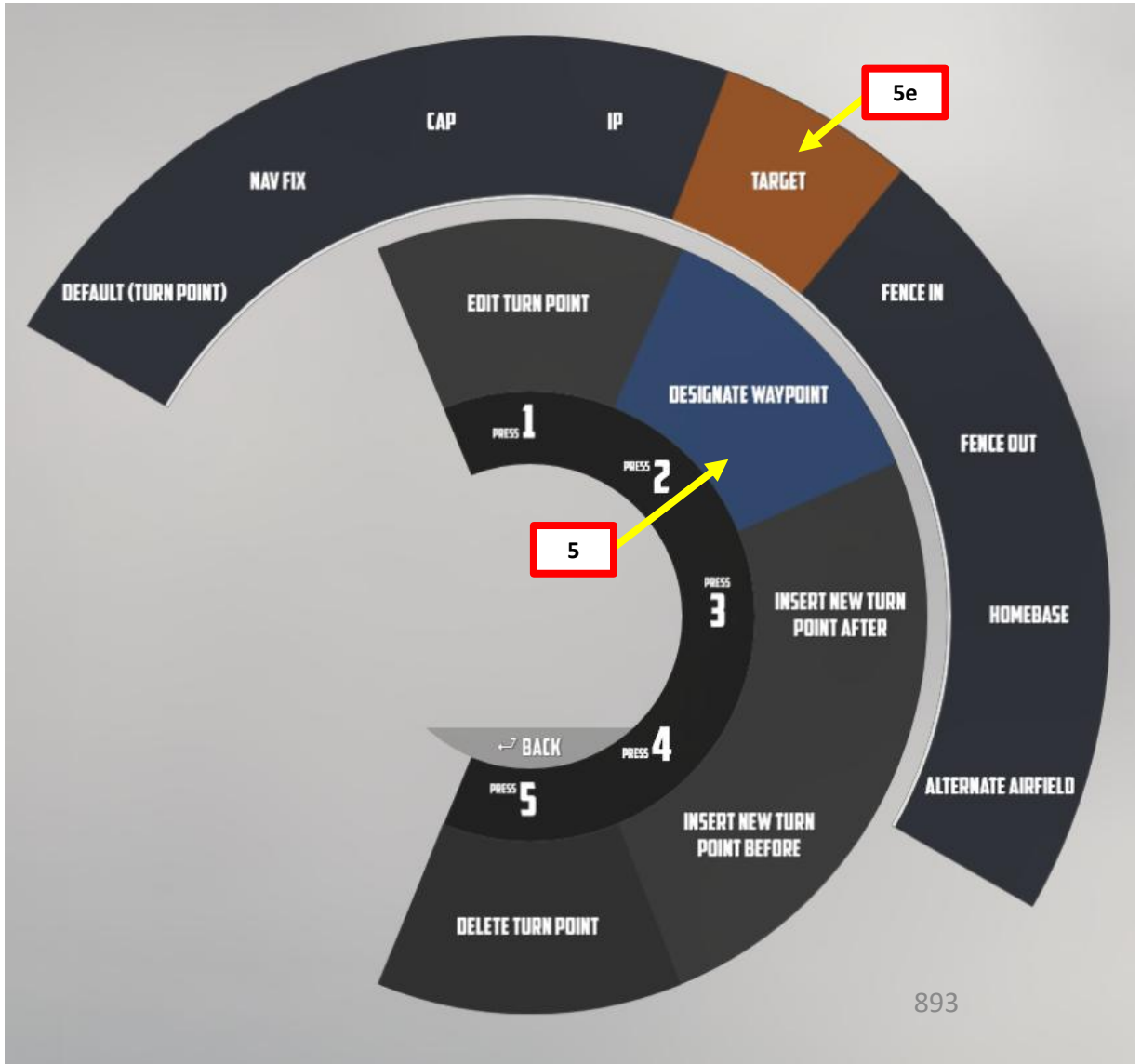


11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.4 – Edit Flight Plan

5. As an example, if selecting DESIGNATE WAYPOINT, you will be able to modify the selected waypoint to another type:
    a) **Turn Point (default)**
    b) **Nav Fix (VIP - Visual Identification Point**
    c) **Combat Air Patrol (CAP)**
    d) **Initial Point (IP)**
    e) **Target (TGT)**
    f) **Fence In (F-IN)**
    g) **Fence Out (F-OUT)**
    h) **Homebase (HB)**
    i) **Alternate (ALT)**

This will determine the way JESTER behaves when approaching waypoints, as explained in section 11.1.

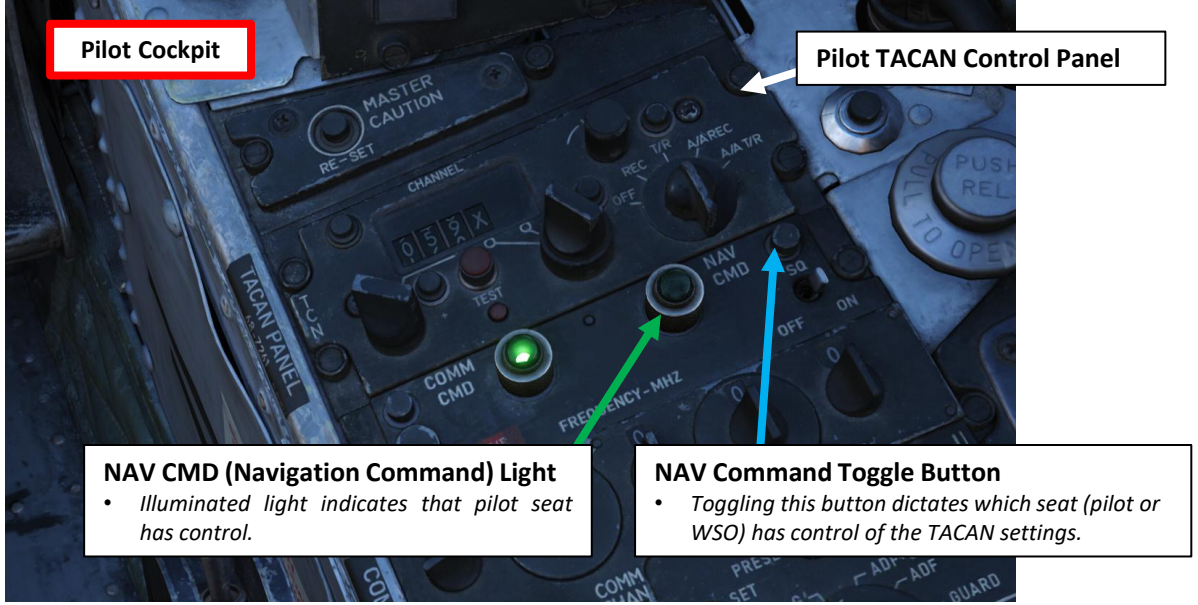


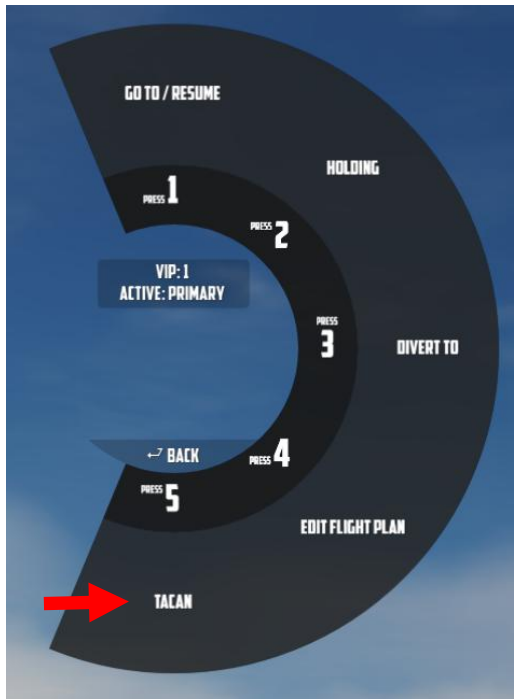


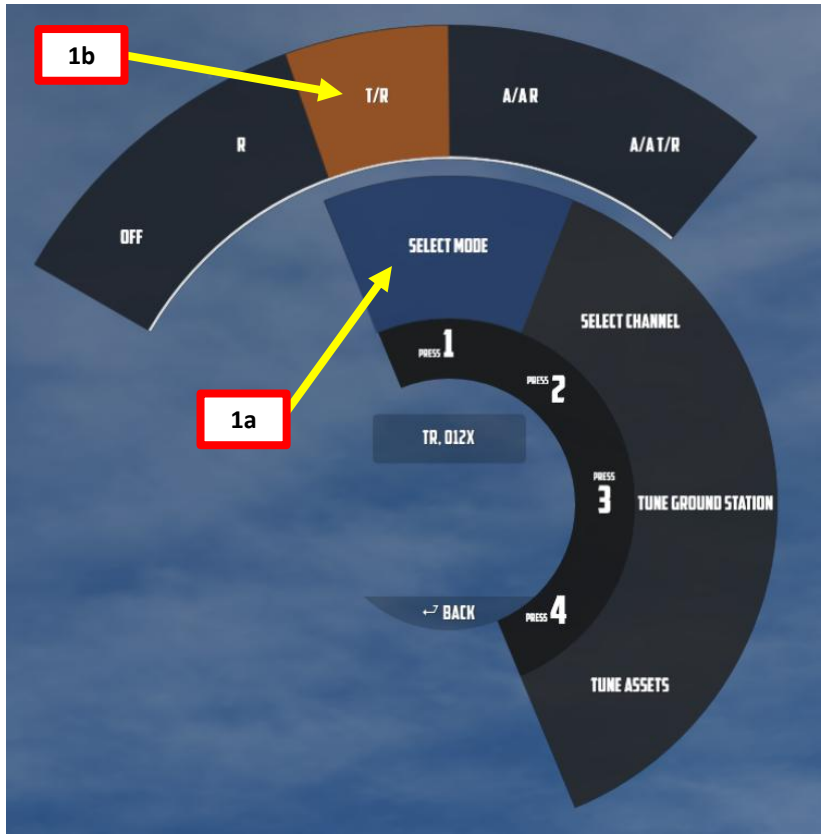
11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.5 – TACAN

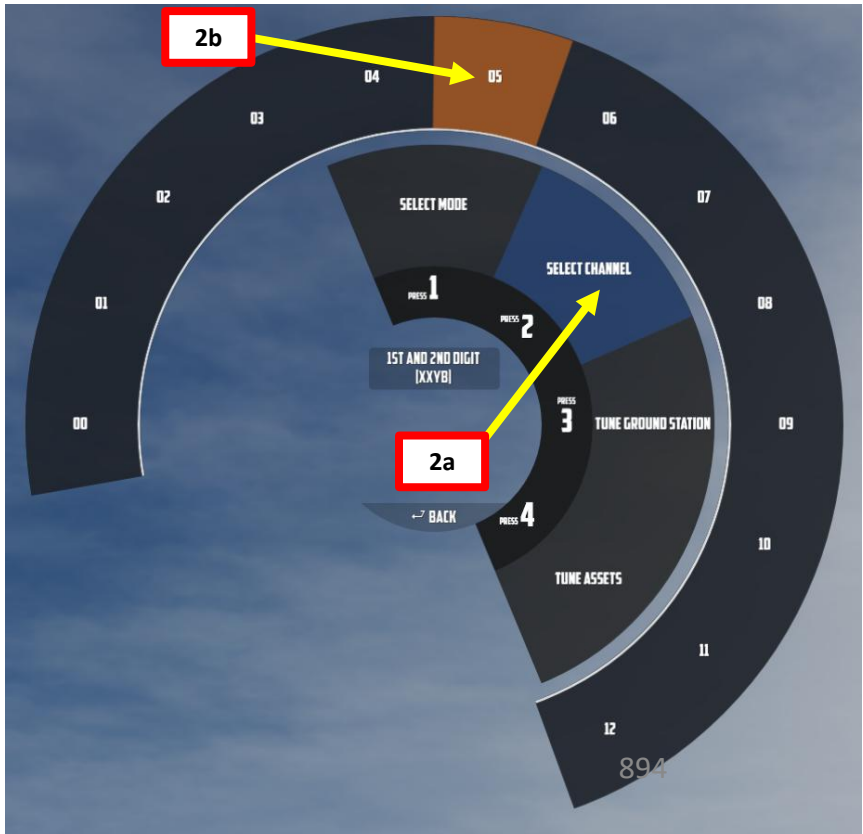
The TACAN option is used to ask JESTER to tune directly to any TACAN-capable asset or ground station from his cockpit. This also allows the pilot to set up Jesters TACAN panel with a secondary setup to then switch between both with a single click on the NAV CMD (Navigation Command) Button.

1. **SELECT MODE** option allows you to select which TACAN mode to use (Receive, Transmit/Receive, Air/Air Receive, Air/Air Transmit/Receive).
    a) From NAVIGATION – TACAN menu, click SELECT MODE
    b) Select desired TACAN Mode.
    c) JESTER will then select this mode on the rear cockpit's TACAN control panel.
2. **SELECT CHANNEL** option allows you to select which TACAN channel to use on the rear cockpit's TACAN control panel.



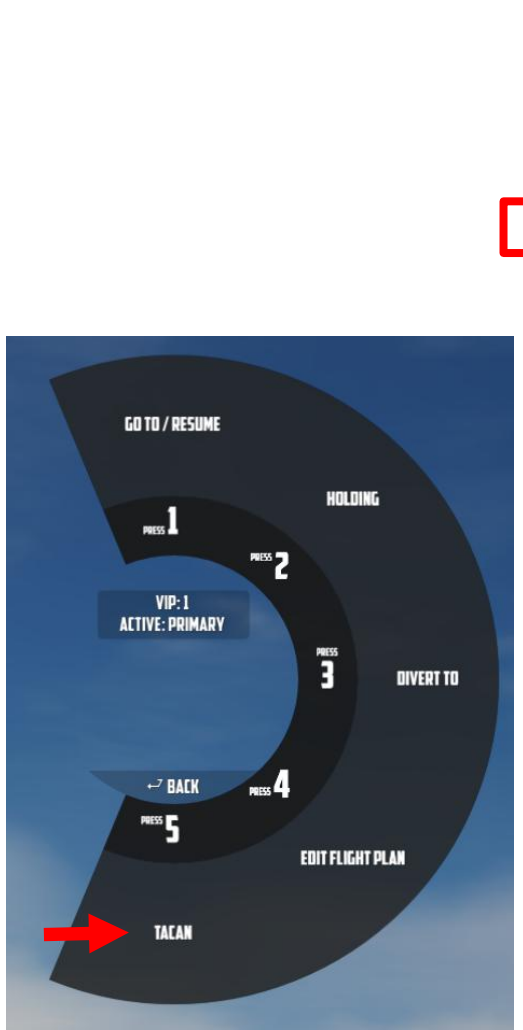


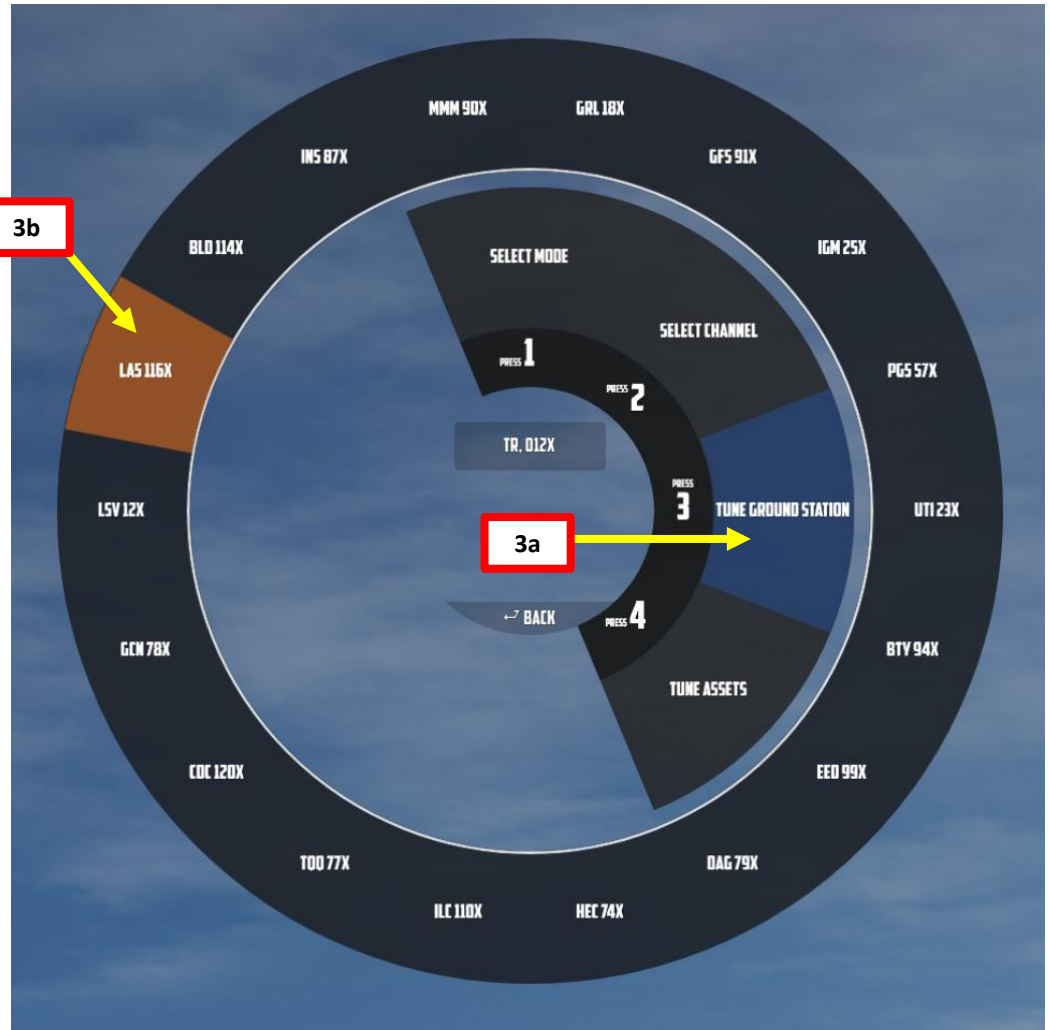


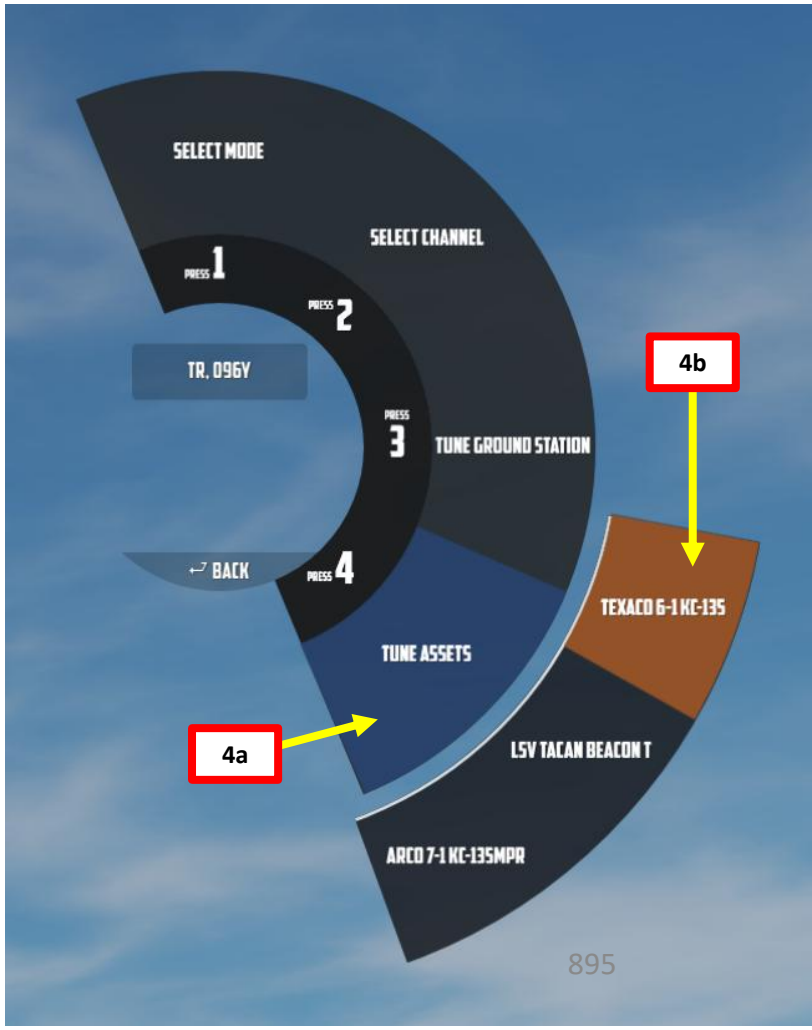


11 – JESTER AI NAVIGATION
11.2 – JESTER Functions
11.2.5 – TACAN

3. **TUNE GROUND STATION** option allows you to select which existing TACAN station to tune to on the rear cockpit's TACAN control panel.
4. **TUNE ASSETS** option allows you to select which existing asset with its own TACAN station to tune to on the rear cockpit's TACAN control panel, These assets can be ships like aircraft carriers, ground stations or refueling tankers.







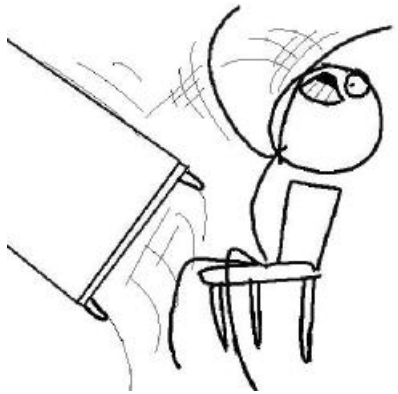

DANGER
EJECTION SEAT & CANOPY
DANGER
CAUTION
CLEAR SILL AREA BEFORE CLOSING EITHER COCKPIT
WARNING
AFT CANOPY MANUAL UNLOCK
TO RELEASE

INTRODUCTION
AIR-TO-AIR REFUELING – WHY WE ALL HATE IT

Air-to-air refueling is one of the hardest, most hated, and most frustrating tasks in DCS. Ever. Of all time.

Why? Well, one of the main reasons for the difficulty behind refueling is the skill required to do formation flying. Flying in formation with another aircraft requires much more practice than you would initially think. Another reason is pure physics: there is this thing called “wake turbulence”. An aircraft flies through a fluid: air. Just like with any fluid, if you have something that displaces itself through it at a certain speed, the fluid will become disrupted (turbulence). Wingtip vortices and jetwash are both effects of this simple concept. Wake turbulence is the reason why airliners need to wait a minimum time between takeoffs: flying through disrupted air will destabilize the aircraft and it is unsafe, especially during critical phases of flight like takeoff and landing.

Unfortunately, wake turbulence is something a pilot **has** to deal with during air-to-air refueling. This is why the aircraft will fly just fine when approaching the tanker, but start wobbling around when flying in close proximity of the refueling basket/drogue and tanker engines.



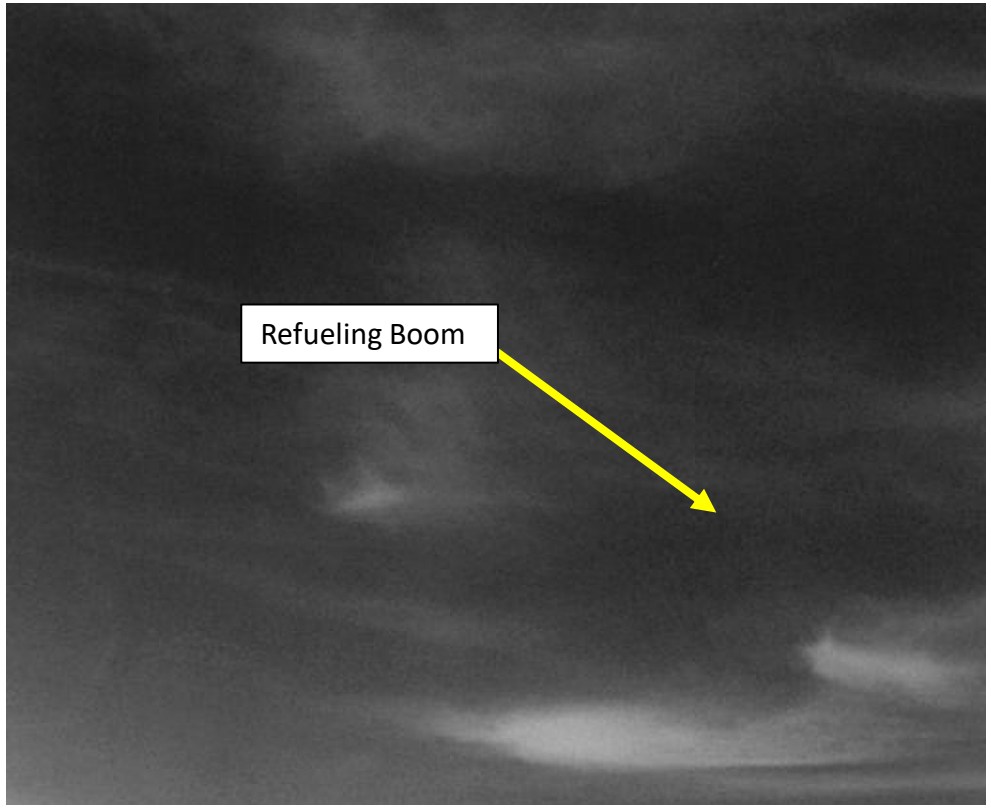
Feel free to consult 104th_Maverick’s F-4E Air-to-Air Refueling Tutorial
https://youtu.be/nLNVyxVZAiw



INTRODUCTION
TYPES OF AIR-TO-AIR REFUELING

There are four main air-to-air refueling techniques used in military aviation:

- Probe-and-drogue (refueling probe must be inserted in the tanker's drogue basket)
- Flying Refueling Boom (guided by boom operator aboard the tanker)
- Buddy Refueling (two fighters can refuel one another independently without a tanker)
- Nose-Probe refueling



F-105 Thunderchiefs being refueled by a Boom system during the Vietnam War



Tornado GR4 being refueling by a Probe-and-Drogue system

INTRODUCTION
TYPES OF AIR-TO-AIR REFUELING

The refueling aircraft available in DCS are:

- The Ilyushin Il-78M “Midas”, a russian **probe-and-drogue** tanker, which was developed from the Il-76.
- The Boeing KC-135 “Stratotanker”, a US Air Force **flying boom** tanker, which was developed from the Boeing 367-80.
- The KC-135 MPRS (Multi-point Refueling Systems), a US Air Force KC-135 tanker modified to add refueling pods to the KC-135's wings, making it useable as a **probe-and-drogue** tanker.
- The Lockheed S-3B “Viking”, a US Navy **probe-and-drogue** tanker.
- The Lockheed KC-130 “Hercules”, a USMC **probe-and-drogue** tanker, which was developed from the C-130.

The F-4E is equipped with a refueling door compatible with a tanker’s flying boom system, so air-to-air refueling can only be performed from the KC-135 tanker in DCS.



KC-135 MPRS

KC-135 Stratotanker



Il-78M



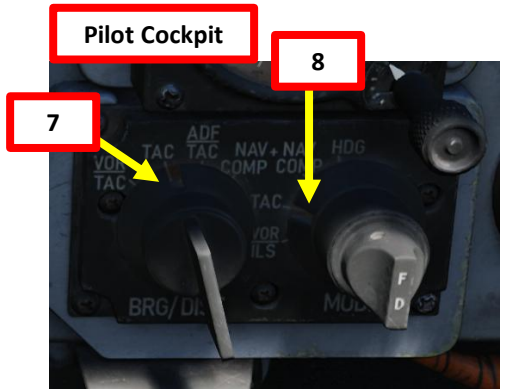
KC-130



S-3B Viking

AIR-TO-AIR REFUELING TUTORIAL

1. Read your mission briefing to know the TACAN station channel of your KC-135 Tanker (56Y) and the UHF channel frequency you can communicate with it (305.000 MHz).
2. Select TACAN Station 56Y.
3. Check NAV CMD light is illuminated. If not, press the NAV Command Toggle Button. This will give TACAN command to your own cockpit.
4. Set TACAN Mode Selector – T/R (Transmit/Receive).
5. Tune TACAN Channel to **56Y (Tanker TACAN).**
    - Left Knob for Hundreds, Right Outer Knob for X/Y and Right Inner Knob for Ones
6. Adjust volume of TACAN tone as desired.
7. Set Navigation Mode Selecter (Outer Knob) – TAC (TACAN).
    - This provides control over the presentation of various displayed information on the HSI (Horizontal Situation Indicator).
8. Set Navigation Input (Bearing/Distance) Selector – TAC (TACAN).
    - This determines the source of navigation information for the HSI (Horizontal Situation Indicator).



SITUATION

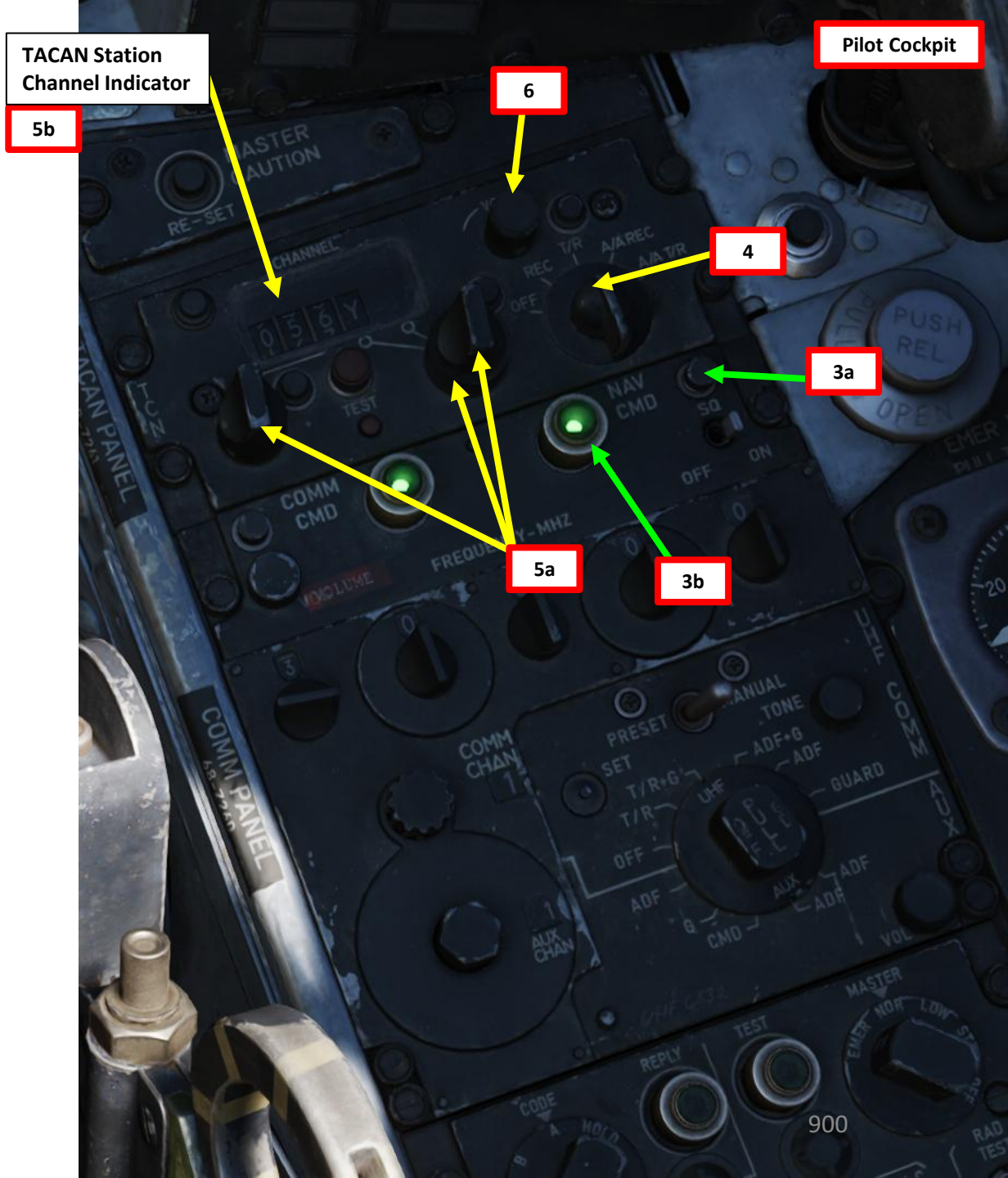
You start in the air at 18,000ft and 270 knots.

Tanker FREQUENCY 305.000 — 1
Tanker Tacan 56Y

The KC-135 refueling tanker Texaco 1-1 is directly in front of you. Rendezvous with the tanker and refuel your jet.
This skill is one of the most difficult in the game and will likely require a lot of practice to get right the first time, and even more to stay connected until fully refueled, and even more to become comfortable with the process. Don't be discouraged; keep practicing.

The tanker will fly a very long racetrack pattern which will allow you to have ample opportunities to refuel while flying straight and level. Basic proficiency will be achieved when you can refuel with 3 or fewer brief disconnects.

Your fuel level is at 50% and you have no external tanks.



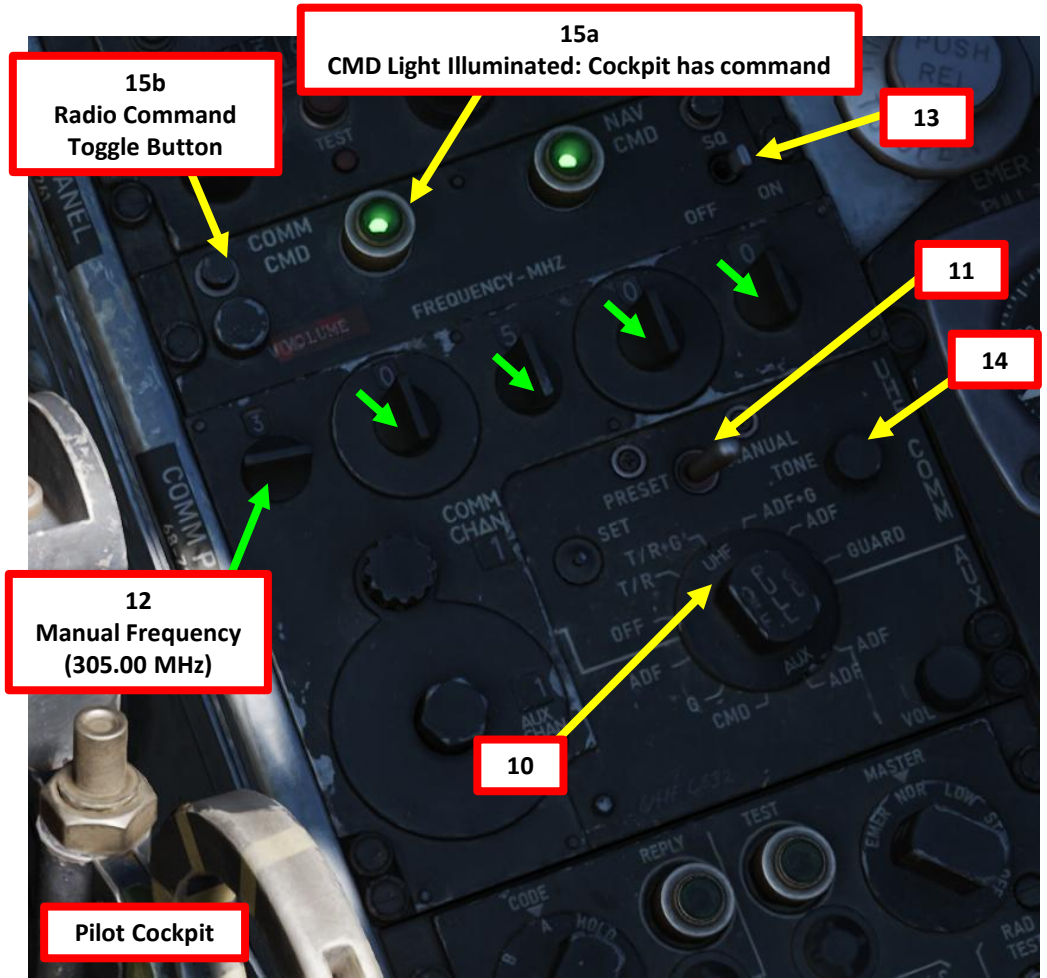
AIR-TO-AIR REFUELING TUTORIAL

9. Use steering cues on the HSI symbology to find the tanker if you cannot find it visually.



AIR-TO-AIR REFUELING TUTORIAL

10. Set UHF Radio Mode Selector – T/R+G (Transmit/Receive + Guard Frequency).
11. Set UHF Radio Frequency Mode Selector – Manual.
12. Set UHF Radio Frequency with Frequency Tuning knobs. We will select 305.000 MHz.
13. Set Radio Squelch Switch – ON (OUTBOARD).
14. Set UHF Radio Volume – As desired.
15. Check COMM CMD light is illuminated. If not, press the Radio Command Toggle Button. This will give radio command to your own cockpit.
16. Transmit by pressing Mic Switch (FWD, UHF) and Contact tanker (F6).
    - Binding: RSHIFT+\
17. Select "Intent to refuel" in the tanker menu. The tanker will give you an altitude (usually 18,000 ft or 10,000 ft) to rendezvous at and a speed to match (i.e. 270 kts).

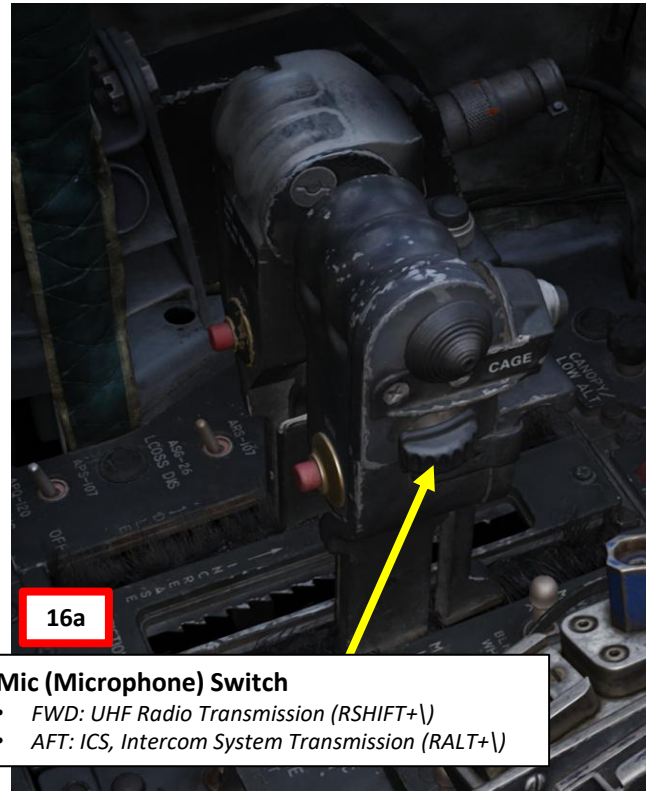


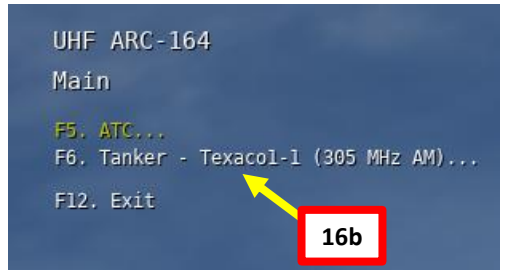
SITUATION

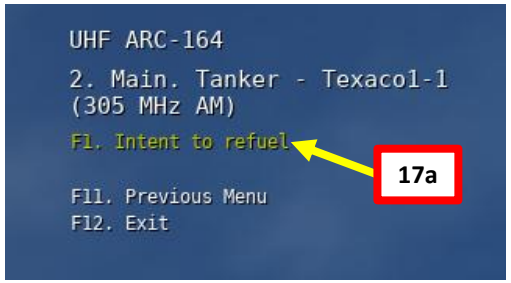
You start in the air at 18,000ft and 270 knots.

Tanker FREQUENCY 305.000
Tanker Tacan 56Y

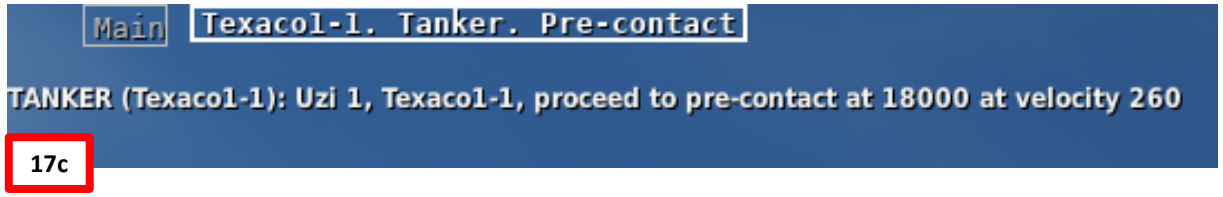
The KC-135 refueling tanker Texaco 1-1 is directly in front of you. Rendezvous with the tanker and refuel your jet.











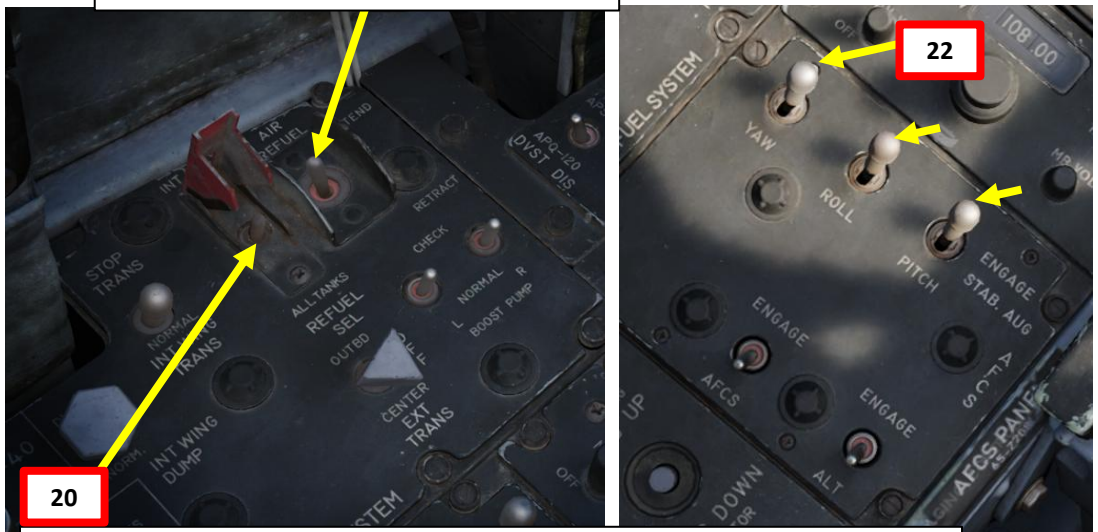
AIR-TO-AIR REFUELING TUTORIAL

18. Open AAR Door (air-to-air refueling trap door). Set the Air Refueling Switch – EXTEND (OUTBOARD position).
    - This extends the receptacle, illuminates the receptacle visual lamps, depressurizes the fuel cells, activates the transfer pumps to redistribute received fuel for CG maintenance, and activates the air refuel READY lamp.
19. Confirm that READY light illuminates, which indicates that door has opened properly.
20. Set Refueling Select Switch – As required. INT ONLY is used for internal tanks only, while ALL is used when external tanks are installed.
21. Set Master Arm switch to SAFE (DOWN).
22. Make sure all Stab Aug (Stability Augmentation) Pitch, Roll and Yaw Channel Switches are ON/ENGAGED (FWD).





18 **Air Refueling Switch**
- *OUTBOARD: EXTEND air-to-air refueling door*
- *INBOARD: RETRACT air-to-air refueling door*



Refueling Select Switch
- *OUTBOARD: INT ONLY, internal tanks only are refueled during air-to-air refueling cycle*
- *INBOARD: ALL, all tanks are refueled during air-to-air refueling cycle.*



AIR-TO-AIR REFUELING TUTORIAL

23. Once you are close enough, position yourself 20 ft below the refueling boom and call the tanker to begin pre-contact. If you are lined up properly, he will grant you permission to approach.
24. Make sure you are perfectly trimmed before beginning your approach.
25. Fly formation with the tanker, not the boom.
26. Perform gentle, small stick inputs to move towards the boom. Do not use rudder pedals. Use short bursts of throttle to advance towards the tanker.
27. Allow the boom to pass just left or right of your canopy, about 2-3 feet above your head. This serves as a good first check that you are at the proper height relative to the tanker.

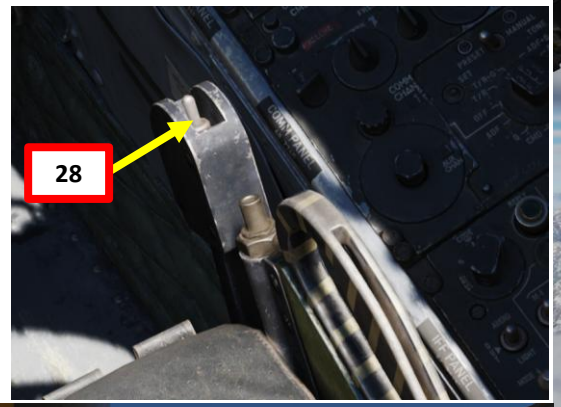




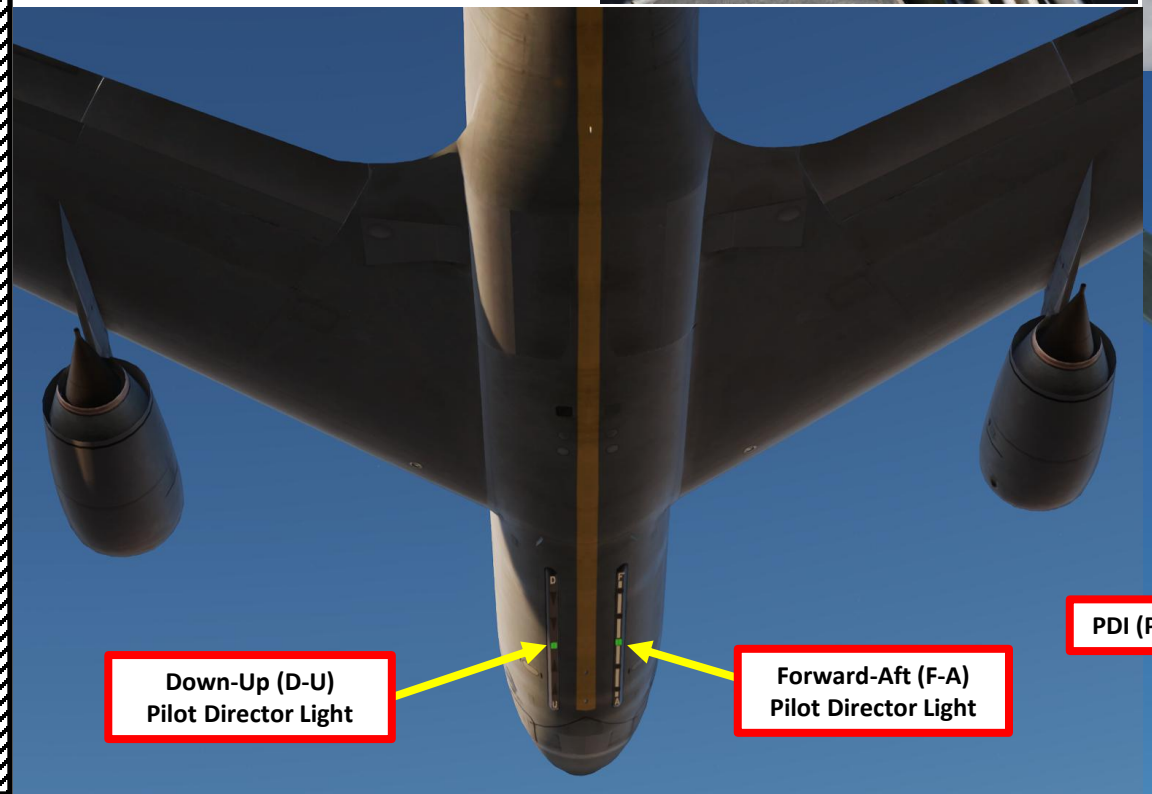


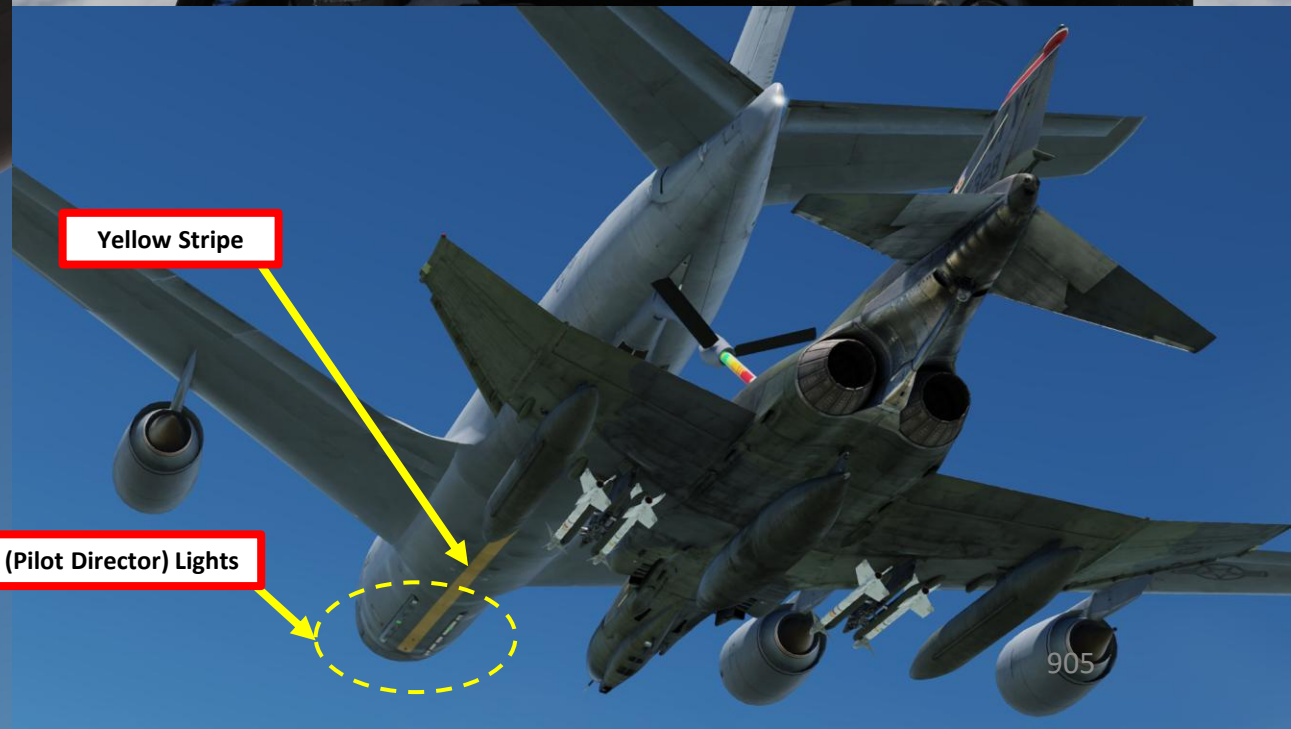
AIR-TO-AIR REFUELING TUTORIAL

28. Adjust seat position to have the Pilot Director Lights in sight.
29. Continue to move slowly forward, maintaining alignment with the yellow stripe painted on the bottom of the tanker. Use the Pilot Director lights on the bottom of the tanker to maintain a position within the limits of the boom.





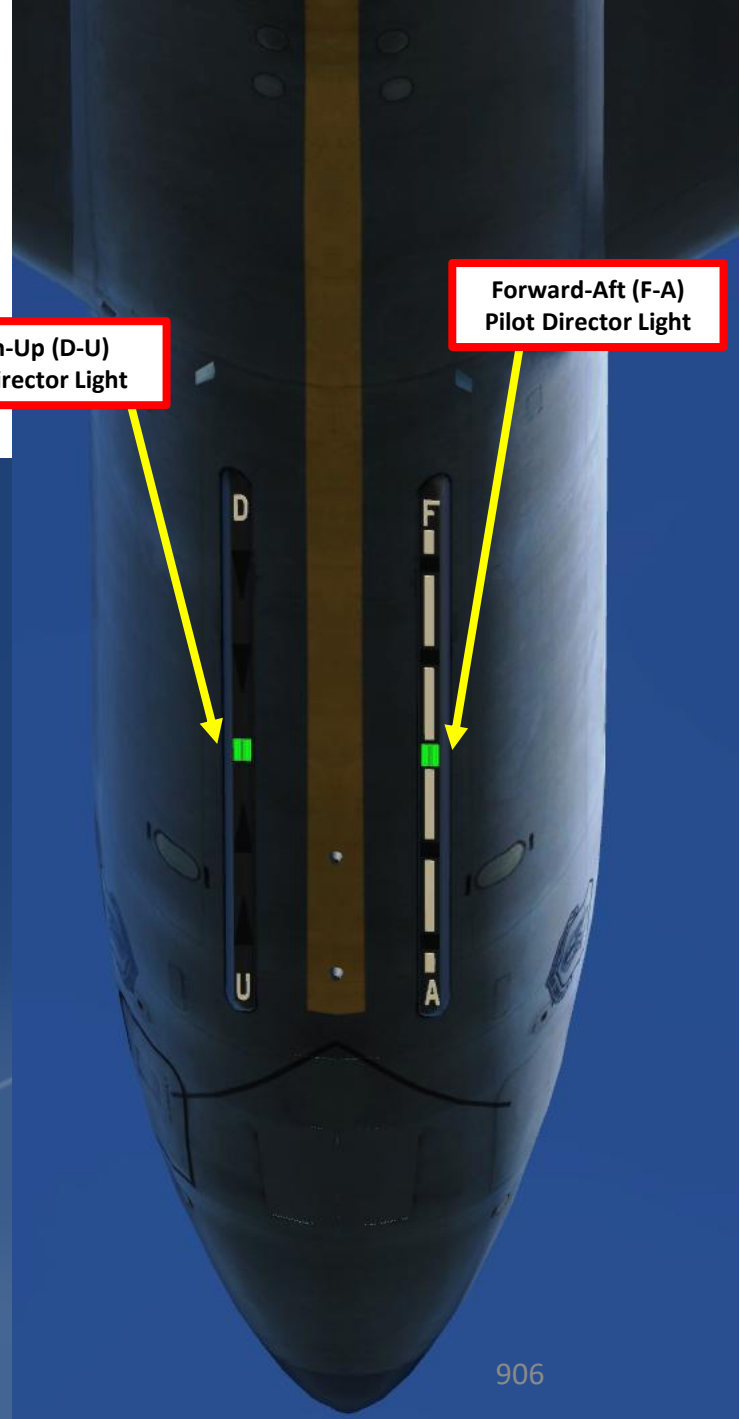




AIR-TO-AIR REFUELING TUTORIAL

30. The PDI (Pilot Director) lights are directive, meaning they tell you the direction to travel and not your current position. In other words, preface the D, U, F and A with the word Go.
    - If the light moves toward the D, go down and if it moves toward the U, go up.
    - If the light moves toward the A, go aft and if it moves toward the F, go forward.
    - A steady light means a substantial correction is required
    - A flashing light means a small correction is required





AIR-TO-AIR REFUELING TUTORIAL

31. Fly formation on the tanker and allow the boom operator to direct the boom into the refueling receptacle behind the cockpit on your aircraft.









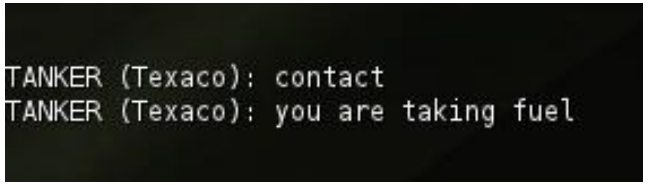
AIR-TO-AIR REFUELING TUTORIAL

32. The boomer will announce “contact” and ”you are taking fuel” when the connection is established.
33. The READY light will extinguish when the boom is connected to the receptacle. Monitor your fuel transfer on the fuel quantity gauge.
34. Keep the aircraft aligned with the tanker using reference points such as its engines and its centerline. This will help you evaluate if your aircraft drifts or not. Correct one axis at a time only.

READY Light

- *Illuminates when the air refueling receptacle is extended and fuel tanks are depressurized. The READY lamp illuminates to notify the pilot refueling can begin.*

33







AIR-TO-AIR REFUELING TUTORIAL

35. Fuel can be delivered to the Phantom at a rate of up to 3900 lbs per minute. Fuel received is delivered into fuselage cell 2, then equalized through the rest of the aircraft cells, wing tanks, and, if installed and selected, external tanks.
    - *Note: While the maximal supported refuel rate is about 3900 lbs per minute, the actual rate in practice is highly dynamic and depends on the tanks that can still take fuel. Refuel Rate is bottlenecked by the pipe layout and their dimensions. For example, being down to just the left and right external tank will rather result in a refuel rate of 1400 lbs per minute. Refueling internal tanks 1-7 takes about one to two minutes. Also filling up the wing tanks and external tanks will take additional four to five minutes.*
36. Refueling procedure will be completed when the boom operator disconnects from the receptacle; the DISENGAGED lamp will illuminate.
    - If external tanks are installed, the L.H. FULL, CTR. FULL, and R.H. FULL (Left Hand, Center, Right Hand) lamps provide confirmation that the external tanks have been filled during the air refueling process. The lamps will remain lit until the air refueling receptacle retracted.
37. Close AAR Door (air-to-air refueling trap door). Set the Air Refueling Switch – RETRACT (INBOARD position).

External Tank FULL Lights
- *LH: Left Hand Side External Tank is Full*
- *CTR: Center External Tank is Full*
- *RH: Right Hand Side External Tank is Full*

36

DISENGAGED Light
- *Illuminates when air refueling boom separates from the receptacle. In the event of a DISENGAGED signal, the system must be reset to continue refueling by toggling the Air Refuel Switch.*



READY Light
- *Illuminates when the air refueling receptacle is extended and fuel tanks are depressurized. The READY lamp illuminates to notify the pilot refueling can begin.*

37



AIR-TO-AIR REFUELING TUTORIAL

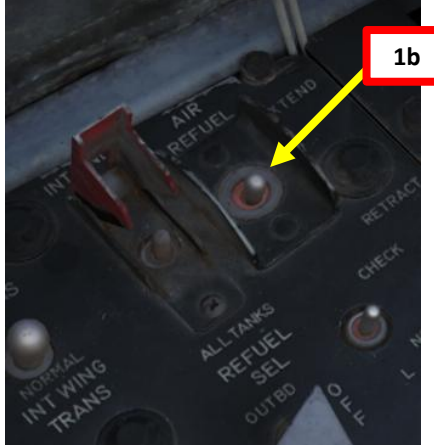
38. And that's it! You may now go back to burning expensive fuel and convert taxpayer money into jet engine noise.

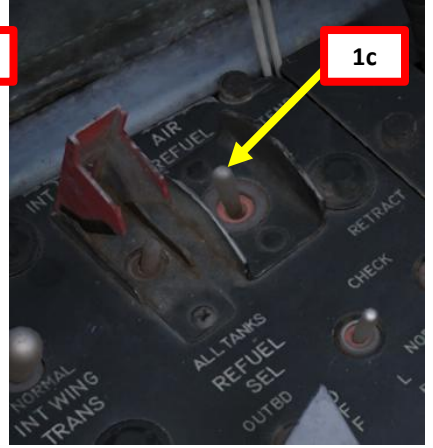


AIR-TO-AIR REFUELING TUTORIAL

Additional Notes

1. Should the boom separate from the receptacle inadvertently, the DISENGAGED lamp will illuminate. In the event of a DISENGAGED signal, the system must be reset to continue refueling. The system must be reset by flipping the air refuel switch to RETRACT and back to EXTEND to allow the boom to connect again.
2. If you wish to release the receptacle from the boom in the event of a manual refueling cycle (one in which the boom operator cannot force a disconnect remotely), or perform a disengagement on demand based on flight conditions or emergency situation, press the Air Refueling Release Button on the flight stick. Pressing the button will disengage the boom, and illuminate the DISENGAGED lamp.

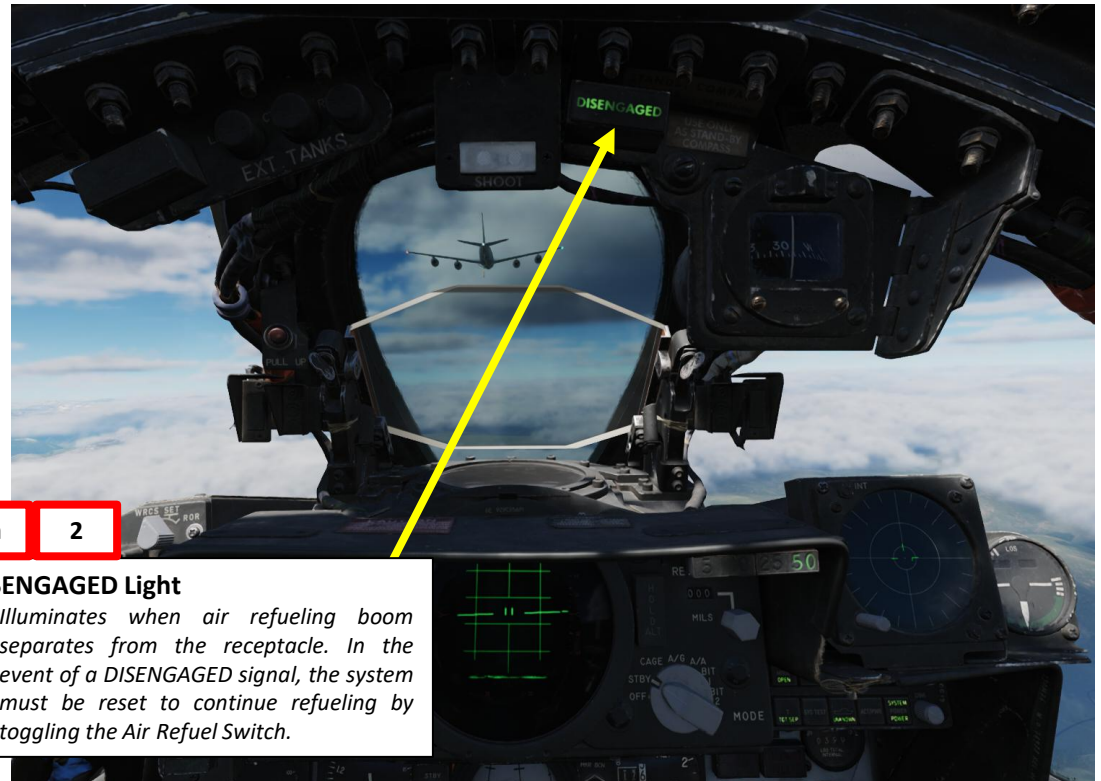






Air Refueling Release Button

- *Dual-role control that performs the boom disconnect function, as well as a number of weapon selection functions*
- *Binding: S*



DISENGAGED Light

- *Illuminates when air refueling boom separates from the receptacle. In the event of a DISENGAGED signal, the system must be reset to continue refueling by toggling the Air Refuel Switch.*




LT. RANDY JAMES
CAPT. KIRK STANT
DANGER
EJECTION SEAT & CANOPY
DANGER
DANGER
CAUTION
CLEAR SILL AREA BEFORE CLOSING EITHER COCKPIT
CANOPY FWD
OPEN
CLOSE
FWD CANOPY MANUAL UNLOCK
TO RELEASE
PUSH
WARNING
CANOPY AFT
OPEN
CLOSE
DANGER
EJECTION SEAT & CANOPY
DANGER
CAUTION
CLEAR SILL AREA BEFORE CLOSING EITHER COCKPIT
WARNING
THIS AIRCRAFT CONTAINS A CANOPY REMOVER CONTAINING AN EXPLOSIVE CHARGE
SEE T.O. 1F-4C-2-3 FOR COMPLETE INSTRUCTIONS
TO RELEASE
AFT CANOPY MANUAL UNLOCK
PUSH
STEP

THE CREW

Make no mistake: operating the F-4E requires **two** crewmembers in order to maximize combat performance.

The effectiveness of a crew is not necessarily a function of how well the pilot flies or how proficient a WSO (Weapon Systems Officer) is with sensors and weapons… it is how well they both work together. The Phantom is a complex machine, and one of its main challenges is managing your workload in a way that avoids task saturation. You will recognize "task saturation" as a moment when you have too much to do with too little time, tools or resources to do it. Basically… you are overwhelmed and you can end up "freezing", being unable to make effective decisions.

This is why it is very important for a crew to:

1. Define who does what and when (cockpit responsibilities)
2. Delegate tasks when necessary in order to keep each crewmember's workload manageable
3. Communicate clearly, efficiently and avoiding unnecessary distractions. Be concise.
4. Practice target acquisition procedures
5. When engaging targets, discuss the game plan beforehand so that both crewmembers are on the same page.
6. Share relevant information between crewmembers (location of friendly/enemy units, etc.)
7. Have two sets of eyes looking around instead of one

All of these things are easy to understand in theory, but practice is essential in order to see what works and what does not. Each crew is different, and your F-4E will only be as good as how you operate with your buddy as a team. This is why training in low-stress environments is of prime importance when learning the F-4E. It's one thing to learn how to use every system… it's another to figure out how to use the right tools for the job as efficiently as possible and live to tell the tale.

Casmo illustrates these points very well in his "Crew Coordination Techniques" for the Mi-24. Even if these tips are for a helicopter crew, the same theories apply pretty much to any crew that operates any aircraft together.



MEET THE PILOT

The F-4's front seat is for the pilot, colloquially referred the "Front Seat Stick Actuator", "Nose Gunner" or the FUF ("F*cker Up Front") by the WSO.

The pilot's primary duties include flying the aircraft (d'uh!), selecting ordnance, employing weapons and most of the tasks related to the handling of the aircraft (including autopilot). The pilot can also operate radios, set up ancillary systems like fuel & ECS (Environmental Control System), set navigation systems and program/deploy countermeasures.







MEET THE WSO (WEAPON SYSTEMS OFFICER)

The F-4's rear seat is for the WSO (Weapon Systems Officer), colloquially referred the GIB ("Guy In Back") or "Wooso" by the pilot. Calling a WSO a "bombardier", "navigator" or "bomb-nav" was considered an insult since these are terms reserved for B-52 bomber crews; Phantom WSOs prided themselves in being Fighter Woosos above all else.

The WSO's primary duties include operating the radar, INS (Inertial Navigation System), radios, set navigation systems, tracking the flight plan, deploy countermeasures, perform electronic warfare, interrogate targets… on top of having to manage an ungodly amount of circuit breakers.

While the stick, throttle and rudder in the rear cockpit could also be used to fly the aircraft if needed… keep in mind that the WSO could not look in front of the aircraft due to the cockpit layout.



CREW RESPONSIBILITIES

Take note that this is not an exhaustive list of all crew responsibilities.

- Mission planning, preparation, and briefing were performed by both the **Pilot** and **WSO**.
- Aircraft Acceptance and Preflight was performed by the **Pilot.**
- Weapons Preflight was performed by the **WSO.**
- System Tests and Checkouts were performed by both the **Pilot** and **WSO**.
- Post Flight Aircraft Debrief with Maintenance was performed by both the **Pilot** and **WSO**.
- Post Flight Mission Debrief, Analysis, and Critique were performed by both the **Pilot** and **WSO**.

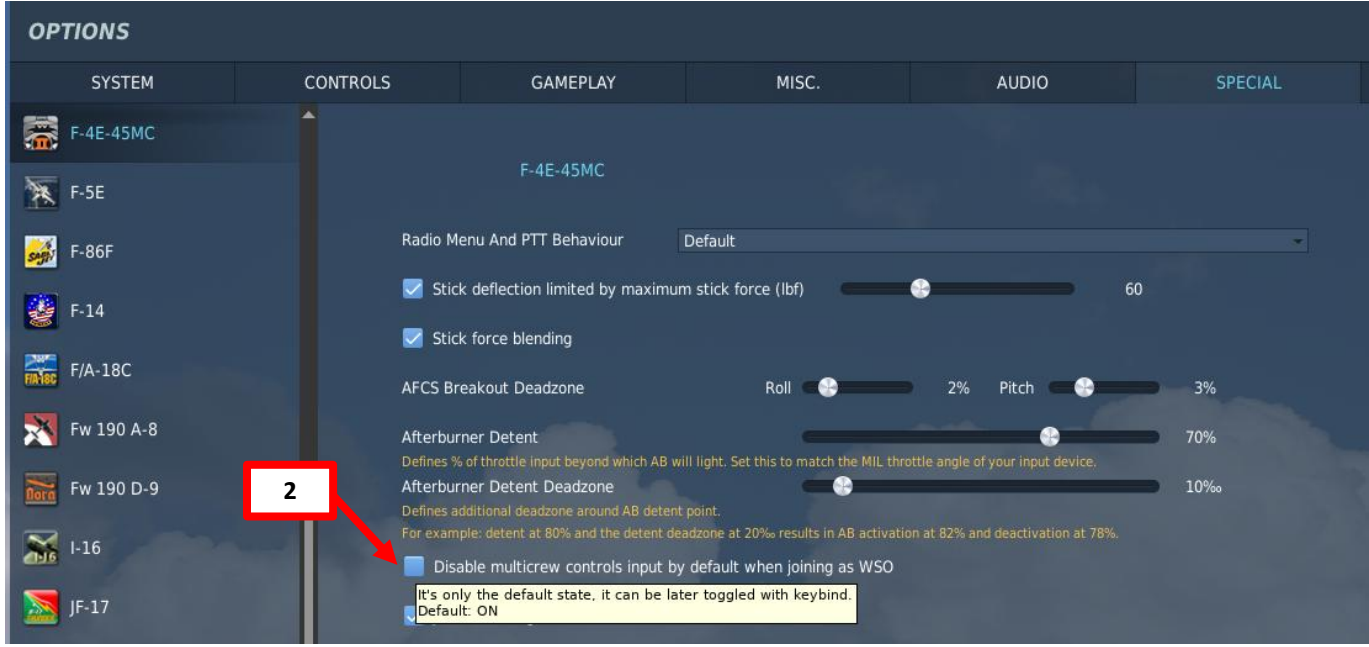
Note: Items in **bold** can be performed by both the Pilot and WSO

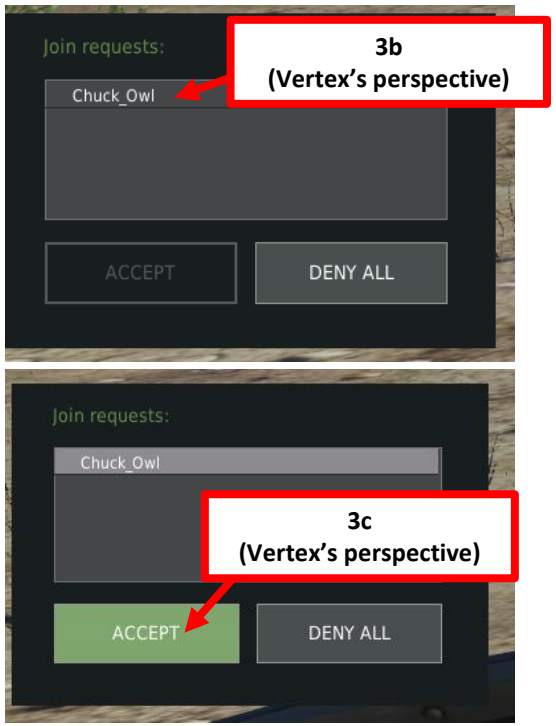
Pilot		Weapon Systems Officer (WSO)	
Fly mission	**Flight Controls (Stick, Rudder Pedals, Speed Brake)** – *Primary Operator*	Track Flight Plan	**Flight Controls (Stick, Rudder Pedals, Speed Brake)** – *If pilot is incapacitated*
Radar Operation (short range, ACM)	**Engine Power Management (Throttle)** – *Primary Operator*	Radar Operation (all ranges, WVR, BVR)	**Engine Power Management (Throttle)** – *If pilot is incapacitated*
Weapon Selection & Release	**Chaff & Flare Countermeasure Dispensing Controls**	Targeting Pod Operation	**Chaff & Flare Countermeasure Dispensing Controls**
Weapon Selection	**Monitor Radar Warning Receiver (RWR)**	IFF (Interrogate Friend-or-Foe)	**Monitor Radar Warning Receiver (RWR)**
Operate Aircraft Autopilot	**Radio Communications**	Radio Encryption	**Radio Communications**
Aircraft Stability Augmentation System Management	Navigation Systems (HSI, **TACAN, VOR**, ILS)	INS (Inertial Navigation System) Management	Navigation Systems (BDHI**, TACAN, VOR**, Course Indicator)
Hydraulic Systems Management	**Oxygen System Management**	Perform Navigation Fixes	**Oxygen System Management**
External Lights Control	**Normal (Toe Brake) + Emergency (Lever) Wheel Brake Operation**	Electronic Warfare / Jamming	**Normal (Toe Brake) + Emergency (Lever) Wheel Brake Operation**
Fire Detection	Normal + **Emergency** Flaps/Slats Operation	WRCS (Weapon Release Computer Set)	**Emergency** Flaps/Slats Operation
Cabin Pressurization / Air Conditioning Management	Landing Gear Operation (Normal + **Emergency**)	Ejection Command Selection	Landing Gear Operation (**Emergency**)
Engine Start/Shutdown	Electrical Systems Management (Batteries, Ground Power, Generators)		Battery Bypass
Jettison Stores	Anti-Ice System Management		
Fuel System Management	Air-to-Air Refueling Door		

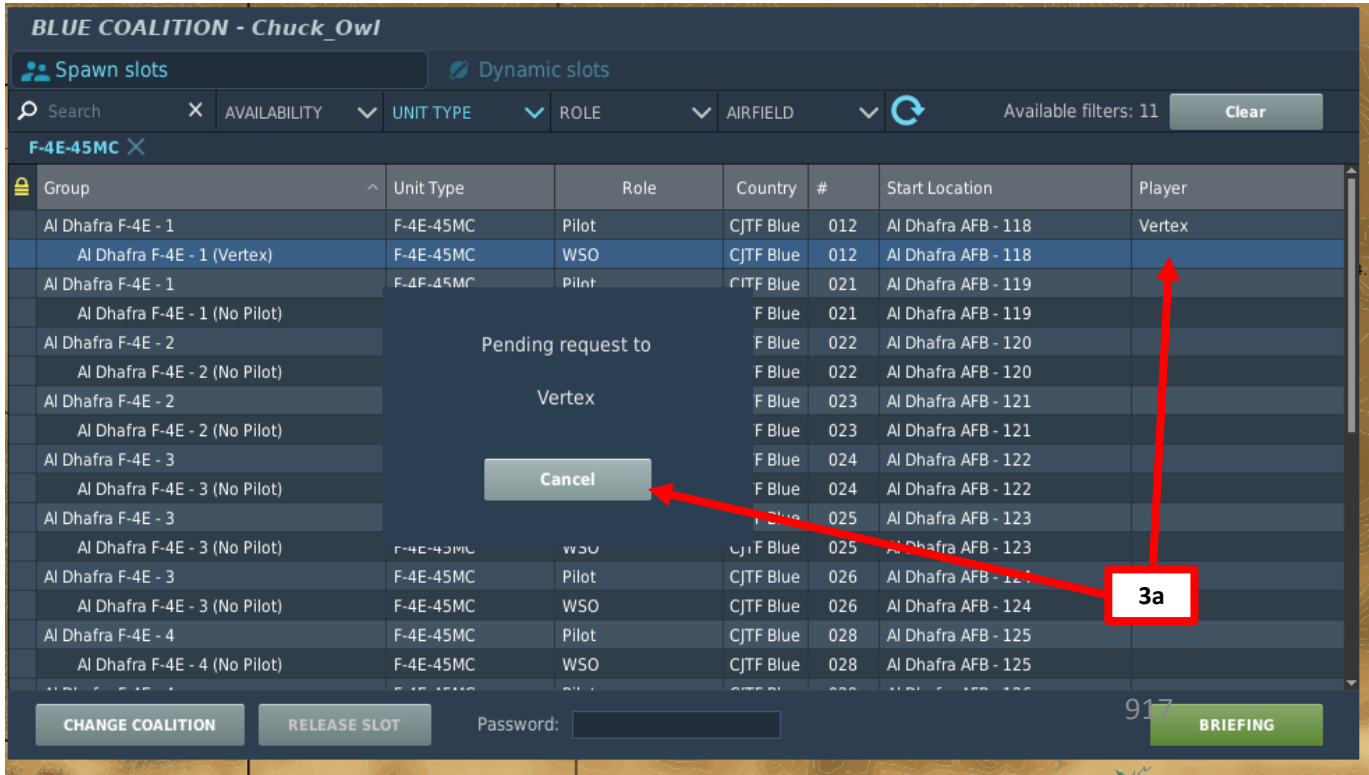
MULTICREW TUTORIAL

The F-4E can be flown by two players in multiplayer.

1. In the real aircraft, the pilot's and WSO's sticks, throttles and rudder pedals are mechanically linked together.
2. There is a "Disable multicrew controls input by default when joining as WSO" setting in the Special Options, but I typically leave it OFF (unticked).
3. When spawning in multiplayer in any seat, the pilot will receive a request to let you take control of the other seat.

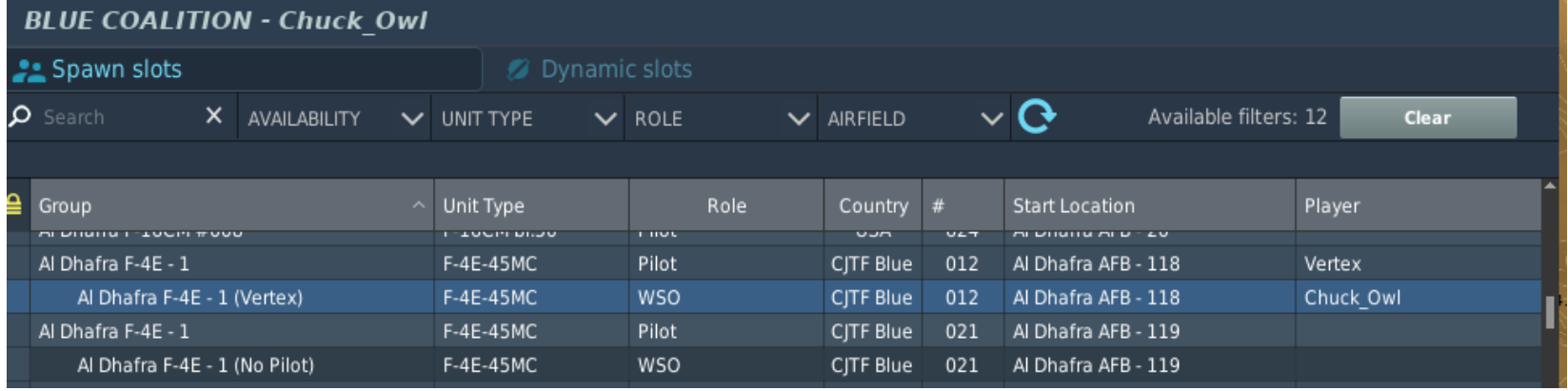




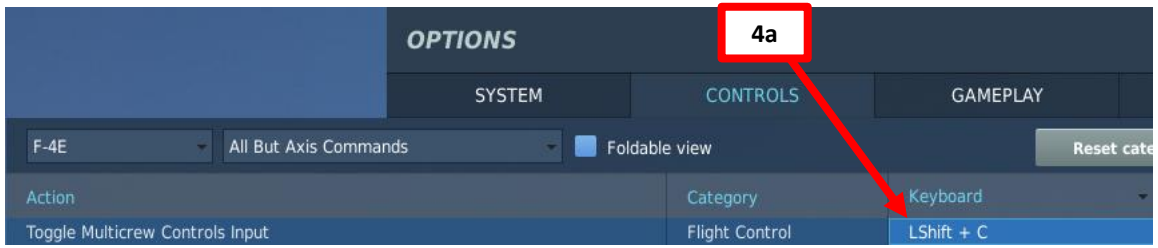


MULTICREW TUTORIAL

4. Once you are spawned, you can take control of the aircraft by pressing the “Toggle Multicrew Controls Input” binding (“LSHIFT+C”).









WHAT IS JESTER?

JESTER is Heatblur's solution to one of the biggest technical challenges in flight simulation : how to implement a WSO AI (Artificial Intelligence) that is smart, functional, useful, and intuitive to use.

JESTER looks deceptively simple at first : you press "A" to show a contextual menu with different options/commands available, which can be selected by either using the "LCTRL + 1" to "LCTRL + 8" keys or by moving your cursor with TrackIR. As you start flying the F-4 for a couple of hours, you will learn to enjoy the elegant yet robust AI solution.

JESTER can accomplish a number of functions, which greatly reduces your workload. He can provide you assistance with start-up checklists, he can set up navigation systems for you, he can tune in on radio frequencies… all you need to do is ask.

Also, JESTER will dynamically scan the sky with his radar to find and call out targets. He will deploy countermeasures if needed, ~~crack jokes~~ give you advice in all sorts of situations. He also has access to the ejection handle… so be nice to him!

Graywolf (who lent his voice to JESTER) did not only a stellar job in creating a compelling voice-over for the AI, but also succeeded in giving different emotions to JESTER based on different situations. He will sound excited and encourage you when you're on a bandit's tail, he will sound focused when calling out bandit bearings, he will sound scared when telling you to break to evade a missile, he will sound annoyed when you mess up your landing, he will crack jokes once in a while… JESTER feels like a living, breathing person. JESTER is more than a set of functions glued together – He's **your** buddy.

Heatblur has successfully done a tremendous technological achievement in the world of flight simulation: creating a crew member that is functional, helpful, relatively smart, and funny all at once.



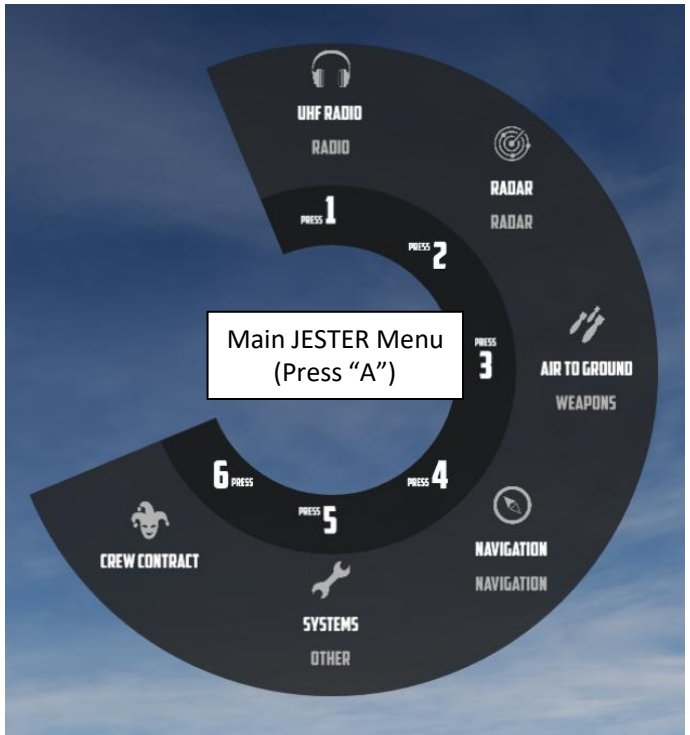
HOW DOES JESTER WORK?

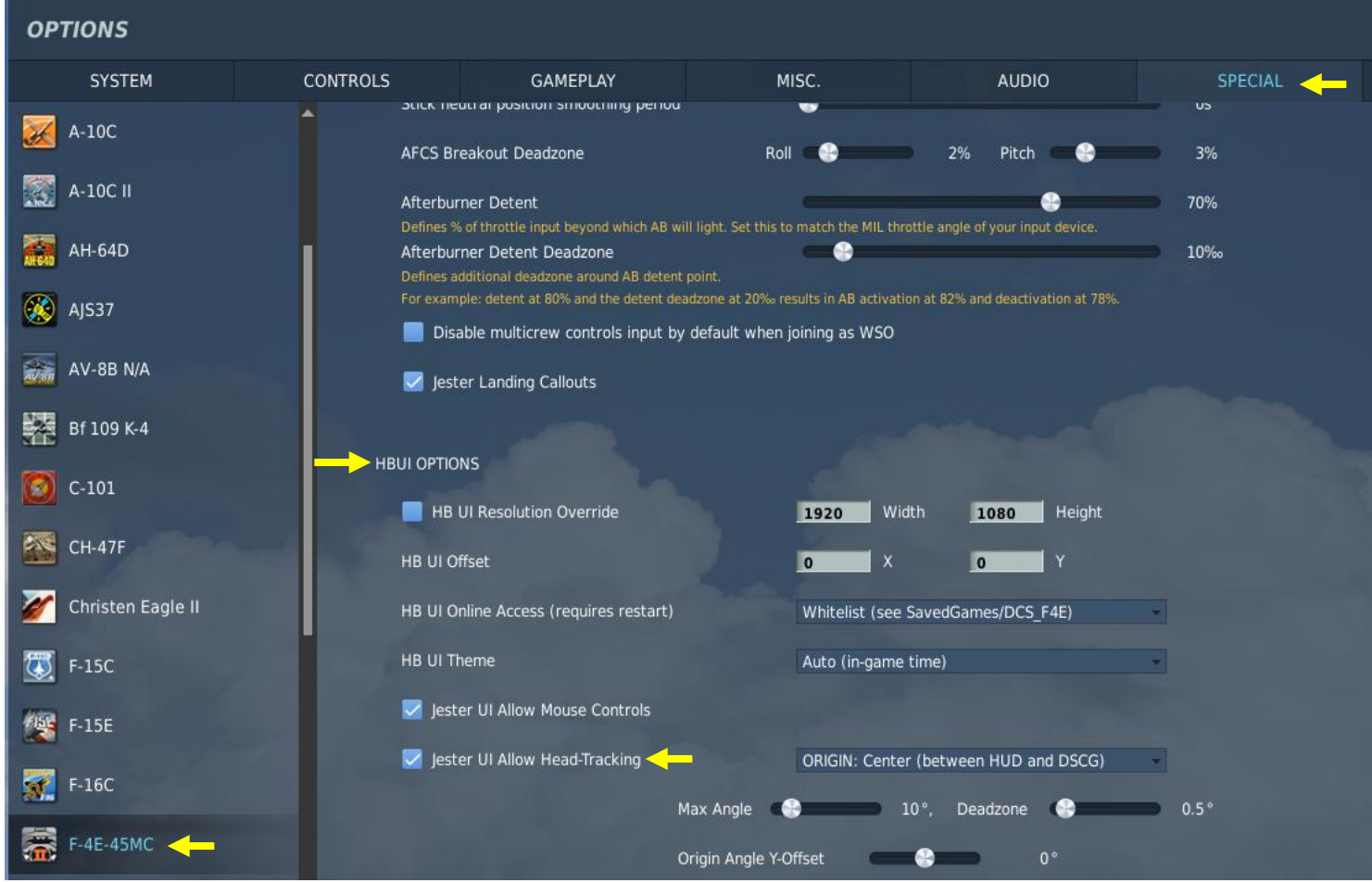
1. To open JESTER AI wheel, short-press "**A**" (**JESTER UI Action binding**).
2. Make sure to map a binding for the **JESTER Context Action** (short, hold, double-click). In my case, I have it set to "**V** ". The JESTER Context Action does different things based in what context you are.
3. The entire UI is accessible via mouse by **left-clicking** options or clicking on the center area of circle to navigate back. Options can also be bound directly to keyboard or other input devices. The default hotkeys to access the options are "**LCTRL+1**" through "**LCTRL+8**".

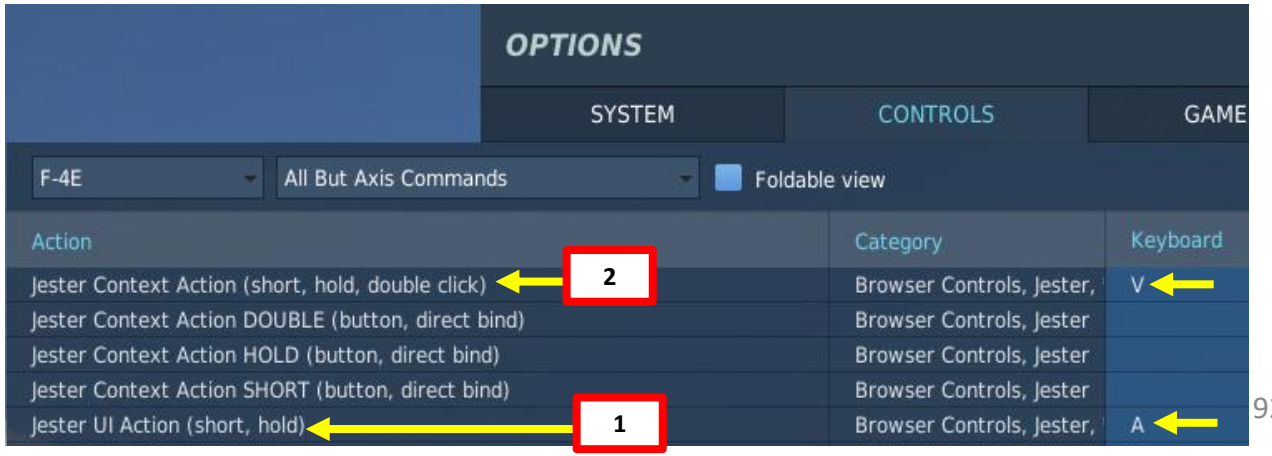
Options on the outer ring are selectable via the following bindings:

- **Q**: Move cursor counter-clockwise
- **W**: confirm selection under cursor
- **E**: Move cursor clockwise

If you have TrackIR, I strongly suggest that you tick the "JESTER UI Allow Headtracking" in the Special F-4E Options menu. You can also use the mouse to click options by having the "JESTER UI Allow Mouse Controls" options enabled (ticked).







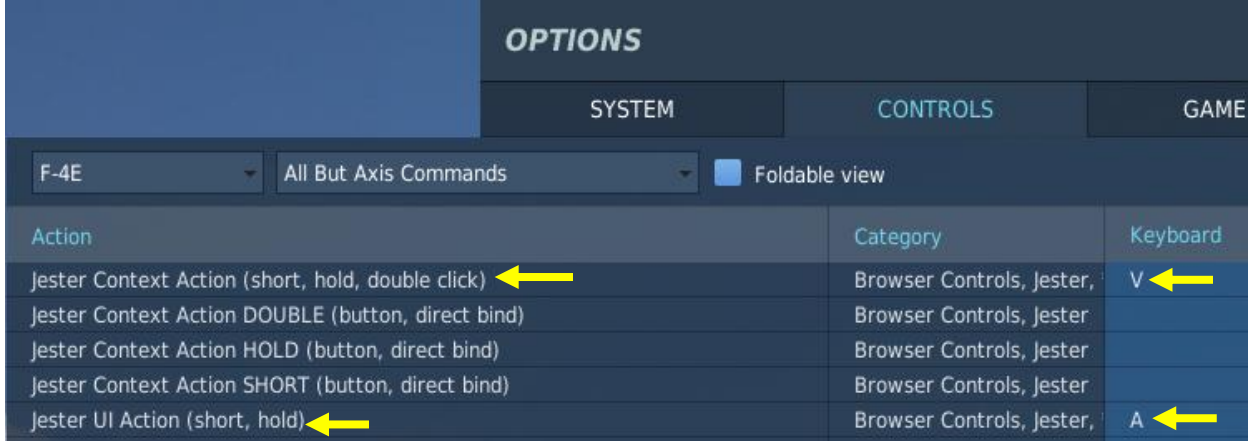
HOW DOES JESTER WORK?

JESTER's assistance for combat situations is generally divided into options on the **JESTER Wheel**, whenever not in a high action environment yet, and a **smart Context Action** for use during situations that require acting quick, such as during a fight.

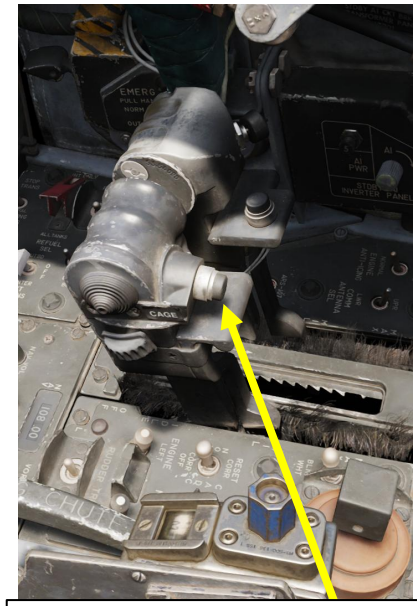
The Context Action command (set to "V" binding by default) allows for cooperation and exchange between Pilot and WSO based on the following contexts:

- **CONTEXT 1**: Pave Spike Targeting Pod – TGT FIND (Target Find) Selected on the **Weapon Delivery Mode Knob**
- **CONTEXT 2**: DT (Dive Toss) or DL (Dive Laydown) selected on the **Weapon Delivery Mode Knob**
- **CONTEXT 3**: Dogfight – CAGE or BORESIGHT Mode selected
- **CONTEXT 4**: Beyond Visual Range (BVR) Radar Operation – Other contexts

Context action can change semantics if pressed only momentarily, if held or if clicked twice (double-click).



General JESTER Context Action Logic (« V » binding)		
Context	**Context Action Press Duration**	**JESTER Action**
BVR – Radar Scanning	Short Press	Select Next Target
	Long Press	Lock selected target
	Double-Press	Reset Target Selection
BVR – Radar Lock	Short Press or Long Press	Drop lock, but keep target in focus
	Double-Press	Drop lock and focus
Dogfight	Short Press	Select Next Target Aspect
	Long Press	Lock/Unlock contact ahead
	Double-Press	Exit CAGE or BORESIGHT mode
Dive Toss (Air-to-Ground)	Short Press	Lock/Unlock ground return
Pave Spike Targeting Pod	Short Press	Lock/Unlock target next to reticle





Air-to-Ground Weapon Delivery Mode Knob

Cage Button

- *When pressed, commands Cage Mode.*
- *Radar goes into BST (Boresight) mode with a five mile range, short pulse, and sets the firing circuit for the currently selected air-to-air weapon relative to the Pinky Switch.*
- *For the optical sight, the command activates the respective elevation and azimuth tracking, roll mark, and range functions of the reticle for the chosen weapon, without the pilot having to remove a hand from throttle or stick to swap the sight mode or weapon control panel functions.*

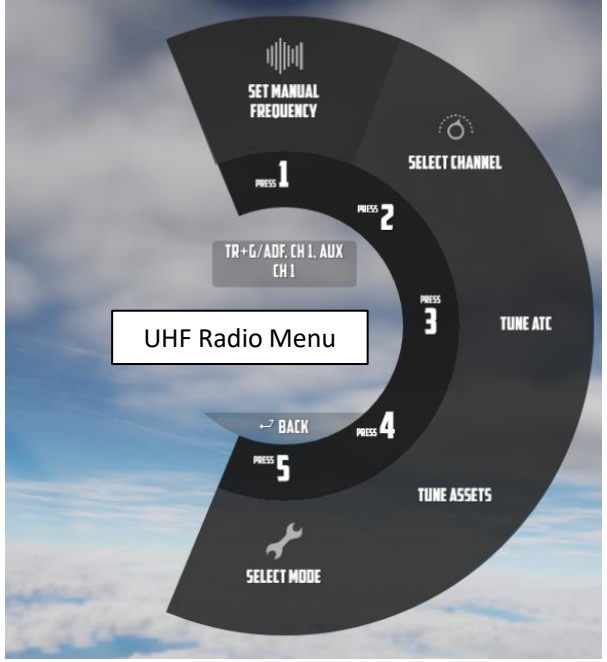
HOW DOES JESTER WORK?

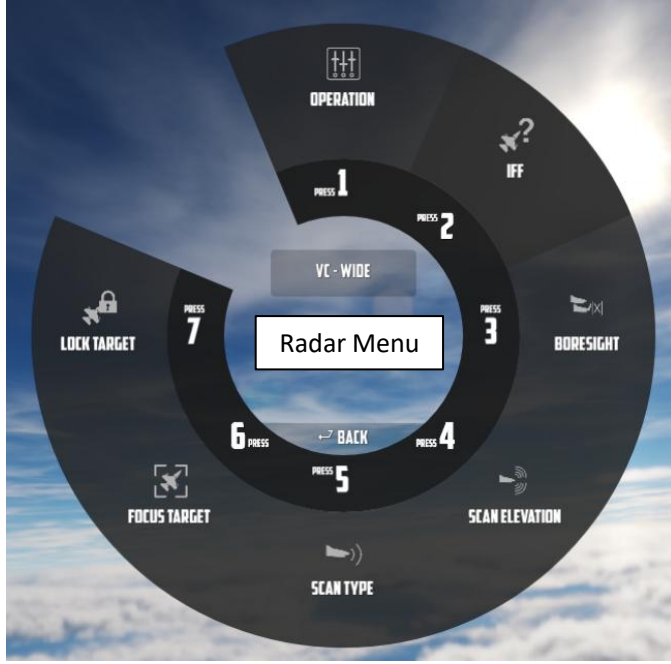
JESTER Context Action – Radar Logic (« V » binding)		
Radar in SCAN/SEARCH Phase (JESTER searching for targets)	**Radar in LOCK/TRACK Phase** (JESTER performing a radar lock)	**Radar in CAGE or BORESIGHT (BST) Mode** (JESTER is in a dogfight situation)
Condition: Normal flight situation, JESTER has not been issued commands	**Condition:** Pilot has already asked JESTER to radar lock a target.	**Condition:** Pilot must press Cage Button or ask JESTER to select BORESIGHT (BST) Mode.
Short Press: Commands JESTER to focus/select the next target visible on the radar scope.	**Short Press:** Commands JESTER to drop the target's radar lock but keep the target in focus.	**Short Press:** Commands JESTER to select Next Target Aspect
Long Press: Commands a radar lock on the target currently selected by JESTER (or the target with the highest priority).	**Long Press:** Commands JESTER to drop the target's radar lock but keep the target in focus.	**Long Press:** Commands JESTER to radar lock or unlock the closest target (radar contact) ahead. Note: Targets have to be within 5 degrees of his boresight or a lock attempt can result in a bad lock. JESTER expects the pilot to place the target within that zone first before being asked to perform the lock.
Double-Press: Resets currently selected target and returns JESTER to his standard behavior of automatically selecting the highest priority threat.	**Double-Press:** Commands JESTER to drop both the target's radar lock and focus (meaning JESTER will focus his attention on other targets).	**Double-Press:** Commands JESTER to exit CAGE or BORESIGHT Mode.

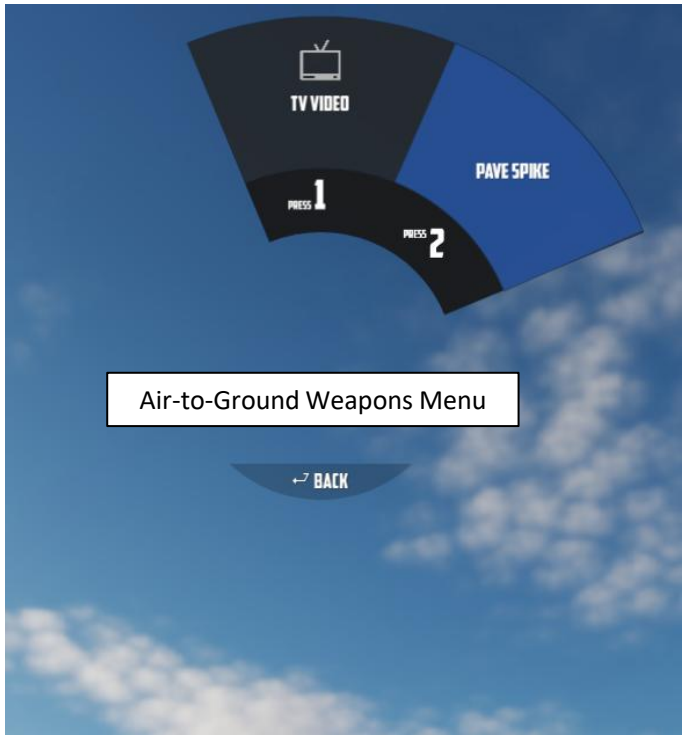
JESTER SUB-MENUS

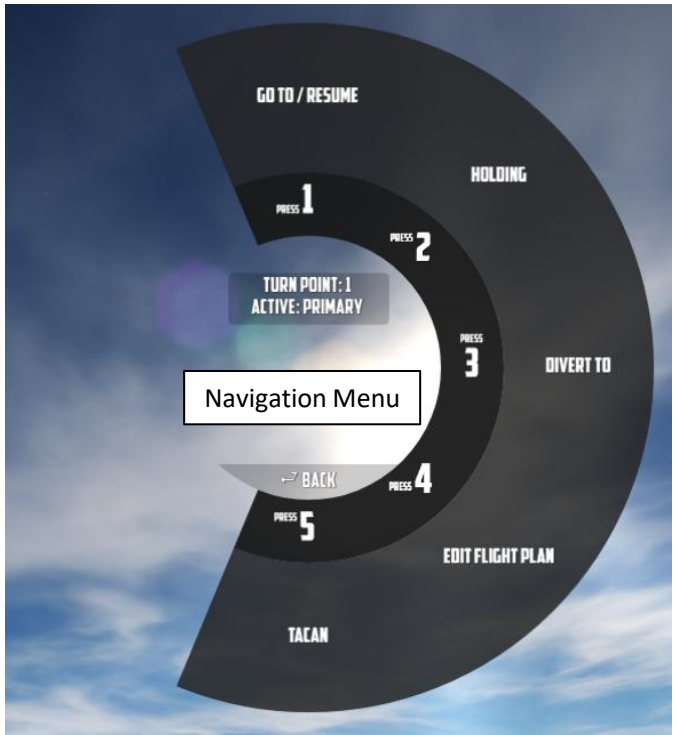
Here are the various menus for the JESTER AI (referred as “JESTER Wheel”):

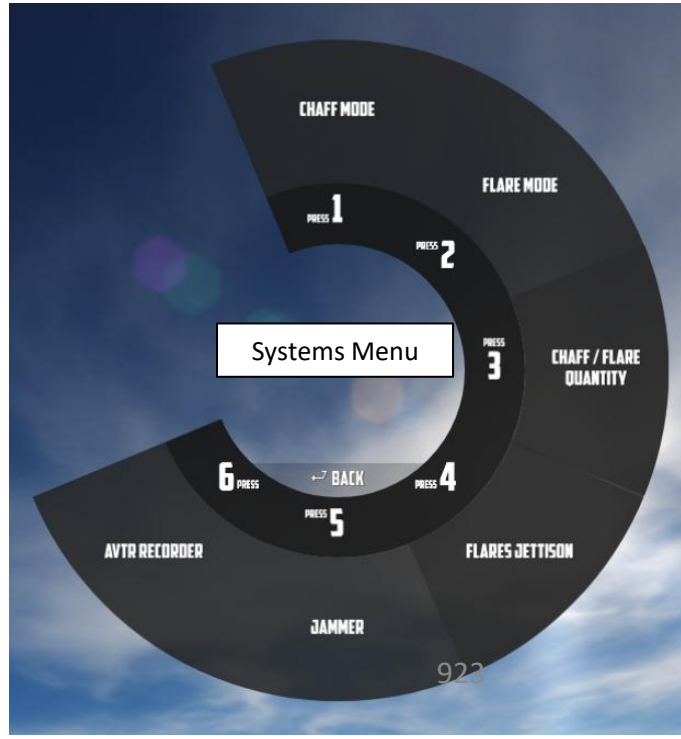
- **UHF Radio**: communications and radio-related control commands.
- **Radar**: radar settings and commands.
- **Air-to-Ground Weapons**: Maverick/HOBOS TV settings and Pave Spike Targeting pod setting and commands.
- **Navigation**: settings related to navigation systems and flight plan parameters.
- **Systems**: settings related to countermeasures, jammer and AVTR (Airborne Video Tape Recorder).







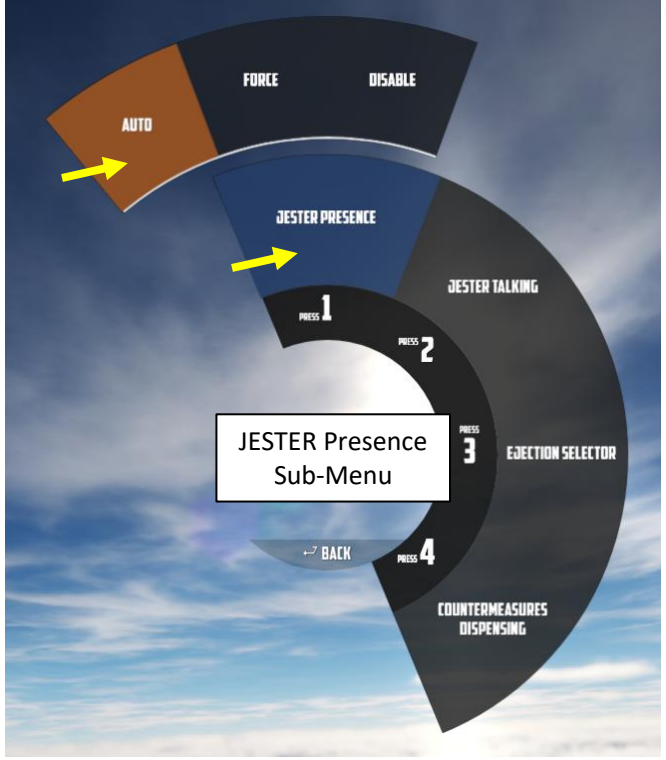


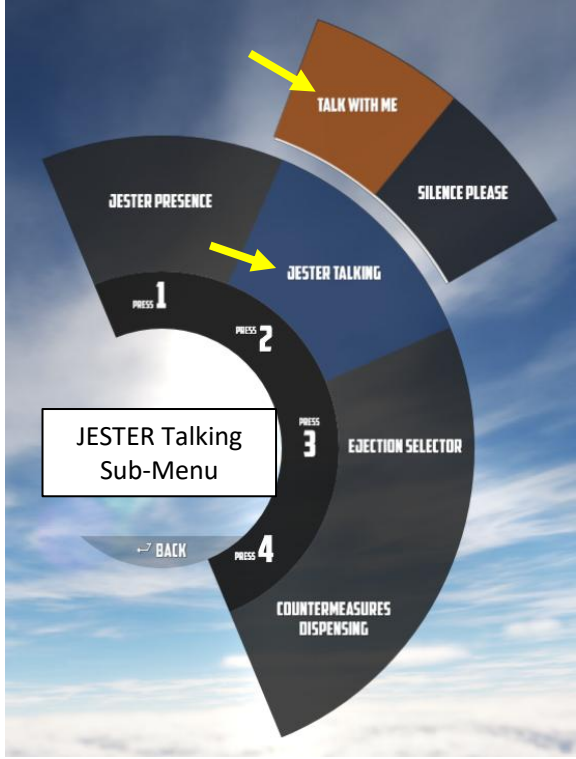


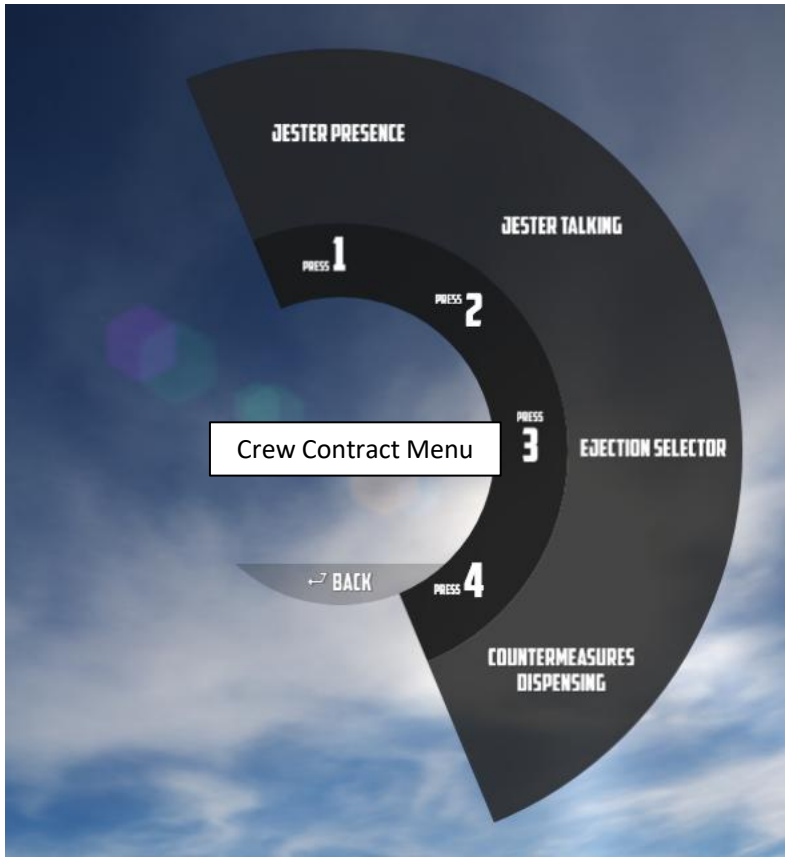
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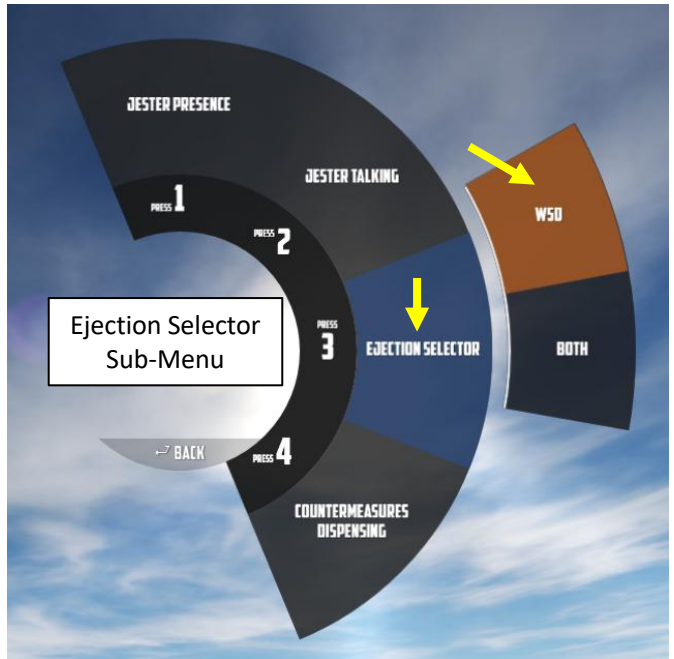
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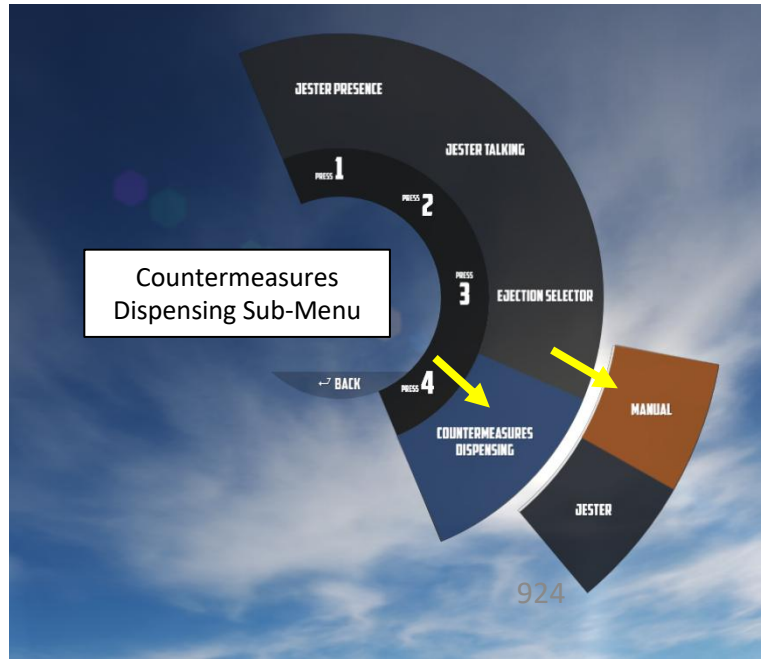
- **Crew Contract**: These functions affect how JESTER interacts with you.
  - JESTER PRESENCE controls if the AI logic is automatic, forced ON or disabled.
  - JESTER TALKING controls if JESTER talks to you or not.
  - EJECTION SELECTOR controls the setting of the ejection handle (ejection seat priority setting).
  - COUNTERMEASURES DISPENSING controls if JESTER dispenses countermeasures automatically (JESTER setting) or lets the pilot countermeasures by himself (MANUAL setting).







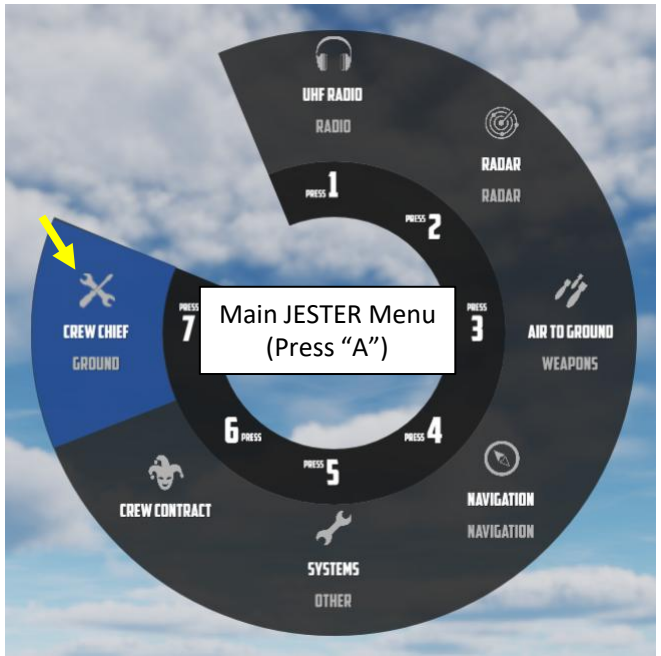


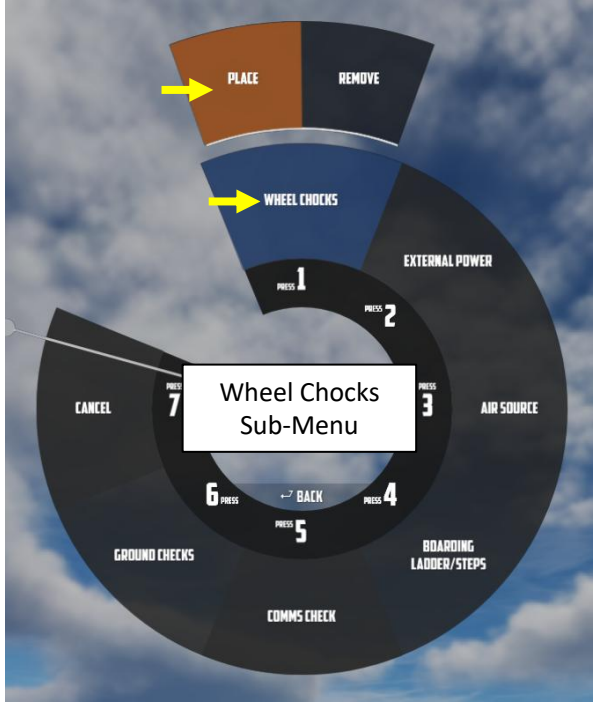


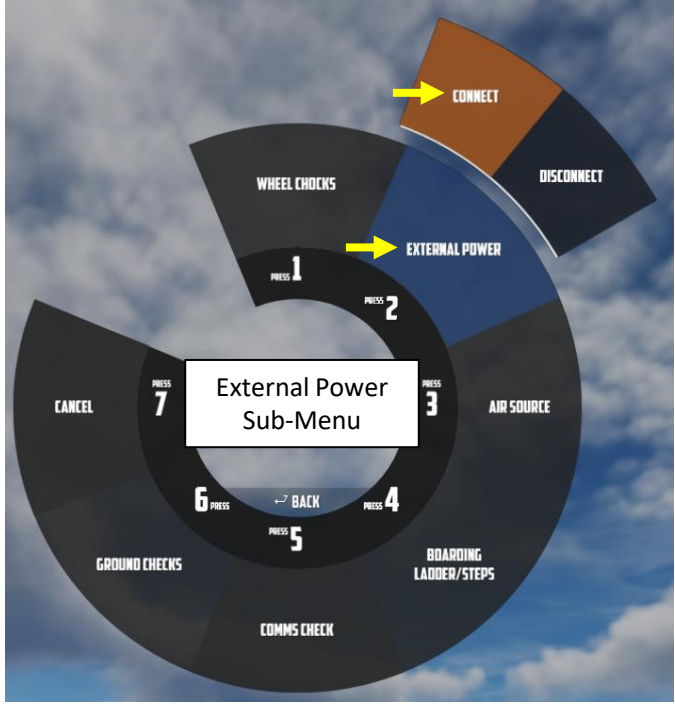
JESTER SUB-MENUS

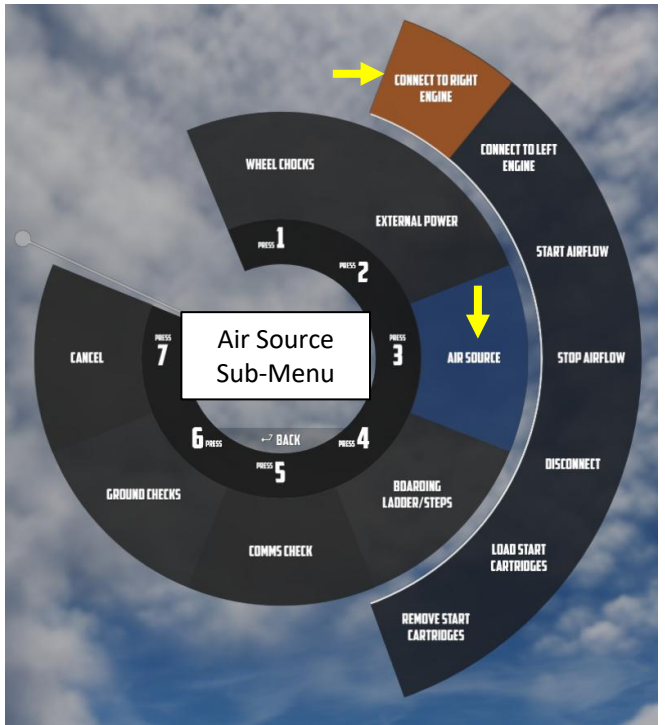
Here are the various menus for the JESTER AI (referred as "JESTER Wheel"):

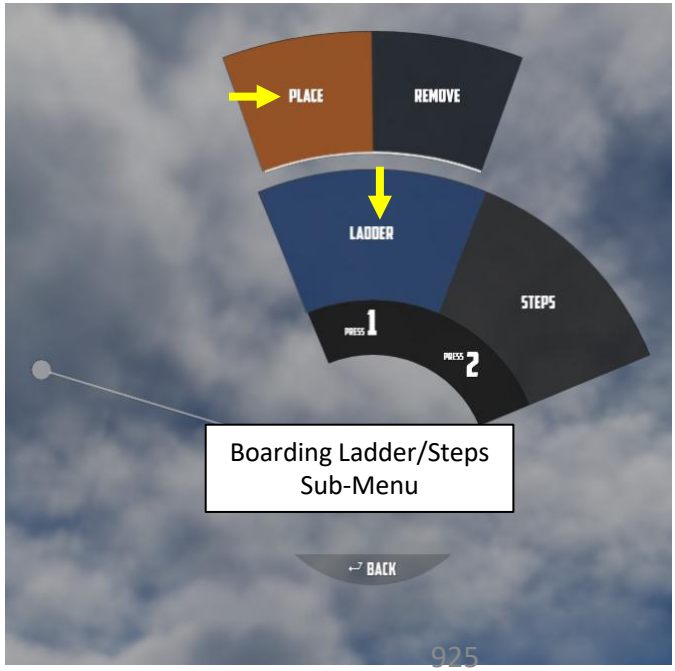
- **Crew Chief**: These functions allow you to talk to the crew chief for tasks that are performed while aircraft is on the ground.
  - WHEEL CHOCKS: Allows to remove or install wheel chocks.
  - EXTERNAL POWER: Allows to connect or disconnect the A/M32-60B External Ground Power Cart (also known as "Dash Sixty", or "Huffer")
  - AIR SOURCE: Allows to connect or disconnect the air pressure cart.
  - BOARDING LADDER/STEPS: Allows the crew chief to install/remove the ladder or steps providing access to the aircraft.







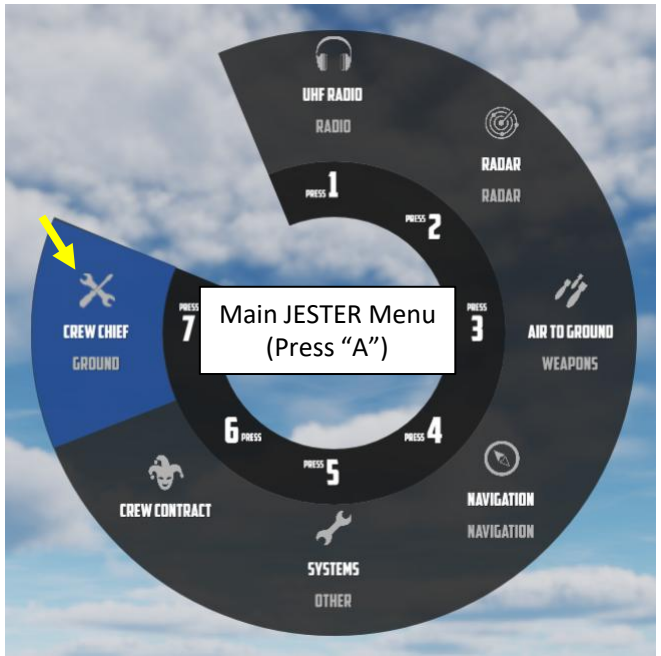


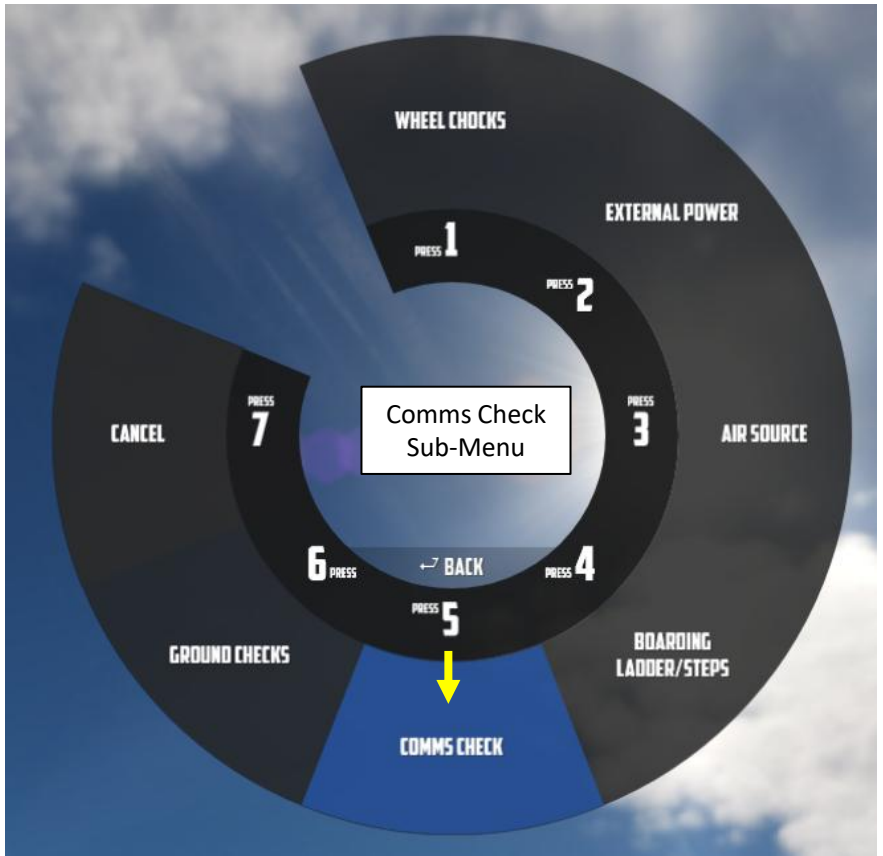


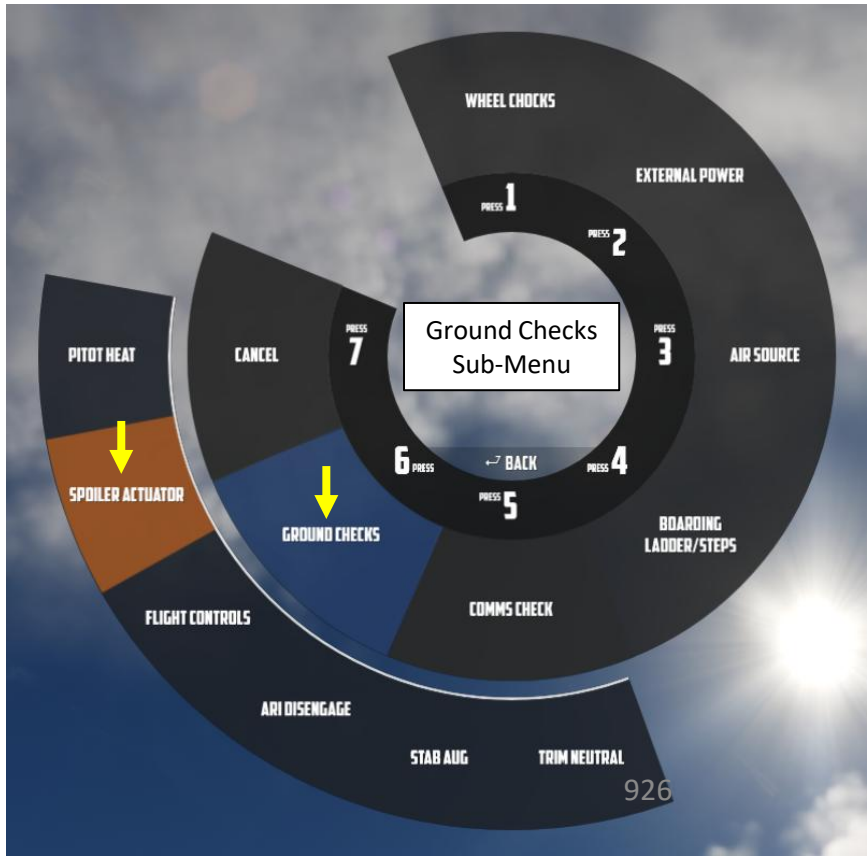
JESTER SUB-MENUS

Here are the various menus for the JESTER AI (referred as “JESTER Wheel”):

- **Crew Chief**: These functions allow you to talk to the crew chief for tasks that are performed while aircraft is on the ground.
  - COMMS CHECK: Performs a radio check.
  - GROUND CHECKS: Performs checks performed on the ground such as spoiler actuators, flight controls, etc.







DYNAMIC JESTER FUNCTIONS

JESTER is dynamic. He will perform most of WSO-related tasks by himself automatically. He will let you know what he sees, what is happening from his perspective. He will call out bandits during a dogfight and give the pilot steering tips. Jester might tell the pilot in which direction to evade when attacked by a missile, make him aware of any friendly traffic spotted or also simply when the AVTR cassette is full. While lacking a fuel gauge in his cockpit, he will observe the clock and the pilots flying style to remind him about checking the fuel level or consumption when forgetting to leave the Fuel Dump switch activated. JESTER also provides steering assistance to the pilot during air-to-air refueling. He really does it all!

JESTER will also talk to you and ask you to make decisions which will drive his behavior. As an example, during taxi operations JESTER will ask you if you plan on going low for the mission. Based on your answer, his tolerance before ejecting due to a perceived risk of pilot CFIT (controlled flight into terrain) will be adjusted accordingly. All you need to do is click on the desired answer.









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- Episode 052: F-4 Phantom II Part 1: https://youtu.be/uxjSyQfUWwM
- Episode 053: F-4 Phantom II Part 2: https://youtu.be/eotHJMJfn_w
- Episode 176: RF-4 Photo Phantoms over Vietnam with "Racehorse“: https://youtu.be/sbc0WFeP4aU

The Fabulous Phantom Documentary
- https://youtu.be/BgWPyiseBu8

The Record Breaking Phantom II Documentary
- https://youtu.be/1RO_0cH3OUQ

The F-4 Phantom II Flight Characteristics Documentary
- https://youtu.be/iZiduQboyow

Ambassadors in Blue Documentary
- https://youtu.be/X_JNL1egQKI

Cal Worthington’s F-4s
- https://youtu.be/pg8-mx4KGK8

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- PART 9 – EMERGENCY PROCEDURES
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- PART 17 – AIR-TO-AIR REFUELING
- PART 18 – MULTICREW
- PART 19 – JESTER AI
- PART 20 – REFERENCE MATERIAL & ACRONYMS

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- Radar Quirks & Features: https://flyandwire.com/2023/08/03/radar-quirks-features-phantom-phamiliarisation/
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- Radar Cross-Section (RCS) and Detection Range: https://flyandwire.com/2024/05/20/f-4e-apq-120-radar-cross-section-rcs-and-detection-range/
- Jamming Effects: https://flyandwire.com/2024/05/21/dcs-f-4e-apq-120-jamming-effects/
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ABBREVIATED CHECKLISTS

START-UP, TAXI & RUNWAY LINEUP

Checklist

Startup

Before engine start - PLT/WSO:

1.	Seat pins	Check removed and stowed
2.	Fore and aft area	Clear
3.	Fire guard	Posted
4.	Throttles	Off

Starting engies - PLT:

1.	External air	Connected - right *
2.	Engine master switches	On
3.	External air	On *
4.	10% RPM	
a.	Right ignition btn.	Press and hold
b.	Right throttle	Half then idle
5.	At lightoff	Release ignition btn.
6.	At 45% RPM	
a.	External air	Stop *
7.	Check parameters	
a.	EGT	220 - 420 °C
b.	Fuel flow indicator	800 - 1400 pph
c.	Idle RPM	65% +-1
d.	Right boost pump	30 PSI +-5
e.	Oil pressure	12 - 50 PSI
f.	Hydraulic pressure	Within limits
8.	Right generator	On
9.	Spoiler actuator	Check left *
10.	AAR door	Check *
11.	Left engine	Repeat steps 1-8 for left engine
12.	Right generator	Cycle - Off/On
13.	Bus tie open light	Out
14.	External air	Disconnect *
15.	External power	Disconnect *
16.	Interior check	Complete

Note: * indicate actions by ground crew

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Checklist

Before taxi

PLT:

1.	Comm & nav equipment	On and checked
2.	IFF	Standby
3.	Radar altimeter	On & check
4.	Altimeter and SPC	Set & check
5.	Speed brakes	Check *
6.	Slats and flaps	Check *
7.	Flight controls	Check *
8.	Slats and flaps	NORM
9.	ARI disengage	Check *
10.	Stab Aug switches	Engage and check *
11.	Reference sys select	PRIM (INS in NAV)
12.	Compass mode ctrl knob	SYNC
13.	AFCS	Check (if required)
14.	Stab Aug switches	Disengage
15.	Trim	Check and set * 1-3 units nose down
16.	Slats and flaps	Out and down *
17.	Optical sight	STBY/CAGE
18.	Pneumatic pressure	Check
19.	IFF	Check
20.	Radar altimeter	Check and set
21.	Wheel chocks	Remove *

WSO:

1.	Interior check	Complete
2.	Comm & nav equipment	On and checked
3.	Target designator	Power ON and stowed
4.	Radar BIT	Initiate
5.	WRCS BIT	Initiate
6.	NAV computer mode	As desired
7.	Altimeter and SPC	Set and checked

Taxi - PLT/WSO

1.	Wheel brakes	Test
2.	NWS	Engage and check
3.	Flight instruments	Check
4.	Oxygen diluter	As required

Note: * indicate actions by ground crew

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Checklist

Before Takeoff

PLT:

1.	Optical sight	Check
2.	Internal wing transfer	Normal
3.	Stab Aug switches	Engage
4.	Flight controls	Unrestricted (WSO confirm)
5.	Slats and flaps	Check out and down
6.	Anti-ice	As required
7.	Stab trim	Check 1-3 units nose down
8.	Fuel quantity	Check
Both 9.	Canopies	Close and check WSO then PLT
10.	Warning lights	Test
11.	Defog and temperature	As required
WSO 12.	Command selector	As breifed
Both 13.	Ejection seats	Arm

After RWY line-up

PLT:

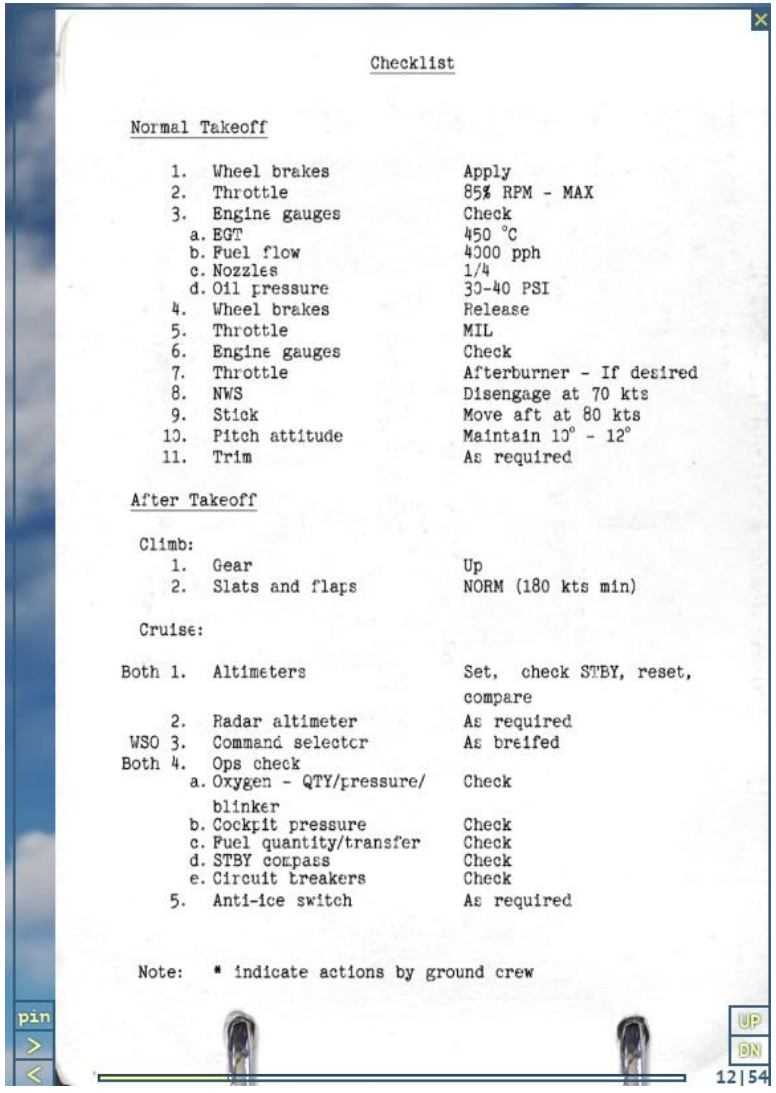
1.	External transfer	As desired
2.	Anti skid	On and light out
3.	Compass heading	Check
4.	Pitot heat	On
5.	IFF	As required
Both 6.	Circuit breakers	Check - In
7.	Warning lights	Check

Note: * indicate actions by ground crew

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ABBREVIATED CHECKLISTS

TAKEOFF & LANDING



Checklist

Normal Takeoff

	1. Wheel brakes	Apply
	2. Throttle	85% RPM - MAX
	3. Engine gauges	Check
	a. EGT	450 °C
	b. Fuel flow	4000 pph
	c. Nozzles	1/4
	d. Oil pressure	30-40 PSI
	4. Wheel brakes	Release
	5. Throttle	MIL
	6. Engine gauges	Check
	7. Throttle	Afterburner - If desired
	8. NWS	Disengage at 70 kts
	9. Stick	Move aft at 80 kts
	10. Pitch attitude	Maintain 10° - 12°
	11. Trim	As required

After Takeoff

Climb:

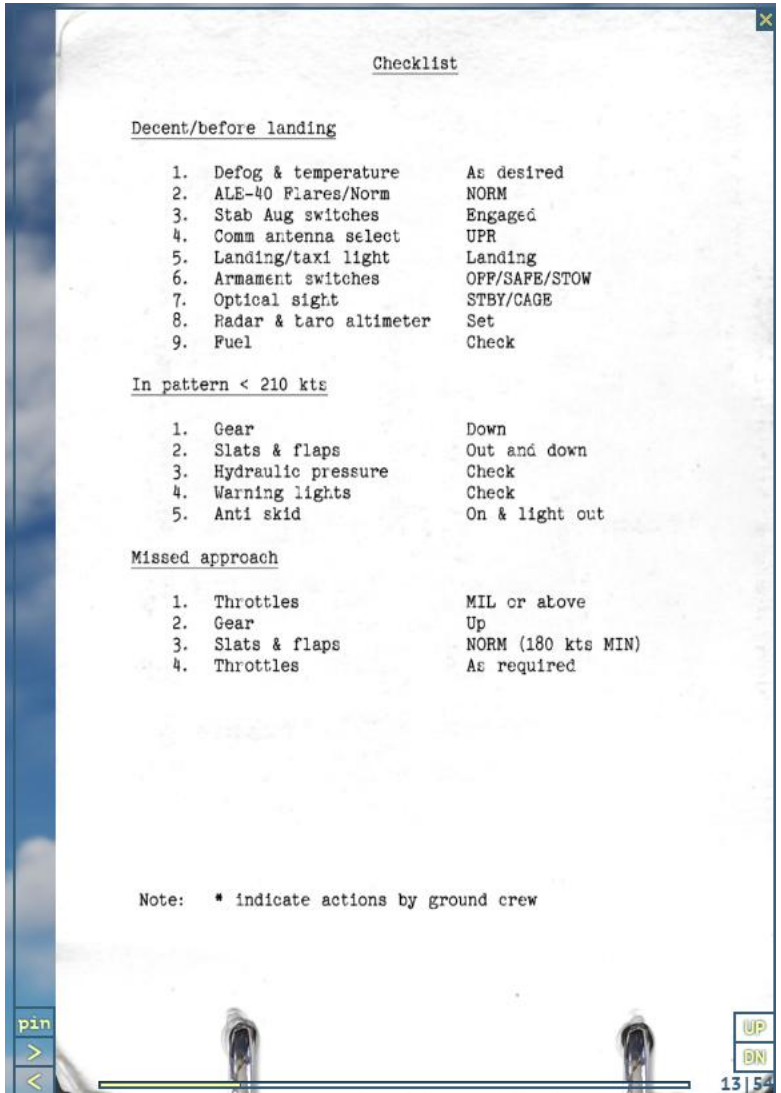
	1. Gear	Up
	2. Slats and flaps	NORM (180 kts min)

Cruise:

Both	1. Altimeters	Set, check STBY, reset, compare
	2. Radar altimeter	As required
WSO	3. Command selector	As breifed
Both	4. Ops check	
	a. Oxygen - QTY/pressure/ blinker	Check
	b. Cockpit pressure	Check
	c. Fuel quantity/transfer	Check
	d. STBY compass	Check
	e. Circuit breakers	Check
	5. Anti-ice switch	As required

Note: * indicate actions by ground crew

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Checklist

Decent/before landing

	1. Defog & temperature	As desired
	2. ALE-40 Flares/Norm	NORM
	3. Stab Aug switches	Engaged
	4. Comm antenna select	UPR
	5. Landing/taxi light	Landing
	6. Armament switches	OFF/SAFE/STOW
	7. Optical sight	STBY/CAGE
	8. Radar & taro altimeter	Set
	9. Fuel	Check

In pattern < 210 kts

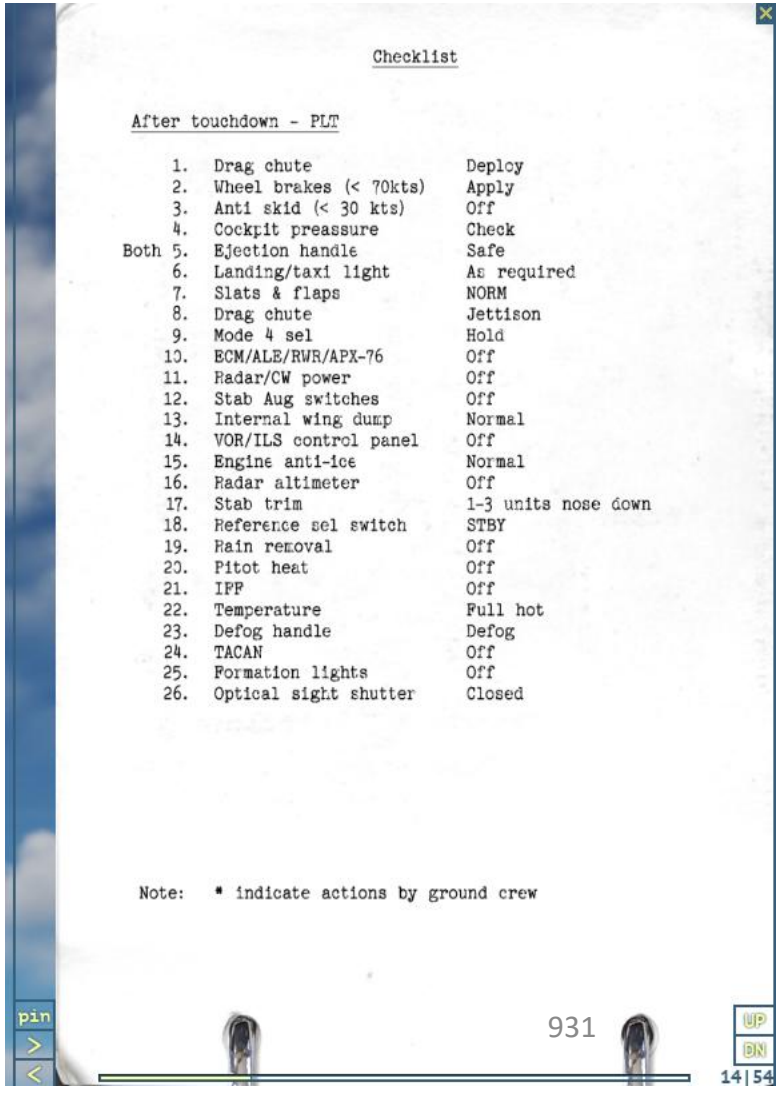
	1. Gear	Down
	2. Slats & flaps	Out and down
	3. Hydraulic pressure	Check
	4. Warning lights	Check
	5. Anti skid	On & light out

Missed approach

	1. Throttles	MIL or above
	2. Gear	Up
	3. Slats & flaps	NORM (180 kts MIN)
	4. Throttles	As required

Note: * indicate actions by ground crew

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Checklist

After touchdown - PLT

	1. Drag chute	Deploy
	2. Wheel brakes (< 70kts)	Apply
	3. Anti skid (< 30 kts)	Off
	4. Cockpit preassure	Check
Both	5. Ejection handle	Safe
	6. Landing/taxi light	As required
	7. Slats & flaps	NORM
	8. Drag chute	Jettison
	9. Mode 4 sel	Hold
	10. ECM/ALE/RWR/APX-76	Off
	11. Radar/CW power	Off
	12. Stab Aug switches	Off
	13. Internal wing dump	Normal
	14. VOR/ILS control panel	Off
	15. Engine anti-ice	Normal
	16. Radar altimeter	Off
	17. Stab trim	1-3 units nose down
	18. Reference sel switch	STBY
	19. Rain removal	Off
	20. Pitot heat	Off
	21. IFF	Off
	22. Temperature	Full hot
	23. Defog handle	Defog
	24. TACAN	Off
	25. Formation lights	Off
	26. Optical sight shutter	Closed

Note: * indicate actions by ground crew

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ACRONYMS & ABBREVIATIONS

AAR	Air-to-Air-Refueling
AC	Aerodynamic center
ACM	Air Combat Maneuvering
AC	Alternating current
ADCS	Air Data Computer Set
ADI	Attitude Director Indicator
AFC	Automatic Frequency Control
AFCS	Automatic Flight Control System
AGC	Automatic Gain Control
AHRS	Attitude Heading Reference System
AJB	Airborne Electro-Mechanical Bombing Equipment (AN/AJB-1, refers to LABS)
AOA	Angle of Attack
APA	Airborne, Radar, Auxiliary Assembly
APN	Airborne, Radar, Navigational Aid
APQ	Airborne, Radar, Special Purpose
APU	Auxiliary Power Unit
AR	Air Refueling
ARI	Aileron Rudder Interconnect
ARC	Airborne, Radio, Control
ARR	Air Refueling Release (Button)
ASA	Airborne, Special Type, Auxiliary Assembly
ASE	Allowable Steering Error
ASN	Airborne, Special Type, Navigational Aid
ASQ	Airborne, Special Type, Combination of Purposes
AVTR	Airborne Video Tape Recorder
AWRU	Aircraft Weapons Release Unit
AWW	Airborne, Armament, Control
BATH	Best Available True Heading
BDHI	Bearing Distance Heading Indicator
BIT	Built-In Test
BST	Boresight
CAA	Computer Automatic Acquisition
CADC	Central Air Data Computer
CAP	Combat Air Patrol
CAS	Calibrated Airspeed
CG	Center of Gravity
CIT	Compressor Inlet Temperature
CNI	Communication Navigation Identification
CSD	Constant Speed Drive
DC	Direct Current
CSCG	Digital Scan Converter Group
CDU	Douglas Control Unit
DMAS	Digital Modular Avionics System
DME	Distance Measuring Equipment
DR	Dead Reckoning
DVST	Direct View Storage Tube
EAS	Equivalent Airspeed
ECM	Electronic Countermeasures
EGT	Exhaust Gas Temperature
FL	Flight Level
G	Gravity
GCA	Ground Control Approach
GCI	Ground Control Intercept
GPM	Gallon per Minute
HSI	Horizontal Situation Indicator
Hz	Hertz
IP	Identification Point
IAS	Indicated Airspeed
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IR	Infrared
I/P	Identification of Position
JP	Jet Propulsion
KTS	Knots
LABS	Low Altitude Bombing System
LCOSS	Lead Computing Optical Sight
LE	Leading Edge
LOX	Liquid Oxygen
LPM	Liters per Minute
MAC	Mean Aerodynamic Chord
MIL	Military
MSDG	Multiple Sensor Display Group
MSL	Mean Sea Level
N/A	Not Applicable
N/E	Not Established
NMPP	Nautical Miles per Pound
OAT	Outside Air Temperature

ACRONYMS & ABBREVIATIONS

P	Pilot
PC	Power Control
PDVL	Pull Down Vent Line
PLB	Personnel Locator Beacon
PRF	Pulse Repetition Frequency
PSI	Pounds per Square Inch
Q	Dynamic Pressure, pounds per square foot
RADAR	Radio Detection and Ranging
RBL	Radar Boresight Line
RF	Radio Frequency
RIP	Radar Identification Point
RPM	Revolutions per Minute
RWR	Radar Warning Receiver
SID	Standard Instrument Departure
SPC	Static Pressure Compensator
TACAN	Tactical Air Navigation
TAS	True Airspeed
TE	Trailing Edge
TISEO	Target Identification System Electro-Optical
TMN	True Mach Number
UHF	Ultra High Frequency
VFR	Visual Flight Rules
VHF	Very High Frequency
VIP	Visual Identification Point
VMC	Visual Meteorological Conditions
VN	Velocity Acceleration Relationship
VORTAC	Very High Frequency – Omni Range and Tactical Air Navigation
WSO	Weapon Systems Officer

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THANK YOU TO ALL MY PATRONS

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