

F/A-18A Hornet

Combat Version

For Microsoft® Flight Simulator X: Acceleration



AIR-TO-AIR GUNS MANUAL

"There are only two types of aircraft—fighters and targets."
Major Doyle "Wahoo" Nicholson, USMC
Fighter Pilot

October 30, 2010

A copy of this manual is found in Airplanes/FA-18_Combat/Docs folder.

INTRODUCTION

FSX is not a military simulator. However a lot of things can be done with military aircraft in FSX – you can fly in formation, land on an aircraft carrier or practice aerial refueling. All of these require a thorough understanding of the fundamentals of flight, a great amount of pilot skill, ability to pay attention to many variables, precision and focus.

The Combat Version of the Acceleration F/A-18 ('Combat Hornet') is another extension to the FSX environment that relies on the same set of skills. Equipped only with a 20 mm gun, it does not require knowledge of complex missile weapon systems that act beyond visual range. But it will put your flying skills to the ultimate test in a dog fight when you try to out maneuver your opponent.

The A/A Gun mode implemented in the Combat Hornet is an accurate and realistic representation of this mode in the real F/A-18A. From the two radar modes, the two gun sights and the flying tracers from the 20mm M61 cannon, everything you experience in the virtual cockpit will be very similar to what you would experience in the real cockpit. Except for turning another aircraft into a fireball. This is not necessary however as you will receive an immediate indication on your HUD if the shot was successful and a bullet hit the bandit.

The Combat Hornet uses the exterior model and virtual cockpit of the F/A-18 Hornet that comes with Flight Simulator X: Acceleration. The exterior model was built by Captain Sim and the virtual cockpit and avionics by FSDreamTeam. The Combat Hornet cannot work without Flight Simulator X: Acceleration.

The flight model is unchanged from the Acceleration Hornet except for enabling manually controlled flaps for more realistic landing speeds, and reducing the arresting wire tension for smoother carrier landings.

The most credit for this addon should go to Mr. Scott Printz who first developed a realistic and conformal Hornet HUD from scratch and supported the future development of the HUD. A lot of credit should go to the dedicated community at the FSDreamTeam forum, who took on themselves to develop and improve the default Acceleration Hornet.

SPECIAL THANKS to the beta testing team: Orion Lyau, Christian "Sludge" Snow, Benjamin "Afterburn" Rothstein, Razgriz, Sonofabeech, Capthaltli, Mickey_Techy, IRONDAN, Steven Frost, Peter797, Frankwi, Paul French, Randall Freeman, DButler.

Thanks to Orion Lyau for his help in editing the manual.

CREDITS

Original F/A-18 Hornet HUD
Carrier ILS and TACAN navigation
In-Flight Refueling Gauge
A/A Gun Mode
Sound Gauge (dsd_xml_sound3)
Transparent HUD glass

Scott Printz
Jivko Rusev
Andy Niko & Jivko Rusev
Jivko Rusev
Doug Dawson
Enrico B.

INSTALLATION

The Combat Hornet requires Flight Simulator X: Acceleration.

1. Copy 'FA-18_Combat' folder to <Microsoft Flight Simulator X\SimObjects\Airplanes>.
2. Copy the content of the 'Effects' folder to <Microsoft Flight Simulator X\Effects>.
3. Map the function 'Release Droppable Objects' to a button on your joystick and make sure the slider *Repeat* is all the way to the right (max).

You can choose the aircraft by selecting "Neutrino" in the Publisher drop-down menu.

Short Guide to the F/A-18 Air-To-Air Gun Mode

The purpose of this manual is to cover only the aircraft A/A gun system and it will not provide any air combat maneuvering (ACM) tactics. There are many good books on this subject such as *Fighter Combat: Tactics and Maneuvering* by Robert L. Shaw.

AIR-TO-AIR RADAR

Let's start by looking into the F/A-18 radar since it is the primary means of detecting and tracking targets. The F/A-18 radar antenna, located in the nose of the aircraft, can scan a maximum of 70° to either side and vertically up and down to a maximum of 60°. This means that your radar cannot see targets located behind you or directly above or below you because they are outside of the antenna's scan area. Also the radar cannot instantaneously search this volume of airspace. The antenna scans the space in front of you by continuously sweeping sideways and then vertically in steps (known as "bars") - the radar scans across one bar, moves up several degrees, and then scans the next bar in the opposite direction. The wider the area you want the radar to scan, the slower the update rates on the targets.

RADAR SUBMODES

The real F/A-18 has many radar sub-modes, but only the two most used in close air combat are implemented in the Combat Hornet. The first is one of the automatic acquisition sub-modes that are designed to rapidly lock on to targets, and is called Gun Acquisition (GACQ) sub-mode.

GACQ (GUN ACQUISITION)

Gun Acquisition (GACQ) sub-mode is entered automatically when you select the A/A Master Mode from the HUD Control Panel (opens with Shift+2). GACQ uses a 20° scan centered on your aircraft's waterline and locks on to the first target encountered within 5 nm. When GACQ is selected, a 20° diameter dashed circle displays on the HUD to indicate that the radar scan coverage encompasses the total HUD field of view. If successful in locking on to a target, from GACQ the radar will transition to Single Target Track (STT) sub-mode.

SINGLE TARGET TRACK (STT)

When the radar is "locked" onto a target the antenna is fixed at the target's azimuth and cannot follow other targets. This also provides the highest update rates on the target position and vectors. Once a target is locked a target designator (TD) box identifies the line of sight to the target and you will get its range and closure rate on the HUD. Since the radar follows the locked target, if another aircraft enters your HUD field of view it will not be picked by the radar. If you need to switch to a different target, you may quickly toggle the A/A button and get back to GACQ mode. The radar will also automatically go back to GACQ mode if it loses the target (for example it goes outside the antenna limits).

INTERNAL A/A GUN

The F/A-18 is equipped with 20mm M61 Vulcan (M61A1) Gatling-style cannon, which is also adopted as standard in the F-14 Tomcat, the F-15 Eagle, the F-16 Fighting Falcon and the F-22 Raptor. The gun is mounted at the nose of the aircraft.

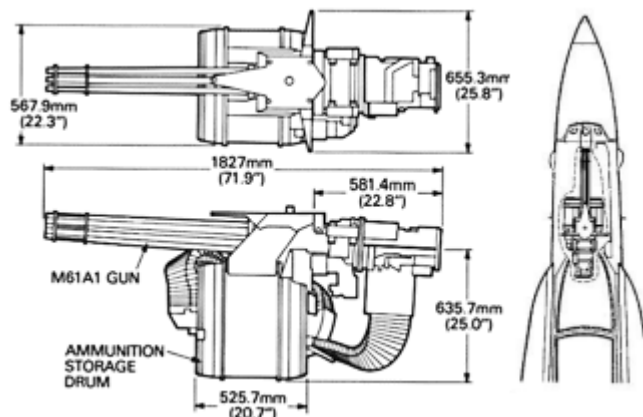


Figure 1. M61 Vulcan

The M61 fires 20 mm rounds at an extremely high rate of 6,000 per minute (100 rounds per second). You can also select a low rate of fire (4,000 rpm) as your aircraft only carries 578 rounds of ammunition and they can get used very quickly in the heat of combat. The gun has 8 milliradians dispersion which means that about 80% of the rounds will pass through an eight foot diameter circle at a range of 1,000 feet.

The M61 uses 20mm PGU-28/B "low-drag" semi-armor piercing high explosive incendiary (SAPHEI) round with muzzle velocity of 3,450 feet per second (1,050 m/s). The PGU-28/B is the only projectile currently used by the Air Force and Navy for fixed wing air-to-air combat. Because projectiles are not visible in flight, in the Combat Hornet each fifth round is a tracer (PGU-30/B).



Figure 2. PGU-28/B round

AIR-TO-AIR GUNNERY

The air-to-air gunnery problem is a difficult one; once you fire a bullet it is completely unguided. You have to hit a moving target from a moving platform with projectiles that follow curved paths at varying speeds. This problem has befuddled fighter pilots since they first strapped machine guns on biplanes.

Modern fighters have aiming references called gun sights. In the F/A-18 there are two different gun sights available to aid you in lining up on your target. The two gun sights available are the Gun Director mode, which requires the radar to be in STT sub-mode with the target locked up, and Funnel mode, which does not require the radar to have a lock on the target. Both gun sights will help you determine the lead or the amount of distance you need to aim out in front of the target in order to get a good shot.

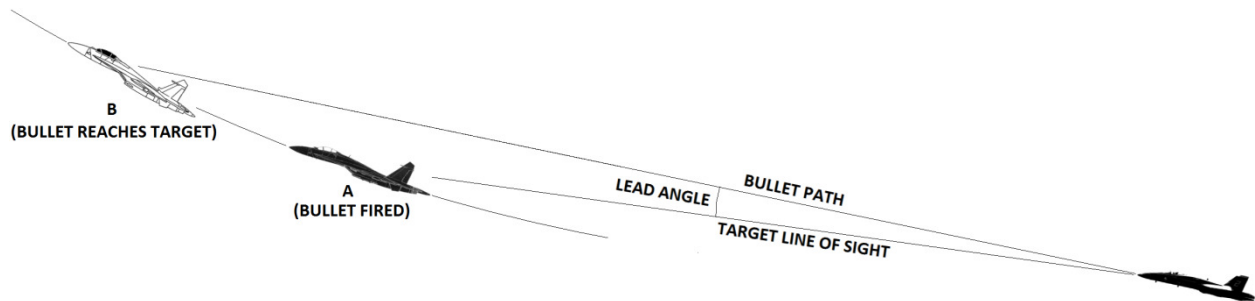


Figure 3. Lead angle problem

GUN BORESIGHT CROSS

Before we get into the specifics of the two gun sights, let's look at the small cross just below the heading pointer (see Figure.5). This is the gun boresight cross which is the static aim point of the gun. Notice it is above the waterline because the gun has a built-in upward slant of 2°. This gives a slight advantage in air-to-air gunnery, but is a disadvantage in air-ground strafe. The gun cross shows the departure line of the bullets as they initially leave the gun and provides a fixed aiming point. Of course you cannot shoot down a target if you simply aim the gun cross at it, unless you and the target fly straight and level.

FUNNEL MODE

Funnel mode is the primary A/A gun mode without a radar lock and is an effective firing mode. Funnel mode is displayed immediately upon selecting the A/A gun or when radar lock is lost or broken. During this time the radar is in Gun Acquisition (GACQ) sub-mode, and if the radar locks on to a target, Funnel mode is replaced with Gun Director Mode unless the FNML mode option is selected.

What the funnel essentially does is show the projected flight path of the bullets if the pilot were to fire at that instant. It takes into account only the motion of your own aircraft. Since there is no radar lock, there is no information about the target. This means that the most important component of the gun solution is missing – the range to the target. This is where the two funnel lines come into play. They represent a fixed 40 feet wingspan at different distances – from 500 feet to 3,000 feet. If you are in the same plane of motion as the target and its wings are within the funnel lines, this means that the bullets will pass behind the target's tail (not enough lead); if the wings are outside the funnel, the bullets will pass in front of the aircraft's nose (too much lead).

So what happens if you fly in the same plane of motion as a target with a 40 feet wingspan and you manage to put it inside the funnel so that its wings are just touching the funnel lines? Well, it means you have just the right amount of lead and if the target is not moving too much relative to the funnel as you take the shot and keeps a fairly consistent maneuver until the bullet reaches it, the bullets will shred it to pieces. The time it takes the bullet to reach the target (called Time Of Flight or TOF) is between 0.3 and 0.6 seconds for ranges from 1,000 to 2,000 ft, so that's all that's necessary for the enemy pilot not to change G or maneuver out of plane.

What about aircraft with different wingspans? The wingspan for the funnel is set to 40 feet by default, which is in between the wingspans of Mig-29 (37 ft) and Su-27 (48 ft). For reference the wingspan of the F/A-18A is 37.4 ft. The exact wingspan really doesn't matter that much (unless you are firing at a bomber) because you will usually fire a burst while moving the target through the funnel. Keep in mind that if the target changes planes, you must also change planes to get a good shot.

In summary, the correct gunshot solution exists when the wings of the target are just touching the funnel lines. When this occurs, you are aiming the proper distance out in front of the target. In addition, if you hold the target in the funnel, you are also in plane with the target.



Figure 4. Is this a good position to open fire?

GUN DIRECTOR MODE

The Gun Director mode is the primary gun mode when the radar is tracking an aerial target and the target is within the effective range of the gun (about 5,000 feet).

The Gun Director takes into account not only the motion of the firing aircraft, but also the range to the target which is now available from the radar. With radar lock you also have the relative motion of the two aircraft, which allows the Director to predict the position of the target for one bullet's time of flight in the future. That's why it is called a "predictor" sight. With all this information, the Gun Director computes where the target needs to be on your HUD in order to get hit by a bullet and places the Gun Reticule there. If the target is within the area of the reticule, you will see a 'SHOOT' cue and you may open fire. As long as the target keeps the same G and maneuver, you will get a kill.

The Gun Director has two major advantages over the funnel. One is that because you know the range, you can open fire at the right moment, while with the funnel you will have to open fire a little in advance while you position the target wings up or down the funnel lines. The second advantage is that because the Gun Director accounts for the relative motion of the target and your aircraft, it takes out the guess work required to fire the bullet before the target crosses the funnel. It also allows to fire out of plane. These two advantages result in improved accuracy and saved ammunition.

IMPORTANT: It is not necessary to open fire before the target gets inside the Gun Reticule. The Gun Director already takes into account the bullet's time of flight and the relative motion of the target and your airplane.

You will put the maximum amount of bullets into the target if you stop the relative motion between the gun sight (either Gun Reticule or Funnel) and the target. This is also called a "tracking" shot in contrast to a "snapshot" where the gun sight merely passes through the target. It is especially important to track when using the funnel.

You can have computer sights or anything you like, but I think you have to go to the enemy on the shortest distance and knock him down from point-blank range. You'll get him from in close. At long distance, it's questionable.

*Colonel Erich "Bubi" Hartmann, GAP
World's Leading Ace, Luftwaffe
352 Victories, WW-II*

HUD A/A GUN SYMBOLOGY

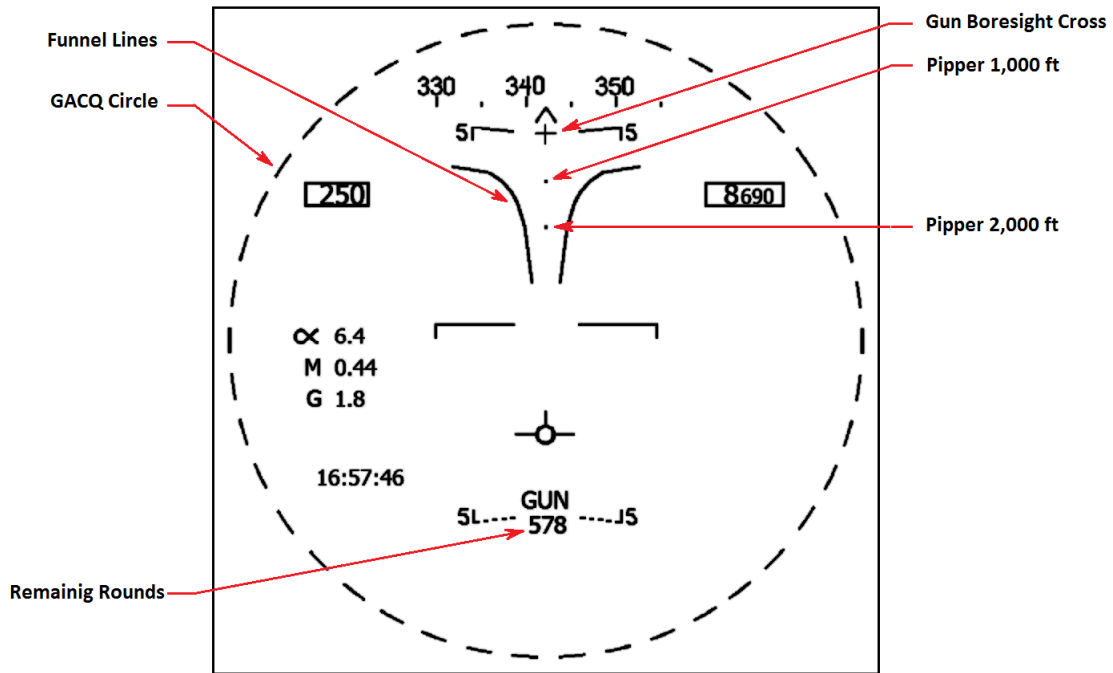


Figure 5. HUD Funnel Mode

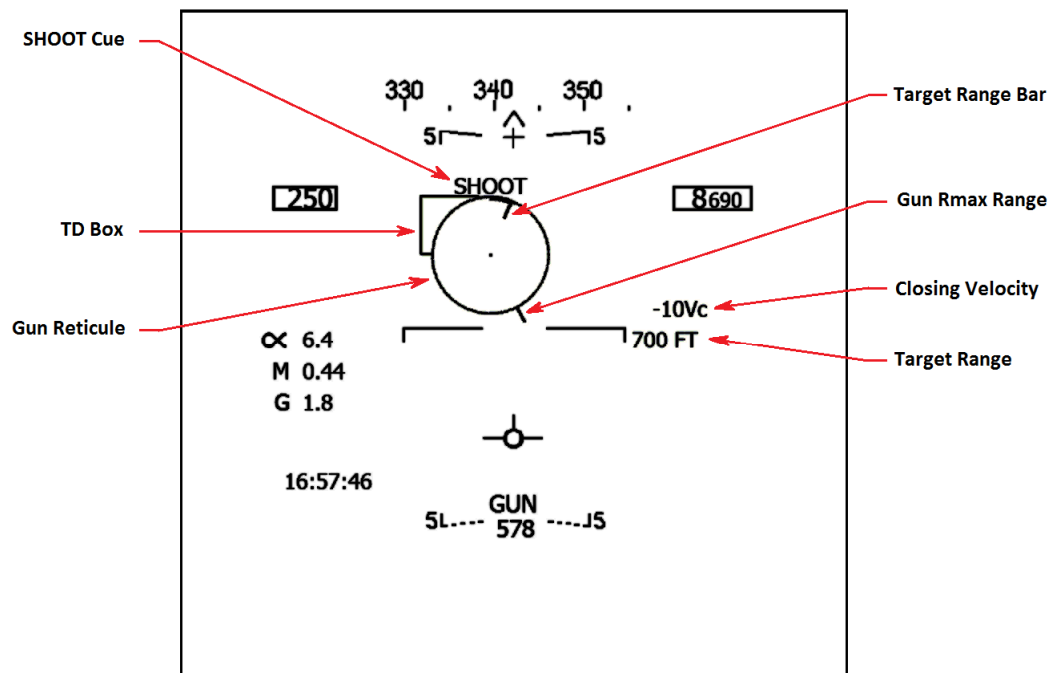


Figure 6. HUD Gun Director Mode

HUD A/A GUN SYMBOLOGY

- GACQ Circle: Indicates that the radar is in GACQ sub-mode. The coverage is 20° in diameter, although the HUD circle is smaller.
- Pipper 1,000 ft and 2,000 ft: The two pippers (dots) represent the points where bullets pass through at 1,000-ft and 2,000-ft in front of the aircraft if you were to fire the gun at that instant.
- SHOOT Cue: When the TD Box is covered by the Gun Reticule, the SHOOT cue will appear indicating a good firing solution.
- Target Range Bar: Rotates clockwise and shows target range from 0 to 12,000 feet. It can be read like a clock – range bar at 3 o'clock means target at 3,000 feet.
- Gun Rmax Range: The gun Rmax bar displays on the outside of the reticule at the computed maximum range of the gun (around 5,000 feet).
- Target closing velocity (Vc) in knots: The closing rate of your aircraft and the target along the target line of sight. If the number is positive, the target is getting closer to you, and if it is negative, the target is moving away from you.
- Target Range: In nmiles above 1.0 nmile and in feet below that.

GOOD SHOT INDICATION

The Combat Hornet is equipped with something the real Hornet is not – an algorithm that calculates if a bullet hit the target. It provides this information in a very simple way – the Gun Reticule (or the TD Box in Funnel mode) becomes red. This feedback is necessary because in Flight Simulator no damage can be caused to another aircraft especially if it is piloted by someone in multiplayer who does not want to be shot down. Also for gunnery practice it is not necessary. The algorithm is very precise in that it can determine the exact spot where the bullet hit the target – a wing, an elevator or the fuselage. Therefore if you are firing at a small aircraft, you will need much more precision than if you were firing at a KC-135.

MASTER ARM PANEL



Figure 7. Master Arm Panel

- **A/A Master Mode:** Puts all systems in Air-to-Air Master mode. In the Combat Hornet the gun is automatically selected and the radar goes in GACQ sub-mode (in the real F/A-18 you can also select A/A missiles). Whenever a target is locked, the radar goes to STT sub-mode. When the button is not illuminated, the Hornet is in NAV Master Mode.
- **Master Arm switch:** Enables or disables the release of weapons. Release of weapons is always disabled with weight on wheels. When fire is disabled the weapon is crossed out on the HUD.
- **Gun Fire Rate:** Toggles between HIGH (6,000 rpm) and LOW (4,000 rpm) fire rate.
- **Ammo:** Toggles between Unlimited Ammunition (only in the Combat Hornet) and Limited Ammunition (F/A-18 Hornet carries 578 rounds).
- **Funnel Option:** The FNNL option forces the Funnel mode even if you have target lock. If you don't want to use the Gun Reticule when the target is locked, select this option.

LEGAL INFORMATION

The "F/A-18A Hornet Combat Version" is Freeware. It may be freely distributed, as long as no money is charged for it, and none of the included files is removed or modified! Personal usage is free. Using this software for any commercial purpose or inclusion of any individual file from this package in other projects is not allowed without written permission of the author!

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