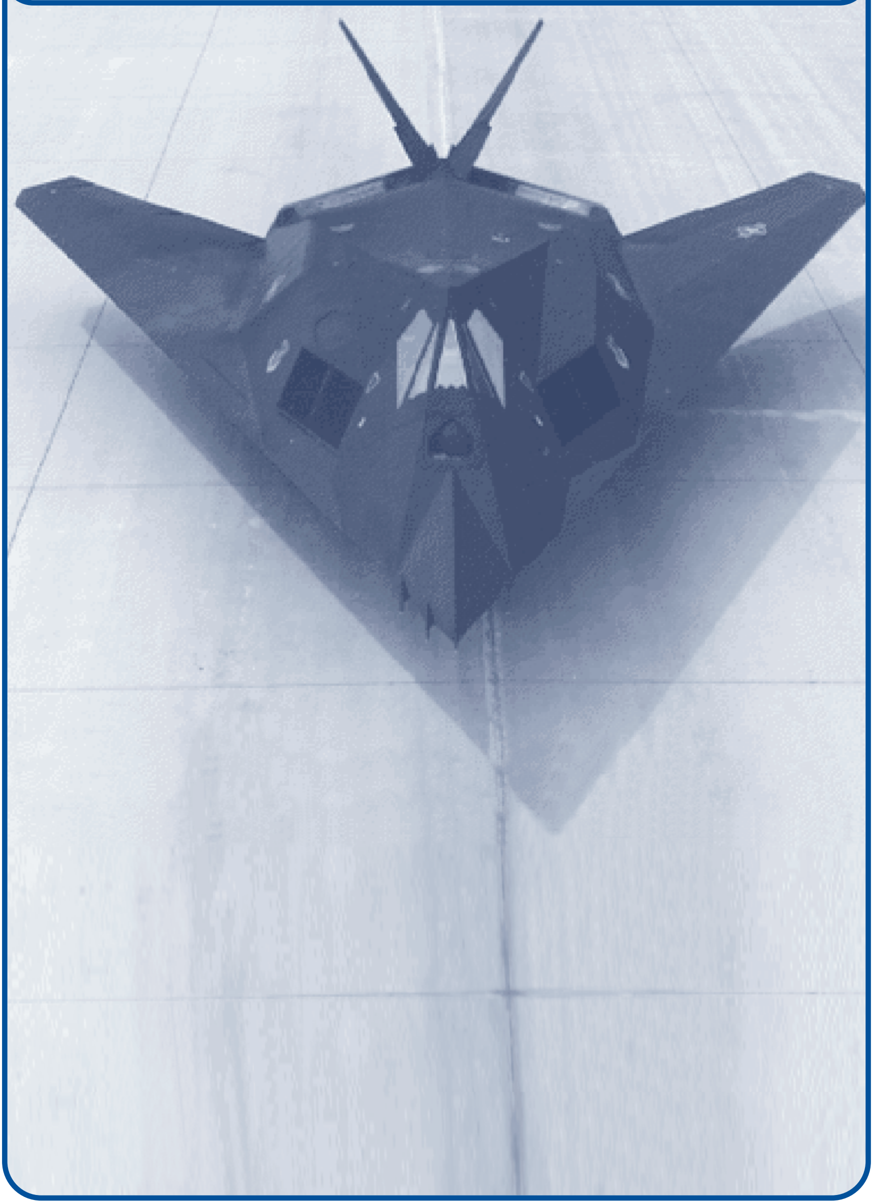
5 – COMBAT



5. COMBAT

COMBAT

Successful air combat boils down to finding the enemy and taking him out while avoiding getting shot down yourself. This combat training guide is divided into seven parts:

Finding the Enemy, p. 107. How to use radar, FLIR and passive radar systems for detection, how these systems are affected by weather conditions, and how to identify bandits, target them and track them.

Weapons Information, p. 115. General notes on types of weapons and how different guidance systems work.

Using Weapons, p. 121. Step-by-step instructions for arming guided weapons (designating targets for each type), general notes on gaining the best firing position, and step-by-step instructions on firing.

Weapons Information Chart, p. 128. Table of weapons, the guidance systems, effective ranges, and preferred targets.

Defenses and Countermeasures, p. 130. How to avoid being detected and how to avoid the missiles and gunfire once you are.

Combat Tactics, p. 134. General theory of air combat and the principles behind air combat maneuvering.

Air Combat Maneuvers, p. 145. Descriptions and diagrams of specific maneuvers.

Wingman Communication, p. 159. Explanation of commands you need to get your wingman into the fight.

Effects of Damage, p. 161. How to check for damage and what to do in different situations.

FINDING THE ENEMY

Detecting the enemy before you're detected gives you the opportunity to gain advantages in altitude, speed and position. In the early days of airwarfare, good eyesight was the only reliable detection system. World War II increased the range of detection and identification with radio communication, formation flying and radar. Advances in radar and infrared detection technology continue to expand ranges of detection and identification, and pilots must know how to use them well in order to maintain the advantage good eyesight once afforded.

Detection Systems

Your aircraft has several sensors that aid you in detecting enemies — active radar, IR (infrared) imagery, the RWR (radar warning receiver) and, of course, your eyes. Which one you use depends on the combat situation. Generally, FLIR and eyesight are useful for detecting ground targets, while radar and eyesight are best for finding air targets.

Eyesight

- Use eyesight to detect targets within visual range.

Regardless of how much gadgetry is in the cockpit, your eyes are among your most valuable assets. You must keep a constant watch both in front of you and around your aircraft. If nothing else, use your "check six" key ([F2]) during combat — turning your head around every so often reduces the chances someone has of sneaking up on you.

Here are some keys to help keep track of your enemies:

[Bksp]	Remove cockpit (except for Head-Up Display)
[F1]	Look ahead. This is your normal view — when in doubt, press [F1]
[F2]	Look over your tail at what's behind you. This is your "check six" key
[F3]	Look above the standard [F1] view
[F4]	This view tracks your target within the bounds of normal head rotation. (You must have a target selected)
[F5]	External view of your aircraft, facing the closest inbound missile
[F6]	External view of your aircraft, facing your wingman
[F7]	Eternal view of your aircraft, facing your current target
[F8]	External view of your current target, facing your aircraft

Right [Shift] + joystick or [←], [→], [↑], and [↓] pans the view in any direction.

Active Radar

Use air or ground radar:

- To detect targets at longest range
- When you're using radar-guided weapons
- When it doesn't matter that enemy RWR can detect you

A radar emits pulses or waves of electromagnetic energy into the air. When these waves strike an object, some of them are reflected back to the transmitting device. An onboard computer analyzes the strength of the returning waves, how long they took to return, and their frequency shift. With this information, it can determine the object's range, altitude, bearing and speed.

Use ground radar to find objects traveling at less than 90 knots (i.e., most ground vehicles). Use air radar to find objects traveling at speeds over 90 knots. The maximum search range varies among different aircraft. Radar is also used to guide some missiles(identified by "Active Radar" in the *Load Ordnance* screen).

The major drawback to using your active radar system is that enemies can easily detect your radar emissions with a Radar Warning Receiver (see p. 110).

R	Turn on air radar (deactivating all other sensors)
Ctrl R	Turn on ground radar (deactivating all other sensors)
Shift 9	Toggle Radar Window. For radar symbology, see Radar Window, p. 96.

Note: *The F-117 has no active radar — it relies solely on an internal FLIR sensor.*

Infrared (IR) Systems

Use FLIR to target objects beyond visual range:

- When you do not want to be detected by enemy RWR
- At night

Some aircraft carry infrared (IR) sensor systems, housed internally or in a pod mounted on a hardpoint. An infrared sensor detects anything radiating heat. By translating heat emissions into visual pictures, IR devices allow you to identify targets at night. They can be used freely in combat because computer enemies never know when they're being detected by IR-sensors. (In player aircraft, however, the RWR detection system can warn you of incoming IR missiles.) However, IR sensors are limited by their search range, which is shorter than active radar ranges. Clouds and fog can further reduce their effectiveness.

I	Turn on IR sensor, turn off IR or HARM sensors
Shift 9	Display IR information in the Radar Window, if IR/LASER ADVANCED TARGETING is not active on the PREF menu. For symbology see Radar Window, p. 96.

Passive Radar Systems

Use passive radar systems:

- To detect objects that are currently emitting radar signals (if the target switches its radar off, the passive radar sensor can no longer pick it up)
- To minimize the chance that you will be detected by enemy RWR

Radar Warning Receiver

The Radar Warning Receiver can detect radar sources up to 50nm away. All radar users — friendly or enemy, in the air or on the ground — appear on your RWR.

Although normally used as a defensive system (see **Defenses and Countermeasures**, p. 130), the RWR can serve as a limited detection device. Any time you have your radar active, your radar emissions can be picked up by an enemy RWR. If you're trying to preserve the element of surprise during an attack, turn off your radar and use your RWR to keep track of radar-emitting threats/targets. Activate your radar in short bursts only when firing a radar-guided weapon or to relocate a target if you lose tally. (See **Radar Warning Receiver (RWR) Window**, p. 94, for details on RWR symbology.)

Shift 5 Display RWR Window

For symbology, see Radar Warning Receiver (RWR) Window, p. 94.

HARM Missiles

HARM air-to-ground missiles have a passive radar seeker built into the nose. Information from this seeker can be displayed in the Radar Window when this missile is your current weapon.

M Turn on HARM and turn off IR or radar sensor

Shift 9 Display HARM info in radar Window

For symbology, see Radar Window, p. 96.

Weather and Detection/Guidance Systems

The table below shows how the range of each system is modified under different weather and light conditions. The numbers are percentages of the system's maximum effective range in clear daylight. For example, night reduces visual range to 25% of normal but extends IR sensor performance to 125% of normal.

CONDITION	VISUAL	LASER*	INFRARED	ACTIVE RADAR
Day	100%	100%	100%	100%
Twilight	75%	100%	100%	100%
Night	25%	100%	125%	100%
Haze	75%	100%	100%	100%
Clouds	10%	50%	10%	75%
Fog	25%	50%	10%	100%

*Laser is not a detection system, but refers to the Pave laser guidance system.
See **Laser-Guided Weapons**, p. 120.

Targeting

The targeting commands below will only target objects that are within visual range (i.e., visible on the screen) or within the range and scope of a sensor device. (See **Finding the Enemy**, p. 107.)

Air targets can be detected and targeted visually and by air radar (R) and IR sensors (I). Ground objects can be detected and targeted visually, or by using ground radar (Ctrl R) or IR sensors. Ground objects that are using radar can be detected and targeted with the seeker heads of HARM missiles.

Enter	Target something within visual range. This command cycles through the objects visible on your screen, from left to right.
	Use the mouse to left-click on a visible aircraft or a contact in the Radar Window.
'	Target the visible object nearest to the center of the screen (in forward view).
Shift T, T	Cycle through targets when the Radar Window is active. These commands cycle though all the targets detected by the sensor system you're currently using (radar, FLIR, HARM).

Note: *If you are using air radar, you will only be able to target objects when the radar is in Track While Scan (TWS) mode. (TWS appears in the upper left corner of the Radar Window.) If you are having difficulty targeting an object, make sure you are in TWS mode; if you are not, decrease your radar range (< and > increase and decrease radar range) until TWS appears in the upper left. See* ***RWS/TWS Indicator****, p. 97.*

IR/Laser Advanced Targeting

When you have IR/LASER ADVANCED TARGETING active on the **PREF** menu, targeting becomes more realistic. Targeting in foggy or dark conditions is often easier, however. With this option selected:

- When you press I or activate a laser weapon, brackets appear on the HUD around all IR/laser-detectable contacts. Only radar or HARM information will appear in the Radar Window.
- You can have **two** current targets — the current radar or HARM target has a square box around it on the HUD, and the current IR or laser target has a rectangular box around it.
- Left-clicking on an object selects it as a radar/HARM target, right-clicking specifies an IR/laser target.
- / cycles through bracketed IR/laser targets; T and Shift T cycle through radar/HARM targets.
- IR/Laser targets now appear in the IR/Laser Target Window. This replaces the Forward View Window, and Shift 2 toggles it on and off (see p. 88). Radar, visual and HARM targets appear in the Radar/Visual Target Window (Shift 4 toggles, see p. 101).

Remote Targeting

Modern sentry aircraft — such as the E-3 AWAC, Il-76, E-2C Hawkeye, recon drones and the E-8C J-STAR — are equipped with special radar systems that transmit targeting information to other friendlies. On missions in which sentry aircraft are deployed, you can target objects detected by ***their*** radar systems, which generally include any object within a 150-km radius of the sentry aircraft.

To activate remote targeting:

Shift A — Toggle remote air targeting on. This automatically downloads air targets to your ground radar.

R — Activate your air-to-ground radar and open the Radar Window. Peach-colored contacts are targets picked up by the sentry aircraft.

Shift G — Toggle remote ground targeting on. This automatically downloads all ground targets to your ground radar.

Ctrl R — Activate your ground radar and open the Radar Window. Peach colored dots are ground vehicles, peach-colored X's are SAM and AAA sites.

You can target remote contacts using the targeting keys listed on the facing page.

Restrictions on remote targeting:

- Your air radar displays only remote air targets, and your ground radar displays only remote ground targets.
- The E-8C J-STAR and the Recon Drones 1 and 2 detect only *ground targets*. All other sentry aircraft only detect air targets.
- In Quick Missions and Pro Mission Creator-designed missions, make sure you add a friendly sentry aircraft if you want to use remote targeting. You will not be able to link to a sentry aircraft if there are none nearby.
- Your Radar Window (in air or ground mode) will only display remote targets within its current range and scope. To see all targets, call up the in-flight navigation map (Shift M).

Easy Targeting

The EASY TARGETING option on the **CHEAT** menu of the *In-Flight* menu bar affects two elements of targeting:

- **TD box.** When *active*, the TD box moves all the way to the edge of the screen if your target does. When *inactive*, the TD box moves only to the edge of the HUD, even if your target moves beyond this.
- **Target Window** When *inactive*, you cannot open the Target Window until the target is within visual range.

Distinguishing Between Friends and Foes

Missiles extend combat to *beyond visual range* (BVR). In a BVR environment, identifying targets as friendly or enemy is understandably difficult, especially if allied countries fly the same aircraft as your enemies. To overcome this problem, air forces typically outfit their aircraft with IFF (Identification Friend or Foe) transponders. These devices allow the pilot to transmit an electronic code to a targeted aircraft. If the targeted aircraft's IFF box "answers" the code, then the pilot knows that he's targeted a friendly aircraft.

Pressing U in the game sends an IFF transmission to a targeted aircraft. If the target aircraft responds with the correct code, you receive a "Friendly" reply. If you receive an "Unknown" reply, the target isn't necessarily hostile. The target aircraft's transponder could be damaged, or it could be a civilian passenger jet not equipped with a military transponder.

U	Send an IFF signal to the targeted craft.
"FRIENDLY" REPLY	Indicates that the recipient is a friendly aircraft.
"UNKNOWN" REPLY	Indicates that the recipient may be a damaged friendly aircraft, a non-combatant or an enemy aircraft.

Note: The transmitter has a range of 100nm — if a bogey is beyond that range, you'll receive an "Unknown" message even if you've got a friendly targeted.

Tracking Your Target

Fighters Anthology has several options that affect target identification and acquisition. Some of these options are less realistic, but they make targeting easier:

IR/LASER ADVANCED TARGETING — When this PREF option menu is active, targeting is more realistic.

SHOW TARGET INFO — This option (Ctrl T) from the CHEATS menu of the IN-FLIGHT menu bar displays the identity of the current air target and all ground targets. In multi-player games the identity and callsign of all player aircraft are also displayed.

Offscreen target marker — This "XX" appears on the edge of your viewscreen when your current target moves offscreen. It indicates the direction you need to fly to bring the target back into view.

Target Window — The Target Window (Shift 4) displays a picture of your target, and gives its range and current action. You must have a target to open this window.

WEAPONS INFORMATION

Knowing which weapons to use in a given situation, what the parameters for a good shot are, and how different guidance systems work are important skills for a modern combat pilot. Several sections in this chapter help you sort through the different types of weapons and learn to use each more effectively.

Air-to-Air Weapons (below) and **Air-to-Ground Weapons** (p. 116) provide general information on the types of weapons in the game.

Weapon Guidance Systems (p. 117) explains how the different types of guidance systems work.

Using Weapons (p. 121) gives step-by-step instructions on arming different types of missiles, gaining firing position and firing all weapons.

Weapons Information Chart (p. 128) compares the guidance systems, effective ranges and best targets for all weapons in the game.

Air-to-Air Weapons

Gun Designations: GAU-, GsH

Missile Designations: AA-, AIM-, PL-, MICA, R-

Sensor Systems: IR, FLIR, SARH, Active Radar

Guns used to be the only weapon available during an air battle, and dogfighting used to be a test of a pilot's visual acuity. In modern air combat, however, the majority of battles are fought without opponents ever coming within visual range of one another.

While guns remain useful at extremely close ranges, air-to-air missiles extend air combat by miles. Long-range, air-intercept missiles can effectively target threats as far as 80 miles; short-range air-to-air missiles can be fired from near point-blank range or from up to 25 nautical miles away.

With the exception of mounted guns, air-to-air weapons are guided by either the aircraft's sensors or an independent "seeker" head. But although these advancements make them effective weapons, striking targets with air-to-air missiles still demands good piloting skills and selective firing.

Air-to-Ground Weapons

Missile Designations: AGM-, HARM, AS-(Anti-Ship), AT-(Anti-Tank)

Bomb Designations: GBU-, MK-

Rocket Designations: LAU-

Sensor Systems: IR, FLIR, HARM, Laser, Active Radar

Air-to-ground weapons include missiles, rockets, bombs and mounted guns. They come in two basic varieties — unguided and guided. Unguided weapons (such as "iron" bombs) fall along a predictable trajectory. Guided weapons, such as Maverick missiles and laser-guided bombs, use the aircraft's seeker or a built-in seeker to steer toward a target after launch.

Some air-to-ground missiles, such as the IR-homing AGM-65 Maverick or the active radar-guided AGM-84E SLAM, are long-range, "standoff" weapons. Once fired, these weapons do not require guidance from the launching aircraft. As such, they are "fire-and-forget" weapons — you can launch them and immediately turn toward a new target. During flight, they have the ability to modify their flight path.

Air-to-ground weapons employ the same guidance systems as air-to-air weapons, although some have other sensor types built into the seeker head. The sensor on a HARM weapon homes in on targets that are emitting radar, while the sensor on a laser weapon homes in on targets pinpointed by a laser beam.

Weapon Guidance Systems

The simplest weapons are unguided, such as Folding-Fin Aerial Rockets (FFARs) and iron bombs. Newer weapons — whether they're air-to-air missiles or air-to-ground missiles and smart bombs — are guided and use radar, laser or infrared tracking to acquire a target.

Each guidance system has its own method of acquiring and locking a target. Some weapons are "fire-and-forget" and have guidance systems built into their seeker head. Others require that you keep the target in view until weapon impact.

Although effective, guided weapons are not the "one-shot, one-kill" devices they are often perceived to be. Used improperly, they can perform dismally.

Summary

Press the key listed to activate the guidance system for each weapon type.

SARH	R, Ctrl R	Semi-Active Radar Homing missiles use aircraft's air or air-to-ground radar to acquire and track target until impact.
ACTIVE RADAR	R, Ctrl R	Active radar missiles use aircraft's air or air-to-ground radar to acquire a target, but a seeker head on the missile guides it after launch.
IR	I	IR missiles require visual targeting (air or ground) or FLIR (ground targets) to acquire a target. An IR seeker on the missile tracks targets after launch. Some planes have an internal FLIR system, but others require you to load a FLIR pod.
LASER-GUIDED	automatic	The Pave laser designator mounted on the aircraft acquires and tracks targets with a reflected laser beam until the missile impacts. The laser must continue to point at the target, or the bomb will go off course.
HARM	M	Radar-homing device in missile's nose acquires and tracks targets that are emitting radar.

Semi-Active Radar-Homing Weapons (SARHs)

Semi-Active Radar Homing weapons (SARHs) use the aircraft's onboard radar system both to acquire and track a target. This air-to-air missile doesn't have a built-in radar. You must keep the target in view (thus "painting" it with radar) so that the missile can maneuver toward it. If the targeting aircraft breaks its lock — even momentarily — the missile is more likely to miss.

SARH missiles can be launched at medium range (usually 15 - 20nm) but perform poorly at short range. They also don't work well when fired from above the target, as radar reflected from the ground confuses the missile.

When attacking with a SARH missile, listen for the high-pitched tone emitted by your onboard weapons computer — when tone is good and strong, the missile is locked onto its target.

Important Note

- Use SARHs against lesser threats and save your "fire-and-forget" missiles for tough combat.

Active Radar Weapons

Active radar weapons use the aircraft's normal radar system to acquire a target. Upon launch, the missile's guidance system receives coordinates from the aircraft's weapon system. The weapon flies to the designated point and activates its own seeker head, which it then uses to home in on the target. Since the weapon guides itself, the launching aircraft can fire the missile and then break away from the engagement. For this reason, active radar missiles are known as "fire-and-forget" weapons.

Important Notes

- Radar works under all weather conditions, although clouds can reflect signals, reducing radar effectiveness to about 75%.

Infrared-Homing Weapons

Infrared ("heat-seeking") missiles use internal sensors to detect and track heat-emitting objects, such as an airplane's engine exhaust or a ground vehicle sitting in the sun. Compared to radar-guided weapons, infrared-homing missiles have short range — point-blank to 8nm for air-to-air heat-seekers, and 3nm to 10nm for air-to-ground IR weapons. However, IR-homing weapons have one clear advantage; once launched, these "fire-and-forget" weapons guide themselves to the target, leaving the pilot free to maneuver after launch.

To launch an IR-homing missile, you must first designate a target (see **Targeting**, p. 112). Once you have a target, point the nose of your airplane (and thus the missile warhead) at the target. A floating diamond on your HUD represents the missile's seeker head. When the diamond locks on top of the target box, the missile has locked on to target and you can fire.

Target lock is also communicated through sound. For air-to-air heat-seekers (such as the AIM-9 series), missile lock is indicated through an audible "growling" sound. The louder the growl, the better the lock. For air-to-ground heat-seekers like the AGM-65 Maverick, a ringing sound indicates target lock.

Important Notes

- Clouds and fog reduce effective range of IR weapons to 10% of normal.
- Older IR-homing air-to-air missiles (such as the AIM-9B) are *rear-aspect*, meaning that they must be fired from *behind* the target, where the hot engine exhaust makes homing easier for the missile. Modern IR missiles are *all-aspect*, meaning they can track a target from any direction. (However, they are still more accurate from behind — the AIM-9M, for example, is 30% less accurate in shots not fired directly at an aircraft's tail.)
- All IR-homing air-to-air missiles have a tendency to be confused by the sun and may stray off toward it. This is especially true of the AIM-9B, but less true of the AIM-9M or AIM-9X.
- Loading a FLIR pod on the *Load Ordnance* screen or flying an aircraft with internal FLIR allows you to target contacts beyond visual range. (Look among the Air-to-Surface Weapons.)

Laser-Guided Weapons

Laser-guided weapons follow a laser beam that is aimed at the target. The beam travels in a line to the target, and the laser seeker head follows its reflections with pinpoint accuracy. Laser weapons are limited to ground use.

A laser-guided bomb is fitted with a seeker and movable canards, small wing mechanisms that help guide the weapon to the target. A PAVE laser-designator pod mounted on an aircraft's hardpoint designates a point on the target. A laser-guided bomb is dropped, and the bomb's laser seeker homes in on the laser reflection off this target. The seeker provides directional cues to the movable canards, which modify the bomb's glide path to some extent, resulting in more accurate hits than conventional bombs.

Important Notes

- Unless you are flying a B-2 or an F-117 (which have internal laser designators, you must load the PAVE laser designator from the *Load Ordnance* screen. (Look under Air-to-Surface weapons.)
- *You must maintain a lock on the target until the bomb has hit* — if you suddenly target another object, the bomb will fall blindly to the ground.

HARM (Radar-Seeking) Missile

The AGM-88 HARM missile is a High-Speed, Anti-Radiation Missile that locks onto targets that are emitting radar transmissions. The HARM seeker is built into the missile's nose and requires no onboard guidance. Information from the seeker appears in the Radar Window. HARMs are highly effective against radar vehicles, radar-equipped SAMs and ground-based radar installations. A threat's only defense against such a missile is to turn off the radar altogether.

The HARM is a "fire-and-forget" missile. However, if a HARM is launched and the target turns off its radar, the missile will continue to the target's last known location and detonate.

USING WEAPONS

To use weapons effectively, you need to know how to designate targets (for guided weapons), how to gain the best firing position, when to fire, and whether you need to maintain target lock until the missile impacts. **Arming a Guided Weapon** (pp. 121-123) explains how to designate targets for different types of guided weapons. **Gaining Firing Position**, (pp. 124-127) describes strategies for using guns, missiles and bombs most accurately and gives step-by-step instructions for firing guns and releasing bombs and missiles, including when to fire and whether or not you need to maintain a lock.

Arming a Guided Weapon

Guided weapons require a sensor system to designate a target. They also require a guidance system to track the missile and steer it to target. For some types of weapon, this guidance system is located on the aircraft; for others, the guidance system is housed in the missile itself.

When loading missiles from the *Load Ordnance* screen, note that the guidance system required by each missile is listed beneath it. (You can pause the game and check the **Weapons Information Chart**, p. 128, for quick, in-flight reference.) The following sections list the designation and guidance systems required for each type of weapon (some of these must externally loaded — check the notes) and give step-by-step instructions for arming them.

IMPORTANT NOTE: *You can visually find and designate targets at short range no matter what system you are using. Press* Enter *to designate visual targets.*

SARH

SYSTEMS NEEDED

Target Designation: Aircraft's radar
Weapon Guidance: Aircraft's radar

HOW TO ACTIVATE

1. **Find and designate a target:**

R or Ctrl R	Activate radar
Shift 9	Display Radar Window
<, >	Increase and decrease radar range. Fly until target is within TWS range.
T, Shift T	Cycle through targets.

2. **Choose a SARH weapon** ([or]).
3. **Keep a lock on your target until the missile impacts.**

Active Radar

ONBOARD SYSTEM NEEDED

Target Designation: Aircraft's radar
Weapon Guidance: Aircraft's radar until near target, then missile's radar

HOW TO ACTIVATE

1. **Find and designate a target:**

R, Ctrl R	Activate radar
Shift 9	Display Radar Window
<, >	Increase and decrease radar range
	Fly until target is within TWS range
T, Shift T	Cycle through targets

2. **Select a radar-guided weapon** ([or]).

HARM

ONBOARD SYSTEM NEEDED

Target Designation: HARM
Weapon Guidance: Radar-homing warhead on missile

HOW TO ACTIVATE

1. **Find and designate a target:**

M	Activate HARM seeker
Shift 9	Display Radar Window
<, >	Increase and decrease seeker range
	Fly until target is within missile range
T, Shift T	Cycle through targets

2. **Select a HARM missile** ([or]).

Infrared (Air-to-Air)

ONBOARD SYSTEM NEEDED

Target Designation: FLIR, visual
Weapon Guidance: IR-seeker in missile

HOW TO ACTIVATE

1. **Find and designate a target:**

(IR/LASER ADVANCED TARGETING inactive)

I, R	Activate FLIR or air radar
Shift 9	Display Radar Window.
<, >	Increase and decrease sensor range
T, Shift T	Cycle through targets

(IR/LASER ADVANCED TARGETING active)

I	Bracket all IR targets onscreen.
\	Cycle through targets

2. **Select an IR-guided weapon** ([or]).

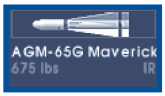
Note: *Not all aircraft have internal FLIR — either load a FLIR pod before you take off (in Air-to-Surface weapons group on* Load Ordnance *screen) or designate targets visually.*

Infrared (Air-to-Ground)

ONBOARD SYSTEM NEEDED

Target Designation: FLIR, visual
Weapon Guidance: IR-seeker in missile

HOW TO ACTIVATE



1. **Find and designate a target:**
   (IR/LASER ADVANCED TARGETING inactive)
   - I, Ctrl R — Activate FLIR or air-to-ground radar
   - Shift 9 — Display Radar Window.
   - <, > — Increase and decrease sensor range
   - T, Shift T — Cycle through targets

   (IR/LASER ADVANCED TARGETING active)
   - I — Bracket all onscreen IR targets
   - \ — Cycle through targets
2. **Select an IR-guided weapon** ([or]).

Note: *Not all aircraft have internal FLIR — either load a FLIR pod before you take off (in Air-to-Surface weapons group on Load Ordnance screen), or find and designate your targets visually by pressing* Enter *instead of* T.

Laser

ONBOARD SYSTEM NEEDED

Target Designation: FLIR, visual
Weapon Guidance: Pave laser

HOW TO ACTIVATE

1. **Find and designate a target:**
   (IR/LASER ADVANCED TARGETING inactive)
   - I, Ctrl R — Activate FLIR
   - Shift 9 — Display Radar Window.
   - <, > — Increase and decrease sensor range
   - T, Shift T — Cycle through targets

   (IR/LASER ADVANCED TARGETING)
   - I — Bracket all onscreen IR targets
   - \ — Cycle through targets
2. **Select a laser-guided weapon ([or]).**
   (The laser system is automatically activated.)
3. **Maintain target lock until the weapon impacts.**

Note: *You must load a Pave laser designator pod from the Air-to-Surface weapons group on the* Load Ordnance *screen before taking off.*

Gaining Firing Position

Before using guns (unguided) or missiles (guided), you need to position your aircraft so that you can take the best shot possible. In an ideal situation, you should be right behind your target — he can't fire on you when you're tailing him, the exhaust pipe is a great target for an IR missile, and a straight shot the target can't see increases any weapon's chance to hit.

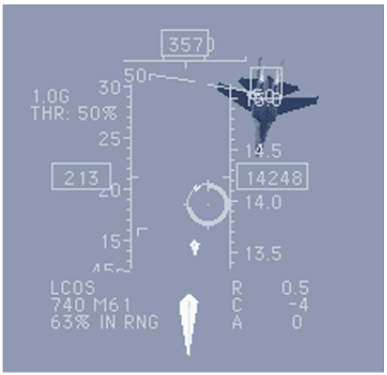
Guns

Guns remain an essential element of air combat, as was proven in dogfights over Vietnam. Damage and range are limited — guns are most effective between 0 and 2nm, and a single burst generally won't kill a target — but, unlike many missiles, a gun's effectiveness increases at close range and sophisticated aircraft systems are not immune to gunfire. In addition, guns require no guidance systems, and aircraft can carry relatively large stores of gun ammunition.

Guns are easy to use against stationary ground targets. Moving air targets, however, require you to "lead" your target — calculate where it's going to be when the bullets reach it.

Leading a Target

You must take into account your enemy's speed and current position and guess how much "lead" is needed to hit him. When your radar is on, lead requirements are automatically calculated. A pipper appears on your HUD, indicating where to aim your gun. Center this pipper over your target, and watch the thick line around the perimeter of the pipper. The longer the arc, the better your chance of hitting the target, based on your speed, the target's speed and aspect angle. The absence of a thick arc means you have zero chance of hitting the target.



[,]	Cycle through weapons
R	Activate radar
Spacebar	(or joystick trigger) Fire guns

If your radar is off, you'll have to figure out how far to lead the target yourself. (Keep in mind the bullets fall somewhat because of gravity.)

Bombs

Bombs are short-range weapons that rely on gravity for "propulsion." Conventional bombs lack guidance systems, but modern bombs have guidance systems that make small tail fin adjustments during flight to improve accuracy.

When you select an unguided bomb as your current weapon, the point at which the bomb will impact (called CCIP) is constantly recalculated and projected onto your HUD. You often can't see this point in level flight — dive to bring it into view and watch the small arc inside the larger ring. As this arc shrinks, your range decreases and your accuracy increases. If you are in a B-2, the CCIP is replaced by a bomb camera though which you view your target while maintaining level flight. (See **Unguided Bomb Elements**, p. 85.)

The HUD symbols for guided-bomb seeker heads are the same as for guided missiles (See **Missile and Guided Bomb Elements**, p 84.) To gain a good firing position for a guided bomb, watch your range and hit percentage on your HUD.

Dropping a Guided Bomb

1. Attain an appropriate altitude (varies for levels of ground defense: 3000ft for lightly guarded areas, 5000ft or higher for defended areas).
2. Fly within several miles of the intended target (approximately 1nm for each 1000ft of altitude).
3. Make sure a guided bomb is your selected weapon ([and]).
4. Press O to open the weapons bay (F-22, X-32, F-117A, B-52, B-2, Tu-26, Tu-95, and Tu-160 only).
5. Drop the bomb when you're in range and have a good hit probability. (Press Spacebar or missile-fire button.)
6. If using laser-guided bombs, keep the target in view until impact.

Dropping an Unguided Bomb

1. Attain an appropriate altitude (varies for levels of ground defense: 3000ft for lightly guarded areas, 5000ft or higher for defended areas).
2. Fly within several miles of the target (about 1nm per 1000ft of altitude).
3. Bring the target in view in front of you and make sure you have an unguided bomb selected ([or]).

4a. (All aircraft except the B-2) Maneuver so that the CCIP (impact point) pipper overlays the box around the current target in your HUD.

4b. (B-2) Yaw left/right to center target inside cross hairs on camera window.

5. Press O to open the weapons bay (F-22, X-32, F-117A, B-52, B-2, Tu-26, Tu-95, and Tu-160 only).
6. Drop the bomb (press Spacebar or missile-fire button).

Missiles

Missiles are a fighter's best offense — they're maneuverable, "smart" and deadly. Most use a guidance system to track targets after launch and feed course corrections to the canards (small "wings") on the aft end of the missile. However, the fewer course corrections the missile has to make, the better its chance of hitting the target. Although you can't control your opponent's maneuvers, you can get in the best position to launch the missile by considering the following parameters.

Range

Long-range missiles can be fired from as far as 150nm away, while medium- or short-range ones have maximum launch distances around 25nm. As a general rule, hit probability increases as range to target decreases. However, most missiles also have minimum launch ranges, usually around 0.8-2nm — they need room to get up to speed and maneuver.

Since the probability of a direct hit on a maneuvering target is unlikely, missiles are designed to cause damage over a large radius, called a *blast radius*. Some release a giant, expanding ring of iron bars; others release hundreds of small metal fragments. Firing a missile within its minimum range, or launching a bomb at too low an altitude, can put you within this radius, so watch out.

Aspect Angle

Target *aspect angle* is the angle between your nose and the targeted aircraft. It is measured in degrees (see diagram), displayed next to the A in the lower right of your HUD.

Aspect angle affects missile performance in the following ways:

- Shots fired from directly in front (0°) or behind (180°) a target have a better chance of hitting the target.
- A missile's maximum effective range is greater when its target is moving towards it (180°). A missile's effective range decreases when the target is moving away from it.

For a more detailed explanation, see **Combat Geometry,** p. 135.

Launch Parameters

In general, you want to launch within the missile's optimal launch parameters. This can be gauged by watching the Hit Probability indicator on your HUD. The higher the probability, the greater chance you have of striking the target. Many factors are used to calculate this hit percentage — such as weather, distance and the size of radar or infrared signatures.

Missile Maneuverability

For long-range missiles, maximum maneuverability only occurs during the first 10 seconds of flight. The missile's engine engages after launch, rapidly accelerating it to top speed. However, once the engine runs out of fuel (5-10 seconds after launch), the missile glides the rest of the way to the target and loses speed as it glides. As speed decays, so does maneuverability.

G-Load Limit

The rail or hardpoint on which the missile is mounted has a maximum G-load limit. When the aircraft pulls a high-G turn, climb or dive suddenly, the rail and missile are stressed by the same G-force. If the G-force is too strong, the missile can't launch properly. If the G-force is above the launch maximum (different for all missiles), you'll lose all lock indicators in your HUD.

In addition, a launched missile must pull at least 7 times the G-load of its target in order to follow it. If the target is pulling 8G, the missile will need to pull as much as 56G to keep up. The more G's the missile has to pull, the more likely it is to miss. You can minimize the amount of G's a missile has to pull initially by firing when you have a good target *aspect angle*.

Firing a Missile

1. Make sure you have a missile selected. ([and] cycle through weapons.)
2. Press O to open your weapons bay (F-22, F-117A, B-2, B-52, X-32, Tu-26, Tu-95, and Tu-160 only).
3. Bring the targeted object into your front viewscreen.
4. Fire when you're in range and have a good aspect angle. (Press Spacebar or missile-fire button.)
5. If using SARHs, keep a radar lock on the target until impact.

WEAPONS INFORMATION CHART

Designation. Name of the weapon as it appears in the *Load Ordnance* screen.
Seeker Type. Sensor system used by the weapon.
Effective Range. Range (in nautical miles) at which the weapon has a chance of striking the target.
Preferred Targets. Targets most vulnerable to that weapon type.

GUNS

DESIGNATION	SEEKER TYPE	EFFECTIVE RANGE (NM)	PREFERRED TARGETS
GAU-8, GAU-12, GAU-13	Radar-calculated lead	0-2	Soft targets, aircraft
GSh-30	Radar-calculated lead	0-2	Soft targets, aircraft
Aden, DEFA, BK27	Radar-calculated lead	0-2	Soft targets, aircraft
M-61 Vulcan cannon	Radar-calculated lead	0-2	Soft targets, aircraft
SUU-16 Gun Pod	Radar-calculated lead	0-2	Soft targets, aircraft

AIR INTERCEPT MISSILES

DESIGNATION	SEEKER TYPE	EFFECTIVE RANGE (NM)	PREFERRED TARGETS
AIM-7 Sparrow	SARH	2-19.7	Aircraft
AIM-9M, 9B, 9X Sidewinder	IR	0.8-3.9	Aircraft
AIM-54C Phoenix	Active Radar	2-148	Aircraft
AIM-120 AMRAAM	Active Radar	2-24.6	Aircraft
PL-7	IR	0.8-5.5	Aircraft
PL-10	SARH	2-75	Aircraft
AEMP-1EM [1]	Active Radar	2-50.7	Aircraft

AIR-TO-AIR MISSILE

DESIGNATION	SEEKER TYPE	EFFECTIVE RANGE (NM)	PREFERRED TARGETS
AA-2 Atoll	IR	0.8-1.4	Aircraft
AA-6 Acrid	SARH	2-14.8	Aircraft
AA-8 Aphid	IR	0.8-1.4	Aircraft
AA-9 Amos	SARH	2-41	Aircraft
AA-10 Alamo	SARH	2-19.7	Aircraft
AA-11 Archer	IR	0.8-9.8	Aircraft
AA-12 Adder	Active Radar	2-24.6	Aircraft
MICA	Active Radar	2-50	Aircraft
R-440	IR	0.8-18.5	Aircraft
R-530	SARH	2-3	Aircraft
R-550	IR	0.8-3	Aircraft

ANTI-TANK MISSILES

DESIGNATION	SEEKER TYPE	RANGE (NM)	PREFERRED TARGETS
AT-2 Swatter	Optical	0-2.9	Tanks
AT-12 Swinger	Laser	0-4.2	Tanks

AIR-TO-GROUND MISSILES

DESIGNATION	SEEKER TYPE	RANGE (NM)	PREFERRED TARGETS
AGM-45B Shrike	HARM	0-11	Radar sites, SAMs
AGM-65G Maverick	IR	0.8-9.8	Tanks
AGM-88 HARM	HARM	0-12.3	Radar sites, SAMs
AGM-84A Harpoon	Active Radar	2-59	Ships
AGM-84E SLAM	Active Radar	2-49	Hangers, silos
AM-39 Exocet	Active Radar	2-92.6	Ships
AS-7 Kerry	SARH	2-4.9	SAMs, parked aircraft, lt. struct.
AS-14 Kedge	Laser	0-6.5	Ships, bridges, runways, Heavy/hardened structures
AS-15 Kent	Laser	0-6.5	Same as AS-14
AS-16 Kickback	Active Radar	2-6.5	Ships
AS-30	Active Radar, Laser	2-6.5	Structures, Ships

AIR-TO-GROUND BOMBS

DESIGNATIONS	SEEKER TYPE	RANGE	PREFERRED TARGETS
CBU-87, 87B	None	1nm/1000ft [3]	Light structures, personnel
FAB-250, 500, 1000 Unguided Bombs	None	1nm/1000ft [3]	Large targets
GBU-10	Laser	1nm/1000ft [3]	Large/vital targets
GBU-27, 28, 28B	Laser	1nm/1000ft [3]	Large/vital targets
GBU-29B, 30	Optical	1nm/1000ft [3]	Large/vital targets
MK-20 Rockeye II	None	1nm/1000ft [2]	Large targets
MK-82	None	1nm [2]	Large targets
MK-82 AIR	None	1nm/1000ft [3]	Large/vital targets
MK-84	None	1nm [2]	Large targets
RBK-250, 500	None	1nm/1000ft [3]	Structures, vehicles, personnel

AIR-TO-GROUND ROCKETS

DESIGNATION	SEEKER TYPE	RANGE (NM)	PREFERRED TARGETS
B-8M1	None	1nm [2]	Armor, structures, personnel
BL-13L	None	1nm [2]	Armor, structures, personnel
LAU-10, LAU-61	None	1nm [2]	Armor, structures, personnel

[1] Fictional weapon that knocks out HUD, radar, etc.

[2] Range is 1nm along a straight line-of-sight to target.

[3] Range is 1nm horizontally for every 1000ft altitude from which bomb is dropped.

DEFENSES AND COUNTERMEASURES

Attacking the enemy is only half the job — surviving the mission is the other half. Your aircraft carries various defensive systems called *countermeasures* that are designed to protect you and your aircraft. They may be electronic (jamming) or physical (chaff and flares).

Signatures

Before you can effectively evade missiles, you need to understand how they track your aircraft. Every aircraft has a set of "signatures" that give away your presence to radar and infrared sensors. This radar or infrared signature indicates how easily your aircraft can be detected.

Your aircraft's configuration can modify signature values. For example, using afterburners creates hot exhaust ports and increases your *IR signature* to 200%, making you twice as detectable as normal. Carrying external stores increases your *radar signature* by 33%, making you one-third more detectable than a "clean" aircraft. Likewise, lowering your landing gear increases radar signature by 25%.

Electronic countermeasures (ECM), such as the ALQ-167 and ALQ-72 ECM suites, reduce the chance that enemy radar will track you accurately, but drastically increase your chances of being detected because of the added radar emissions they employ (see below). However, once you've been detected, this should be your first defense against enemy radar systems.

Pointing your aircraft toward a sensor also greatly reduces the signature, because the radar cross-section of your aircraft (amount of surface area visible to radar) is smaller when the aircraft is detected from the front. Conversely, a full side or top-down view gives a large cross-section.

For more information on radar signatures and stealth technology, see **Stealth**, p. 229.

Shift 0	Activate RCS Window, displaying your Radar Cross Section (see p. 4.19)

Jamming

Jammers attempt to deceive enemy radar with large amounts of electromagnetic waves designed to mimic or scramble radar returns. You'll see JAM in your RWR Window when jamming is active.

Shift 5	Activate RWR Window (for an explanation of symbology, see p. 4.18)
J	Initiate jamming

Since enemy RWRs also detect jamming signals, never activate your jammers before you are detected. Once you're spotted, use your jammers freely.

How Jamming Works

Jammers have several different operating modes, including Noise, Pulse, Continuous-Wave, Transponder and Repeater. Part of the radar warning receiver's job is to direct the intensity, frequency and direction of the jamming transmission.

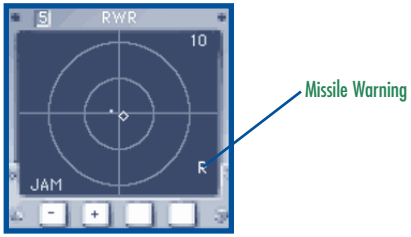
These jamming signals reflect false radar returns to the radar source. The radarscope at the point of origination sees both the real radar return, and also the "fake" ones generated by the jammer. The idea is to either make large targets look small, or make small targets look large. Even though the radar can determine the presence of an aircraft and its direction, the false reflections distort the aircraft's true location. Jamming announces your presence to the enemy, but it hides your exact position.

For more information, see **Electronic Countermeasures**, p. 237.

RWR Warning Tones

The radar warning receiver detects incoming radar emissions and warns you when you're being tracked by a guided missile. Two audible tones support the RWR: one for radar-guided missiles, and another for IR-guided missiles. A slow, pulsing tone indicates an enemy seeker is tracking your aircraft. A fast, pulsing tone indicates an inbound missile is tracking your aircraft. (Both of these tones are lower pitched than the lock tone indicating that one of your missiles is locked on to a target and ready to be fired.)

A flashing "I" or "R" in the corner of the radar warning receiver also indicates that a missile is tracking you. "R" warns you of incoming radar-guided missiles. The missile itself shows up as a flashing dot on the RWR display. When you see a flashing "R" on the RWR, drop chaff and attempt to evade the missile. Likewise, a flashing "I" indicates an incoming IR-guided missile. When you see this, drop flares and attempt to evade the missile.



The next two pages offer more detailed instructions on beating IR and radar-guided missiles.

Chaff

Chaff is the oldest trick in the book for confusing radar threats. A chaff dispenser releases a cloud of small, metallic strips that distort incoming radar beams and often lure away missiles that are seeking out the targeted craft. These strips are compressed into small cartridges called *pods*, which are released by the pilot or RIO at the press of a button. The filaments or strips inside each pod are made of Mylar film or fine glass fibers covered with metallic particles of aluminum or zinc. Cut to match the wavelength of the expected radar emitter (or a multiple of it) they act as two-ended rods (dipoles) that efficiently deflect radiation.

Radar beams operate on different frequencies, a characteristic that has resulted in the development of a "smart" chaff system that can interface with a fighter's sensors. The onboard computer relays wavelength information to the dispenser. The dispenser then cuts the chaff filaments to an appropriate length (usually from 1/2-inch to 1-inch long) to best reflect the frequency of the currently tracking radar beam. With luck, the material will reflect more radar energy than your aircraft, thus providing a "brighter" target for the missile's seeker.

Beating Radar-Guided Missiles

An "R" in your RWR Window and a pulsing tone indicate that a radar-homing missile is tracking you. Its position appears as a bright dot in the display. With a combination of chaff and quick maneuvering, you can shake the missile.

1. If the missile is still far away, begin a turn that forces the missile to approach your aircraft from the side. Continue to turn, forcing the missile to turn with you in order to maintain its lock. If you can keep this up long enough, you'll burn up the missile's fuel supply. (At close-range, you probably can't avoid being hit, so don't try this.)
2. Keep the missile off your wing using low-G turns (turns under 2-3G).
3. When the missile closes to within 2000 feet or so, execute a maximum-G break turn *toward* the missile. Release chaff (press Insert) until the missile warning tone stops sounding and the dot representing the missile on the RWR goes dim.

Flares

Flares "distract" IR-homing missiles. Heat-sensitive missiles head for the hottest spot in the vicinity, usually an aircraft's exhaust pipes and engines. Flares explode into hot, bright fireballs creating an intense heat source between the missile and the airplane. If the burst is correctly positioned and timed, the missile will turn toward the flare and miss its target.

Beating Heat-Seeking Missiles

The same procedure for radar-guided missiles holds true for heat-seeking missiles, except that you fire off flares (press Del) instead of chaff cartridges.

Heat-seeking missiles work best if they have an unobstructed view of your aircraft's exhaust port.When you execute the break turn, you move out of view and hide your exhaust pipe from the missile's seeker. Turning toward the sun and shutting off your afterburners may also help. With any luck, the flares or the sun will lead the IR missile away from your aircraft.

Jinking

When you've got a bandit on your tail or at very close range, he'll likely use both missiles and guns. Use the previous tactics to distract the missiles, and jinking to evade guns.

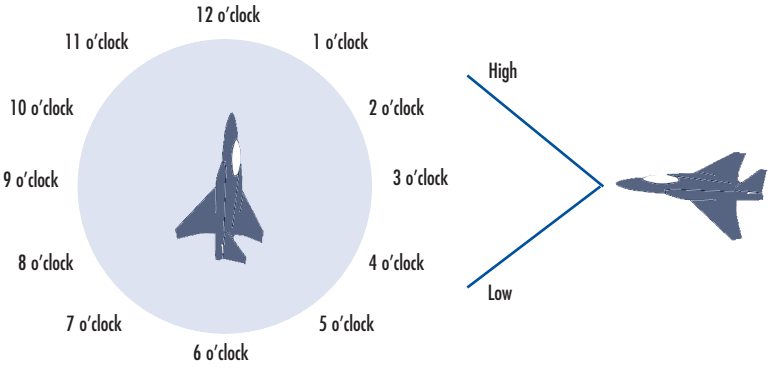
"Jinking" refers to making numerous, erratic flight movements. The key to evading enemy gunfire is being quick and unpredictable. Since bullets are unguided, your enemy has to guess where your aircraft will be at any given time after he fires. For this reason, unpredictably changing course is your best defense.

COMBAT TACTICS

Despite the technological advances of the last few decades, dogfighting still involves the same basic strategy — find the enemy before he finds you, get into an advantageous firing position, and stay there.

Situational Awareness

In the middle of a fight, you must constantly remain aware of what's going on around you. Aircraft work together in wings, supporting each other by keeping track of and communicating the positions of threats and targets. Target and threat positions are given as positions on an analog clock, accompanied by "high" or "low" to denote altitude advantages.



These cockpit elements and keys keep you apprised of the battle situation:

F10 — The chase view gives you a view from behind your aircraft.

F2 — This "checks six" and shows any bandits behind your aircraft.

ALTIMETER — Keep an eye on your altitude so that you don't attempt a vertically draining maneuver, or one that may provoke a stall or spin too close to the ground. Altitude gives you advantages.

Shift 5 — Open RWR (Radar Warning Receiver) window, which identifies threats painting you with radar, and alerts you to incoming missiles.

"XX" — An Offscreen Target Marker (looks like "XX") appears on the perimeter of your screen when you've acquired a target and it moves out of view. Maneuver toward the XX to bring the target into view.

Ctrl Z — "Cheat" that reveals position of the nearest air threat.

Ctrl X — "Cheat" that reveals position of the nearest ground target.

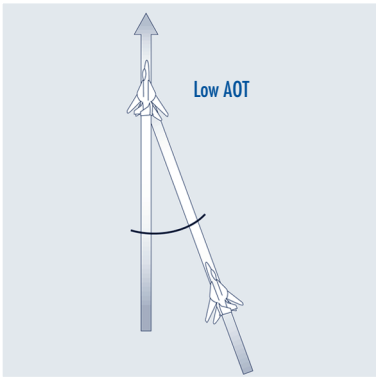
Ctrl A — "Cheat" that reveals position of the nearest friendly aircraft.

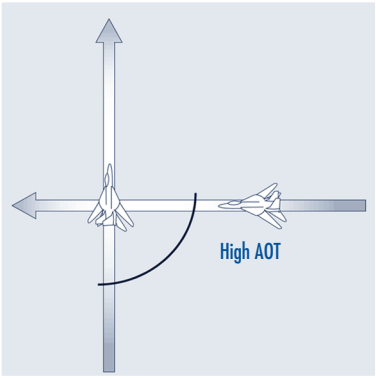
Combat Geometry

Geometry plays a large role in air combat. To develop a complete understanding of air combat, you need to know a few geometrical concepts: *angle-off-tail*, *aspect angle*, *closure rate*, *turn rate/radius* and *corner speed*. All describe the differences in position, speed and flight path between your aircraft and an air target.

Angle-Off-Tail

Angle-off-tail (AoT) is the angle between your flight path and the flight path of your opponent, as shown below. If your AoT is low, your flight path is nearly parallel to your opponent's. If it is high, your flight path is nearly perpendicular to the opponent's.



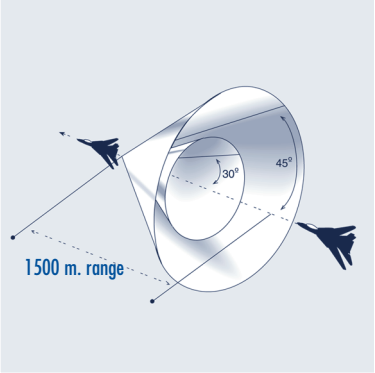


At low AoT, you are either headed directly at an opponent's tail, it is headed directly at your tail or you are facing each other head-on. In each case, your weapons and/or his weapons have a direct line of fire. Almost all weapons perform better when fired at low AoT.

As AoT increases, your opponent flies more perpendicularly to your flight path. Your missiles have to turn more to track their target, and you must "lead" the target more when you're using guns.

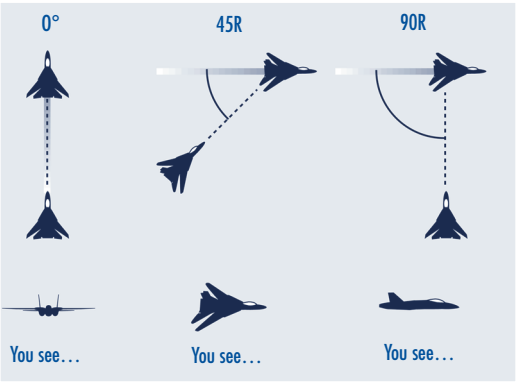
During a sustained engagement, your goal is to reduce AoT as much as possible before firing. This usually involves turning so that you align your flight path with that of the target.

Cone of Vulnerability



When you're within range of an enemy's weapons, you're inside the cone of vulnerability. If an attacker has closed to 1500 meters (about 4000ft), you're vulnerable to his gunfire at any AoT less than 45°. As he moves closer in range, the cone of vulnerability narrows (because the missiles can't maneuver as sharply in short range, and you fall within his lethal cone of fire at any AoT less than 30°. You can use break turns to keep outside the cone of vulnerability.

Aspect Angle



Aspect angle indicates which aspect of the target is facing you, and is measured in degrees. Think of it as a numerical way of expressing what part of the target you're looking at. The aspect angle to your current target appears next to the "A" in the lower right corner of your HUD.

A "90R" aspect angle means you are perpendicular to your target, facing its right wing. At "45R", you see the target's right wing as it crosses your flight path at a 45° angle. At "0" aspect angle, you are facing the aircraft's tail and at 180°, you are facing its nose.

Awareness of a target's aspect angle is vital when you're using missiles. Missiles are loaded to face directly ahead, and must break hard to hit a target when the aspect angle is 90°. The harder they have to turn, the less likely they are to hit. Try to fire directly in front of or behind a target to give your missiles a straight shot.

Closure Rate

Closure describes your aircraft's speed relative to the speed of your target. The closure rate appears in the lower right-hand corner of your HUD display. A positive closure means the target is approaching you; a negative closure means it is moving away.The larger the number, the faster the range is changing. A closure of -700 knots means the target is moving away from you very quickly while a closure of +70 knots means the target is moving toward you slowly.

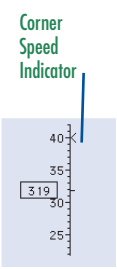
Closure also impacts weapon performance. At a high positive closure rate, the range to the target is rapidly decreasing. A missile doesn't have as far to fly, since the target reduces range by flying into the missile. Thus you can sometimes fire a missile at an approaching target that is outside missile range, because the target will fly into range in time for the missile to track it. If the closure rate is high and negative, the target is moving away and the missile must fly farther to overtake it.

Turn Rate/Radius

An aircraft's *turn rate* is the number of degrees it can pivot per second. An aircraft with a high turn rate can turn quickly. An aircraft's *turn radius*, is the distance it requires to turn. An aircraft with a low turn radius can turn sharply. Note that an aircraft can have a fast turn rate, but require a large turn radius, or vice versa.

Corner Speed

Turn rate and radius are determined by the design of an aircraft and the power of its engine, but they can be reduced by flight factors such as airspeed and air density. *corner speed* (also known as calibrated speed) is the speed at which an aircraft achieves its best turn radius. If you get into a turning fight, maintaining your corner speed will allow you to turn as sharply as your aircraft can.



Your HUD has a corner velocity indicator caret that marks your aircraft's optimal corner speed for your current altitude on your airspeed indicator tape. The Other View Window also has symbols on the left side which indicate whether you are above or below corner speed (see **Other View Window**, p. 89).

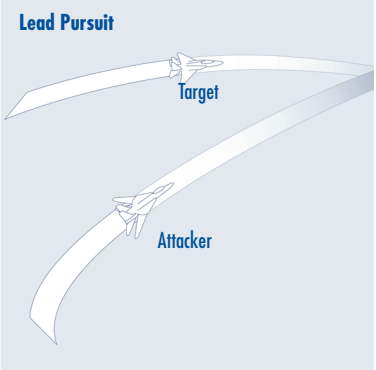
You may have to lower your airspeed (cut back on thrust) to reach your corner speed. (See **Turn Performance**, p. 58, for more information on corner speed.)

Pursuit Curves

In close-range fighting, your primary aim is to gain a better aspect angle (firing position) than your opponent. Once you have this advantage, you can tail the enemy using three types of pursuit — *lead*, *lag* and *pure*. Depending on the situation, you may find all three necessary.

Lead Pursuit

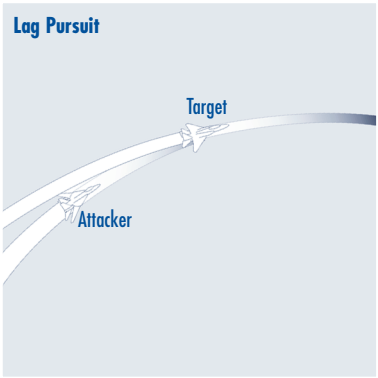
- To initiate lead pursuit, bank your aircraft so that your nose is headed for a point just ahead of your opponent's nose. (Keep in mind that tighter turns bleed off kinetic energy — continually turning will cause you to lose speed.



As its name implies, *lead pursuit* refers to predicting the flight path of a target. You guess where the threat will be in the immediate future, and then point your nose at that predicted position. By redirecting your flight path so that it crosses the target's flight path, you stand a better chance of striking the enemy with your weapons. Of course, the trick is to accurately predict where your opponent is going to go.

If you're in the aircraft with the smaller turn radius, lead pursuit tactics can give you a continuing advantage. By making sharper turns than your opponent, you cut across his flight path. This, in turn, reduces your target aspect angle, brings you closer to your opponent, and increases your closure rate.

A danger of lead pursuit is that it can cause the target to disappear beneath your aircraft's nose. If the target makes this erratic maneuver, you may not see it. Keep your turns small but persistent and the target will remain in sight.



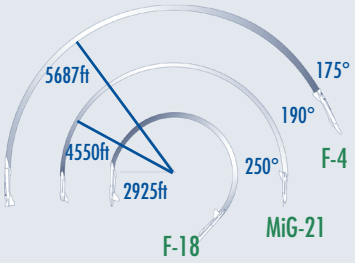
Lag Pursuit

- To execute lag pursuit, pull back on the stick until the target aircraft is positioned just above the flight path indicator in your HUD. Then, ease up slightly on the stick to maintain the enemy's position in your HUD.

Lag pursuit is the exact opposite of lead pursuit. Instead of making a tight turn in the direction your opponent is headed, you use a "softer" turn with a larger radius to follow a point just behind the tail of the enemy aircraft. The potential advantages of lag pursuit are illustrated in the following example.

The diagram on the left compares the turn rates (measured in degrees per time allotted) and turn radii (measured in feet) of an F-18, F-4 and MiG-21 for a 4G turn at 36,000 feet. At the low speed needed for a 4G turn, the F-18 obviously has a significant turn rate and turn radius advantage over both aircraft.

Turn Rates/Radii for 4G turn at 36,000ft



However, imagine that the F-18 comes screaming in at Mach 1.4 toward the MiG-21, which is traveling a mere Mach 0.5. At this high speed, the F-18 still has a superior turn rate, but its speed has greatly increased its turn radius, and it cannot possibly cut off the MiG's turn. (See **Turn Rate and Turn Radius,** p. 58, and **Corner Speed**, p. 58)

Why shouldn't the F-18 pilot try to match the MiG-21's turn with *lead* pursuit? If he does, he'll have to pull 5.25G and he'll overshoot the MiG by some 3000ft. Additionally, his aircraft will rapidly bleed off speed as drag increases, wasting his initial velocity advantage. However, using *lag* pursuit would keep him from overshooting and conserve his energy (in the form of speed).

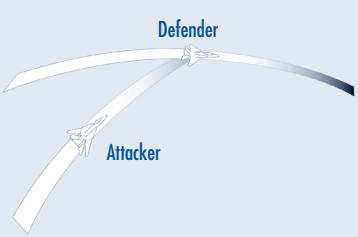
The F-18 pilot can still use his turn rate advantage to *lag pursue* the MiG. The F-18 is able to relax the turn to approximately 4G, while continuing to match the MiG-21's turn rate. The end result is that the F-18 flies in a concentric circle *outside* the MiG-21's flight path, ending up directly on the MiG's tail.

Pure Pursuit

- Pure pursuit is a direct chase — simply point your aircraft directly at the target and follow its maneuvers as closely as possible.

Pure pursuit is most useful when firing weapons at close range, where you can place your sight directly over the target and fire.

Pure Pursuit



Speed vs. Altitude

The energy elements of speed and altitude are the core components of aerial combat. Altitude is a measurement of the aircraft's potential energy, which can be converted to speed by diving. Speed is a measure of an aircraft's kinetic energy, which can be turned into altitude by climbing. Think of kinetic energy as energy in motion, and potential energy as energy in reserve.

At any given instant, an aircraft possesses both a certain amount of kinetic energy (speed) and a certain amount of potential energy (altitude). This energy translates directly into maneuverability. Air Combat Maneuvering, or ACM, is a game of managing energy to maximize maneuverability and defeat the enemy. Finding the balance between speed and altitude requires skill and timing.

Several in-flight controls adjust speed and altitude:

[2], [7] Reducing your throttle to a low setting will reduce speed, and eventually altitude as lift drops off. Do this if you're overtaking an enemy too quickly. ([2] reduces throttle to 25%; [7] reduces current speed by 5%.)

[B] Your air brakes can slow you down if you're approaching a target too quickly. This helps prevent overshooting.

[6] Afterburners can be a lifesaver during escape maneuvers, or moves that require an increase in airspeed or altitude. However, your fuel consumption and heat signature more than double for the duration of the burn.

[F] Flaps are used during takeoffs and landings and provide extra lift during low-speed turns (under 300 knots or so). Flaps effectively create a "larger" wing surface by changing the way air flows around the wing, thus providing added lift.

Exchanging Energy

Potential and kinetic energy are exchangeable. An aircraft at high altitude and low speed has lots of potential energy, but little kinetic energy. By diving, the aircraft can convert its altitude into speed and increase its kinetic energy. Similarly, the aircraft can convert some kinetic energy back to potential energy by climbing. The aircraft slows down, but its altitude increases.

A cardinal rule of air combat is that an aircraft with energy has maneuvering options; an aircraft without energy becomes a target. Maneuvering uses energy, and every unnecessary maneuver you make "burns" kinetic energy. When it's gone, you can't easily get it back.

Because you want maximum maneuverability from your aircraft at all times, you must ration your energy use, always maintaining a sufficient supply for whatever maneuver you might execute. For example, don't go into a high-G turn if you can accomplish the same task with a lower-G turn. Before expending energy, determine whether what you get in return (such as a shot opportunity) is worth the loss of energy.

Playing the Energy Management Game

When you've got an enemy on your six that's about to fire at you, you need to extract every ounce of maneuverability possible from your airframe. And when you're out of energy, you have to get some back. You can do so by applying thrust, relaxing your turn radius or diving to gain airspeed. In some cases, you may even need to bleed off speed by climbing or pulling tight turns.

You can take one of two approaches when you find yourself in a combat situation — you can choose the energy fight or the turn fight. Which one you choose depends on your skill and your aircraft's capabilities.

Choosing Your Attack

Unarguably, the first few seconds of a fight are the most important and can often determine the outcome. Most dogfights last less than one minute, meaning that whoever gains the initial advantage usually wins. Every fight is different, and an aircraft designed for turn fighting may find itself better suited for an energy fight. How do you decide which to use?

First, estimate your turn performance versus your opponent's. Maintaining your corner speed (the optimal balance between turn rate and airspeed) means nothing if the bandit can out-maneuver your best turn.

Second, estimate your energy status. If you enter a fight 200 or 300 knots above your corner speed, don't waste all of that energy and decelerate to achieve your aircraft's corner speed. Instead, initiate an energy fight and make use of your power. A well-flown energy fight is difficult to beat, as proven in Vietnam by F-4 pilots flying against MiG-17 and MiG-21 opponents.

The Energy Fight

In an energy fight, you take advantage of your aircraft's superior speed and avoid unnecessary turning. Ideally, you want to start the fight in an advantageous position, such as directly behind the bandit in his 6 o'clock low blind spot. Most of the time, however, that's not an option. You must rely on your energy advantage and skills to overcome your adversary.

Initiating the Energy Fight

When you choose the energy fight, you basically concede turn performance to the enemy and rely instead on speed. You must keep your airspeed extremely high, minimizing the distance between you and your enemy's aircraft as you make a series of head-on attacks. The idea is to strike, then outrun your opponent's weapon range (not too difficult if the bandit has only guns or heat-seeking missiles).

While the bandit busily executes a high-G turn to enter the fight, you (as the energy fighter) zoom away in a spiraling dive or climb. Eventually, you can execute a wide turn (to conserve airspeed) and make another offensive pass.

If you execute the initial turn correctly, you'll remain outside your enemy's weapon envelope (range at which his weapons are effective) for nearly the entire fight. You choose when and where to engage, always bringing the fight on your terms. Thanks to your speed surplus, you can enter and exit the fight almost at will.

The energy fight requires discipline, though. One speed-bleeding turn, and you immediately lose your energy advantage.

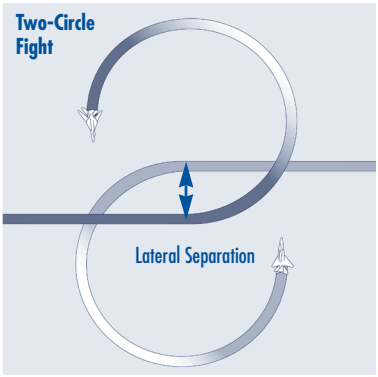
The Turning Fight

Your second choice in combat is to enter a maneuvering fight and rely on your turn performance to win the day. The idea behind a turning fight is to reduce the amount of room in which the enemy can make a turn. You accomplish this during the merge (head-on pass) by minimizing lateral separation, or the horizontal distance that separates your aircraft from your enemy's.

The merge, or meeting the bandit head on, generally leads to one of two types of turning fights: one-circle or two-circle. You should choose a two-circle fight when you're flying a more maneuverable aircraft than your enemy. Use a one-circle fight if you have all-aspect missiles (or if you believe the enemy doesn't have them).

Two-Circle Fights

Two-circle fights, also called nose-to-tail fights, commence when you and your enemy meet head-on. After you pass each other (known as the *merge*), you both loop around in opposite directions, trying to get on each others' tail. The distance between your flight paths is turning room that both of you use. In other words, the turn radii of your aircraft overlap.

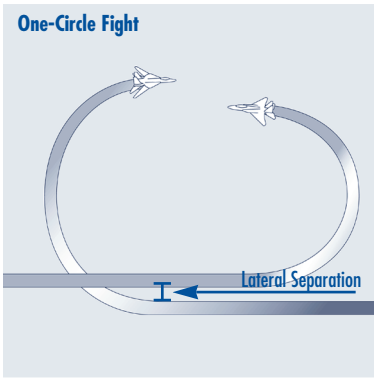


Two-circle fights rely more on turn rate than turn radius. You create only enough lateral separation at the merge point to allow for your full turn radius, and then rely on a superior turn rate to bring your nose back to bear on the threat. Two-circle fights keep your target in view at all times and tend to increase the lateral separation between the two aircraft.

In two-circle fights, always attempt to minimize lateral separation. If the enemy aircraft has substantially worse turn performance than you, don't give him any extra room to work with — keep lateral separation to the bare minimum you require for your turn.

Conversely, if the bandit has significantly better turn performance than your aircraft, deny him the chance to use it by closing in at maximum speed with as little lateral separation as possible.

One-Circle Fights

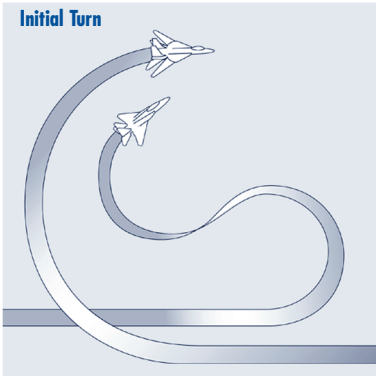


One-circle fights commence when both you and your opponent happen to loop in the same direction (instead of the opposite direction, as in two-circle fights). One of you sacrifices lateral separation, relying instead on turn radius to out-maneuver the enemy. In general, only use the one-circle fight when you have a significant turn radius advantage over the bandit.

The one-circle fight tends to keep you and your target closer together than the two-circle fight. If you choose to turn away from your opponent, you'll momentarily lose sight of him as he crosses your tail. In fighters with poor rearward visibility, this loss of visual contact can be devastating. Since taking the one-circle approach surrenders the lateral separation to the bandit, you should minimize lateral separation during your next head-on approach.

The Initial Turn

Timing the initial turn in a head-on approach is critical to maintaining the advantage during a fight. Turning too soon pulls you across the bandit's nose, which not only gives him a snapshot opportunity, but also puts you on the defensive. Turning too late, on the other hand, puts you out of position and allows the bandit to gain a better target aspect angle on you.



A perfectly timed turn will deny the bandit any advantage while maximizing your own performance. However, while the initial turn is important, you may soon find yourself in a twisting, turning fight. When this happens, you need to apply additional air combat skills and maneuvers (discussed in the next section).

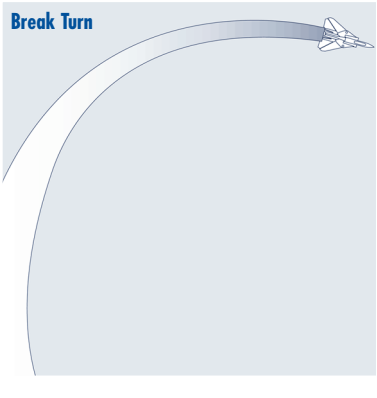
AIR COMBAT MANEUVERS

In the world of combat, getting into position for a good shot is often called "achieving a firing solution." It can happen in half a second, or it may take several minutes. The manner in which you attain this position differs from conflict to conflict, so it's imperative that you develop a good reserve of combat maneuvers.

The following section examines various air-to-air maneuvers and describes how to use them to your advantage during combat.

Break Turn

- Use the break turn to evade enemy fire. Follow with a turn in the opposite direction.
- Initiate a break turn by banking (pull the joystick toward you and to one side).



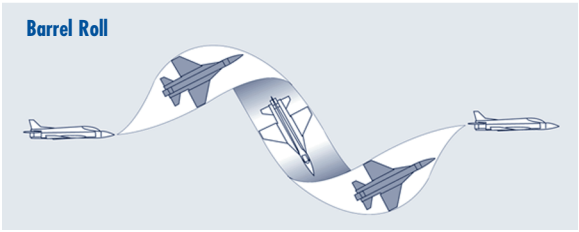
The break turn is the most basic combat maneuver, for it rapidly increases the angle-off-tail (angle between you and your enemy's flight path) when a bandit is preparing to shoot you. It is a high-G maneuver that takes advantage of a maximum instantaneous turn rate and forces your attacker to take a high-aspect angle shot.

You can make a tight, instantaneous break turn (in which you lose speed, but gain a maximum AoT — Angle off Tail), or you can make a sustained break turn (in which you conserve speed, but forfeit several degrees of AoT). Making a hard break turn bleeds airspeed, which in turn, can cause your enemy to overshoot. Generally, the closer you think the enemy is to firing, the harder you should turn.

Once you move through the break turn, immediately follow it with another maneuver. Sustaining a break turn too long is dangerous — it makes you a wide-open, predictable target. As a rule, your next maneuver should further remove you from the bandit's weapon envelope. Try an immediate scissors turn in the opposite direction. Your opponent will be going too fast to lead your turn, and you may be able to maneuver into a more advantageous position.

Barrel Roll

- Offensively, use the barrel roll if you're overtaking an enemy too quickly.
- Defensively, use the barrel roll to force your attacker to overshoot and pass you.
- Initiate a barrel roll by rolling slightly and applying pitch. Keep the nose pitched to spiral around the axis of your flight path.



The barrel derives its name from the flight path the aircraft performs, circumscribing the shape of a barrel as the aircraft rolls around a central axis. It is an energy management maneuver possessing both offensive and defensive potential.

Offensive Barrel Rolls

If you find yourself traveling too fast, you may both overshoot your foe and fly directly into his gun envelope. This happens because your closure rate is too high, and you overtake your target. The barrel roll provides an effective solution by wasting speed.

If you can't bleed enough speed with a barrel roll, pull back harder on the stick and execute a roll opposite the direction of your current turn. The increase in pitch reduces airspeed, and the rollout turns you away from the target and keeps you from overshooting. As you complete the roll, you'll be back on your original course, but at a slower airspeed.

Defensive Barrel Rolls

Defensively, the barrel roll can be used to force a quickly approaching attacker to overshoot. It can also maintain enough angle-off-tail to put you out of his lethal cone of fire. Defensive barrel rolls must be carefully timed, however. Initiate the roll too soon, and the bandit will follow you through it. Start too late, and the bandit will have several shot opportunities before you begin the turn. Perfect timing requires that you both surprise the enemy and deny him sufficient reaction time.

Scissors

Scissoring occurs when an attacker overshoots, and the target reacts by making a reverse turn too early (before the attacker crosses his weapon envelope).

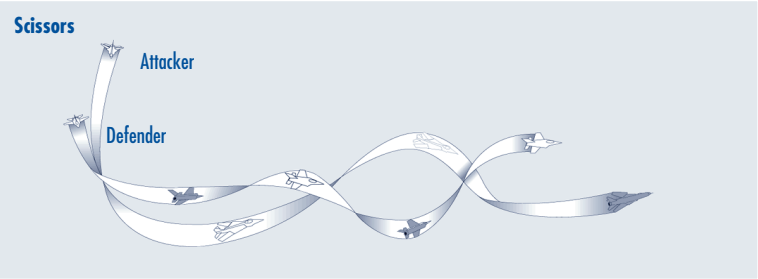
- Never purposefully enter a scissors fight — it bleeds off speed and altitude.
- To break a stalemate, roll 180° during one of the passes.

Scissoring refers to a series of reversing break turns in which two aircraft turn back and forth toward each other, each trying to force the other out in front. This usually begins when the attacker starts a late high yo-yo or barrel roll and realizes he's going to overshoot his target. The defender, predicting the overshoot, reverses his turn. Although this is the right solution, he turns toward the attacker too soon, resulting in a fairly neutral pass and initiating scissors.

Scissor moves reduce the *forward velocity vector*, or the fighter's speed along the axis of its flight path. The aircraft turns across the flight path at varying speeds, reducing its average forward speed with every turn.

If you're an attacker, the only way you can get into a scissors duel is by starting a maneuver too late and overshooting. If you're on the defensive, you correctly predicted his overshoot, but reacted too quickly and compounded the attacker's error.

Once in a scissors, there's nothing to do but keep turning into the bandit. This bleeds off both speed and kinetic energy. The "winner" of a scissors match is usually whoever can conserve enough energy to force his opponent out front and bring the aircraft's nose around for a shot. More often than not, scissoring ends when one aircraft loses so much speed that it stalls out and plummets. If the other aircraft has any energy left, it can roll, dive and take a shot before the falling aircraft can recover.



Vertical Rolling Scissors

Alternatively, two pilots about to engage may begin a series of barrel rolls instead of break turns. The resulting vertical rolling scissors is a speed-reducing maneuver as well, draining kinetic energy during the series of climbs, reverse turns and overshoots. Each time the aircraft cross paths, they risk both collision and gunfire. Allowing too much lateral separation (passing too far apart) affords your opponent a shot opportunity, while passing too close may result in a crash.

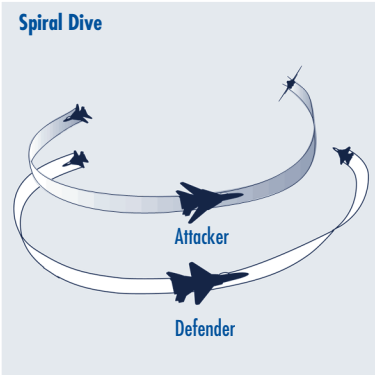
In a guns-only environment, you may be able to escape scissors by executing a split-S immediately after crossing your opponent's tail. Then, by rapidly increasing your speed, you can outrun his guns.

Don't try this if your enemy has IR missiles — the split-S invites a heat seeker up your exhaust pipe. If you can't get outside the bandit's weapon range, then you have to win the scissors fight. If you can't win the fight by out-turning the bandit, you're as good as dead.

Spiral Dive

- Use spiral dives as a last resort, and only if your aircraft has the superior turn radius.
- Fall into a steep dive, then make a hard-G turn. Throttle back midway through the turn and invert. Pull the nose up hard to maneuver onto the enemy's tail.

If you use every maneuver imaginable and still can't shake an opponent despite a better turn radius, try a spiral dive. You carry out this maneuver by leading your opponent into a steep dive as soon as he moves to one side of your tail and falls into an overshoot position. He won't have a direct line of fire at you at that instant, but you can't dive for long without him re-achieving a firing solution.

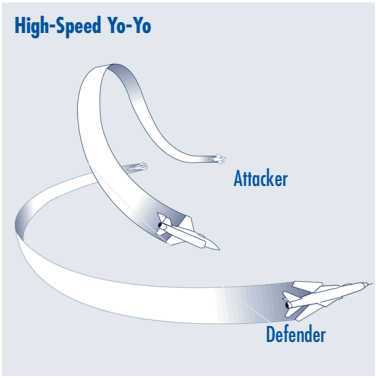


End the dive quickly by taking advantage of your aircraft's superior turn radius and pulling hard pitch (but not so hard that you sacrifice maneuverability). As you come out of the turn, reduce throttle, invert with a 180° roll, and pull up sharply again. Your attacker probably won't notice that you've slowed down and will be forced out in front of you.

High-Speed Yo-Yo

- Use the high-speed yo-yo to reduce AoT and bring a target into your firing cone.
- Perform by relaxing a turn, then pulling up into a sharp climb. Invert, then apply pitch to slide back down onto the threat's tail at a smaller AoT.
- Cycle between the F1 and F7 camera views to keep track of your enemy during a yo-yo.

The high-speed yo-yo is a basic component of offensive air combat and reduces AoT at the cost of increasing the distance between you and your target. The yo-yo begins during a turning fight when you have assumed an aggressive position behind the bandit, but are stuck in lag pursuit and unable to bring your nose to bear. In this case, you can use gravity to your advantage.

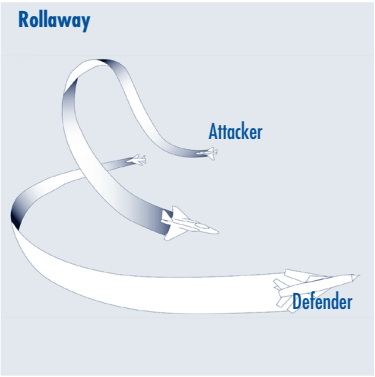


Roll out slightly when your enemy initiates a break turn (maintaining lag pursuit), then pull the nose up. At the apex of the climb, invert and roll back down onto your target's six o'clock position. You'll be further away from him, but in a better firing position.

Don't make the yo-yo too extreme. Once you commit to a large one, you'll be unable to respond to any sudden changes the bandit may make. Patiently work small yo-yos by bringing the nose just above the horizon and chipping away at your AoT problem. This will move you into the target's cone of vulnerability without pulling high-G loads.

Rollaway

A variation of the high-speed yo-yo, the rollaway involves rolling *away* from the target's turn as you invert. By diving and reversing direction with a 180° turn, you can drop in behind the defender's tail as he ends his break turn.



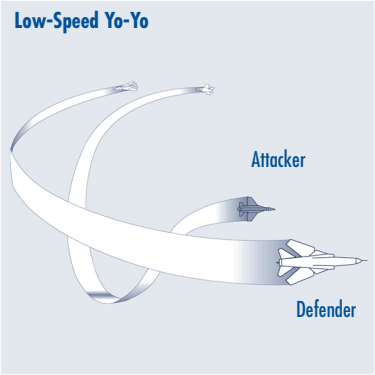
Low-Speed Yo-Yo

- Use the low-speed yo-yo when you have a good firing angle but need to bring the target in range.
- This maneuver decreases range at the cost of increasing AoT.
- Execute by diving inside of a target's turn and gaining airspeed. Then, pitch up and slide onto his tail once more.
- Cycle between the F7 and F8 camera views to keep track of your position as compared to your enemy.

The low yo-yo is the logical opposite of the high yo-yo, and achieves the exact opposite effect. While the purpose of the high yo-yo is to decrease AoT (at the cost of increasing range), the low yo-yo is intended to decrease range (at the cost of increasing AoT).

Use the low-speed yo-yo when you have a good shot opportunity, but you're still outside your weapon's maximum range. This often occurs in chases where the bandit has superior speed and is trying to run home in level flight. You're chasing him, but he remains just outside your weapon's effective envelope.

To get closer to your target, lower your nose below the horizon and dive. This increases speed, but almost always forces you into lag pursuit and increases AoT. A low yo-yo, therefore, almost always requires an immediate high yo-yo to correct the angle problem generated by the increase in speed.



Be careful not to dive too steeply during this maneuver — you may be unable to bring your nose to bear on the target if it ends up too far above you.

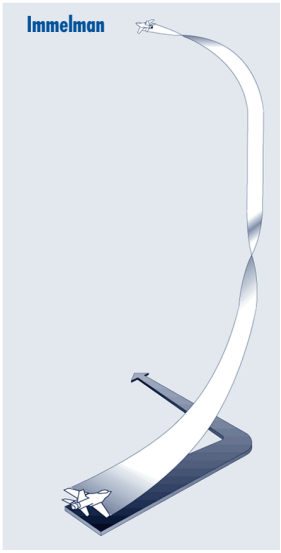
Countering a Low-Speed Yo-Yo

If you anticipate your attacker's low-speed yo-yo, try making a half-roll toward the end of your break turn, then roll out of the turn instead of carrying through with the original break turn. By rolling in the opposite direction, you face your attacker's nose as he emerges from his dive. This brings the fight back to a merge pass.

Immelman

- Use this maneuver to increase altitude and reverse direction.

The Immelman is neither an offensive nor defensive procedure. Instead, it is a high-thrust maneuver that changes your bearing and increases your altitude. By pitching the nose up and climbing, you can execute one-half of a loop. To terminate the maneuver, invert and execute a roll. (The amount of roll applied determines your new direction of flight, as indicated in the diagram.) This leaves you flying in a different direction, but at a higher altitude. Once your wings are level, perform a half-roll again to reassume a vertical position.

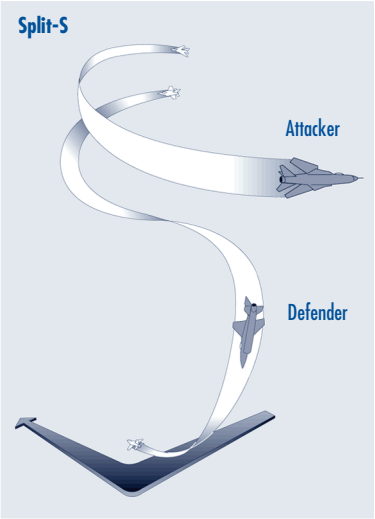


The Immelman is most useful for aircraft that have low thrust capabilities. Modern high-thrust jets can broaden this maneuver by making a vertical climb, then using an aileron roll to complete the half loop.

Split-S

- Use the Split-S to increase airspeed or bleed off altitude.

A Split-S maneuver is a diving half loop that is useful when you want to disengage a threat. It is a high-altitude maneuver that requires a lot of vertical airspace, so make sure you're at least several thousand feet above the ground beforehand.



During a turn, invert by rolling, then immediately pull back on the stick to go into a dive. Your aircraft will rapidly accelerate and gain airspeed. Pull back on the stick until the aircraft levels out, then ease into level flight. You'll be uninverted, and you'll have a higher airspeed and lower altitude.

The split-S has the advantage of providing a quick burst of speed. Additionally, rolling while inverted adds the aircraft's lift vector to gravity, thus increasing the force of acceleration and adding speed. On the down side, however, this increased speed increases the vertical turning radius, making it hard to pull the nose up into level flight. Starting a split-S from low altitude, or maintaining too much speed during the dive, can prevent the aircraft from pulling out of the dive.

The split-S makes a great escape maneuver in a guns-only environment because the rapid speed gain moves you out of gun range. It's usually ineffective against missiles, though, since they have significantly longer ranges.

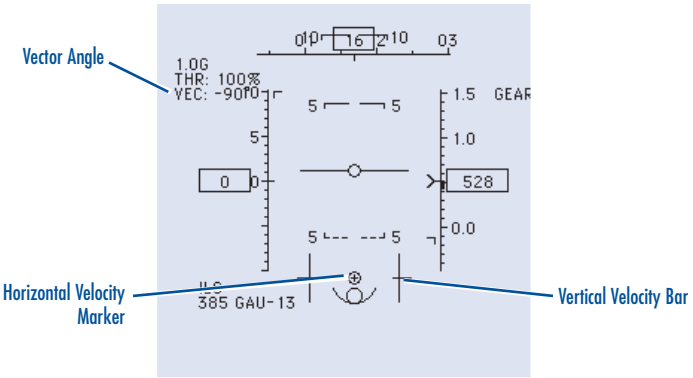
Vectored-Thrust Hover and Brake Maneuvers

- You can only hover in a lightly loaded X-32, Yak-141, Sea Harrier, or AV-8B. When the aircraft are loaded to combat weight, you may be able to direct some of your thrust downward to maintain lift at lower speeds, but you will never be able to fully hover.
- To hover, slow down and vector the nozzles -90° (press Shift X). Keep throttle at 100% (5). To resume forward flight, press Shift Z.
- Vectored thrust can also be used to brake quickly, in an attempt to get an opponent to overshoot. Press Shift X *twice*, putting your vector nozzles at -100° (-120° in the ASTOVL) then press Shift Z *twice* to drive them back to 0° once you've lost speed.

Hovering is not a term generally associated with aircraft. With the advent of the STOVL fighters, however, hovering is making its debut in air combat. STOVLs feature variable-thrust engines that use extreme applications of thrust-vectoring to maintain a semi-hover position. This is primarily useful during takeoffs and vertical landings.

It is difficult to maintain any of these aircraft in a hover, and doing so burns an enormous amount of fuel. However, a brief hover or a semi-hover could be useful if you're using rockets against air threats, or if you're strafing ground targets with gunfire or rockets. Using your vector nozzles (or lift fan in the X-32) to increase braking can help in combat when you are trying to induce an opponent on your tail to overshoot.

The angle of your vector nozzles appears on your HUD. If you drop below stall speed, vertical velocity bars and horizontal position markers also appear. See **Constant HUD Features — Thrust Vectoring Aircraft**, p. 81.



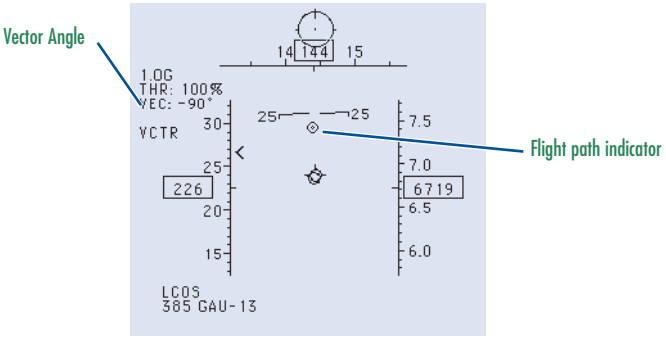
Vectored Thrust Turns

- In the F-22, X-31, X-32, and Su-35, vector thrust up and down (Ctrl ↑, ↓) to make quick, small-radius turns, climbs and dives.
- In the X-31, you can also vector left and right (Ctrl ←, →) to yaw sharply without banking. This is useful for lining up shots.
- The F7 camera view is useful during thrust vectoring maneuvers. It helps you compare your position to your enemy's.

Thrust vectoring turns allow you to decrease your turn radius and turn more sharply than your opponent. Vanes on the exhaust ports can be angled, redirecting thrust and decreasing the turn radius by as much as 50%.

To make this type of turn, go into it just above corner speed. Then, vector in the direction of the turn. The extra drag created when you start to turn will slow your aircraft down below its corner speed and decrease the G-load.

For example, if you're making a break turn to the left in an X-31, press Ctrl ← to vector thrust left. In a F-22 or X-32, press Ctrl ↑ to tighten a turn in which you're completely banked.



In the X-32, watch the VEC: reading in the upper right hand corner of the HUD — it indicates the current angle of thrust (0° is straight back, in normal flight position; -90° is straight down beneath the aircraft). Keep Ctrl ↑ pressed until the reading falls between 40° and 60°.

In other aircraft, the degree of vectoring does not display, but a small circle moves away from the center reticle and indicates your current flight path. The center reticle of the HUD continues to indicate where your nose is pointed.

You can vector thrust during a head-on pass. As the merge begins, reduce throttle and pitch the nose up 5° or 10°. Make a break toward the enemy once he has committed to a direction. As your aircraft's nose slides around, you can squeeze off a few rounds.

Herbst Angle-of-Attack Maneuver (Post-Stall)

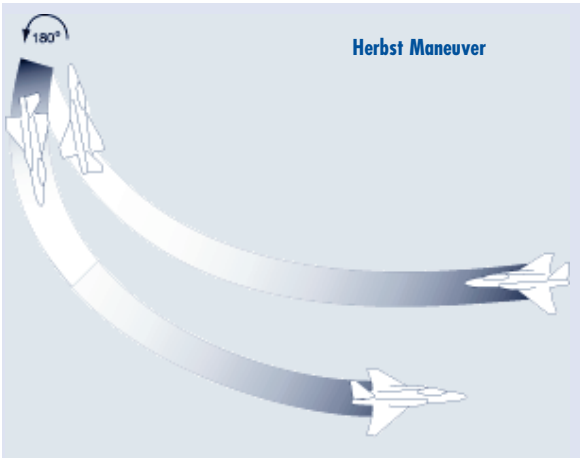
- Use this maneuver to reverse heading when a bandit is on your tail.
- Use this maneuver to fire on enemies above you.
- Execute by going into a vertical climb and applying upward thrust vectoring. As the aircraft reaches its stall speed, vector the nose down and bank.

The Herbst Angle-of-Attack (AoA) maneuver was perfected by the X-31, one of the first advanced tactical fighters to incorporate thrust-vectoring. The idea is to maintain control during a tight-radius, post-stall turn by applying vectoring at the apex of the stall. The tactic itself is named after Wolfgang Herbst, a German pilot who first used a variation of this move to attack enemies during vertical stalls. Today, the most common application of the Herbst AoA maneuver is to reverse heading. If an enemy is on your tail, you can vector into a 180° turn and transform the pursuit into a head-to-head fight.

To perform a Herbst in the X-31, increase airspeed and go into a pure vertical climb with an enemy above and slightly behind you. As your aircraft rapidly decelerates, apply upward vectoring (press Ctrl ↓). You can attain as high as a 70° angle of attack, greatly increasing your aspect angle and allowing you to fire on targets above you.

Thrust-vectoring is used to maintain control of the aircraft's attitude at this point. When the aircraft begins to enter a vertical stall, bank, pitch the nose down and apply vectoring in the opposite direction (press Ctrl ↑) to whip the nose of the aircraft down. Your aircraft will immediately reverse direction by 180° and undergo a tight turn (80% tighter than normal maximum-rate turns). At the end of this maneuver, you've lost some altitude, but you've also made a quick 180° reversal.

This maneuver has been tested (and has been quite successful) against the F-16 and F/A-18. The X-31 is the only aircraft to date able to perform the Herbst Maneuver.



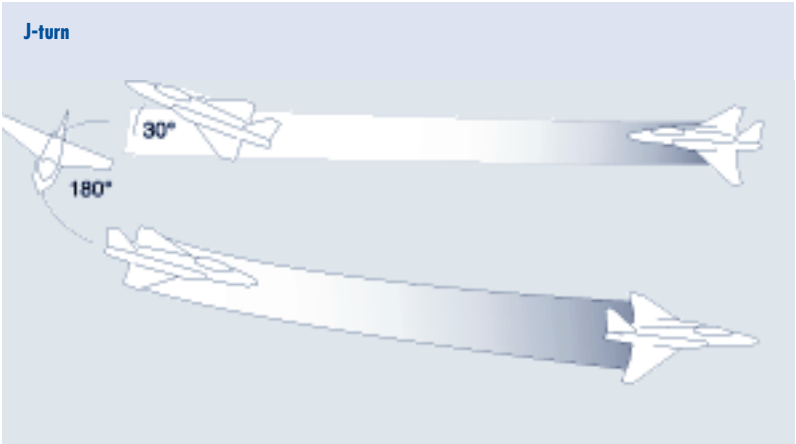
J-Turn

- Use this maneuver to quickly change headings when a bandit's on your six.
- This is similar to the Herbst maneuver, only you don't climb vertically.
- Perform by pitching the nose 30° upward and applying speed brakes. Next, pull the stick back (70° AoA) and vector sideways ([Ctrl][←], [→]). Once you turn 180°, apply throttle and level the wings.

The J-Turn is another post-stall maneuver that calls on the X-31's thrust vectoring capabilities. It is similar to the Herbst maneuver. First, the stall occurs because air flow over the wings is reduced, not because you're climbing. Second, horizontal thrust vectoring is used instead of vertical thrust vectoring (pitch). Since the X-31 is the only production aircraft that vectors in the pitch and yaw axes (in other words, all four directions), it has the advantage of being the only fighter that can perform the J-turn.

For this move, fly level at around 300 knots. Pitch the nose up 30° and apply speed brakes ([B]). As you lose airspeed and the wings begin to stall, perform three tasks: pull back on the stick all the way, bank either left or right, and vector in the same direction as the bank to apply yaw (press [Ctrl][←] or [Ctrl][→]). The yaw thrust effectively "snaps" your aircraft's nose in the direction of the roll. Finally, apply full thrust and level the wings.

The result of the J-turn is that you "slide" through a quick turn and change your heading by 180° without gaining much altitude.



Engaging Ground Targets

Since ground targets aren't very maneuverable, few actual "combat tactics" exist. The general tactics — surprise and dealing with anti-air defenses — are discussed below. The **Stairstep** bombing maneuver developed in World War II is described on the next page.

Surprise

In an attack fighter, try flying in low (500ft above the ground or less), under the enemy's radar. Ground-based radar systems can detect your aircraft at high altitudes, but not close to the ground. If you approach undetected from an unexpected direction, the air-defenses may be unprepared. It takes time for them to turn and engage, giving you an opportunity to deliver ordnance and escape.

Radar waves are like light; they cannot penetrate solid objects like hills and buildings. Try flying at low altitudes between hills or behind clusters of buildings to hide from enemy radar. As an added measure, leave your radar off as you approach an enemy position. Use it only in short bursts to identify target coordinates — this reduces your chances of being detected by their RWR.

Dealing with Anti-Air Defenses

Try to stay outside of enemy defense envelopes. If the target is heavily defended with radar-guided SAMs, approach at low altitude; such SAMs often have trouble engaging low-altitude targets. If the primary defense is automatic anti-aircraft artillery (AAA), fly above 15,000ft.

Similarly, try using long-range weapons. If the enemy defenses have a maximum range of 20nm, attack with a 30nm-ranged weapon. This keeps you safely outside of the enemy's defenses. Obviously, standoff weapons won't always be available or suitable for a given mission, but always consider using them.

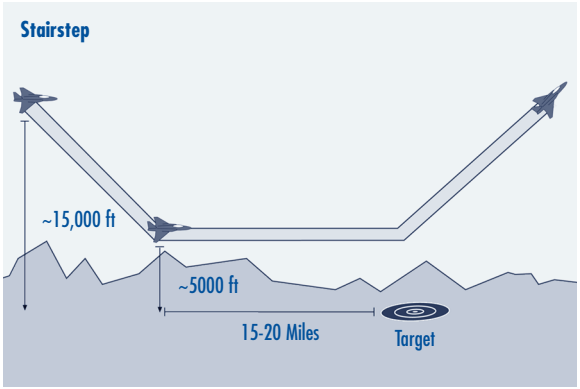
AAA Weaknesses

AAA is deadly against low-altitude targets but does have limitations. While modern AAA uses radar to calculate lead requirements, older AAA systems must eyeball you in their sights and therefore, must lead you. If you approach them from any direction other than head on, you're almost guaranteed that they'll miss. Furthermore, the faster you fly and the more you jink, the harder it is for AAA to calculate lead. Keep in mind, however, that the military doctrines of some countries favor indiscriminate barrage attacks, in which no attempt is made to target the aircraft, but as much anti-aircraft fire as can be mustered is pumped into the aircraft's flight path. There is no avoiding a barrage, except to fly above it and take your chances with SAMs.

Stairstep

- To execute a stairstep bombing run, climb above 15,000ft by your first waypoint and level off. Fifteen to twenty miles from your target waypoint, reduce throttle to 25% ([2]) and dive 25-30°. Use your brakes ([B]) to keep from gaining too much speed, and level off at around 5000 feet. Find your target, drop your ordnance and pull back up to your initial altitude.
- You may need to significantly decrease speed if you're having trouble finding or lining up on your target, or if you must maintain a target lock for a laser-guided weapon. Keep your throttle between [2] and [3].
- Drop your payload when you have a hit probability of 65-70% ([Spacebar] or missile trigger), and order your wingman to engage your target ([Alt][E]).

The stairstep was first developed in World War II, for use against heavily defended targets where a low-level approach would be fatal. It is still in use today — as in the initial runs of Operation Desert Storm — and can easily be adapted for use by modern aircraft. In a stairstep maneuver, bomber wings approach their target above air defense radar and weapons range — at altitudes of at least 15,000ft for older air defense systems, above 20,000ft for more modern aircraft and defense systems. Within 15-20 miles of the target waypoint, the wing drops quickly to a lower altitude. The range from target at which to drop depends on how heavily defended the target is and how easily it can be located. A precision run may require more time on target than an area suppression. The altitude over target varies between 3000 and 10,000 feet, depending on the types of munitions involved, the type of aircraft and the level of ground defense. After the bombs are dropped, the wing climbs back to its initial altitude to avoid additional air defense and fighter patrols.



WINGMAN COMMUNICATION

Aircraft work in groups called *wings* for mutual support and protection. Your wingman is there to protect you, and you're there to protect him. During a *Fighters Anthology* battle, you can issue certain commands to your wingmen. Although you don't have total control over him (he does, after all, possess free will), you can direct him to certain targets or ask him for help when you need it.

Wingmen execute commands based on formation control, either LOOSE or MEDIUM. You can set the default control for each waypoint when you design missions with the Pro Mission Creator. During flight, you can toggle between formation controls with Alt C.

LOOSE CONTROL Your wingman will break out of formation when he detects an enemy or an incoming missile. Once he drops out of formation and finishes his first attack, he'll continue to search out and engage enemies until you give him other orders.

MEDIUM CONTROL Your wingman remains in formation unless you specifically direct him to attack a target. (He will, however, break in order to avoid an incoming missile and then return to formation.)

You have 20 different wingman commands at your disposal during flight:

KEYS	COMMAND	WINGMAN ACTION
Alt 1	FLY STRAIGHT AND LEVEL	Rolls out and flies straight and level
Alt 2	BREAK LEFT	Breaks left
Alt 3	BREAK RIGHT	Breaks right
Alt 4	BREAK LOW	Breaks low
Alt 5	BREAK HIGH	Breaks high
Alt 6	APPROACH LEFT	Approaches target from the left
Alt 7	APPROACH RIGHT	Approaches target from the right
Alt 8	APPROACH LOW	Approaches target from below
Alt 9	APPROACH HIGH	Approaches target from above

KEYS	COMMAND	WINGMAN ACTION
Alt P	PROTECT ME	Attacks bandits threatening you
Alt E	ENGAGE MY TARGET	Breaks out of formation and engages your current target
Alt W	ENGAGE TARGET CLASS	Engages all targets of the same type as your current target
Alt R	ENGAGE FROM FORMATION	Engages your target, but remains in formation
Alt D	DISENGAGE	Breaks off his attack and reforms on your wing
Alt B	BUG OUT	Returns to base (wingman will no longer respond to commands)
Alt C	SET FORMATION CONTROL	Assumes LOOSE or MEDIUM control
Alt T	SET FORMATION TYPE	Moves into selected formation type (see p. 7.16 for diagrams)
Alt H	SET HORIZONTAL SPACING	Assumes whatever horizontal separation — FAR or NEAR — you specify (see p. 7.16 for diagrams)
Alt V	SET VERTICAL STACKING	Assumes whatever vertical stacking — HIGH, LOW or LEVEL — you specify (see p. 7.17 for diagrams)
Alt F	ATTACK ON CONTACT	Only works if IR/LASER ADVANCED TARGETING is active on the pref menu of the In-Flight menu bar, and wingman has reported a contact — wingman will attack the first threat he finds.

EFFECTS OF DAMAGE

In the event that you take some hits, it's good to know what's critical and what's not. Every aircraft has multiple systems and components. You can manually display percentages of component damage, but additional messages appear at the bottom of you screen describing the type of damage you're taking as you are hit.

D — Display component damage as a percentage

Control Surface and Hydraulic System Damage

As surfaces become damaged, the aircraft becomes difficult or impossible to control. Autopilot is unavailable after even slight damage to any control surface. Damaged elevators reduce pitch control, damaged ailerons reduce roll control, and a damaged rudder usually causes the aircraft to persistently yaw one way or the other. Any damage to the hydraulic systems that move the control surfaces causes controls to become less effective. When hydraulic pressure and fluid reach zero, control surfaces and gear freeze.

Structural Damage

If your airframe is damaged, pulling high-G maneuvers will probably destroy the aircraft.

Engine, Oil and Compressor Damage

Generally, damage to any of these systems causes a loss of engine power. Failure results in total loss. Damage to the oil systems causes engine overheating unless the throttle is kept low. Even then, the aircraft may eventually overheat. Compressor damage risks catastrophic engine failure when the engine is above 25% throttle.

Any hint of fire means the aircraft is about to explode — bail out!

Shift E — (Press twice) Eject

Pilot Damage

You, the pilot, may also take damage from explosions, shrapnel or fire. Each wound requires medical attention or you will die. You have up to 15 minutes or so to return to base after the first wound, but subsequent wounds greatly reduce that time.

Avionics and Weapon Damage

Damage to these systems is troublesome, but not life-threatening. Basically, if a system or harpoint is damaged, you can no longer use it.

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