

FLIGHT

Air combat is often a one-on-one fight to outmaneuver your opponent, point your nose at him and fire off your weapons first. Understanding how and why your aircraft maneuvers is essential for combat success.

Flight Physics (below) explains the basic physics principles of flight. **G-Forces** (p. 3.5) discusses the physics of turning, G-forces, **Flight Envelope** (p. 3.5) discusses aircraft limits, and **Flight Characteristics** (p. 3.9) covers how to maximize turn performance. **Flight Controls** (p. 3.7) describes some of the control surfaces of the aircraft and explains how to maneuver the aircraft. The final sections cover takeoffs and landings, stalls, spins and refueling.

FLIGHT PHYSICS

The following sections give a basic understanding of the forces at work behind flight. For technical references, please see **Appendices:**

Bibliography, p. E.1.

Flight is the result of several forces acting upon an aircraft. The first is the aircraft's *weight*, or the gravitational force pulling it toward the ground. The second is *thrust*, the force produced by the engines that propels the plane through the air. This forward movement causes air to move over the wings, which in turn creates a *lift* force that counteracts the gravitational force. The final force acting on an aircraft is *drag*. Drag is a force that is generated in a direction opposite to flight.

Multiple forces can act on an object simultaneously, and in several directions. The individual forces are called *component forces*, while the overall effect of these forces is called the *net* or *resultant* force.

THRUST

Generating thrust is the main purpose of an aircraft's engines. This force is what causes the aircraft to overcome *inertia* (an object's tendency to resist a change in motion). Thrust produces forward motion, allowing the aircraft's wings to create lift.

For aircraft, a common measure is the *thrust-to-weight* ratio. This is a ratio between an aircraft's total weight and its thrust capability. A ratio greater than 1:1 indicates that an aircraft can overcome gravity in a vertical climb. The F-15E's dual afterburning engines can each generate approximately 23,450 pounds of thrust (with the PW-220 engine).

When thrust is created, it propels the aircraft forward and causes air to move over and under the wing surface. This creates a pressure differential that pushes up on the wing (details are given in the following section). Thrust also brings about changes in velocity.

LIFT

Lift is produced when an airfoil (the wing) moves through the air and splits it. Half of the air goes over the wing, and the other half travels under the wing. This air flow-ing around the wing separates at the *point of impact* (see diagram) and flows both over and under the exterior surfaces.

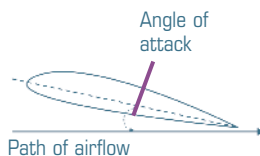


The top surface of the wing is more curved, and thus longer than the bottom surface (see diagram). Because of this, the air that goes *over* the wing has more surface area to travel than the air that goes *under* the wing.

Since air on top of the wing has a longer distance to travel, it must travel at a greater velocity than the air on the bottom. The faster airflow over the top surface of the wing creates a lower pressure on the top of the wing than on the bottom. This results in a *pressure differential*, or an imbalance of pressure forces between the top and bottom of the wing. The net force pushes upward, causing lift.

ANGLE OF ATTACK

The amount of lift produced by the wing varies according to the angle at which the wing hits the air. This is called the *angle of attack* (AoA). This should not be confused with an aircraft's *attitude*, or the pitch angle of the nose relative to the horizon. In the F-15, AoA is measured in units, while attitude is measured in degrees.



There is no single angle-of-attack on which you can rely all of the time — the desired angle varies with the situation. In some cases, you may want to maximize your aircraft's cruise range by keeping AoA around 14 units; this will deliver maximum range. In other cases, conserving energy during a turn may be the primary concern, and you might need an AoA of 16 - 22 to make an optimal, energy-sustaining turn. For acceleration, an AoA of 8-10 works best.

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If the AoA is too high, an audio tone will activate in the cockpit, warning of an impending stall. To check your AoA, look at the symbol and number

directly below the indicated airspeed on the left side of the HUD. This shows your angle of attack in units. See **Cockpit: Basic HUD Symbolology**, p. 2.5, for more information.

DRAG

Drag is a force that causes an aircraft to resist movement in the direction of flight. Any object that moves through a fluid (and air is a type of fluid) produces friction. In aircraft, drag is caused by the friction of air against the wings as the aircraft moves forward, as well as a buildup of pressure due to air pushing against the aircraft's surfaces.

Induced drag is the rearward component of lift. As the wings produce more lift, they also produce more drag. *Wave drag* occurs as the aircraft approaches Mach 1. More pressure is created in front of the aircraft's wing than behind it, which creates a backward drag force. Finally, *parasitic drag* includes wind resistance and all other types of drag that are not lift-induced.

No matter what type of drag is encountered, the overall performance of an aircraft depends on the relationship of the *coefficient of drag* to the *coefficient of lift*. Different angles of attack yield differing amounts of lift and drag. Each aircraft has an ideal combination of angle-of-attack, thrust and lift, and different types of drag occur at different airspeeds.

AIRSPEED

As an aircraft travels through the atmosphere, air flows over the surfaces of the aircraft. This flow creates pressure. At higher altitudes, air is less dense, and less air flows over the aircraft's surfaces. By measuring the pressure of the airflow, the F-15's *pitot tube* allows the flight computer to compute airspeed.

Because of atmospheric density, a difference can exist in the computed airspeed of an aircraft flying at one altitude with a constant thrust and AoA, and the same aircraft travelling at a different altitude under the same thrust and AoA conditions. For this reason, an aircraft has both an *indicated airspeed* (apparent velocity, based on current air density and altitude) and a *true airspeed* (airspeed corrected for variations due to air density and altitude).

As an example, imagine you're in an aircraft flying at an altitude of 5000 feet at 350 knots (true airspeed), and a second aircraft is flying at 30,000 feet at the same true airspeed. Because the second plane is flying at a higher altitude (and through less-dense air), the pitot tubes on the two aircraft measure different indicated airspeeds. The upper aircraft registers a slower indicated airspeed than your aircraft at the lower altitude. If you and the other pilot are trying to arrive somewhere at the same time, you both need a reading that you can compare regardless of altitude. This adjusted reading is the true airspeed.

By comparing true airspeeds, you and the other pilot can figure out if one aircraft is actually traveling faster than the other. Even though the indicated airspeeds might differ, if the true airspeeds are the same, you'll arrive at your destination at the same time.

AoA AND AIRSPEED

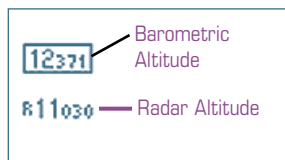
Although thrust is the force behind airspeed, the angle of attack (AoA) greatly affects airspeed. If you're trying to fly a level path, it's important to remember that you must accompany any change in AoA with a change in throttle to keep altitude constant. At very low speeds (i.e., during takeoffs and landings), the effect of AoA on speed is most pronounced.

As a guideline, first select your AoA using the flight stick, then adjust the throttle until you are flying. (In the game, your current indicated airspeed — in KIAS, or knots indicated air speed — appears in the rectangle on the left side of the HUD, as well as in the ADI MPD. See **Cockpit: Basic HUD Symbolology**, p. 2.5.)

ALTITUDE

An aircraft gains altitude as a result of lift.

As with airspeed, altitude can be expressed in several ways. The two most important altitude measurements in the game are the *indicated* (barometric) and *radar* altitudes. In the Up Front Control display, you can choose whether or not to display radar altitude. (See **Cockpit: Customizable Basic Symbolology: Radar Altitude**, p. 2.9.)



Barometric altitude gives your altitude above sea level (ASL). *Radar altitude* indicates your altitude above the ground over which you are flying (AGL).

Altitude reduces engine performance as a result of lower atmospheric air pressure. As altitude increases, air becomes less dense. An aircraft's *critical altitude* is how high it can fly while maintaining normal engine power. There is a certain limit to how high an aircraft can fly with any efficiency. At 25,000 feet, an aircraft's jet engines are only producing about half the power they can at sea level.

G-FORCES

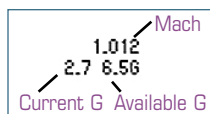
The relationship between the forces of lift and weight can be described in terms of “G.” 1G is equivalent to the gravitational force on an object at sea level. An airplane in level flight experiences 1G of force, as the earth pulls on it.

G-forces are most commonly felt during sharp turns or heavy accelerations, and can be positive or negative. Positive Gs during a turn push you back into the seat, while negative Gs exert a pulling effect. In high-G maneuvers, your heart must work harder to pump blood away from the direction of the pull.

A well-trained pilot can endure about 9-10 positive Gs for a limited time — anything beyond that can cause tunnel vision or blackout. Blood collects in the lower torso and the legs, denying blood to the brain. Eyesight starts to “gray-out,” and eventually you will black out. A similar condition called “red-out” occurs when the aircraft pulls too many negative Gs — blood collects in the upper regions of the body, and the blood vessels in the eyes swell. This causes your vision to go red. Usually, this starts occurring after several seconds of flying at -3Gs or greater.

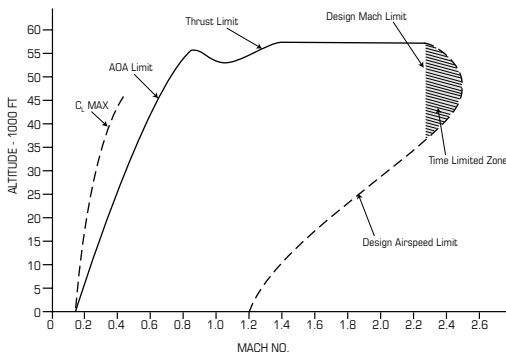
The F-15E Strike Eagle has a superior airframe that can withstand more Gs than its pilot can. Both red-out and black-out effects are accurately simulated in the game.

For this reason, you must pay attention to your current G-force level by checking your HUD. If you exceed your available G limit, an audio warning will sound in the cockpit.



THE FLIGHT ENVELOPE

Lift is a function of an aircraft's speed, altitude and angle-of-attack. All of these factors work together to produce flight, and all three must be considered together when talking about how airplanes maneuver. Their limits are graphically described by an aircraft's flight envelope.



Above is a flight envelope diagram for the F-15 Strike Eagle. As G-forces change, the positions of the curves may change accordingly.

The fighter's altitude is on the vertical axis. Its speed measured in Mach numbers is on the horizontal axis. The curve plotted on the graph represents the envelope limits at 1G. This is a simple depiction of the F-15E's performance limitations; different weapon configurations require adjusted envelopes since they modify weight and drag.

ABSOLUTE LIMITS

Angle of Attack (AoA). Angle-of-attack is one of the most important considerations in the flight envelope. No matter what altitude, loadout or airspeed the aircraft has, AoA is a limiting factor. Generally, the safe operating AoA limit for the F-15E is 30 units. For maximum lift, the AoA should be about 17 units. If AoA becomes too steep, a high-pitched, 900-hertz audio tone will activate in the cockpit.

In the flight envelope, the solid, ascending part of the curve shows the maximum lift available at subsonic speeds. Toward the top of the curve (flight at higher altitudes and speeds), buffeting and other airflow-induced turbulence will occur.

In the game, the current AoA reading appears just below the indicated airspeed on the left side of the HUD.

Airspeed. The right section of the curve shows the F-15E's maximum airspeed at different altitudes. Higher airspeeds are possible at higher altitudes because the air is less dense, and therefore, less induced drag occurs. Exceeding the airspeed edge of the envelope can cause structural damage to the aircraft.

The F-15E's airspeed limit is about 800 knots, and its Mach limit is 2.5. These limits vary slightly according to weapon and fuel loads.

Mach number. The upper right section of the curve shows the maximum mach speed limits. Note the dashed area on the right tip of the graph — flight within that part of the envelope is time limited. Maintaining Mach 2.3+ speeds for longer than that can cause structural overheating.

Thrust. The flat, top part of the curve indicates the maximum airspeed that can be obtained at max thrust while maintaining a level flight path. Climbing to a higher altitude will reduce airspeed, and (if the AoA is too high) cause the aircraft to lose altitude and come back into the flight envelope.

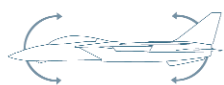
G-forces. The aircraft can sustain several negative Gs for about ten seconds, although this depends partly on the fuel and weapons load. The example envelope gives the flight envelope for 1G of force. If greater G-forces are incurred, the envelope changes shape. The aircraft's maximum G-force capability and current G-force reading appear on the HUD.

FLIGHT CONTROLS

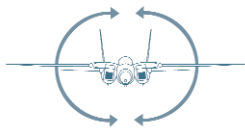
Lift is normally generated perpendicular to the wing. Movable control surfaces — ailerons, elevators and rudders — alter this lift to rotate the aircraft around its aerodynamic center. You use these controls to maneuver the airplane.

PITCH, ROLL AND YAW

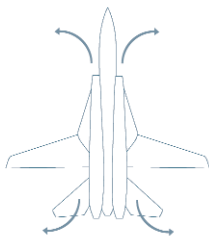
Aircraft maneuver in three dimensions: *pitch*, *roll* and *yaw*. These dimensions are always referenced from the pilot's point of view, regardless of the aircraft's orientation or flight attitude. When you move one of the aircraft's controls, you're providing *input*.



Pitch



Roll



Yaw

Pitch is the movement of an aircraft's nose up and down. Pitch is controlled by the aircraft's stabilizer—the flat, rear control surface on the F-15E (sometimes referred to as the elevator). During a pitch maneuver, the entire stabilizer surface angles up or down. This causes a difference in pressure above and below the stabilizer surface, and pitches the nose of the aircraft down or up, accordingly.

Roll is controlled by the aircraft's ailerons. Ailerons, like flaps, are hinged panels on an aircraft's wings. Unlike flaps, ailerons move in opposition to each other, increasing lift on one wing and decreasing lift on the other. This difference in lift causes one wing to dip down as the other rises, which rolls the aircraft about its nose-tail axis. The F-15E's rudder can also be used to induce roll.

Yaw is the sideways movement of an aircraft's nose. The attitude of the aircraft (angle of the nose) remains constant, while the aircraft pivots left or right. Yaw is controlled by the aircraft's tail rudders.



Combination movements that involve both pitch and yaw inputs result in *coupled motion*—motion that occurs along both the longitudinal and directional axes. By contrast, simple movements (yawing or pitching up) are non-coupled motion. Yaw can be coupled with pitch to create a banking turn or a rolling effect.

FLIGHT STICK

Moving the stick forward or backward moves the aircraft's stabilator and causes a change in pitch. Pulling the stick back, or *applying aft stick*, causes the aircraft's nose to rise. Pushing the stick forward — *applying forward stick* — causes the aircraft's nose to drop. Moving the stick right and left, or *applying lateral stick*, controls the ailerons. For example, moving the stick left causes the aircraft to roll left; moving it right rolls the aircraft to the right.

RUDDER PEDALS








The rudder pedals move the aircraft's rudders, controlling yaw. Applying right rudder yaws the aircraft's nose right. Pushing the left rudder yaws the aircraft's nose left. The F-15E has a rudder lockout at speeds greater than Mach 1. This means that above that speed, you can't apply any more rudder input. The lockout is a safety feature designed to keep the aircraft under control.

Rudder usage also induces roll. When using rudder, the aircraft will roll in the direction that rudder is applied. Rudders are primarily used for lining up shots and spin recovery. Control them with rudder pedals if you have them, or use the **RUDDER_LEFT**  or **RUDDER_RIGHT**  keystroke functions.

THROTTLE

The throttle controls the engine's thrust output. Pulling the throttle back decreases engine output. Pushing the throttle forward increases engine output. The engine's maximum output without using afterburners is called *mil power*. Afterburners increase engine thrust by dumping raw fuel into the engine's exhaust then igniting it. The increase in thrust is significant, but fuel is consumed much faster.

In the game, you control the throttle position with a throttle device as described below. Or, you can use the corresponding keyboard throttle functions to control your thrust.

Throttle Position	Effect	Keystroke Function
Move completely forward	Increase throttle to full /engage afterburners	THROTTLE_AB 
Move most of the way forward	Increase throttle to military power	THROTTLE_MIL  
Move slightly forward	Increase throttle	THROTTLE_UP 
Move slightly backward	Decrease throttle	THROTTLE_DOWN 
Move completely backward	Throttle to flight idle	THROTTLE_IDLE  

To display the current throttle reading on the lower left corner of the HUD, see **Cockpit: Customizable Basic Symbolology**, p. 2.5.

FLIGHT CHARACTERISTICS

Flight characteristics are a collective set of tendencies that reflect an aircraft's stability and maneuverability. An aircraft's shape, weight, external stores and built-in flight control systems determine its basic flight characteristics in a specified flight envelope. As changes occur in the center of gravity, lift, speed and momentum, the flight characteristics may vary. A fully loaded aircraft traveling at Mach 2 at an altitude of 30,000 feet isn't going to act the same as a lightly loaded plane.

TURN PERFORMANCE

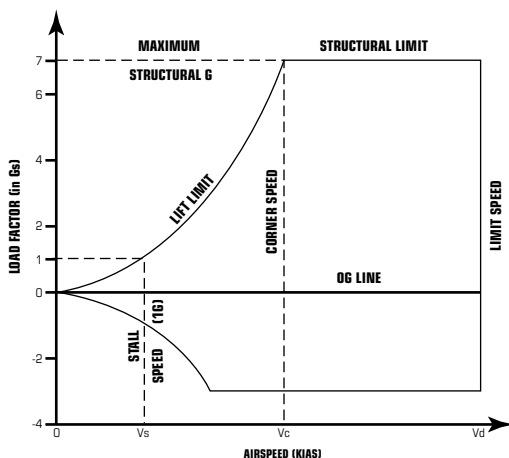
An aircraft's *turn performance* is its ability to change direction during flight. This is often referred to as maneuverability. The number of Gs an aircraft can pull in a turn is a general indication of how tightly it can turn.

An aircraft's maximum turn performance can be characterized in two ways — *instantaneous* and *sustained*. The acceleration felt during a turn is the *load factor*.

Load Factor. This is a component of the centrifugal acceleration created during a turn. Making a turn increases the aircraft's acceleration and adds G-force — this is called the *load factor*. The higher the airspeed, the greater the load factor during a turn.

Instantaneous Turn Capability. This refers to an aircraft's best turn performance at any one instant in time. As speed and altitude change, so does the aircraft's instantaneous-turn capability. The amount of lift an aircraft can produce relates directly to instantaneous-turn performance.

A V_n diagram is a graphical representation of the load factor versus the airspeed. Above the OG line, the aircraft pulls positive Gs; below it, the aircraft



pulls negative Gs. Lift limits for various airspeeds and load factors are also shown on the graph.

Sustained Turn Capability.

In a sustained turn, the aircraft maintains a specific turn rate and radius for some time. The load factor must be at least 1G to maintain current lift and

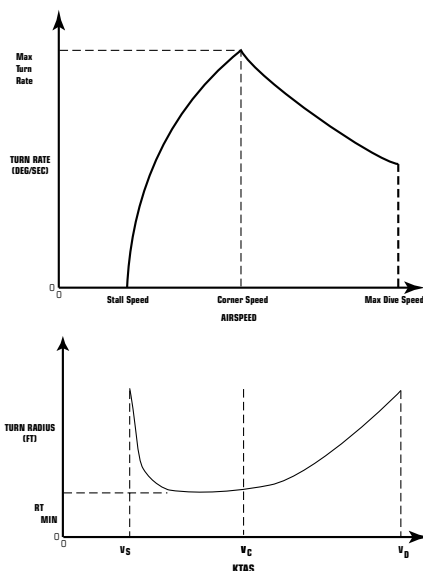
altitude. At higher load factors, turn performance improves, but drag increases. The overall sustained turn capability of an aircraft depends on its thrust-to-weight ratio and its lift capability.

Lower airspeeds yield optimal sustained turns — in general, the lower your airspeed (to a point), the more quickly you can execute a turn. This gives credence to the old fighter pilots' adage "Slow down, and get there faster."

TURN RATE AND TURN RADIUS

Turn performance is measured in terms of turn rate and turn radius. *Turn rate* is the number of degrees per second a particular aircraft can turn. Higher airspeeds and smaller bank angles slow down the turn rate. *Turn radius* is the radial distance required to complete the turn. The radius increases with velocity and decreases with a more extreme bank angle. A high turn rate and a low turn radius yield the best turn performance.

Angle-of-attack (AoA) affects turn performance. During a *maximum turn* (the tightest turn possible), the AoA should be near (but not exceed) 30 units. In an *optimum turn* (the fastest turn possible), the intent is to save momentum while sacrificing turn radius. The AoA during this type of turn is less, usually falling inside the 16-22 unit range.



CORNER SPEED

For any given altitude, the speed at which maximum lift occurs without structural damage during a turn is known as the *corner speed*. The corner speed gives the best turn performance — that is, the highest possible turn rate with the lowest possible turn radius. At the corner speed, the aircraft experiences its maximum instantaneous turn performance.

The V_n diagram above shows corner speed. Note that the corner speed occurs at a velocity that provides maximum lift at the structural boundaries of the aircraft.

AUTO-CONTROL SYSTEMS

Each aircraft has unique handling capabilities that result from the aircraft's shape, size, weight and structural strength, and the F-15E is no exception. The Strike Eagle has several systems that assist you in handling the aircraft.

The first of these is the Control Augmentation System (CAS), which attempts to stabilize the G-forces the aircraft experiences during normal flight within the flight envelope. The CAS is designed to automatically modify your original pitch, roll and yaw inputs to account for varying flight conditions. If CAS is operating correctly, you can maintain a certain stick force and a certain G-force during flight, regardless of speed or load changes.

Another system used in the F-15E is the Pitch Trim Compensator (PTC), which automatically *trims* the aircraft's pitch. (The process of trimming involves using the aircraft's onboard computer to automatically make fine adjustments to maintain stable, 1G flight.)

Aircraft handle differently at higher Mach numbers and angles-of-attack, and it's easy to overcompensate with the flight controls. The F-15E's Automatic Flight Control System (AFCS) helps bridge this gap by modifying each control input you provide so that the adverse effects of changing speeds and AoA are minimized. This allows you to take advantage of the Strike Eagle's entire flight envelope.

The AFCS can adjust for unbalanced weapon and fuel loads and single-engine failure. It can also make certain adjustments when the aircraft is in its landing configuration. However, if the AoA is too high during these conditions (over 30), undesired yaw may occur.

FLIGHT DISRUPTIONS

While modern aircraft have overcome many aerodynamic limitations, they're still not completely immune to problems. If airflow is sufficiently disrupted by a steep AoA or yaw maneuver, the aircraft can depart from its normal flight path and enter a spin or stall. The next sections talk about adverse flight conditions under which disruptions might occur and describes how to recover from them.

Most flight disruptions have early cues that, if noticed, can be addressed before the situation becomes more severe. Under each discussion, you'll find cue and recovery entries — study these, and you'll be equipped to recognize problems as they occur. If you stay within the aircraft's limits, most problems can be avoided.

If the aircraft is not responding to any flight control inputs, it is out of control. Not much can be done to regain normal flight until the controls respond. In some cases, the only choice may be to bail out. Sometimes, you can use the flight controls to neutralize the undesired movement. Other times, it's best to leave the controls alone.

ADVERSE YAW (HIGH AOA)

Adverse yaw is the movement of the aircraft's nose (or rear) to one side, also known as *sideslip*. The nose points in a different direction than the aircraft is actually flying. This occurs naturally when you use the aircraft's ailerons to make a banked turn — the wing that dips during a left-hand bank incurs less drag than the opposite wing. This makes the airplane yaw to the right, even though the turn is to the left. In some aircraft, you must apply rudder in the direction of the turn to overcome undesired yaw and make a *coordinated turn*.

In the F-15, the CAS automatically compensates for adverse yaw by adding rudder input. However, during a high-speed, high-AoA turn, problems can result.

Cues. The slip indicator and/or velocity vector indicates sideslip in one direction. In a roll maneuver, the roll rate may decrease, or the roll may reverse direction.

Recovery. The AFCS automatically compensates for this. However, you can reduce AoA and apply more rudder in the direction of the turn until the slip ball in the HUD is centered.

DEPARTURE

Departure is a general term used to describe an undesired change in the aircraft's flight path. In most cases, departure occurs when AoA is high and directional stability (stability on the wing-wing axis) is disturbed by uneven weapon and fuel loads. Departures often occur at high altitudes and high AoA, when the center of gravity is too far forward, or when you give control inputs in the wrong direction while the aircraft is unstable.

Cues. High AoA can contribute to departure. The first indication normally resembles an early stall, and a yaw tone may sound. As departure occurs, the aircraft starts yawing or rolling to the right or left without any input from you. If you don't deal with this immediately, the aircraft may enter a spin.

Recovery. If you watch for early signs of a stall, you can usually prevent departure. If it does occur, quit pushing the flight stick sideways, and reduce AoA by pushing forward on the stick. You can apply additional rudder if the departure is severe.

AUTOROLL

True to its name, the autoroll is a prolonged roll that continues even after the flight stick and rudder are in neutral positions. This is one type of coupled motion, usually caused by starting a roll using the rudder while AoA is high and airspeed is between 200-300 knots. If all you do is reduce AoA, the roll simply speeds up.

Cues. The aircraft rolls and accelerates even after you neutralize the flight stick and rudder. AoA remains high, and the HUD registers a negative G-force.

Recovery. To prevent autorolling, don't apply sharp rudder while AoA is high, and don't make quick pitch/yaw motions. If it does occur, apply rudder in the direction opposite the roll and lower the AoA. Once the roll slows down, the nose will drop.

SPINS

A spin is a type of coupled motion that occurs when one wing (but not the other) loses a significant amount of lift. It is almost always preceded by departure. The wing drops, pulling the aircraft into a rotating, spiral dive that combines roll and yaw. A spin can consume several thousand feet of altitude per revolution, and spin recovery may require several revolutions. Spins at low altitude are extremely dangerous.

There are several different types of spins:

A *flat spin* is characterized by high negative G-forces (up to -4G). The yaw rate is between 75 and 135 degrees per second (a full circle every two to five seconds) and, for the most part, remains constant. AoA is low, accounting for the "flatness" of the spin.

An *oscillatory spin* resembles severe yaw, at least from your perspective as a pilot. One wing is stalled (or close to stalling), and control attempts fail. The yaw rate usually falls between 60 and 90 degrees per second (a full circle every four to six seconds), and AoA usually exceeds 70 units.

An *inverted spin* can occur if you stall while experiencing negative G-forces. Most often, this happens when you suddenly drop the nose by pushing the stick forward, then apply full rudder or roll inputs. The yaw rate nears 45 degrees per second (a full circle about every eight seconds) and remains constant, and AoA is usually around negative 60.

An *inadvertent nose high* or *nose low spin* occurs when you make a steep vertical climb at low airspeed. The aircraft loses speed and the controls fail until the aircraft falls back and regains airspeed through a dive.

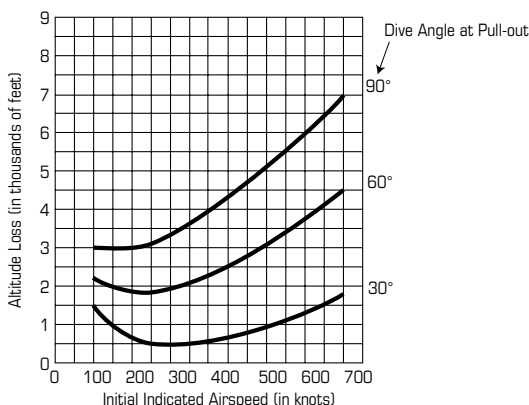
SPIN RECOVERY

A spin used to be nearly unrecoverable. However, spin recovery procedures possible in the F-15 make most spin situations survivable. You'll need several thousand feet of altitude to recover from a spin, so make sure you've got room to try. (For major emergencies, you can command the **PILOT_EJECT** **[Shift] [E]** function.)

In the game, use the following steps if you find yourself in a spin:

1. Center your joystick. Using the ailerons to bank often aggravates the spin.
2. Apply full opposite rudder.
3. Push your joystick forward slightly to keep the nose down.
4. Maintain these stick and rudder positions until the aircraft stops spinning. You will generally find yourself in a low-speed dive — a perfect target for enemy aircraft. Increase throttle until you reach a speed of around 200 knots, gently pull out of the dive and return to normal flight.
5. If the aircraft is still unwilling to recover after the steps above, go through the procedure again.
6. If it still doesn't work, eject.

Dive Recovery — Emergency Pull-Out Chart



STALLS

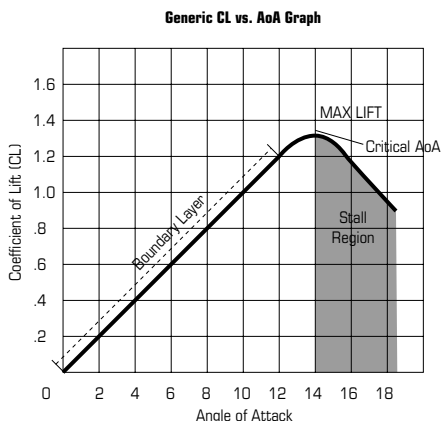
A stall occurs when AoA exceeds maximum allowable levels and smooth air-flow over the wings is disrupted. It is the condition under which any increase in AoA decreases lift.

As an aircraft flies straight and level, its wings meet airflow at a low AoA. As the airplane pitches up, AoA increases and thus lift increases — up to a point. If the angle becomes too steep, the force of the air pushing backward is greater than the force of the air pushing up. Called the *critical angle of attack*, this is the point past which the wings cease to create lift.

If AoA passes the critical point, the layer of air moving around the airfoil becomes turbulent. It no longer separates and flows around the wing in an optimal fashion. Stability is reduced, lift vanishes, and the aircraft can literally fall out of the sky. This is known as a *stall*. Increasing AoA in an attempt to pull out of a stall will aggravate the stall.

The adjacent generic graphic illustrates that increasing AoA will increase lift up to a point, called the “critical AoA.”

Beyond this point, the effective surface area on the top of the wing that is being used to create lift is reduced.



STALL AVOIDANCE/RECOVERY

- Always monitor airspeed, especially if you're pitching above 45°. Watch your external stores as well. If you're carrying a full load of air-to-ground weapons, your aircraft will be heavier, and it will require more airspeed for adequate lift.
- Take particular care to avoid stalls at low speeds and altitudes. If you can't dive to regain speed, you're going to buy the farm.
- To recover from a stall, push the stick forward to reduce your angle-of-attack and add engine power.

TAKING OFF AND LANDING

This section introduces the basics of flight and teaches you how to take off and land in the F-15E. For information on the F-15E's cockpit, see **Cockpit**, Chapter 2.

The first rule to learn about takeoffs (and landings, for that matter) is that you should use your throttle, not necessarily the flight stick, to control your altitude. By throttling up or down, you can directly affect the amount of available lift.

TRAINING MISSIONS

The game's training simulator provides several missions that let you test your takeoff and landing skills.

To practice, select a mission and left-click **ACCEPT**. Read the briefing text, and when you're ready to practice, left-click **FLY**.

TAKEOFF

You can achieve a good takeoff by following a few simple guidelines:

- Make sure flaps are extended. (This is their default position at takeoff in the game.) When flaps are down (extended), the green flap indicator light on the right side of the console glows (**FLAPS** **[F]**).
- Release the wheel brakes (**WHEEL_BRAKES** **[B]**).
- Increase throttle to full by rolling your joystick's throttle device all the way forward (**THROTTLE_AB** **[V]**). (Afterburners automatically activate when you operate at full throttle.)
- Watch the boxed number on the left side of the HUD — this represents your current indicated airspeed. (See **Airspeed**, p. 3.3.) The number should be increasing.
- When you gain enough airspeed (see chart), pull back on the flight stick.

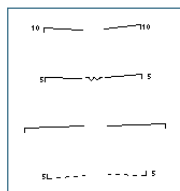
Takeoff speed varies according to how much fuel you're carrying, and how many external weapons are loaded onto the aircraft. Lightly loaded aircraft require less airspeed, while heavier aircraft must travel faster to lift off the ground. The following chart gives general guidelines for takeoff speeds at various weights.

TAKEOFF SPEEDS - MAXIMUM THRUST (KIAS)

GROSS WEIGHT (LBS)	ROTATION	NOSEWHEEL	LIFT-OFF
40,000	110	133	159
45,000	115	136	162
50,000	120	140	166
55,000	125	145	169
60,000	130	150	173

Three speeds are listed. The first is rotation speed, the point at which you initiate pullback. The second number indicates the speed at which you will experience nosewheel liftoff. The third number gives the speed at which you will become airborne. In between the first and second speeds, you should apply aft stick to maintain a pitch angle of about 12 degrees.

- After takeoff, relax the pressure on the flight stick to neutral. Keep an eye on your current radar altitude — the boxed number on the right side of the HUD.
- Pitch the nose up slightly (between 10° and 20°, but don't exceed 30°).
- Relative to the watermark, the horizontal ladder lines in the middle of the HUD display your current pitch (in degrees). The more angled the lines, the greater the pitch angle. The tiny brackets on the outside edges of each line point toward the horizon. Positive angles are solid, while negative angles are dashed.



Don't confuse pitch angle with AoA — the first compares the angle of the aircraft's nose relative to the horizon, while the second describes the angle at which the wing meets the air. AoA appears just below the indicated airspeed on the left side of the HUD. See **Angle of Attack (AoA)**, p. 3.2.

14.9

- Once you're sure that you're safely airborne, retract the landing gear (LANDING_GEAR **[G]**).
- Retract the flaps (FLAPS **[F]**).

Extending flaps increases lift during takeoff and landings, but also increases drag. Raising flaps after takeoff reduces lift and drag during normal flight.

- Reduce throttle to the desired cruise setting. The most efficient airspeed for climbing is around 300 to 350 knots.

LANDING

Landing is a challenging task, and a rewarding finale to a successful mission. If you want to practice landing, try flying the landing tutorial mission.

To make a safe landing, you must first make a good approach, flying in at the correct speed, altitude and direction. A number of factors come into play when landing.

Direction. Flying toward your last steer point should correctly orient you so that you're flying directly toward the airbase. When you can see the runway, make sure you're aligned with it.

Angle-of-Attack. Your current angle of attack appears on the left side of the HUD. Remember, during landing, use the *throttle* primarily to control AoA and altitude, not the flight stick. By throttling up or down, you can alter the amount of available lift, and therefore, your altitude. Be careful about pitching the nose up and down — at low airspeeds, this can be problematic and may cause a stall.

During the final stages of landing, keep the AoA steady between 20-22 units. Use the throttle to adjust this as necessary.

INSTRUMENT LANDING SYSTEM

To correctly align your aircraft with the runway — especially at night or under reduced visibility — you'll need to rely on the Instrument Landing System (ILS) and indicators on your HUD.

This system places horizontal and vertical “needle” indicators onto your HUD that help you line up with the runway. You can activate the ILS when you're about 10-20nm away from the runway.

Activating ILS

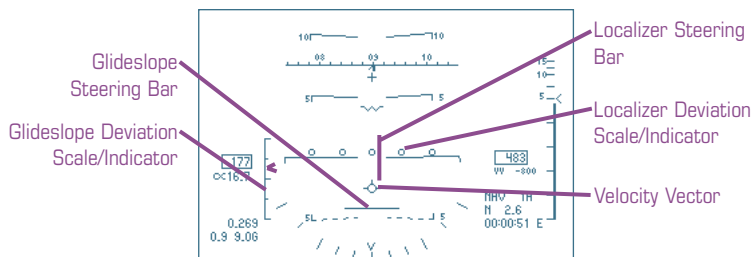
- Fly within approximately 10nm of the runway.
- Make sure Navigation or Instrument master mode is active.

NAV or INST should be glowing yellow on the master mode pushbutton (near the bottom of the cockpit display — if not, left-click that button). You can also use the **MASTER_MODE_SELECT** (M) key.

- Press the ILS pushbutton (PB #5) in the UFC. (The text will then read ILS ON.)

In this manual, the MPD and UFC pushbuttons are numbered 1-20, beginning in the upper left and moving counterclockwise. PB #5, for instance, refers to the bottom left UFC pushbutton. See **Cockpit: Multipurpose Displays (MPDs)**, p. 2.24 and **Up-Front Controls**, p. 2.64.

The ILS has several indicators that help you correctly line up. The idea is to maneuver so that the horizontal and vertical steering bar lines form a cross and fall on top of the velocity vector indicator. These indicators appear on the ADI as well.



Glideslope Steering Bar. This horizontal line indicates your altitude relative to a 3° glideslope (the optimal angle for descent.) If you are above this glideslope, the velocity vector will be above this line. If you are below this glideslope, the velocity vector will be below the line.

Glideslope Deviation Scale/Indicator. This scale on the left side of the HUD measures your deviation from the recommended 3° glideslope. A small, v-shaped caret shows your current deviation. The center of the scale marks the recommended glideslope. The top tick marks 1° above the glideslope, while the bottom tick marks 1° below.

Localizer Steering Bar. This vertical line indicates your horizontal lineup with the runway. If you are to the left of the runway, the velocity vector will be to the left of this line. If you are to the right of the runway, the velocity vector will be to the right of the line. This bar shows your position relative to the center line of the runway and doesn't depend on your heading.

Localizer Deviation Scale/Indicator. This row of dots in the center of the HUD measures your deviation from a dead-on (straight-ahead) approach to the runway. A vertical arrow marks your current deviation. The center circle marks a dead-on approach. The leftmost circle marks a 2.5° deviation to the left of the runway, and the rightmost circle marks a 2.5° deviation to the right.

Velocity Vector (Flight Path Indicator). The velocity vector is a circle that moves around on the HUD. It indicates the direction in which your aircraft is actually moving (which is often different from the direction in which your nose is pointing).

When landing, keep the velocity vector centered over the lined-up localizer and glideslope steering bars. Steer toward the center of the cross. This will give you the ideal landing approach.

MAKING THE LANDING

Follow these steps to make the final approach.

- Adjust thrust so that you've got about 300 knots of airspeed. If the throttle is about 25% power and you're still going too fast, use the speed brake to bleed off some airspeed.
- At 230 knots, lower the landing gear and flaps (GEAR **[G]**, FLAPS **[F]**).
- Use the throttle to keep the AoA between 20-22 units.
- Make slight throttle adjustments to gain or reduce airspeed and lift as necessary. Use the rudder if you need to make slight yaw adjustments to stay lined up with the runway.
- Overlap the horizontal and vertical ILS steering bars so that they form a symmetrical cross. Then, center the velocity vector over this cross. When this happens, you are descending at the correct glideslope angle (3°). Finally, use your throttle and rudder to keep the lines crossed and centered on top of the velocity vector.
- Check your pitch angle. Just prior to touch down, it should read about 12° or so, and your AoA should be approximately 21 units.
- At touch down, reduce throttle to idle (move the throttle device all the way back).
- (Optional) Activate the speed brake **[S]**. At the same time, maintain a pitch angle of 12° or so. This helps soften the nose wheel landing, and also uses wind resistance against the aircraft to bleed off some speed.
- When your speed slows to about 80 knots, drop the nose down onto the runway.
- Apply the wheel brakes (WHEEL_BRAKES **[B]**).

ABORTING A BAD LANDING

If you're too low, too high, too fast or too slow, you may not be able to correct your landing in time. If this happens, abort the landing and try again:

- Punch your throttle to 100% (move the throttle device all the way forward), but don't change course.
- Retract the flaps and speed brake (if active).
- Raise the landing gear.
- Climb back to an altitude of 6,000 feet.
- Make a wide 180° turn to the left, straighten out, and try a second approach from the original direction.

NAVIGATING

This section describes basic navigation terms and covers different navigational tasks that you'll use every time you fly. It also covers in detail the various navigational functions of important cockpit displays.

TERMS

Before exploring the wild blue, you should be familiar with the following navigational terms:

Sequence point. A set of coordinates denoting a geographic location. These points are stored in the aircraft's computer and collectively form your flight route. A graphical representation of these points appears in a cockpit display called the **Tactical Situation Display Page** (see p. 2.34).

Bearing. Lateral direction relative to your plane's nose, measured in degrees from 0° to 360°. An enemy directly to your right has a bearing of 90°, no matter what direction you're traveling.

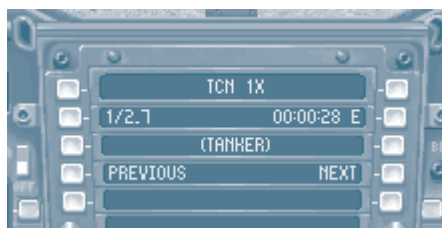
Heading. Direction relative to true north, measured in degrees from 0° to 360°. If you're heading north, your heading is 0°. If you're flying due south, your heading is 180°. If you're flying southwest, your heading is 225°. You can always determine what your current heading is from the heading scale (see p. 2.6).

TACAN. Tactical Aid to Navigation, which refers to signals broadcast by airbases and aircraft. These signals act as beacons and can aid in navigation.

TACAN SIGNALS

TACAN stands for Tactical Aid to Navigation, a system that many friendly ground stations and airborne tankers use to emit a signal broadcasting their position. TACAN channels provide pilots with positional information. Each TACAN object (such as an airfield or tanker) has a different station ID and operates on a unique TACAN channel.

Not all missions contain TACAN objects. In the ones that do, you can activate different TACAN channels in the UFC display via the TACAN submenu. To access this display, select the TCN pushbutton in the UFC (PB #2).



Initially, the selected channel defaults to the initial TCN channel, if one is available. (If not, “xxx” appears.) When one is available, a channel number will appear, followed by a letter. Ground stations have the letter “Y” after the channel number, while airborne aircraft have an “X.”

To select a TACAN signal:

- Select the TCN pushbutton on the UFC display (PB #2).
- Cycle through available TACAN channels. To select the previous channel, click the PREVIOUS pushbutton (PB #4). To select the next one, click the NEXT pushbutton (PB #7).

The station ID (name) of the current channel station appears in parentheses. Its bearing and range appear on the left above the name, and the estimated time-to-arrival (or time-on-route, if selected) appears on the right above the name.

Select the dark gray MENU pushbutton on the UFC keypad to return to the UFC main menu display.

To follow a TACAN signal:

- Select a TCN station as previously described.
- Switch to Navigation master mode, if it isn't already active, by selecting the NAV master mode pushbutton at the bottom of the screen.

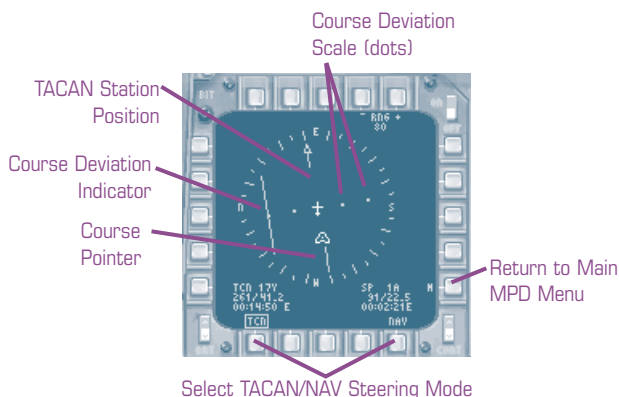
The Nav master mode activates the Air-to-Air Radar MPD (left display), Horizontal Situation Indicator (HSI) MPD (right display) and Tactical Situation Display (TSD) MPD (low, center display). In addition, it places a bank angle indicator and information about the current sequence point on the HUD.

- Select the TCN pushbutton (PB #6) in the HSI MPD or select the TCN STR pushbutton (PB #6) in the UFC display (see **Cockpit: Up Front Controls**, p. 2.64). This activates TACAN steering, meaning that the navigational system will now track TACAN signals instead of sequence points in the HSI.

Once you switch the tracking method, more information displays on the HSI. The line with the arrow is called the *course pointer* and points toward the physical location of the TACAN station. If the object is within HSI range, that station will appear on the HSI as an icon.

A second, parallel line called the *course deviation indicator* indicates how far off course you are relative to the course pointer. It drifts left or right, but should ultimately be centered on the course pointer.

The row of five dots is the *course deviation scale*, which remains perpendicular to the course pointer. Try to line up the course deviation indicator with the center dot. Each dot from the center represents 5° of error. If you have more than 10° error, the course pointer will be pinned to the edge of the compass rose.



- Adjust your heading so that the HSI course pointer arrow faces the top, and the course deviation indicator is directly on top of it. If you continue on this course, you'll be flying toward the TACAN signal.

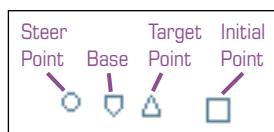
With TCN steering active, you can also select an autopilot mode that will automatically follow the chosen TACAN signal. See **Autopilot Modes**, p. 3.27, for details.

SEQUENCE POINTS

Sequence points denote navigational paths that are set before flight in the Briefing Screen and stored in the aircraft's computer. (See **Interface: Briefing**, p. 1.6.) Generally speaking, you fly to *steer points*, *initial points* and *target points* to complete your mission flight path. It isn't required that you visit points other than your target location, but the preplanned sequence points indicate the best probable path for accomplishing the mission.

A pictorial representation of them appears in your Tactical Situation Display (TSD) MPD. In the TSD, steer points, initial points and target points are connected by lines that indicate your planned flight path. You may be able to change some of these points before taking off.

The TSD and its navigation and color map information can be useful when navigating — see **Cockpit: Tactical Situation Display Page**, p. 2.34.



Base point. The original airbase from which you took off is marked by a homeplate-shaped *base* icon.

Steer points. Series of geographical points that mark the route you are to fly. In the TSD, they are represented by small, sequentially numbered circles.

Target points. Target points are marked by numbered triangles, and indicate areas at which air-to-ground weapons will be launched — see **Combat: Finding and Designating Targets**, p. 4.51.

Initial points. An initial point indicates a steer point just prior to a target point. Initial points are numbered squares.

NAVIGATING THROUGH SEQUENCE POINTS

All sequence points — steer, target and initial points — are numbered, and may be followed by a letter (3A, for example). You follow the points in order. Once you are within range of a particular point, the navigation system automatically selects the next sequence point. You can manually change sequence points as well.

See **Cockpit: Steering Data**, p. 2.68, for more information about sequence point numbering.

To change the selected Sequence Point:

- Press the STR pushbutton (PB #10) in the upper right corner of the UFC.

The number of the currently selected navigation point appears to the right of STR. Each time you click the pushbutton, the number changes to reflect the next sequence point in order. You can also cycle through sequence points by assigning this function to the keyboard. (See **Cockpit**, p. 2.71, for details.)

To fly toward the next Sequence Point:

- Center the *command heading bug* on the heading scale.

To see what direction you're currently flying, look at the heading scale at the top of the HUD. It gives your current heading in tens of degrees (36 indicates 360°, etc.).

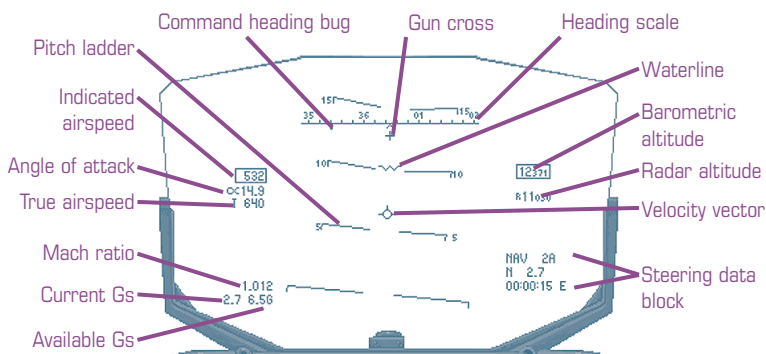
If you're already headed in the right direction, a small, heavy line will be directly underneath the heading scale. (See **Cockpit: HUD**, p. 2.5.) This line, called the *command heading bug*, indicates the heading of your current sequence point. Try to keep this line centered on the scale. Bank slightly if necessary.

If the bug moves off the scale, a small number appears to the right or left of the scale, indicating the heading for that sequence point. Bank toward the number until the command heading bug reappears in the HUD.

To view Sequence Point information on the HUD:

- Switch to NAV, A/G or INST master mode. (Press a master mode pushbutton just below the UFC keypad.)

When one of these master modes is active, the HUD displays three lines of text in the lower right corner. This text is collectively known as the steering data block and gives you information about your current sequence point. The top line gives the alphanumeric description (2A, for example). The second line gives the compass direction, followed by the range in nautical miles. The third line gives an estimated time of arrival (ETA) or estimated time en route (ETE). See *Cockpit*, p. 2.7.



STEERING

You can select a steering mode in the Horizontal Situation Indicator (HSI) MPD by selecting a steering type (TCN — the system tracks TACAN signals, or NAV — the system tracks sequence points). See **TACAN Signals**, p. 3.22, for information about TACAN beacons.

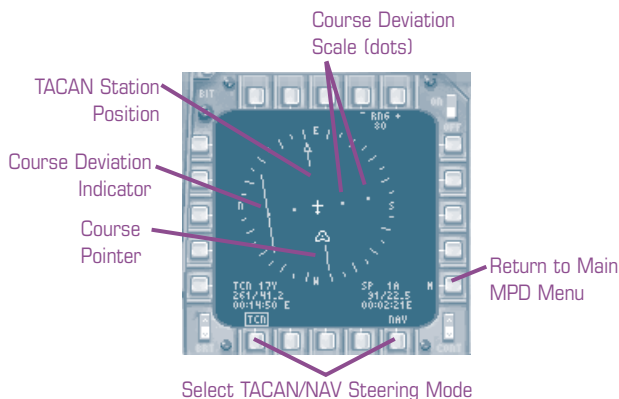
The HSI appears on the right MPD by default in Navigation master mode and shows a top-down view of the area around your aircraft. Your position is marked by the small aircraft symbol in the center of the display, with the nose always oriented to the top of the display. The current steering mode is boxed. To switch modes, select the TCN or NAV pushbutton (PB #6 or #10).

When NAV steering is active, your next scheduled sequence point appears as a circle. As you fly, the circle moves to reflect where you are in relation to that sequence point.

When TCN steering is active, a long line with an arrow (course pointer) gives you a constant idea of what heading adjustments you need to make to fly toward the TACAN signal. A second, parallel line (course deviation indicator) shows your horizontal alignment with respect to the TACAN signal — if it's not centered on the course pointer, you need to yaw or bank toward the signal. (See the picture below.)

No matter which steering mode is active, the bottom right corner displays range, bearing and estimated time-to-arrival information about the current sequence point. The bottom left corner displays the same information for the current TACAN signal, if one is active in that mission.

See **Horizontal Situation Indicator Page**, p. 2.32, for more information about this MPD.



AUTOPILOT MODES

The F-15E's autopilot system is complex and has several modes available. You activate autopilot by selecting the **AUTO** pushbutton (PB #9 in the UFC menu), and you set the mode using the UFC. You can also use the **AUTO_PILOT** function mapped to the keyboard (**[A]**).

If neither **ALT HOLD** or **STR MODE** autopilot is selected via the UFC (which is the default state), the autopilot automatically defaults to one of two modes. If you are banked beyond 7° , you automatically enter into an *attitude-hold* autopilot mode (which maintains your current pitch and bank angle). Otherwise, if your bank angle is less than 7° , you go into a *heading hold* autopilot mode (which maintains level wings, along with your current heading and pitch attitude).

Most autopilot modes deactivate automatically when AoA exceeds 20 units, bank angle exceeds $\pm 60^\circ$, pitch angle exceeds $\pm 45^\circ$, G-force exceeds available Gs or speed falls below 250 knots.

To switch modes:

- Press the **A/P** pushbutton (PB #9) in the UFC. This displays the autopilot submenu.
- Select a mode. An asterisk appears next to the active autopilot mode. You can select either **ALT HOLD** or **STR MODE**.

STR MODE (Steering Mode) Puts autopilot in coupled steering mode, meaning that the autopilot will fly toward something. In the HSI, you can use pushbuttons (PB #6 and #10) to choose between **TCN** (flies toward the selected TACAN signal) or **NAV** (flies toward the selected navigational steer point). The currently selected steering mode appears on the next line as **TCN** or **NAV**. You can also switch steering modes by pressing PB #6 in the UFC main menu.

ALT HOLD (Altitude Hold) Maintains your current radar (or barometric) altitude. The currently selected altitude type appears on the next line as **RAD** or **BARO** — you can toggle between them by pressing the pushbutton next to the name (PB #5).

AUTOPILOT AND TERRAIN-FOLLOWING RADAR

Whenever you activate terrain-following radar by pressing the **TF** pushbutton in the UFC (PB #4), it overrides any active autopilot functions and resets the autopilot mode to **OFF**. The reason this happens is that when you turn off terrain-following radar at low altitudes, you don't want to resume with an old autopilot mode active — especially if there's a mountain in front of you.

Terrain-following radar autopilot mode automatically deactivates if your airspeed falls below 375 knots.

REFUELING

If you're on a long mission, chances are that a tanker aircraft will be available for refueling. By locating and radioing a tanker, you can approach it and link up in mid-air to replenish your fuel supply. Be forewarned, however, that good refueling hookups take a lot of practice. Also, at higher difficulty levels, the allowable margin of error decreases.

You can use the game's **Auto Refuel** function to automatically refuel (AUTO_REFUEL [Alt F]). Or, you can follow these steps:

- Activate the HSI MPD, if it's not displayed. (Select HSI from the MPD main page.)
- Press the TCN pushbutton in the lower left corner of the HSI (PB #6). This activates TACAN tracking — see p. 2.66 for details.
- Locate a tanker and get its TCN bearing. Not all missions have tankers available. (Campaign missions will list tankers in the mission briefing.) You can locate tankers in one of two ways:

Method 1. Select the TCN pushbutton in the UFC (PB #2). Keep clicking NEXT in the UFC until TANKER appears in the description field (see picture on p. 3.30). When this happens, you've got the tanker's TCN signal locked. The tanker's heading and channel appear below the name in the window.

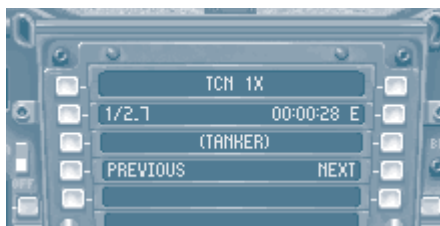
Method 2. Activate communications (RADIO2_TRANSMIT [Shift Tab]) and select AWACS. (Press the key corresponding to the number of the message.) If an AWACS aircraft is available, that message option will be bolded. Select REQUEST CLOSEST TANKER. The AWACS will radio the TACAN bearing of the closest tanker, if a tanker is also available in that particular mission.

- Once you have the tanker's TCN bearing, adjust your heading so that you're flying toward the tanker. The range and bearing of the tanker appear in the HSI.

One quick way to approach the tanker is to activate TCN steering mode and use your aircraft's autopilot function. To do this, select A/P in the UFC, then STR MODE to set autopilot to follow a selected TCN signal. (See **Autopilot (A/P) Submenu**, p. 2.70, for more details on changing modes.) You can then activate autopilot by left-clicking the AUTO button on the cockpit console or you can use the keyboard command AUTOPILOT [A]. *If you use this method, be sure to deactivate autopilot when you're within 5nm of the tanker.*

- When the range is about 15nm or so, activate communications and send a TANKER REQUEST message (RADIO1_TRANSMIT **[Tab]**).

The tanker will acknowledge your request and change its holding pattern to match your current bearing. It will relay its new bearing, current speed and refueling altitude in thousands of feet ("Angels 10," for instance, means 10,000 feet of altitude).



- Look for the tanker in your A/A Radar page (the default left MPD in Navigation master mode).
- Once you're about 5nm away from the tanker, set your radar to SNIFF mode (press the SNIFF pushbutton — PB #18) to disable the radar. The radar won't transmit, and existing data on the display is not updated. (Pressing the EMIS LIMIT **[E]** pushbutton accomplishes the same thing. The WSO will select EMIS LIMIT if you forget.)
- Change your altitude and heading as necessary to approach the tanker's position. The TCN display in the UFC provides up-to-date range and bearing information.
- Approach the rear of the tanker. Your altitude should be slightly lower than that of the tanker. Once you're within 100 feet or so of the tanker, you'll start receiving more specific cues from your WSO. After you are past the pre-contact position, he'll tell you to come left, right, etc.
- You'll see the boom in front of you. The nose of your aircraft should line up with the base of the tanker's right wing.
- Once the boom connects with your aircraft, follow the tanker's light cues to stay in position — the two light strips on the bottom of the tanker will display green lights for slight adjustments (detailed below), while red lights indicate more pronounced adjustments.

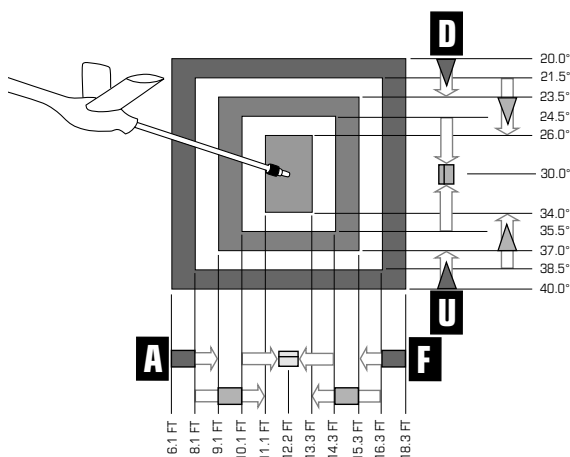
Right Strip — Aft/Forward Indicator Lights (A/F)

Solid red rectangle	You're too far back/forward. Move toward front/back of tanker.
Solid green rectangle	You're slightly too far back/forward. Move toward front/back of tanker.
Striped green rectangle	You're centered. Stabilize your forward position.

Left Strip — Down/Up Indicator Lights (D/U)

Red arrow	Your pitch angle is too high/low. Move vertically in direction of arrow.
Green arrow	Your pitch angle is slightly too high/low. Move vertically in direction of arrow.
Striped green rectangle	You're centered. Stabilize your vertical position.

The graphic at right shows the lights and their range indications. Since the constraint ranges for the outer and inner indicator lights overlap, more than one light may glow at once. This indicates the end of one light's range and the beginning of the next light's range.



For instance, you get a red arrow and green arrow when you're 6.5° to 7.5° off vertically. Pitch down a couple of degrees, and you see only one arrow. As you get closer to the optimal vertical position, you'll get a green arrow and a striped green rectangle. Finally, when you're aligned vertically, you see only the striped green light.

- Once you're in the correct position, the tanker will broadcast a "Stabilize" message. At this point, your altitude and airspeed should remain constant — don't change any of the flight controls.
- Wait. In a few moments, you'll receive a **Refueling Success** message, and the analog fuel gauge will read full.