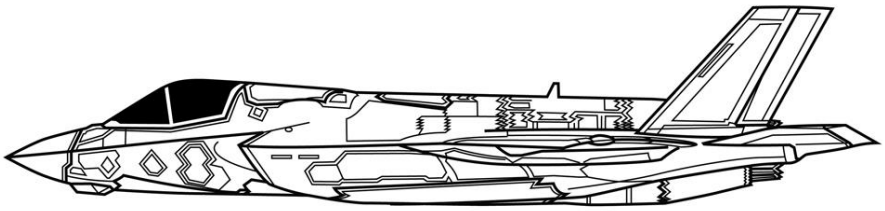
VERSION 2.0

AOA SIMULATIONS

FLIGHT MANUAL
V/STOL MODEL

F-35B
LIGHTNING II



OCTOBER 2020

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GLOSSARY

Abbreviation	Term
A2A	Weapons system Missile mode
A2G	Weapons system Bomb mode
AB	Afterburner
ADF	Automatic Direction Finding (radio) Gives pilot bearing info TO station
AGL	Above Ground Level (determined by radar altitude)
AOA	Angle Of Attack (difference between nose attitude and velocity vector)
AP	Autopilot mode switch (Off, On, Auto)
APC	Approach Power Compensation (autopilot speed hold sub mode)
ATR	Auto Throttle (autopilot speed hold mode)
CAS	Close Air Support
CM	Counter Measures (chaff, flares, towed electronic decoy, etc.)
CNI	Communications/Navigation/Identification (transponder) radios
CTOL	Conventional Take Off and Landing
DAS	Distributed Aperture System (multiple external camera system)
ECS	Environment Control System
EOTS	Electro Optical Targeting System (under nose external view camera)
EW	Electronic Warfare (electronic deception/jamming system)
FBW	Fly By Wire (electric flight control system)
FCS	Flight Control System
GBU	Guided Bomb Unit (GPS or Laser guidance)
GCAS	Ground Collision Avoidance System
GPS	Geo spatial Positioning System
GUN	Weapons system gun mode
HMD	Helmet Mounted Display (replaces Head Up Display in F-35)
HOTAS	Hands On Throttle And Stick
IAS	Indicated Air Speed
ICAWS	Integrated Caution and Warning System
IFF	Identification Friend or Foe (military code transponder)
IFR	In Flight Refueling
INS	Inertial Navigation System (self contained gyro based navigation system)

IPP	Integrate Power Pack (auxiliary power unit +)
JSM	Joint Strike Missile (Kongsberg developed anti-ship missile)
KTS	Speed in nautical miles per hour
KNUW	ICAO identifier code for Whidbey Island Naval Air Station/Ault Field
LGB	Laser Guided Bomb
MACH	Speed of sound (~ 660 knots at sea level, 560 knots at 35,000 ft MSL)
MSL	Mean Sea Level
NDB	Non Directional Beacon (signal received by an ADF radio)
PCD	Panoramic Cockpit Display (two 20" x 8" LCD cockpit displays)
PK	Probability of Kill
POV	Point Of View
PVI	Pilot Vehicle Interface (mission specific data display logic)
RA min	Radar Altitude minimum
R2c	Roll to See (AOA Simulations pilot POV camera control plug-in)
RDR	Radar display (background clutter removed)
RTB	Return To Base
SA	Situational Awareness (aka not texting or day dreaming)
SDB	Small Diameter Bomb (~250 lb bomb with pop out wings)
SMS	Store management System (weapons status display)
SRO	Short Roll On landing
STOL	Short Takeoff and Landing
STO	Short Take Off
STO/VL	Short Take Off / Vertical Landing (pronounced "stoval")
TAS	True Air Speed (speed corrected for altitude)
TRD	Towed Reactive Device (pronounced "turd") electronic decoy
TRK	Target Track (plug-in locks pilot POV camera to AI target plane location)
VEC	Engine exhaust nozzle deflection angle, 0 to 100% = 0 to 90 degrees
VL	Vertical Landing
VOR	Very high frequency, Omni-directional, Range. Short range navigation signal received by Nav1 and 2 radios. Gives pilot bearing and distance
VTO	Vertical Take Off

Term	Definition
2D cockpit	"Static" pilot POV camera, fixed forward view
3D cockpit	"Dynamic" pilot POV camera, camera can look anywhere
Alpha status	Aircraft maintenance status code (alpha 1, 2, etc.)
Cow Pie	Colloquial name of F-35 throttle control. Named after its shape)
Level Flight	Defined as > -500 fpm descent and < +500 fpm climb below 500 ft AGL and > -1,000 fpm descent and < +1,000 fpm climb above 500 ft

F-35B LIGHTNING II

CHAPTER 1 - THE AIRCRAFT

Thank you for purchasing this model. We really appreciate it and we completely understand why you wanted it. There is simply nothing else like it for the X-Plane flight simulator. Nothing does what it does. Vertical takeoff and supersonic flight followed by a vertical landing. Carefree high AOA handling and complete situational awareness. It does it all. It is the complete package.

A F-35B in stealth configuration with full afterburner

A lot of time and effort went into its initial creation (2013-2015) and further development (2015-2020). It is a very sophisticated piece of kit. To get the most out of it will require some additional time and effort on your part. We hope you give it that effort and to help you along the way I am going to try my best to make this tutorial as thorough and enjoyable as possible.

1.1 WHAT IS THE F-35B?

The F-35B is the second of three models of the F-35 Joint Strike Fighter.

The **F-35A** model, also available from AOA Simulations is a conventional long runway takeoff and landing aircraft. It cannot land vertically.

This **F-35B** is the short takeoff and vertical landing version. In addition to an exhaust nozzle at the tail that pivots 90 degrees to direct engine thrust down it has a lift fan directly behind the cockpit and roll control nozzles under each wing to allow the jet to slow to a hover in the air and land vertically.

A Royal Navy F-35B performing a vertical take-off

In normal operation the F-35B will takeoff from a conventional runway just like the F-35A. The F-35B however can use its vertical lift system and aft nozzle set to ~ 60 deg to takeoff from a much shorter runway than the full-length runways used by an F-35A.

After a mission the F-35B can return and land using its vertical lift system to fly at a much slower approach speed and perform either a SRO (Short Roll-On) landing or a VL (Vertical Landing). That is something the F-35A cannot do.

The **F-35C** is a big wing version of the F-35A configured to takeoff and land from the US Navy's large deck nuclear powered aircraft carriers. We have not modeled that version, yet ;-)

1.2 INSTALLATION

The installation is fairly simple, as is any aircraft for X-Plane.

- Locate the Aircraft folder inside your X-Plane installation folder.
- Create a new AOA Simulations folder inside the Aircraft folder.
- Extract your downloaded file and copy the F-35B 2.0 folder to your X-Plane Aircraft/AOA Simulations folder.

1.3 WHAT YOU SHOULD DO BEFORE YOU GO ANY FURTHER?

1.3.1 What should I know before I attempt to fly this model?

First, you should read and follow this tutorial. Since you appear to be doing that, continue.

This will be a comprehensive, detailed Tutorial / User Guide. Every switch and display in the cockpit will be explained; what it does and why it does it.

When you are done reading this document you should know everything there is to know about this model.

If you have any questions contact us at our X-Plane.org F-35B support page or by e-mail at aoa.simulations@gmail.com

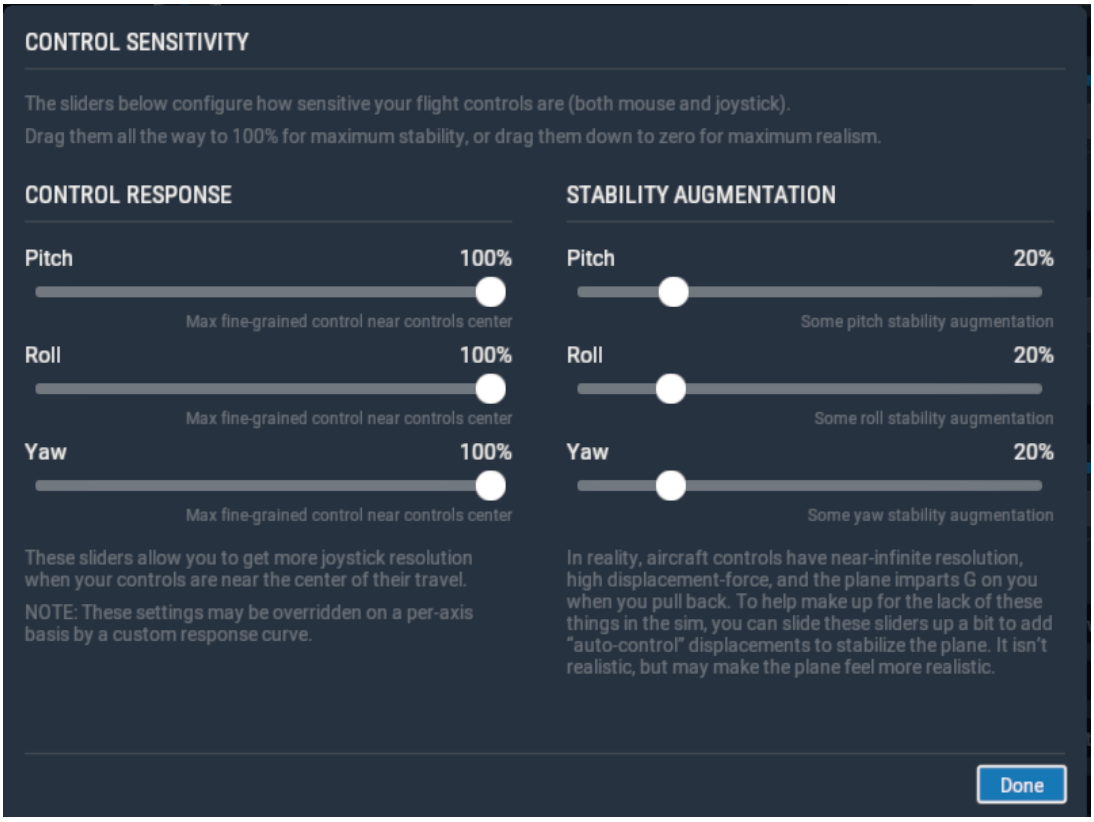
Ideally, you should have at least a basic joystick to fly this aircraft. Trying to use all the systems and features of this model and control the plane with just a mouse and keyboard is not recommended.

A programmable hands on stick and throttle (HOTAS) system like a Saitek X-55/56 or the Thrust-Master Warthog is highly recommended.

1.3.2 Joystick sensitivity settings

All joysticks and throttle hardware is different. They require calibration at least once. Some require frequent recalibration until you finally decide to throw them out. Trying to keep a dying joystick or throttle control alive another week, month, year until you can afford a new one is a terrible waste of time better spend earning the cash to just go out and replace the dying one(s). Trust me. I've lived the hell and speak from experience.

This model has been thoroughly test in X-Plane 11.50 final, standard and experimental flight models. My stick calibration settings are: control response 100% on all axis, which gives maximum fine-grain control near the control center. I have stability augmentation set to 20% on all axis because F-35s have a FBW (Fly-By-Wire) flight control system. That means a computer is actually flying the jet using commands you give it just like here in the simulator on your desktop. Go figure.



Control sensitivity dialog

1.3.3 Program keyboard pg up/pg dn keys or throttle switch to control thrust vector

The real F-35B uses a drive shaft from the plane's single engine to drive the lift fan in vertical / short takeoff and landing mode. Unfortunately it is not possible to model that in X-Plane (Plane-Maker) so instead we replace the shaft driven lift fan in the real airplane with a second fuel burning jet engine in our model.

Care has been taken to accurately reproduce the thrust levels and fuel burn rates of the single engine in both vertical lift and conventional flight modes.

What this means to you is that while this model may look inside and out like a single engine aircraft it is actually a twin-engine aircraft. This fact has caught more than one unsuspecting customer off guard when their throttle control hardware was set up to control just one engine and

not ALL engines. If the nose of your model lifts off in VTOL mode but the tail stays glued to the ground you now know what's going on.

1.3.4 Program your throttle to control ALL engines

Do not attempt to takeoff vertically with an aircraft gross weight (aircraft empty weight + fuel + weapons) > 38,000 lbs. You might not get off the ground and if you do the jet will be sluggish and hard to control. If your total weight is slightly above 38,000 lbs and the extra weight is mostly fuel then tap the DEFUEL button to transfer the excess fuel to a fuel truck standing by for just that purpose. DEFUEL will automatically stop when the jet gets down to 38K.

1.4 COLD & DARK

This is the preferred condition to be in when the model loads in the simulator. It will allow you the best opportunity to learn all the switches and systems as you start them one by one.

The F-35B in cold and dark mode

1.4.1 Navigating the cockpit

Start the simulator and load the F-35B_VTO model.

When that is done and you are positioned in the 3D cockpit, continue reading.

The remainder of this User Guide will assume you are in the cockpit, you can see what is described and you can operate all the switches and controls.

If you do not have a Track IR (or similar device) or VR headset you can use your mouse to pan the pilot's head camera to look around the 3D cockpit

Key pad #8 view shown

In addition, the keyboard number keys 7 8 9 and 4 5 6 have been pre-programmed to look at certain panels to help you get familiar with the cockpit.

Important: make sure R2c and DAS plug-in On/Off rocker switches located on the center sub panel are OFF.

Tap through num pad keys 4 thru 9 now to see what each one shows you.

Number pad 1 2 3 show you preset exterior views of the jet.

Key pad #1 view shown

Key pad #2 view shown

Key pad #3 view shown

1.4.2 Power On

Key pad #4 shown

Num pad 4 is the place to start. This shows you the aft area of the left sub panel and the group of switches needed to get the jet up and running.

1. Turn the battery ON
2. Turn the Avionics master switch ON
3. Turn the Fuel system ON (toggle switch outboard of throttle "cow pie").

Note: this actually toggles the X-Plane fuel mixture control data reference from 0=full lean to 1 = full rich. If you have a HOTAS control knob or mixture lever assigned to fuel mixture control make sure the knob or lever is set to full rich or you will end up with control vs software conflict. You will hear a constant clicking sound from the sound file as the software switch position fights against the physical control position.

4. Rotate the IPP (Integrated Power Pack) switch to START, then release to AUTO.

Take note of the location of the Engine Start button forward of the Fuel switch, then press num pad 7 key. Your view will shift slightly forward and up giving you a better view of the main panel as you proceed with engine start.

1.4.3 Engine Start

Start button located on left side of throttle

PRESS and HOLD the engine start button until the N1 rotation needle starts moving, then release the button.

When the engine is running at idle flip the GENERATOR switch ON (num pad #4 quick view)

1.5 PANORAMIC COCKPIT DISPLAY (PCD)

Panoramic Cockpit Display

The main glass panel you see before you is called the PCD. It is divided into 4 quarters.

Each quarter is referred to by its number (1, 2, 3 & 4) in order from left to right.

On the left side of the PCD is panel #1.

This **Checklist** page is the default when the model loads in the simulator.

Listed here are two columns of items you need to check before you taxi.

On the left are **Vehicle Systems** and on the right are **Mission Systems**.

Vehicle systems are critical to the safe operation of the jet. If any of these systems are not **GO** at the start of your flight you need to get the issue resolved before takeoff.

1.5.1 AB = afterburner.

The afterburner will normally be switched off. The engine is powerful enough that the jet does not need afterburner to take off unless you really want the extra performance.

F-35 SOPs (Standard Operating Procedures) require afterburner use if estimated takeoff runway ground roll is > 50% of the available runway length.

1.5.2 ECS = Environmental Control System.

Cockpit pressurization, heating, cooling and onboard avionic systems cooling is managed automatically by the ECS.

If you see a green **GO** you don't need to do anything.

The ECS uses fuel circulated through a fuel/air heat exchanger to remove excess heat generated by the avionics and other heat generating on board systems. Therefore, low fuel quantity and high OAT (Outside Air Temperature) is something to watch out for.

If the system displays a flashing yellow **HT** (Hot, fuel temp > 120 F) then seek to limit your ground idle time and get airborne as soon as possible.

Taking off and climbing to cooler temperatures at high altitude will lower your fuel temperature.

If the next item down on the vehicle system check list (**ENG** = engine) is **GO** (engine running, no warnings) then takeoff is an option but, check the remainder of your systems before you make that decision.

If the ECS system displays a flashing red **OH** (Over Heat, fuel temp > 150) then it's time to shut the engine down and wait for a fuel truck to arrive.

More fuel on the jet will give you a larger heat sink to absorb the heat generated by the jets systems.

Note: This is a real F-35 issue and not one made up by us.

In-flight overheating is possible in this model just like on the real jet. The combination of a really hot day (>100 deg F), low fuel load (< 50%), low altitude (< 10,000 ft MSL) and high airspeed (> 400 knots IAS, more speed means more friction heating) could lead to high fuel temps or even over heating the ECS.

To mitigate load more internal fuel to start the mission, fly higher if you can or, if you cannot fly higher limit your speed at low altitude.

If you want to fly fast at low altitude plan to have lots of fuel onboard for that portion of your flight.

1.5.3 ENG = Engine.

If the engine is running it's burning fuel, so there IS a fire back there somewhere behind you. As long as it's contained within the engine you're good to **GO**.

1.5.4 FUEL = the % of max internal fuel available on this model of the jet.

The F-35A holds ~18,500 lbs of internal fuel, the F-35B ~ 14,000 lbs and the F-35C ~ 20,000 lbs. The B model hold less fuel than the A model because the lift fan behind the cockpit replaces a large fuselage fuel tank on the A model. The F-35A cannot land vertically though.

1.5.5 FCS = Flight Control System.

All F-35's have a FBW (Fly-By-Wire) flight control system that sends control commands to the flight control actuators via electronic signals along a network of wires routed throughout the jet.

The system is redundant, sending duplicate signals via at least three separate routes from the control computer(s) out to the various flight control actuators.

Damage along one wire route is ignored and the jet continues to fly with signals along the other routes until all routes are damaged or the jet RTBs (Returns To Base).

Damage is reported to ground maintenance via an over the air data link so they know what to expect, who to have available and what tools to have on hand when the jet taxis up to its parking spot.

The F-35 flight control actuators are unlike any other jet.

Electrical signals, not flight control cables or push rods signal the actuators what to do. That is the FBW system and most modern jets use a similar system.

The actuators use hydraulic pressure to actually move the flight controls, just like other jets do but where that hydraulic pressure comes from is very different.

Instead of a centralized hydraulic system pressurized by engine driven hydraulic pumps the F-35 uses small electric motor driven pumps and a closed hydraulic system within the actuator itself.

The pumps pressurize the closed hydraulic system and the electric control signals tell the actuator what to do.

Damage to a flight control actuator is isolated to that control surface and the jet flies on using the remaining control to compensate.

Pilots are cautioned in the cockpit and ground maintenance notified via data link but other than that the mission can continue unless something more extreme happens.

1.5.6 Maintenance Alpha status

Pilot's report alpha status to maintenance immediately after landing before leaving the jets parking spot to head back to the squadron.

- Alpha One means the jet is ready to go again, no maintenance issues.
- Alpha two means there is an issue that needs to be addressed. An FCS issue would definitely be an Alpha two issue.
- Alpha three means there are multiple issues.

Your jet for this initial training flight should be Alpha One.

1.5.7 FLAP = % of maximum available flap travel currently in use.

F-35 flaps (all models) are automatically control by software. No model of F-35 has a flap switch in the cockpit.

Flap speed range goes from flaps fully down at 160 to flaps fully up at 260 knots IAS.

1.5.8 GCAS = Ground Collision Avoidance System.

This is an automatic system that seeks to prevent you from flying your expensive jet into the ground and killing yourself.

In 2020 the F-35B costs ~ $100 million including engine.

It is a real system on the real jet. Developed from the software implemented on the F-16 Viper it was released for use on all models of the F-35 in summer 2019.

AOA Simulations' Auto GCAS system has been available on our F-35B since December 2014 and on our F-35A since March 2019. Our T-7A Red Hawk has this system too.

Auto GCAS starts working as soon as the jets landing gear is up and monitors the jets gross weight, true airspeed, pressure altitude, pitch and roll attitudes, vertical velocity, radar altitude, flight control stick position, throttle position and autopilot mode.

All the data collected above is fed into an algorithm to continuously compute a time to impact with the ground.

When the system calculates you are approaching a moment of decision green warning chevrons start to converge toward the center of your HMD (Head Mounted Display).

If you do not react to the warnings with control inputs the system will takeover the jet, roll you wings level (if you are inverted) and pull the nose up to keep you from hitting the ground.

Large red X's will overlay the PCD until control of the jet is handed over to the autopilot.

You need to make sure the system is turned ON (white rocker switch on the center sub panel) in order to get a green **GO** on the checklist.

Flying without turning GCAS ON is possible, but not recommended.

Pulling back or pushing forward on the control stick overrides the system so that it does not interfere with normal pilot control of the jet near the ground and during aggressive low altitude maneuvering.

Relaxing stick pressure and allowing the stick to enter its neutral position enables the GCAS system to assume you are not actively controlling the jet, either because of a distraction or unconsciousness and if you are at the last ditch recovery opportunity the system will recover the jet, with you in it.

If you are below the last ditch recover altitude the system will still attempt to recover the jet but may also automatically eject you before ground impact so at least you survive while the jet buries itself in the ground.

1.5.9 HMD = Helmet Mounted Display.

Basic flight performance data is displayed on the pilot's helmet visor instead of a fixed glass HUD (Heads Up Display) like most other advanced fighter jet have. The F-35's are the first and only jets to have this feature.

The HMD needs to be ON (white rocker switch on the center sub panel) in order to get a green **GO** on the checklist.

You can fly the jet without the HMD functioning. There is enough basic flight information in the cockpit displays to operate safely.

To enable the ILS course guidance bars to appear in the HMD you must tune in an ILS station frequency into Navigation radio 1 and "flip" it into the active (top) position.

Select Nav1 as your navigation system "source" using the touch switch located between the Nav radio frequency displays.

ILS course guidance bars will only appear in the HMD if all of the following conditions are met:

- Radar altitude > 3 ft so guidance bars will disappear after touch down
- Radar altitude < 3,000 ft normal glide slope entry point.
- Real life glide slopes need to be "captured" from below the slope angle.

If you descend onto the slope angle from above the autopilot will not capture until you get below the slope, level off and fly into the slope angle again from the bottom side.

- IAS >=100 and < 295 knots so guidance bars will disappear at cruising speeds.
- Climb rate < 1,500 fpm so guidance bars will disappear on climb out.
- Nav1 source select so guidance bars will not appear during Nav2 or GPS navigation.

1.5.10 LG = Landing Gear.

The landing gear can be raised and lowered manually but there is automated back up logic to prevent you from raising the gear too early after liftoff or forgetting to raise the gear before exceeding gear operating limit speeds.

Logic also prevents you from forgetting to lower the gear before landing.

You can choose to memorize the operating altitudes and speed limits or just allow the system logic to manage the landing gear while you focus on more important things, like steering the jet.

I'll give you those speeds and altitudes when we actually get to flying the jet.

1.5.11 LL = Landing Light.

The landing light is attached to the nose landing gear strut. It turns off automatically when the gear is retracted and turns on again when the gear is lowered.

The cockpit switch is there if you want to turn the light off when the gear is down.

1.5.12 R2c = "Roll to see" plug-in script.

Manually activate with white rocker switch on the center sub panel.

Three modes. Default **OFF**, **SIM** = Simple mode, **ADV** = Advanced mode.

1.5.13 Difference between 2D and 3D cockpit modes

You must be in 3D cockpit mode for R2c to function.

Assign a keyboard key or joystick button to toggle back and forth between 2D and 3D cockpit modes.

2D cockpit looks just like the 3D cockpit only it is a static, forward facing view.

3D cockpit mode is the dynamic cockpit mode where you can move the pilot POV camera around by click, hold and dragging the camera to point where you want.

With R2c ON the plug-in controls the camera pointing function. This is why it is not compatible with Track IR or VR headsets.

1.5.14 Taxi with R2c ON (both modes)

If you do not have a Track IR (or similar device) or VR head set you can choose to switch this plug-in ON before you start your taxi to the runway.

The plug-in moves the pilot POV camera left and right in sync with the rudder pedals to allow you to see into turns as you taxi the jet. Centering the rudder pedals centers the camera.

The look angle is speed sensitive.

- Below 20 knots full rudder looks up to 70 degrees left or right.
- Above 20 knots the angle is reduced to no more than 20 degrees.
- Above 40 knots the pilot's attention is focused straight ahead until lift off.

1.5.15 In-flight with R2c ON (both modes)

The pilot's POV camera looks up and in the direction of a banked turn when you roll the jet left or right. When you roll wings level the camera points back to center.

1.5.16 In-flight with R2c ON (Advanced mode only)

Advanced R2c mode adds additional features. The DAS (Distributed Aperture System) peripheral camera system is automatically activated when R2c Advanced model is set.

In flight, when you pull the jets nose up > 30 degrees above the horizon the pilot POV camera points straight back behind you to look back at the ground.

The pilots POV camera also responds when you roll the jet, looking up and in the direction of the roll.

These head movements are intended to increase your situational awareness and add a bit of the physiological sensations of flight.

The plug-in can be switched ON and OFF manually at any time.

If a Track IR device or VR head set is detected as attached to your computer R2c and DAS will be automatically disabled

Those other devices also require control of the pilot camera x, y and z axis so they and our plug-in can not operate at the same time. You can have one or the other.

R2c has been operational on our AOA Simulations F-35B since December 2014.

1.5.17 SEAT = the ejection seat.

Red means the seat has NOT been ARMED. If you were to pull up on the black and yellow striped loop handle between your legs the ejection seat will not fire.

Press num pad 9 to focus the pilot camera on the seat safety handle next to your right knee.

Note the small white patch on the inboard side of the handle? That means the seat is "safed" (NOT ARMED)

You can climb into the cockpit and sit on a safe seat, wiggle around while strapping in and do all sorts of physical gymnastics in a "safed" seat without fear of ejecting your butt out onto the ramp.

Before you start to taxi the jet you should ARM the seat by pressing the small white square button at the top of the seat safety handle. The white patch will turn red and the red SEAT text on the checklist will change color (to green) and say **GO**.

DO NOT PULL ON THE BLACK AND YELLOW STIPED-LOOP HANDLE unless you have a genuine emergency and need to get out off the jet right NOW!

The seat is certified for use from sea level to any altitude, and from zero up to 630 knots IAS (Indicated Air Speed). Above 630 knots a yellow ">LMT" warning will start to flash on the panel checklist page.

1.5.18 VEC = thrust vector angle degrees of the swiveling engine aft exhaust nozzle.

There are a number of ways to control the thrust vector system on this jet, manual and automatic. You get to choose.

The Manual / Automatic mode select switch is a square white button located to the left of the PCD. It is labeled VTOL / STOL.

Mode status is displayed at the top of the checklist page on the PCD.

An optional display in place of the Checklist page is the **ENG/FUEL** page.

Click the **ENG/FUEL** tab at the bottom of the checklist page to switch to the engine/fuel page and the same vector status mentioned above will be displayed at the top of the page.

1.5.19 Manual thrust vector control methods

Manual nozzle vector control

On the **ENG/FUEL** page. See the side profile view of the jet? With the mouse grab the tail of the jet and notice you can change the nozzle vector by dragging an invisible control handle up and down.

The actual movement of the various doors is much slower than the handle so allow for the doors to catch up with your handle movements.

To get back to the Checklist page click the CK LIST tab.

1.5.20 Pop-up vector control buttons

Popups Menu

In the top left corner of the PCD is a square box with the word MENU displayed inside.

In your head number the boxes within the square 1 thru 9, with 1 thru 3 left to right across the top. The second row is 4 thru 6 and the bottom row is 7 thru 9.

Clicking in box 4 pops up preset vector control buttons along the left edge of your screen.

Preset vector angles and speeds

The **TOP** popup button replicates the function of the VTOL/STOL mode button in the cockpit.

Clicking on the remaining buttons is a quick way to control the vector nozzle and monitor its current position.

These buttons can be used whether you fly with internal or external views.

In-flight you can pop up these buttons any time you like but above 300 knots and 10,000 ft AGL the nozzle is locked at zero degrees = straight aft.

Wait until you are below 10,000 ft AGL and slow to < 300 knots before selecting a nozzle position button.

The nozzle pop up buttons will also appear when you click the master pop up menu button in the lower left corner of your screen.

The master button pops up the auto throttle preset speed buttons and, as long as your airspeed is < 300 knots the vector buttons will pop up as well.

1.6 MISSION SYSTEMS

Missions Systems panel

Mission systems provide the critical capabilities this jet uses to perform its military function to: see everything, know everything, kill everything and live to tell about it.

1.6.1 CM = Counter Measures.

These are the radar confusing chaff and IR missile seeker confusing flares. The jet holds up to 120 of each type of these "expendables."

CM **GO** means the chaff and flare magazines are full.

Look over at the **F C S** tab again, the one with the overhead outline of the jet.

Clicking on the CHAFF or FLARES touch screen buttons will release bundles of chaff or fire a series of flares, though you might not want to do that while you are on the ramp.

1.6.2 CNI = Communications, Navigation, Identification radio systems.

The F-35 does not have individual communications, navigation or identification (IFF) radio black boxes like other jets. Instead, the radios are software distributed across multiple circuit

cards. If one circuit card malfunctions or fails the radio functions are shifted to another card. This checklist item confirms whether or not the software is providing the required radio functions.

1.7 DAS = DISTRIBUTED APERTURE SYSTEM.

This is a set of six fixed infrared video cameras positioned around the periphery of the jet that detects and tracks warm objects in the air and on the ground. Camera imagery is projected onto the pilot's helmet display. It allows the F-35 pilot to see above, behind and below the jet in daylight or at night.

On our AOA Simulations F-35 we imitate the DAS system to enable you to lock the pilot's head camera onto any one of up to 8 AI planes you may have loaded in the simulator.

Once locked the pilot's head will stay focused on the AI plane no matter where it goes in relation to your jet. Above, behind or below, we automatically switch camera points of view around the jet so that the AI plane always stays visible to you as if looking thru the jet's fuselage and wings. All you have to do is maneuver your jet to get behind the other plane.

DAS is default OFF when the model loads in the simulator.

You can fly the jet without DAS if you want to.

Selecting R2c Advanced mode automatically turns DAS ON.

If a Track IR device or VR head set is detected as attached to your computer DAS will automatically disable.

1.8 EOTS = ELECTRO OPTICAL TARGETING SYSTEM.

EOTS is a steer-able / zoom-able infrared video camera located in a geometric glass gondola below the jet's nose.

It has all the features and capabilities of an advanced targeting pod as carried *externally* by all the other modern strike fighters except, on the F-35 the entire system is *internal*.

This camera on our AOA Simulations F-35 model is part of the Distributed Aperture System described above. It covers the entire hemisphere below, forward and aft of the jet in coordination with the Target Tracking feature described later in this document.

On our model the EOTS camera is ON when ever DAS is ON.

1.9 EW = ELECTRONIC WARFARE.

All versions of the F-35 are equipped with a digital electronic warfare system designed by BAE Systems, UK. Send (jamming) and receive (passive listening/geo location of emitters) antenna are located around the fuselage and wing for spherical coverage and all frequency bands.

Laminar Research's recreation of a sophisticated real world digital electron ware-fare system is top secret so we will not discuss it.

1.9.1 GPS = Global Positioning System.

Global Positioning System navigation capability is embedded in the F-35's core navigation software suite. This mission systems checklist item confirms that enough GPS satellites have been acquired and the system is maintaining contact with them.

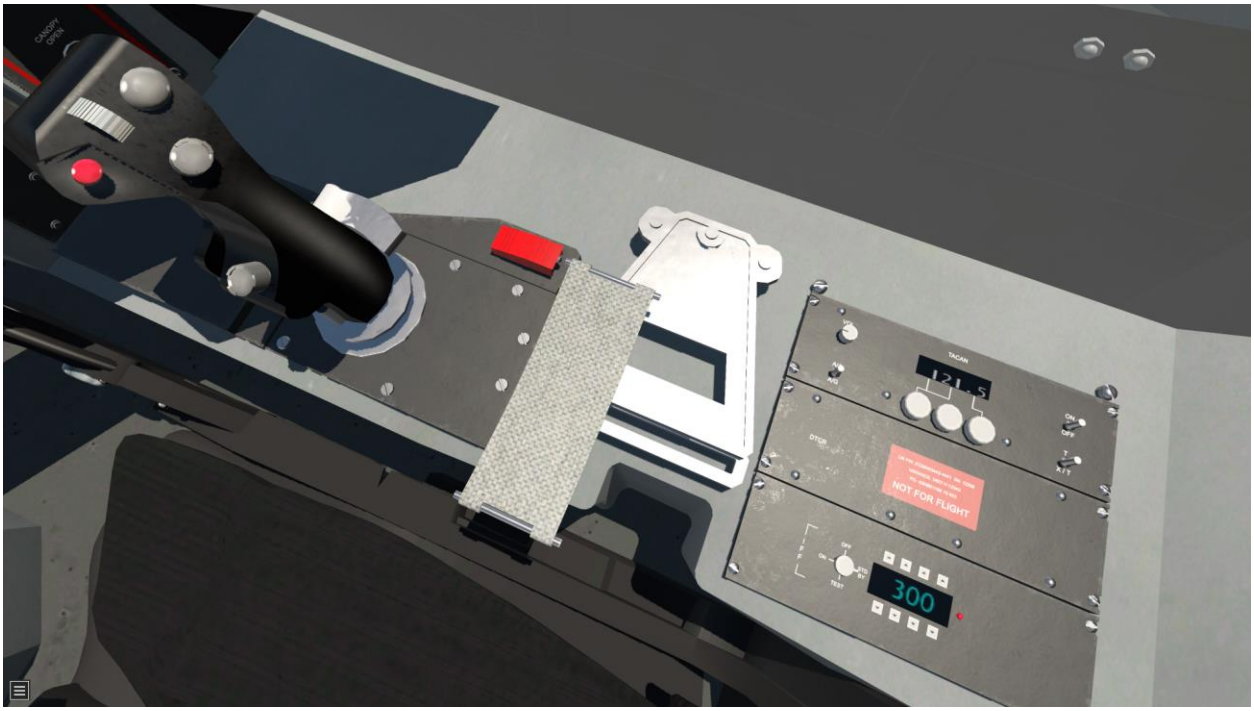
1.9.2 GUN = the gun.

GO means the centerline external gun pod is installed, ammunition is loaded and the gun is functional. A white ZZ means the gun is empty and might as well be asleep.

1.9.3 INS = Inertial Navigation System.

GO mean the logarithms within the core software program dedicated to maintaining geographic position awareness without referencing external signals is functional and free of errors.

1.9.4 IFF = Identification Friend or Foe interrogation system.



Transponder panel

IFF is a military transponder. Codes are entered through a panel control box located next to your right hip.

They system is OFF by default when the model loads in the simulator and has to be turned ON before you takeoff.

If you do takeoff without turning ON the system is will turn itself ON automatically once you reach 200 knot IAS.

1.9.5 PVI = Pilot Vehicle Interface.

The Panoramic Cockpit Display (PCD) is the large multifunction glass screen that dominates the area in front of you in the cockpit.

Multiple redundant high end video cards drive the graphics and video features on a real F-35's PCD.

When all those cards check good the checklist item reports **GO**.

1.9.6 RDR = Radar

Radar (2nd screen from left as shown above)

Camera (CAM) is the optional screen that can fill this space. Select the camera by clicking on the CAM tab. To get back to the Radar screen a new tab (RDR) will appear below the screen when you select camera. All the screens and tabs work this way. Click a tab to get to a new display below the current display and a new tab appears to get back to the other display, which is now the one beneath the currently showing display.

The F-35 has a fixed radar antenna. It has no moving parts.

In level flight the radars beams are steered electronically around the sky up to ~60 degrees left and right of center, ~75 degrees above and ~45 degrees below the horizon.

The radar "hops" frequencies, constantly changing its transmitting frequency hundreds of times a second to prevent anyone from recognizing that it is a coherent radar system.

To anyone with the ability to detect a radar signal in the first place it looks to them like a bunch of random electronic noise scattered wildly around the sky. It is not.

The system memorizes the "random" sequence of its own transmissions and looks for the same sequence on radar wave returns. Gaps in the known pattern reveal distant objects.

Once an object is detected and identified the radar automatically adjusts its transmitting power to maintain contact but stay just out of range of being detected itself.

On our model the radar has no dedicated controls. It is operating all the time in the background. Detected targets are displayed on the default x-plane moving map / radar display and the default g1000 color moving map by small aircraft icons.

Detected targets on radar display

1.10 SMS = STORE MANAGEMENT SYSTEM.

The gun pod, air-to-air missiles, bombs, chaff, flares and the towed reactive device are all managed by the SMS.

To check on the number and type of weapons loaded on the jet before flight click the **F C S** tab and the overhead outline of the jet. Internal weapons will appear within the outline of the jet and external weapons will appear out under the wings.

There are five weapons systems modes. Off, Gun, Target Track, A2A (air to air missiles) and A2G (Air to ground or "bombs").

Weapon outlines are white when the weapons system is OFF.

As each type of weapon is selected the available weapons of that type change color from white to red.

When selecting weapon modes the tab at the bottom of the page changes from **F C S** to **W E P** whether the tab is selected of not.

When a weapon is selected it is automatically "armed" and ready to fire or release.

When a bomb is released the GPS coordinates from the point on the ground overlaid by the red cross in the HMD is automatically transferred to the bomb.

When a missile is fired or a bomb is released it disappears from the **W E P** display.

More details about the methods and techniques for delivering weapons on target will be covered later in this document.

1.11 TRD = TOWED REACTIVE DEVICE.

The TRD or "turd" as the military pilot's like to call it is an electronic decoy reeled out on a fiber optic cable hundreds of feet behind the jet to lure away radar guided missiles.

If a turd is still "on the leash" and the jets descends to < 200 ft AGL the cable will automatically release so you don't drag a turd through expensive approach lights.

TRD off/deployed status can be found on the **F C S / W E P** page mentioned above.

1.12 BIT TEST

Mission Systems in BIT test mode

While the canopy is still open the Mission Systems will continue to cycle through a 60 second BIT test. Closing the canopy stops test cycle.

Below the checklist page is a display box with a simulator session run time counter. IPP (Integrated Power Pack) mode display, F-35B version number and date.

Click on the **ENG/FUEL** tab to see a side profile view of the jet with canopy and vector system door status display.

Aircraft gross weight tops the list of data points displayed here so you know what is going on with your jet.

How much thrust is your engine producing? Is it enough to support the weight of your jet in a hover the jet? How much fuel do I have remaining in the tank? How much am I burning per minute? How long will it last? How far can I fly with my remaining fuel? Those answers and more can be found here on the ENG/FUEL tab.

An easy to interpret fuel quantity status bar dominates the right side of this display.

All data is update continuously in real time. With the engine running on the ground slide the throttle lever forward and aft and see what happens.

CHAPTER 2 - COCKPIT FAMILIARIZATION

Now that we have the engine running (1.3.3) lets tour the rest of the cockpit while I explain what's left.

The F-35B cockpit is dominated by a panoramic cockpit display (PCD)

2.1 THE MEANING OF "PANTHER"

Let's starting in the upper left corner of the PCD with the word "PANTHER".

This is the common username adopted by F-35 air and maintenance crews similar to the way the same individuals chose to call the F-16 Fighting Falcon "Viper" instead.

The military services have their official names for the aircraft they purchase but the people who fly and maintain those aircraft have their own ideas.

To the aircrews and maintainers "Panther" describes the F-35 qualities they value and admire the most. Sneaking up on their prey and pouncing on them when they least expect it are classic fighter pilot tactics.

Below "PANTER" is the "MENU" box sub divided into nine smaller squares.

I mentioned to you before how to number these squares in your head.

2.2 SUPPORT PAGE

Support and flight test popups

Touching #1 pops up the AOA Simulations F-35 Support notice (upper left corner of your screen) with a reminder of where you can seek out answers to support question and how to contact us.

2.3 DATA FOR FLIGHT TEST PILOTS

Touching #3 pops up a flight test display panel (upper right corner of your screen).

Across the top pf this test display are touch buttons for:

- Auto pilot mode status.
- Real time GCAS factors that go into determining when to trigger an automatic recovery maneuver.
- Flight test vector and rate data as well as flight control position and engine thrust data.
- Cockpit view and pilot's head position data and track IR / VR head set status.
- Advanced navigation and situational awareness information.

- Cycling up through the available weapon modes (NAV> = OFF, then <GUN>, <TRK>, <A2A> and <A2G>) with either the embedded panel switch or a programmed joystick switch brings up tips relating to the specific weapon you are about to use.
- Cycle up and down through the weapons modes now and see what is there.
- Cycle down from <GUN> to NAV> mode again brings you back to a blank page with AP, GCAS, FLIGHT VIEWS and NAV across the top of the page.

Click on any one of those tab headers to bring up that data set.

2.4 POP UP PRESET THRUST VECTOR CONTROL BUTTONS

These were mentioned earlier. Touch #4 pops these buttons up along the left edge of your screen.

Touching the #4 square again after they have been popped up makes them disappear.

2.5 PRESET AUTOPILOT AIRSPEED BUTTONS

Touching the #7 square pops up a set of preset airspeed buttons to use in conjunction with the auto pilot's auto throttle mode.

These popup buttons can also be activated by a dedicated master pop up menu button located in the lower left corner of your screen.

Once they are visible chose a speed by clicking on that button 200 (knots IAS), 300, 400, .80, .92 or 1.2 (mach), then clicking on the ATR button to activate the auto throttle.

The pop up buttons are white when inactive and green when activate.

These buttons do not activate the autopilot's flight control servo actuators. They only set autopilot speed and activate the auto throttle. You still have to hand fly the jet.

2.6 APC (APPROACH POWER COMPENSATION)

APC is a sub mode of the auto throttle. This is a real feature on all F-35 models.

Logic written by AOA Simulations in a SASL plug-in LUA script looks at a number of parameters to determine the appropriate approach speed for the aircrafts current weight.

To enable APC mode, reduce AP airspeed setting to < 200 knots.

For full autopilot control of the jet use the autopilot AP button on the autopilot control panel located in the upper right corner of the PCD.

Modes are OFF, ON (auto throttle only) and AUTO (flight control servo actuators).

Autopilot flight control servos and auto throttle do not work when the thrust vector system is active. That is, whenever nozzle position is > 0

2.7 ENGINE N1 SPEED

Engine speed as a percentage of maximum is display as a clock handle sweeping an arc from 12 o'clock to 9 before engaging the afterburner pushes the hand to ~ 11.

2.8 AOA (ANGLE OF ATTACK) CUE

A U.S. Navy style AOA cue "meat ball and chevrons" is just to the right of the N1 display.

- A green ball means you are maintaining the proper approach speed and AOA.
- A red down facing chevron means you are too slow or your AOA is too high. Either speed up or lower the jets nose.
- A yellow up chevron means you are too fast or your AOA is not high enough. Either slow down or raise the jets nose.

Try not to over react to momentary illuminations of the chevrons.

Using the APC mode will ease your approach airspeed management burden and allow you to concentrate on flying the jet smoothly and nailing your touch down spot.

2.9 ICAWS = INTEGRATED CAUTION AND WARNING SYSTEM.

Pressing this touch screen text button will test the warning and caution system lights and also automatically disconnect the autopilot if it is ON.

Press and hold while you scan the PCD for illuminated warnings and cautions: engine fire, generator failure, low fuel or oil pressure and high oil temperature.

Do this test before you leave your parking spot to taxi to the runway.

2.10 WHEEL BRAKES

When the jet is stationary and the wheel brakes are set the display will read **PARK**.

While in motion the display will read **BRAKES** when the wheel brakes are applied.

2.11 LANDING GEAR STATUS LIGHTS

Three **green** lights mean the gear is down and locked.

Three **red** lights mean the gear is in transit, either going up or coming down.

When the gear is up and locked in the wheel wells the lights go out.

2.12 NAVIGATION RADIO PANEL

The F-35 navigation radio functions are all grouped together above the radar display.

Nav radio 1 frequencies are on the left, nav2 on the right.

Active frequency on top, standby frequency on the bottom.

Frequency changes are made by touching just to the left and right of the standby frequency digits. The mouse cursor will appear to guide you when you hover over the right spot.

Use the flip touch switch to "flip" the standby frequency up into the active spot.

A navigation source select touch switch is located between the nav radio frequency displays.

Three switch options are 1. Nav radio 1 or 2. nav radio 2 as the "sources" driving the autopilot course heading function or the ILS Localizer and Glide slope needles.

When a Nav radio is selected its active frequency is blue.

Standby frequencies are always white.

The third Nav source select switch option is GPS.

When GPS is selected the blue switch turns green to help you understand your selection.

The autopilot will steer the jet to a GPS destination using the LOC mode of the autopilot heading function as long as GPS is selected as the navigation source.

Below the standby frequencies are digital displays of the remaining distances in nautical miles to each navigation source. VORs for Nav radios left and right and GPS destination in the center.

2.13 RADAR DISPLAY

Radar display

The radar display occupies PCD panel #2 just below the Nav radio displays.

The radar display is the X-Plane default moving map with black background.

Latitude and longitude are displayed in the top left and right corners.

A partial compass rose arcs across the top of the screen.

The magenta number is a repeat of the Autopilot heading selector.

The keyhole shaped outline in the radar display is the side-to-side view angles of the fixed, electronically scanned radar beam.

The touch screen map range scale adjustment switch is display between range up and down pointers.

When a VOR DME, GPS or AI target aircraft range information is available the radar maps range automatically adjusts itself to keep the VOR station, GPS destination or AI target within the range scale of the map.

AI aircraft, airports, navigation stations (VORs), navigation waypoints and weather are also displayed on the radar screen.

Touch switches for **APT** (airports), **WPT** (navigation waypoints) and **WXR** (weather) are arranged at the bottom of the radar screen. Use these to de-clutter the display screen.

The radar display orientation is always facing the direction of the jets flight path.

When toggled ON airports, waypoints and weather proceed from the top of the displays to the bottom of the display as the jet travels past. This is different from the G1000 based color-moving map I will explain later in this document. That display is always oriented North up, East to your right, South down and West to your left when sitting in the cockpit.

2.13.1 VOR's (Very high frequency, Omni-directional, Range).

Enter a VOR station frequency via the NAV1 or 2 radio control head located above the radar display or use the X-Plane "auto tune" feature through the pop up sectional map.

Pop the map up, search for a blue VOR compass circle on the map, touch it with your mouse (it will turn yellow) and a popup frequency-tuning box will appear.

Select which of the two NAV radios you want to tune then click to auto tune that radio.

Close the tuning box, then close the popup sectional map.

TO and FROM shown at the bottom of the radar display indicates whether or not the NAV radios OBS (Omni Bearing Selector) headings are directing you to fly TO (toward) or FROM (away from) the tuned VOR station signal.

TO will always be blue. FROM will always be white.

Touch screen VOR1, OBS1 and VOR2, OBS2 bearing adjust knobs are located in the rectangle box below the radar display.

A **solid blue line** in the radar display points the way TO VOR1 if a correct frequency is dialed into Nav1 radio and you are in range of the station.

The **dashed blue line** points the way TO VOR2 for the Nav2 radio.

Both blue navigation lines point to their stations regardless of the **NAV SOURCE** selected (**Nav1, Nav2** or **GPS**).

When VOR stations are out of range the solid blue and dashed blue lines "park" themselves by pointing directly to the right and staying stationary.

If bearing information but no range is info is received then the solid or dashed blue VOR lines will turn white.

2.13.2 GPS (Global Positioning System).

In the simulator click the plug-ins drop down menu, then GPS FPL Input/Show Input box. (You did download that plug-in, didn't you?)

Enter a GPS destination by entering its four-letter code into the GPS system.

Unlike the blue VOR lines the green GPS line can never be "parked" because you are never "out of range" of overhead satellites. If you have a destination entered into the GPS the green line will always point the most direct route to that destination, even if it is on the other side of the planet.

2.13.3 ADF's (Automatic Direction Finding stations)

Also located in the same rectangle box below the radar display are the ADF 1 & 2 frequency displays. These are three-digit number throughout the USA an four digit numbers in Europe.

2.13.4 NDB (Non Directional Beacons)

NDB’s on this model are tuned via the **ADF** radios using the default X-Plane popup sectional map.

Pop the map up, search for an NBD symbol on the map, touch it with your mouse and a popup frequency-tuning box will appear.

Select which of the two ADF radios you want to tune then click to auto tune that radio.

Close the tuning box, then close the popup sectional map.

When NDB do not provide range to station information.

When the stations are out of range the solid yellow and dashed yellow lines "park" themselves by pointing directly to the right and staying stationary.

When the station is in range **ADF1 (**the **solid yellow line** on the radar display) will point the way TO that station.

Likewise for **ADF2** (the **dashed yellow line).**

2.14 CAMERA

As explained briefly above under **EOTS** (1.7.00) all F-35s are equipped with an electro-optical video camera under the nose. That camera image can be viewed here on the PCD in place of the radar display.

Click the **CAMERA** tab to swap the radar display for the camera image.

The camera will always point straight forward when the jet is on the ground or in the air when the vector control system is lock in **CTOL** (Conventional Take Off & Landing) mode.

When the vector system is in operation the camera will gradually point further and further downward as you slow the jet on approach to a short roll on or vertical landing.

In a hover the camera will point straight down until you touch down, when the camera will automatically switch to pointing straight forward.

2.14.1 Know issue with the default x-plane camera and sunlight

When facing directly toward the sun, even though the sun is overhead and the camera is under the nose of the jet the camera display will blank out.

If wind direction and wing speed allow, try to point the nose of your jet away from the sun during a vertical landing.

To get back to the radar page click the RADAR tab.

2.15 COMMUNICATIONS RADIO PANEL

The F-35 communications radio functions are all grouped together like the Nav radios.

Com1 frequencies on the left, Com2 frequencies on the right.

Active frequency is on top and standby frequency on the bottom.

Frequency changes are made to the standby frequency, then "flipping" the standby and active frequencies, making the standby the active and the formerly active the standby.

Change standby frequency by touching just to the left or right of the frequency digits.

Left side for digits left of the decimal point. Right side for digits right of the point.

Your mouse cursor will appear to guide you when you hover over the right spot.

When the new frequency has been entered use the "flip" touch switch to flip the standby frequency up into the active spot.

A Com source select touch switch is located between the frequency displays. This switch chooses which Com radio is active for transmitting and receiving voice communications.

2.16 PRIMARY FLIGHT DISPLAY (PFD)

The PFD is located directly below the Com radios and occupies the 3rd quarter of the PCD over from the left edge.

A color artificial horizon (blue sky, yellow earth) is flanked by indicated airspeed (IAS, left) and pressure altitude (feet, right).

The IAS display numbers are white below 300 knots, green between 300 and 630 knots, yellow between 630 and 699 knots and red from 700 and beyond.

AOA will display above IAS if airspeed is > 70 knots and AOA > 0

If any wind speed is detected a wind bearing/speed and direction arrow is displayed directly below the IAS.

A tail wind will display in red

The altitude is white below 18,000 ft MSL and green above that altitude.

Radar altitude is displayed directly below the altitude.

Vertical speed will display above altitude when the jet is climbing or below altitude when the jet is descending.

Terrain elevation directly below your jet displays in the bottom right corner of the PFD.

Directly below the PFD is a green rectangular status display box.

Within this box are displays for GCAS status, ground speed (GS), true air speed (TAS), Distributed Aperture System (DAS) status and Barometric pressure.

The barometric pressure display (xx.xx), like the pressure altitude display is also white below 18,000 and green above 18,000 where it is auto set to 29.92.

When descending through 18,000 remember to reset your barometric pressure to your local setting.

2.17 VIEWS PAGE

Clicking the VIEWS tab swaps the PFD for an overhead view of your jet. Touch buttons array around the jet give you one click access to external views from: Tower, Runway, Weapons in flight, Forward view with HUD, Circle and Chase views and 2D/3D cockpit status.

To get back to the PFD page click the PFD tab.

2.18 FUEL SYSTEM PAGE

The Fuel page occupies the fourth quarter of the PCD all the way on the right side.

- Internal fuel tank quantities are graphically displayed.
- Aircraft gross weight (empty weight + fuel + weapons) is displayed at the top of the page.
- OAT (out side air temperature), fuel temperature are displayed on the left.
- Refuel status will display on the upper right side if the IFR switch is flipped ON.
- A touch screen DEFUEL button is located on the lower right side of the page.

On the ground click DEFUEL to reduce weight before takeoff.

In the air click DUMP to reduce weight before landing.

2.19 WEAPONS PAGE

Weapons page (right side of the PCD)

The FUEL page can be swapped out for the WEP (weapons) page.

The weapons page shows you an overhead view of your jet.

- Loaded weapons display within the fuselage outline for internal weapons and under the wings for external weapons.
- Load weapons use white outlines when the weapon is unarmed and red when armed and ready for fire or release from the jet.
- IFF (identification Friend or Foe) status and code are displayed in the upper left corner.
- Landing light (LL) status is displayed upper center.
- Pitch (elevator) and roll (aileron) trim is displayed within the box on the upper right.
- Control stick pitch deflection (%) is displayed above the trim box.
- Digital pitch trim setting is displayed below the trim box.
- Flap and slat positions are displayed around the jets outline.
- Control surface positions are blue when retracted and green when deployed.

- Along the bottom of the display are chaff and flare remaining counters., afterburner on/off toggle switch and status display and the TRD status display and toggle switch.

2.20 COLOR MOVING MAP (G1000)

The color-moving map is an option available from the weapons page but not directly from the fuel page.

It covers the right half of the PCD; both the PFD / VIEW tab and the W E P tab.

- Click the upper left corner of the color-moving map to POP UP the display.
- Click the lower right corner of the color map to POP OUT the display.
- Click the lower left corner of the map to zoom in.
- Click the upper right corner to zoom out.
- Click on DCLTR to de-clutter the display of airspace borderlines.

To get back to the PFD / VIEW and WEP pages click the FUEL tab.

2.21 CENTER SUB PANEL SWITCHES

A dedicated control switch panel sits directly below the PCD.

From left to right are:

1. HMD on/off toggle switch
2. HMD brightness control
3. R2c (Roll to see plug-in) off/simple/advanced mode select switch
4. GCAS on/off switch
5. Panel brightness control
6. DAS system on/off toggle switch (auto ON in R2c ADVanced mode)

Also on the center pedestal is a dedicated backup attitude display, back up fuel counter and red guarded fuel dump switch.

The BRAKE handle sets and releases the parking brake.

2.22 LEFT SIDE VERTICAL SUB PANEL (NUMBER PAD 7) (R2C OFF)

On the left is a large recessed JETTISON ALL WEAPONS button for use in an emergency when you need to get rid of all your weapons quickly or something bad will happen. I do not know what that emergency might be but this button is in the real jets cockpit.

Below that is a wheel brakes status light and an afterburner on/off toggle switch.

The gear handle is next and a red guarded Emergency Gear Extension button (which does NOT work on this model).

Below that is a landing light on/off toggle switch.

2.23 RIGHT SIDE VERTICAL SUB PANEL (NUMBER PAD 9) (R2C OFF)

On the right is a guarded AUTO RECOVERY toggle switch. If you loose situational awareness in the clouds or at night you can lift the guard and toggle this switch to trigger the Auto GCAS logic and return the jet to straight and level flight and hand over to the autopilot.

Below and slightly to the right, directly in front of the control stick are the refueling and the canopy open/close toggle switches.

2.24 AUTOMATED LOGIC ASSOCIATED WITH THESE TWO SWITCHES

This jet is smart and takes care of itself.

Releasing the brakes automatically stops ground refueling if one is in progress.

If the jet will not refuel when you flip the IFR open switch UP while on the ground it is probably because the brakes are NOT set.

Closing the canopy automatically shuts down the IPP if the engine is running.

If the engine was not running and you start it with the canopy closed the IPP will shut down as soon as the engine reaches idle.

2.25 WHAT IS AN IPP?

What is called the IPP (Integrated Power Pack) on the F-35 is really a small jet engine that provides several things in one package that other jets need several different systems to achieve.

The IPP is an APU (Auxiliary Power Unit) providing electricity and pressurized air for the back up pressurization system. Most jet's a have an APU but not one like this jet.

The IPP also provides "conditioned" (cooled) air for cockpit and avionics cooling on the ground. That service is usually provided by a dedicated ECS (Environmental Control System) on other aircraft.

After main engine start the systems that provided electric, cooling and pressurized air to the jet also provide those services but instead of burning fuel (burn mode) to do the work the IPP is powered by the main engine in bleed mode (receiving engine bleed air).

So the IPP is always engaged and the systems that run off it are always getting their energy from it. Those systems don't know where the IPP is getting it power from; either burning fuel itself or getting its power from the main engine. They do not care.

This fact allows the IPP to instantly respond as an emergency back up should the main engine fail.

This model can execute the in flight transition from main engine failure (or intentional main engine shut down) and automatic emergency IPP back up air-start without pilot intervention, but only if the reason for the engine stopping was something other than running your jet out of fuel. The IPP needs fuel to operate in burn mode.

2.26 RIGHT AFT SIDE PANEL (NUMBER PAD 6) (R2C OFF)

IFF (identification Friend or Foe) control box is located here. Enter a four-digit code using the up/down arrow above and below the code digits.

This completes your item-by-item, switch-by-switch tour of the jets cockpit. Now I need to prepare you for your first flight in the jet.

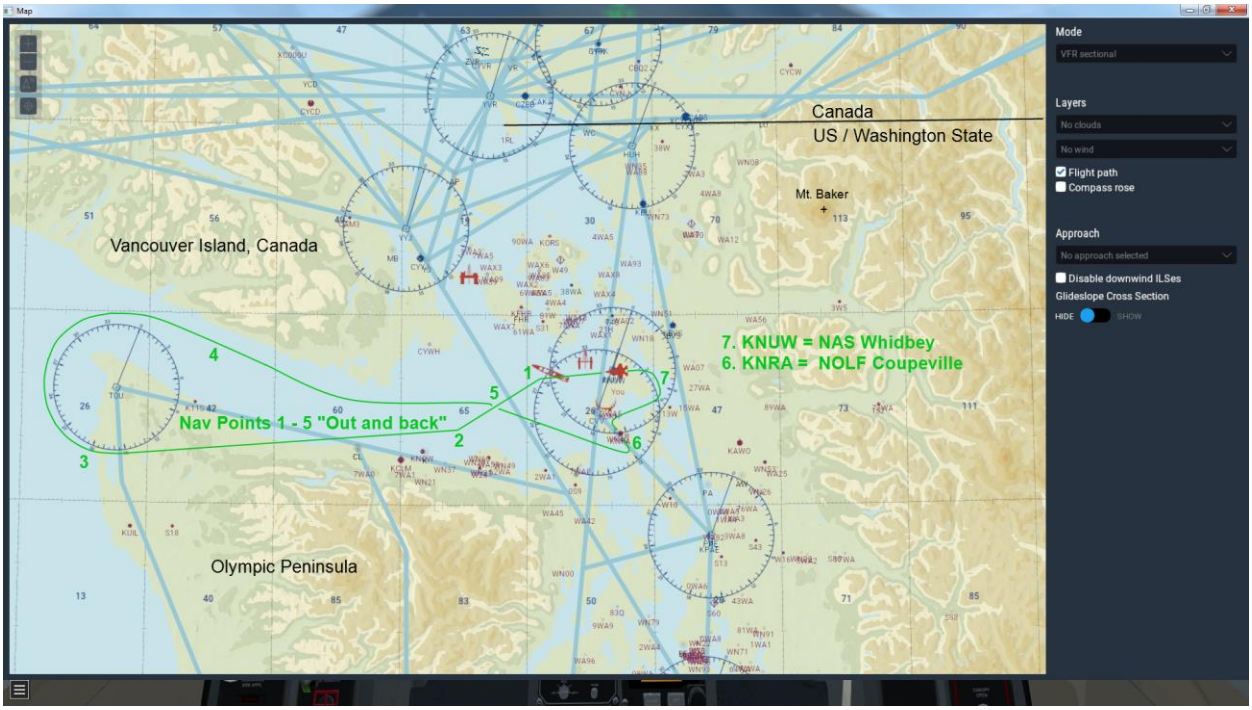
CHAPTER 3 - FIRST FLIGHT

3.1 FLIGHT PREPARATION

Principle: Time spent setting up now will save your life later

Go to the Flight Configuration menu, Change location (upper right corner of menu), search Whidbey Island NAS (Naval Air Station) KNUW then click Customize (upper right corner again) pick runway 25 to start.

Bring up the X-Plane sectional map and expand it to fill your computers screen.



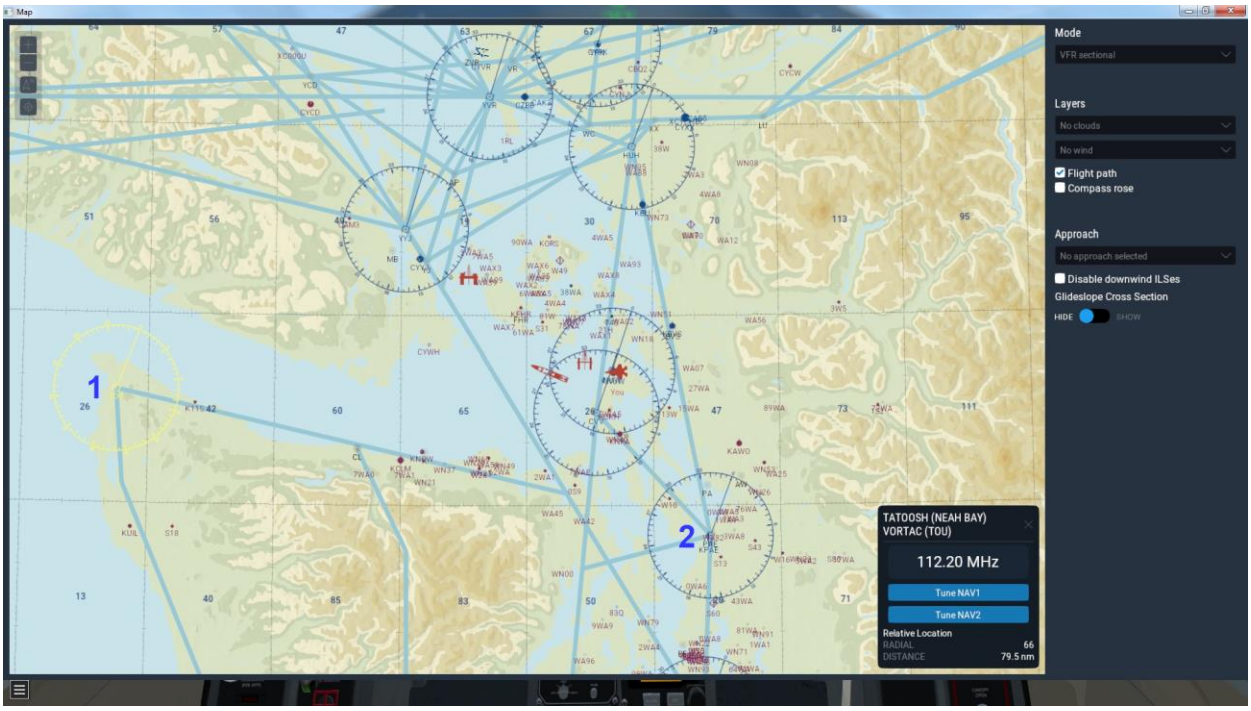
Your first flight from KNUW

Your jet will be centered in the map facing west. Note the geography around you.

The route for this first flight is going to be straight out, heading 250 while climbing to 15,000 MSL.

You will be flying down the middle of the Straight of Juan De Fuca, where the Pacific Ocean enters Puget Sound.

Vancouver Island, British Columbia, Canada will be on your right as you fly west and Washington State's Olympic Peninsula will be on your left.

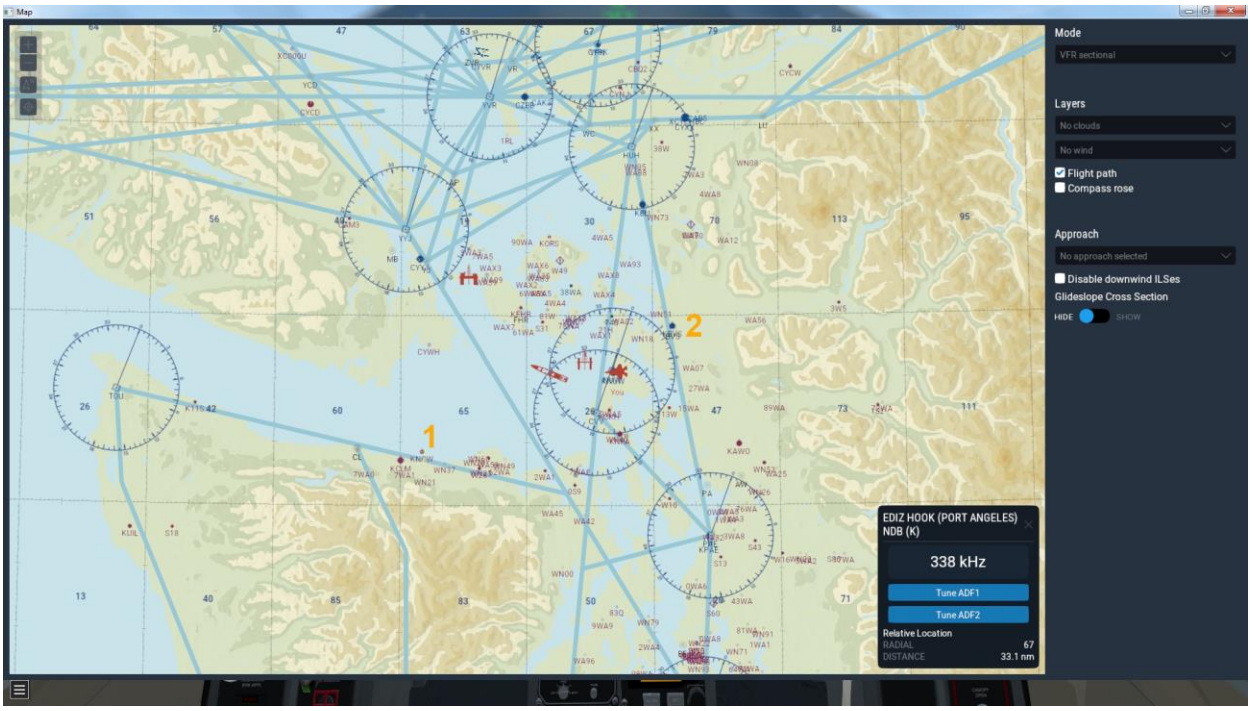


TATOOSH (Neah Bay) VORTAC

Your first navigation point is going to be at the far Western tip of the Olympic Peninsula, TATOOSH (Neah Bay) VORTAC.

Find it and click on the center of the blue compass circle. An auto tune entry box will pop up in the lower right corner of the map where you can click to auto tune Nav1 to 112.20 MHz.

Remember, if you manually tune the Nav1 radio you are tuning the standby frequency and you need to "flip" that to the active frequency window.



EDIZ HOOK (Port Angeles) NDB

On the way out to Neah Bay you will pass Port Angeles on the north coast of the Olympic Peninsula. Zoom in on that area and locate the NDB next to KNOW; EDIZ HOOK (Port Angeles) and click the beacon symbol on the map. This will pop up the auto tune box for the ADF radios. Click "Tune ADF1" to auto tune the radio to 338 kHz.

You will be using this beacon on the way out to Neah Bay and on the way back to keep yourself oriented and monitor your progress along the route.

Note that, since you are still on the ground and probably out of range of either of those first two navigation stations the solid blue (nav1) and solid yellow (adf1) lines on your radar display screen will remain "parked". They will "come alive" probably as soon as we get airborne.

There are still two more nav points to program. On the sectional map South East of Whidbey NAS at Paine Field is PAINE (Everett) VOR/DME.

Click on the center of the blue compass circle, then click to auto tune Nav2 to 110.60 MHz.

There are two NBD's just north of Paine Field but we will ignore those and scroll the map further north to Skagit Regional (KBVS). This airfield is just north east of Whidbey and has an NDB right on the field.

Zoom in on the field and locate the Skagit/Bay View (Burlington) NDB and click on the beacon symbol to bring up the auto tune box and then click Tune ADF2 to 240 kHz.

If for some unexplained reason a suggest navigation aid does not work on your installation of the simulator then select another one in the local area instead.

Now you have four nav reference points out to Neah bay and back to Whidbey Island. All that is left to do is enter Whidbey Island NAS into the jet's GPS system.

3.1.1 Enter the four letter GPS code for departure airfield it into the GPS system.

This is where I use the **GpsFPLInput** freeware [Windows only] plug-in by Gtagentleman from the X-Plane.org freeware download manager to make this step as quick and easy as possible.

Enter KNUW for NAS Whidbey Island.

3.1.2 Select Nav1 as NAV SOURCE

Use the touch switch between Nav1 and 2 radios frequency displays.

Arrow will point left to Nav1 and color will change to blue.

Nav Source selection also drives the tadpole in the HMD. If you select Nav1 the tadpole points to the navigation beacon frequency set in Nav radio 1. If you select Nav2 the same happens. If you select GPS the tadpole points to the destination set in the GPS system.

Remember: Nav Source selection also drives the tadpole in the HMD.

3.2 YOUR FIRST FLIGHT

A F-35B from Marine Fighter Attack Training Squadron 501

Your first flight is going to be a conventional "long" runway CTOL Mode departure followed by a conventional landing back to the same runway.

Principle: Run before you walk, walk before you crawl

F-35B corollary: Conventional takeoff and landing before short takeoff and short landing. Short takeoff and short landing before vertical take off and vertical landing

Set the Com1 radio to tower frequency if you want to talk to other people or go "radio silent" if you like. I don't care one way of the other. Who is going to know?

The F-35, with its BIG color moving map spanning half the PCD gives you complete SA (situational awareness) of the surrounding airspace. You do not really need to talk with anyone to know where everyone else is and what they are doing.

During this short flight I am going to point out how the color-coded navigation lines built into the radar display boost your situational awareness level. You will easily know where every nav aid is in your vicinity as you complete your circuit out, back and onto your approach for landing. Complete situational awareness makes this ridiculously easy.

Your engine is running (1.7), you are set to go, so lets close the canopy. Closing the canopy also retracts the built in boarding ladder and closes the ladder cover door. The jet is ready to taxi.

3.2.1 Click the ENG/FUEL tab

Note your aircraft gross weight and idle engine thrust, idle fuel burn rate in pounds of fuel per minute, fuel temp and fuel TOT (total). These numbers are continuously fed into an equation to determine your endurance and range. The big green fuel status bar is easy to monitor with your peripheral vision. It turns yellow when you get down to 2,700 lbs and red when you get down to 1,350 lbs of fuel.

Before you release the brakes to taxi to the runway take a last look at your fuel load. If you have been sitting hear a long time reading through this User Guide with the engine running you might want to add some fuel before you go flying. It's up to you. If you do want to add fuel the flip the "IFR OPEN" toggle switch on the right vertical side panel.

Fuel will be added to your jet even while the engine is running. This is called "hot pit" refueling and is common on fast jet aircraft.

I almost always fill the tanks before takeoff, even thought I know I can in-flight refuel in this jet any time I like. Refueling before takeoff takes less than a minute so, why not?

3.3 TAXI

If you do not have a Track IR or VR head set toggle the R2c plug-in ON now.

Release the parking brake with the mouse by clicking **PARK** on the PCD with rudder pedal toe brakes if you have them, a key board or a stick/throttle switch if you don't or, just pull back on your control stick a little and a nifty plug-in releases the PARK brake.

Add a little power and taxi forward.

Turn the jet with rudder pedals if you have them. I have a "twist" joystick.

Make a complete 360-degree turn. Note how the pilot's head camera swings in the direction of your turn.

Below ~ 10 knots the camera will turn up to 75 degrees left or right. Between 10 and 20 knots the left / right view is limited to just 15 degrees. Above 20 knots the camera looks straight ahead until you get airborne.

Taxi in a complete circle now to see how the camera works then taxi back into position and at the EOR (End of Runway) 25 and hold.

Set the brakes. You can do this by pushing forward on the stick if you do not have toe brakes.

On the autopilot panel is a **magenta** heading number. Use the up/dn arrows to adjust the heading to match your departure runway heading. This number is repeated on the radar moving map display and a dashed magenta line displays this flight path forward.

Add a little nose up stabilizer pitch trim for takeoff. For a light jet ~ .10 is good.

Once airborne you can adjust pitch trim until the jets nose stays where you want it even when you release the stick.

The jet normally controls the flaps automatically during flight and on the ground but if maintenance wants to do some work under the wings, like loading pylons and weapons then the flaps can be raised. If you have flaps switch on your throttle control or set up a keyboard key to control flaps you can raise the flaps if the jet is going < 40 knots.

The flaps should be lowered before you start a takeoff roll. If they are not down (maintenance left them up) then they will automatically deploy when the jet accelerates past 40 knots.

On touch down the flaps ("flaperons" actually = flap and aileron) on both wing trailing edges will deflect upward when the speed brakes deploy. This action by the flaperons is designed to eliminate wing lift and increase weight on the wheels for better braking.

This feature only happens on landing roll out or in the event of a rejected takeoff where the jet reached a ground speed > 100 knots. Below 80 knots the speed brakes will automatically close and the flaperons will revert to normal flaps again.

On this flight you will takeoff **without** afterburner**.**

You have two options. You can toggle the afterburner enable switch off or just stop short of pushing the throttle lever all the way to the forward stop.

The advantage of using the toggle switch is that you can slam the throttle forward and be assured of achieving maximum dry (non afterburning) thrust.

The disadvantage is that you have to find and flip a switch if you suddenly need the afterburner for more thrust.

The advantage of stopping short of the forward stop is that afterburner thrust is instantly available if you suddenly need it.

The disadvantage is that by stopping short of the forward stop you might not be getting max dry thrust from the engine throughout the takeoff roll. Perhaps leading you to have to resort to afterburner to get airborne before the end of the runway.

Decisions, decisions. That is really what flying a fast jet is all about.

If you do not like making lots and lots of hard decision at a rapid and accelerating pace for one to two hours at a stretch well, what are you doing in the cockpit of an F-35?

3.4 TAKEOFF

A F-35B performing a conventional take-off

Release the brakes and push the throttle forward

Accelerate to ~ 150 knots IAS and rotate the nose up 10-15 degrees to lift off.

Takeoff acceleration is "moderate" without afterburner.

Continue to accelerate and the flaps will start to come up.

Between 160 and 260 knots the flaps will auto retract according to a speed schedule.

At ~ 200 knots raise the landing gear. If you forget to raise the gear at 200 knots the speed brakes will deploy automatically at 250 to keep you from exceeding the 300-knot max gear operating speed limit. At 300 knots the gear will retract automatically.

Accelerate to at least 400 knots and climb to 15,000 ft.

Up to 16,000 ft you can use the 500-knot pop up button and stay sub sonic.

Above 16,000 use the .92-mach pop up button.

During the initial climb glance at your radar moving map display and see if the solid blue and solid yellow lines have come "alive"?

As you fly out on the departure runway heading note the small number below MAG heading in the HMD. That is the reverse heading you will turn to when making a 180-degree turn. Whatever the MAG heading currently is, this number will always be the reverse. This **helps you maintain SA (situational awareness)**.

Select GPS as your Nav Source (touch switch between the Nav radio frequency displays)

A glance now to the upper left corner of the HMD will reveal the GPS xx.x nautical miles increasing as you fly further and further away from Whidbey. Monitoring this distance as you proceed on course **helps you maintain SA**.

The GPS "tad pole" is a little **green circle with a tail** in the center of the HMD below the reverse heading digits.

The tail always points to the destination entered into the GPS (KNUW = Whidbey).

This device **helps you maintain SA**. You always know where you are by distance and direction in relation to a known point on earth programmed into the GPS.

On your radar display is a **green line** that corresponds to the tad pole in the HMD. It also points toward the destination entered into the GPS to **help you maintain SA.**

Both the solid green line and the tadpole should be pointing down because Whidbey is behind you and getting further and further away.

The solid blue line on the radar display will to point to TATOOSH (Neah Bay) VORTAC as you fly along your outboard course. This **helps you maintain SA**.

The **solid yellow line** (ADF1) in the radar display continuously points to EDIZ HOOK (Port Angeles). This **helps you maintain SA**. Are you starting to get the picture here?

The dashed **yellow line** (ADF2) in the radar display is probably "parked" because you are out of range.

3.5 MAINTAINING SITUATION AWARENESS

Maintaining SA is a major issue in a fast jet. Right now you are tooling along a 400 knots, 4 x faster than a Cessna. Learning how to prepare the jet to help you maintain SA is vitally important. If you do not keep up with these basics then, when a Mig or Sukoi pilot shows up to mess with you you're not going the have the spare mental capacity to deal with them effectively.

Switch back to Nav Source Nav1 and focus on your flight to the West.

The white increasing number below NAV SOURCE is the GPS distance from Whidbey.

Note the small red circle the yellow line keeps point toward. That is the NDB beacon on the ground.

For training purposes in our model this represents an active SAM (Surface to Air Missile) system and something you want to avoid so, keep your distance. Stay away from small red circles.

3.6 INDICATED AIR SPEED

The HMD airspeed displays IAS (Indicated Air Speed)

IAS is different from **TAS** (True Air Speed) or **Mach**.

The difference is only slight near sea level.

The differences increase dramatically with altitude.

Indicated airspeed is a measure of the **pressure** of air molecules acting on the jet.

Indicated airspeed **increases when you accelerate** thru a volume of air because you encounter more air molecules per given period of time at higher speeds.

Indicated airspeed **decreases with altitude** because there are fewer air molecules in a cubic volume of air the higher you climb in altitude.

TAS is the speed of the jet thru air and is equal to GS (Ground Speed) **IF** there is no wind to add or subtract.

Mach is a percentage of speed of sound (mach 1) which varies from ~ 660 knots TAS at sea level to ~ 560 knots TAS at 35,000 ft.

The jet's wings only understand indicated airspeed.

260 knots **indicated** is the slowest speed your wings want to fly without the flaps.

It does not matter what altitude you are at, IAS measures the number of air molecules.

IAS	At	Is around
270 knots	~ sea level	275 knots true
270 knots	5,000 ft	294 knots true
270 knots	10,000 ft	315 knots true
270 knots	15,000 ft	340 knots true or .54 Mach
270 knots	20,000 ft	366 knots true or .59 Mach
270 knots	25,000 ft	396 knots true or .66 Mach
270 knots	30,000 ft	426 knots true or .72 Mach
270 knots	35,000 ft	460 knots true or .80 Mach
270 knots	40,000 ft	506 knots true or .88 Mach
270 knots	45,000 ft	560 knots true or .97 Mach
270 knots	50,000 ft	690 knots true or Mach 1.20

So you see, 270 knots is a measure of the ability of the remaining air molecules at altitude to support the aircrafts wings and not a useful indication of how fast you are traveling through the air (TAS) or over the ground (GS).

Wings do not know or care about TAS or Mach.

Wings only care about how many air molecules there are to support lift.

More molecules equals more lift potential.

More lift equals more G potential.

More molecules gained by flying faster at any altitude or by descending into denser air at lower altitude is all any wing cares about.

Why is it important?

More air molecules equals more lift potential.

More lift potential equals more G potential.

The 7 G limit of the F-35B cannot be reached at 270 knots IAS. You will have to be going much faster than that, closer to 500 knots.

Not 500 knots TAS but 500 knots IAS.

So, you can see how you are not going to be pulling 7 G's at altitudes above 30,000 ft MSL because you cannot reach and sustain 500 knots IAS.

Even down at 20,000 ft you will need to have the afterburner lit to reach and hold 7 G's for any length of time before the drag of high G flight slows you down and limits your lift potential.

Note: a 40,000 lbs jet will weight 280,000 lbs at 7 G's so even a 40,000 lbs thrust engine is only going to give you a thrust to weight ratio of .14 That is a far cry from the high thrust to weight ratios advertised by marketing departments for various modern fighters.

3.7 BACK TO THE FLIGHT

Scoot past the Port Angeles SAM site (NDB) by keeping the yellow line pointing off to your left and continue west to Neah Bay.

Since you are out over the water and > 15,000 ft why not go for a ~ 50 nm supersonic run out to Neah Bay?

Click the **1.2** pop-up button. As you approach the small red circle at Neah Bay remember, stay away from them. They are the "threat." Swing wide around the Peninsula point maintaining a safe distance by staying outside the blue compass circle on the G1000 color-moving map. That circle is the distance where, if you were stupid or unaware enough to fly inside of it, the SAM system would be able to see and target you. Look closely at the red line in the screen shot below. Keep the white jet icon outside the "threat detection range" circle.

Virtual threats near Neah Bay

Once you've made a wide half circle around the threat head back East down the middle if the straight.

The Port Angeles "threat" is now too far away for the solid yellow line to become active so be on the lookout for that to happen as you fly east.

From the tip of the Peninsula to NAS Whidbey is ~ 80 nm on a heading of ~ 75 deg.

3.7.1 Switch to Nav Source Nav2 as you fly east.

You want to fly a heading of at least 90 deg or more for now to stay out of Canadian airspace, not that they could do anything about it.

When the yellow line comes alive change course 10 deg left to 080.

The dashed blue line points to Paine Field, South of NAS Whidbey and ~ 80 nm away, while Whidbey is ~ 60 and slightly North of your course.

You are going to approach Whidbey Island from the West, heading East and I will point out the Coupeville Navy Auxiliary landing field where currently EA-18G Growlers practice "field" carrier landings. You will be going there on your next flight.

At any time you can pop up the default X-Plane sectional map and get a "big picture" look at the area you are flying over or, click the FCS, then MAP tabs to fill the right side of the PCD with the G1000 color moving map. I prefer the built in G1000 map.

Click in the upper right corner of the map to zoom out or lower left corner to zoom in.

Whidbey Island approach

As you approach Whidbey Island reduce your auto throttle speed by clicking the **400** popup speed button and descend to 10,000 ft before enter the long rectangular magenta box on the map, heading ~ 95 degrees (Nav point 5).

Slow the jet to 400 before you enter the blue box on the G1000 color map at ~ 2,000 ft AGL.

Once in the blue box bank left and approach NOLF (Naval Offsite Landing Field) Coupeville (KNRA) from the South.

Fly straight down the Coupeville runway 32 (~NNW) at 500 ft AGL then climb to 2,000 ft and turn to a heading of 045. A major landmark for your future flights in this area is 10,000 ft high Mount Baker off in the distance ~ 30 nm away.

3.7.2 Switch back to Nav Source GPS

The tadpole in the HMD will point off to your left at Whidbey NAS ~ 7 nm away.

You are going to fly a large left hand arc around the East side of the island and approach runway 25 directly from the East.

As you turn through North heading 000 following the island shoreline stay out over the water and ~ 2,000 ft until you pick up the airfield.

Run in straight at 2,000 ft MSL and at least 400 knots IAS.

At mid field note the reciprocal heading (small number below MAG heading in the HMD) and roll into an aggressive left 180 degree turn and roll out on the reverse runway heading = downwind for runway 25.

Bring the throttle to idle if you have switched the autopilot auto throttle off or, click the 200 pop up speed button.

Bleed airspeed in the turn by maintaining 2,000 ft MSL.

At 260 knots the flaps will start to come down automatically according to their schedule.

IAS	Flaps position
<160	full down
160-170	80%
170-180	60%
180-220	40%
220-260	20%
>260	full up

At 250 lower the gear. If you forget they will come down automatically when you slow to less than 210 knots below 1,000 ft AGL.

Extend your downwind leg back out to the water on the East side of the island and make another, slower 180 deg turn back toward the runway.

3.8 FINAL APPROACH

Cross the shoreline 3 nm from touchdown at 1,000 ft.

When the gear comes down the autopilot auto throttle mode will switch to APC and maintain optimum airspeed down to 40 ft AGL. Hopefully you will be over the runway when that happens. Otherwise, if you are manually controlling the throttle manage you speed by maintaining ~ 10 deg AOA while keeping the velocity vector ball on the runway numbers.

At 40 ft a female voice will call out "forty". Leave the throttle where it is and carry the power through the flare and touchdown, and then pull the throttle to idle.

Hold stick back 1/2 at touchdown and keep the nose wheel off the runway with more back stick until you see "AERO BRAKE" display in the HMD.

3.9 SPEED BRAKES

Speed Brakes will automatically deploy on touchdown and stay deployed until the jet slows to 80 knots.

F-35's do not have a dedicated speed brake like an F-15 or Eurofighter Typhoon. Instead, they use a combination of flight controls deployed opposite each other to create drag that slows the jet. The most notable speed brake action are the twin rudders "toeing" out board opposite each other instead of moving in unison like they usually do. In addition, the wing trailing edge flaperons (flaps/aileron combo) deflect up to reduce wing lift and increase weight on the wheels and improve braking effectiveness.

When the jet slows to ~ 80 knots gently lower the nose wheel to the runway and apply wheel brakes. With the auto brake plug-in just push forward on the stick to apply brakes.

Above 5 knots you will get anti-skid function out of the brakes. Below 5 knots the parking brake will be set.

Taxi back to the departure end of runway.

Now that you have taken a fast run around the neighborhood on the next flight we will learn to walk around close to home with a short rolling takeoff and a slow gear down transit down to Coupeville where you will make your first SRO (Short Roll On) landing.

CHAPTER 4 - STOL OPERATIONS

4.1 STO/VL OPERATIONS (MANUAL MODE)

A F-35B transitioning from vertical to horizontal flight

Load the F-35B_VTO model in the simulator. Engine start and cockpit preparations are exactly the same as the first flight.

For this flight you do not need to fully program the navigation system but you might want to program the GPS with the local airfield code; KNRA. That will drive the tadpole in the HMD to give you direction and range to the new airfield you will be visiting; NOLF Coupeville.

After engine start taxi to the EOR (runway 25) and hold.

The VTOL / CTOL switch should be in the MANUAL mode (default).

Mode is displayed at the top of the Checklist page.

In MANUAL mode you have complete control of the nozzle angle on the ground and in flight.

Use any method you like to control the nozzle position. 1. Keyboard up and down keys or 2. Throttle control switch or 3. Popup preset vector buttons (use square #4 next to "MENU" or the Master Menu button).

Choose the mode you prefer and **set the nozzle to 60 deg** for the short takeoff.

Release the brakes, taxi onto the active runway and line up for takeoff.

Check fuel now, before you takeoff. Landing minimum is 2,800 lbs. Emergency landing minimum is 1,400 lbs. You will use ~ 2000 lbs for a 20 minute flight. 8-10,000 lbs is a good starting fuel for this sortie.

Select GPS as your navigation source. Coupeville is 10 nm south.

Apply full power, accelerate to 60 knots and rotate.

Limit pitch to 15 deg and reduce power almost immediately after lift off to keep the green velocity vector ball at or below the water line "w" marker in the HMD.

If pitch exceeds a 30 deg nose up the nozzle will go to zero automatically.

Climb to 2,000 ft AGL and reduce power to lower the HMD velocity vector ball to level flight near the horizon.

Keep the nozzle at 60 degrees throughout the remainder of this flight.

Keep the gear down and limit airspeed to < 200 knots.

With the gear down speed brakes will auto open if you exceed 250 knots.

The lift system doors will auto close if you exceed 250 knots.

Follow the tadpole cue in the HMD. After a runway 25 departure you can follow the Whidbey Island western shoreline south get to Coupeville. Stay out over the water for noise abatement.

When the tadpole is pointing off to your left 90 deg then begin a left turn toward the Coupeville runway. The point of land you will round is the Keystone ferry terminal.

Once you are lined up with the runway (~ 320 deg) reduce power to start your descent, keeping the waterline "w" on or above the horizon and the velocity vector ball near the approach end of the runway.

Flaps will auto deploy according to their speed schedule.

Maximum descent rate is < -2,000 fpm.

VVI in the HMD will flash if < -2,000 fpm is exceeded.

Add or reduce power as required to control your descent rate, keeping the velocity vector ball on the nearest end of the runway as you approach.

PATH ~ - 6 degrees

Touch down speed ~ 100 knots (walk in).

Push the stick forward on touchdown (no aero braking).

Anti-skid brakes apply automatically with forward stick push.

Pull the stick back to release the brakes.

4.2 STO/VL OPERATIONS (AUTO MODE)

The models vector lift system has an AUTO mode too.

The key to using the AUTO mode to manage the nozzle **is understanding the logic** operating in the back ground, then flying the jet in such a way as to trigger the logic to do what YOU want instead of the logic interfering with your head.

Here are several key things to understand about auto_vector logic.

1. Altitude

2. Climb / descent rate

3. Airspeed

4. Nose pitch attitude (theta)

5. Angle of Attack (aoa)

6. Velocity vector (path)

The system only works when your airspeed below 250 IAS.

The system only works if your altitude is below 10,000 ft MSL.

The system has two logics once you are below 10,000 ft.

Takeoff and while below 500 ft AGL

Climb rate > 500 fpm the nozzle stays at 60 degrees.

"Level flight" is defined as between -500 and +500 fpm below 500 ft AGL.

The nozzle will stay at 60 deg or where ever you manually position it between 60 - 100%

Even thought you are in "auto" mode you still have manual control of the nozzle if you are in "level" flight.

60 deg is the maximum forward limit below 500 ft AGL.

If you stop your after takeoff climb out below 500 ft AGL and allow a descent rate of < -500 fpm to develop the nozzle will automatically go to 100 % (straight down).

4.3 ABOVE 500 FT AGL AND UP TO 10,000 FT MSL

If the jet is climbing > 1,000 fpm the system is **biased** to tilt the nozzle aft (decrease nozzle angle = more aft thrust for faster speeds).

Climb/descent rate > - 1,000 but < 1,000 fpm = "level flight" in my logic when you are above 500 ft AGL. This "looser" definition of "level flight" above 500 ft AGL allows you more room to play in before triggering an automatic nozzle reposition. The tighter definition of level flight below 500 ft AGL is there because you don't have as much altitude to play with anyway, especially when figuring what descent rate needed to move the nozzle down.

If the jet is descending < - 1,000 fpm the system is **biased** to tilt the nozzle down.

If you are within the climb and descent limits stated above then airspeed does not mater as long as you are below 250 knots.

Once climb or descent rate exceeds a limit other logic starts to come into play.

Above 500 ft AGL and > 1,000 fpm climb there are three airspeed "blocks" to be aware of:

< 50 knots	Nozzle 60 deg
Between 50 and 150 knots	Nozzle 40 deg
Between 150 and 250 knots	Nozzle 20 deg
> 250 knots	Nozzle 0

As you can see above the faster you go the more the nozzle shifts aft to propel you even faster, as long as you climb rate is > 1,000 fpm. That's the "bias" I spoke about above.

"Level" off (>-1000<1000) and the nozzle goes to 60 deg.

The "trick" is to fly the jet in the pattern just like in CTOL or STOL modes. 150 - 200 knots at > 500 ft AGL and the nozzle will stay put.

Your pattern altitude should be ~ 2,000 ft AGL so you have a 1,500 feet of altitude and 2,000 fpm between the "descent rate floor" and climb rate "ceiling" to play in before you hit the 500 ft altitude "floor" and auto vector tilts the nozzle down 100%.

A different set of airspeed blocks apply when you are descending.

Normal descent rate = < -2,000 and - 1,000 fpm	
< 100 knots	Nozzle 100 deg
Between 100 and 150 knots	Nozzle 80 deg
Between 150 and 250 knots	Nozzle 60 deg
> 250 knots	Nozzle 0

Rapid descent rate = < -3,000 and - 2,000 fpm	
< 150 knots	Nozzle 100 deg
Between 150 and 200 knots	Nozzle 80 deg
Between 200 and 250 knots	Nozzle 60 deg
> 250 knots	Nozzle 0

As you can see above the slower you go and the faster your descent rate the nozzle shifts down to provide more lift from the engine thrust to replace the wing lift lost due to flying at slower airspeeds. This is the descent "bias" I spoke about above.

You have to increase engine thrust though. If you don't you are going to end up smacking the ground pretty hard.

As you get closer to 500 ft AGL you need to increase engine thrust to limit your descent rate and not blow through the altitude "floor" at < - 3,000 fpm.

4.4 BELOW 500 FT AGL

The nozzle is limited to 60-100 % angles only.

Auto logic will set the nozzle to 100% with < - 500 descent no matter what your speed is, as long as you are less that 250 knots IAS. Otherwise you have manual control of the nozzle to reposition it up to 60 deg. **This is with auto mode enabled.**

Below 100 knots and with the nose of the jet < 10 deg above the horizon the ailerons will be locked out by FCS (Flight Control System) logic. This gives you roll stability during the SRO (Short Roll On) / VL (Vertical landing) transition and pre-touch down flare.

On vertical landings aim to touch down in a three-point attitude.

Shall we give it a try? Lets go fly.

Select AUTO mode and the nozzle will move automatically from 0 to 60 deg.

Perform a short takeoff as before with the nozzle set to 60 degrees.

Observe automatic nozzle repositioning as you climb through 500 ft AGL.

Level off at 2,000 ft AGL and fly a racetrack pattern to a 3-mile final approach.

Keep the gear down and limit airspeed to < 200 knots in the pattern.

On final reduce power to start your descent, keeping the waterline "w" on or above the horizon.

Observe automatic nozzle repositioning as you slow and descend through 500 ft AGL.

Add power as you slow the jet, using engine thrust to replace lost wing lift as explained above.

Add or reduce power as required to control your descent rate, keeping the velocity vector ball on the approach end of the runway.

Your aim is to slow to ~ 40 knots at ~ 40 ft above the runway.

Your options at that point are to:

1. SRO with ~ 40 knots of forward speed

2. VL, hold the nose up ~ 5 deg and stay at 40 ft AGL until you reach 0 forward airspeed, then reduce power and pitch to land vertically with the nose on the horizon.

4.5 VERTICAL TAKEOFF AND HOVER PRACTICE

This sortie can be flown over a runway or the ramp, in auto or manual mode.

Aircraft gross weight must be < or = to 38,000 lbs. Since the jet weights 32,500 lbs empty that leaves you with ~ 5,500 lbs of payload to divide between fuel and weapons.

If your starting airfield is > 1,000 ft MSL subtract 1,000 lbs of weight (fuel/weapons) for every additional 1,000 ft of altitude. Attempting vertical takeoffs and landings > 4,000 ft MSL is not recommended. Switch to STO/VL or Conventional long runway operating procedures you learned earlier to takeoff and landing at higher altitude airfields.

Add power and lift off in VTO/L mode (nozzle 100%), reducing power as required immediately after lift off to check climb and remain < 100 ft AGL. Above the runway or ramp.

Once established in a stationary hover there are two ways you can move the jet forward and aft. You can use the stick method for short, low speed moves or vector the nozzle manually a few degrees to move over longer distances.

Try the stick method first. With your right hand use a very slight stick push to pitch the nose down and "air taxi" the jet forward.

Limit forward speed to 10 knots for now, lifting the nose to the horizon to limit forward speed as soon as you get the jet moving. Use your left hand on the throttle to control your altitude above the ground.

Slow the jet by lifting the nose above the horizon, dropping the nose again in time with the jet coming to a stand still.

Practice this starting and stopping exercise until you have a feel you how much you need to raise and lower the nose to jet the jet going and then stopped again.

Using the nozzle involves keeping the jets nose on the horizon and tilting the nozzle back a few degrees (max 90) to get the jet moving. Once you get it going move the nozzle back to the 100 setting and let the jets momentum carry you to where you plan to set down again. To bring the jet to a full stop in the air use the stick pitch method, then reduce power to set the jet back down on the ground.

X-Plane's visible heat shimmer from the engine exhaust nozzle has a unique quirk associated with it. The heat shimmer emanates from the back of the nozzle, as you would expect, but only when the nozzle is pointing straight back (0 deg) through straight down (90 deg). As soon as the nozzle goes past 90 (to 91+) the heat shimmer flips 180 degrees and points straight up! [Laminar Research has been made aware]. For this reason the nozzle on our jet stops at 89.9 degrees (= 100%, not 100 degrees). Once laminar fixes the issue we will increase the forward movement of the nozzle to 100 degrees like the real jet. This will allow you to apply a bit of "reverse thrust" to slow the jet while air taxiing down a ramp or runway.

CHAPTER 5 - WEAPON SYSTEMS

The F-35B in “beast” mode

X-Plane is not a "combat simulator" by any stretch of our imagination.

It is not a competitor to any dedicated combat simulator and most probably never will be.

So why do we spend so much time and effort building "combat" aircraft for X-Plane?

The answer? We like combat aircraft. They represent the latest airframe and avionics technology and the highest level of flight performance in the aviation world.

In short, combat aircraft are loud, fast and exciting to fly.

You do not have to blow anything up to enjoy flying them.

X-Plane is by far the best available and most accessible flight simulator platform for replicating the dynamic feel of actual high-speed flight, integrating 3D physical models with the dynamic flight model and creating modern avionic displays. All this could be done for other simulator platforms but it would be prohibitively expensive in terms of dedicated development software, time and market access.

Where X-Plane comes up short is simulating a modern combat aircrafts ability to find and fix an air or surface target and guide a simulated weapon (missile or bomb) to that target.

The tools are pretty basic and almost everything has to be done by plug-in code.

Here is what we provide you.

The weapons on this model consist of the aircraft centerline external 25 mm GAU-25 gun pod with 500 rounds of ammunition. (Though the real jet only carries 220 rounds).

There is no internal gun on the F-35B (or Navy F-35C). Only the F-35A has an internal gun.

The jet carries its other weapons (missiles and bombs) internally and, if the need for stealth is not essential, weapons can be carried the "old fashion" way, under the wings.

All these models (CAS, JSM and VTO) carry the standard A2A (air-to-air) load internally; two AIM-120D missiles.

The CAS and JSM also carry 8 x SDB2s (GBU-53B Small Diameter Bomb II) internally.

The CAS model also carries 4 x GBU-12 LGB (Laser Guided Bombs) and two AIM-9X IR guided missiles under the wings while the JSM model substitutes 4 x JSM (Joint Strike Missile) jet powered air to surface missiles in place of the LGBs.

5.1 HOTAS SET UP

All the avionic features of the F-35 weapon system on this model are coded in the SASL plug-in systems Lua scripts for the pilot's HMD. Things like gun aiming cues, target tracking, missile launch cuing and aiming GPS guided bombs.

Selecting the different weapon modes; Gun, TRK, A2A (missile) and A2G (bombs) and sorting through targets is designed to be controlled using the **HOTAS** (Hands On Stick And Throttle) method.

You will need to program hardware stick or throttle four-way hat switch as recommended in the Joystick recommendations folder with this model.

Hat switch right	weapons system up one
Hat switch left	weapons system down one
Hat switch up	target select up one
Hat switch down	target select down one
Toggle up	3D "dynamic" cockpit mode
Toggle down	2D "static" cockpit (fixed forward view)

Once you have your HOTAS switches set up you will need to add AI planes to the simulator and designate them as enemy aircraft for them to then be available to be tracked by our plug-in code.

Automatic Target Tracking is available in GUN, TRK and A2A (missile) modes.

Once in the air select one of those modes and scroll through the available targets [1, 2, 3 etc up to 8].

When a target ID is selected the code will lock the pilot POV camera on that target location and follow it while you maneuver the jet to face the threat.

The trigonometry used to locate the AI plane in the simulated world is a little bit wonky when you maneuver the jet into extreme nose up or nose down flight when the target AI plane is behind you.

In these instances it is best to quickly switch to the 2D static forward facing cockpit view until you bring your jets nose back down to the horizon, then switch back into the dynamic 3D cockpit mode to re-acquire the target.

Otherwise try keeping the jets nose near the horizon when tracking an AI plane that is behind you and you will not get disoriented. You will actually enjoy knowing where the "other guy" went after you blew past him at mach 1.5+ relative speeds. What a hoot!

Rapid switching between the dynamic cockpit mode for target tracking and the static cockpit for nose awareness then back to dynamic target tracking is how you will maintain SA and requires a toggle switch programmed on your stick or throttle control.

The Target Track feature takes over control of the pilot's POV camera to automatically look at and keep looking at the selected AI target plane while you maneuver your jet.

Target Track requires complete control of the pilot POV camera and is therefore *not* compatible with any Track IR or VR head set.

If one of those devices is detected as connected to your machine our Target Track code will be automatically disabled.

The reason is that those devices also require complete control of the pilot head camera so they can point that camera wherever you turn your head.

You can have *either* one of those devices and *no* AOA Target Track or *neither* of those devices and our code will work to automatically locate and track selected AI planes in the simulator if you are in the 3D dynamic cockpit and have selected one of the weapon modes that support Target Tracking (Gun, TRK or A2A = Missile).

Toggling between 3D and 2D cockpit modes allows you to look at a target off to one side (for instance) and "glance" back at the cockpit panel, then back to the target in rapid succession to maintain that all important situational awareness mentioned earlier.

5.2 GUN MODES: A2A AND A2G

HMD in gun mode

For obvious reasons the gun in the external centerline gun pod cannot be fired when the landing gear is down.

In gun mode the HMD is cleared of unnecessary navigation information and the airspeed display switched from IAS to TAS.

A red aim cross appears to show you where your bullets will fly and a funnel shows you how far those bullets will disperse left and right when you roll the jet to lead a target.

If you are already in 3D cockpit mode Target Track will snap the pilots POV camera to look at the selected target as soon as you enter Gun mode.

Used this way Gun mode can be said to be in A2A mode.

A circle appears near the targets location in the sky. Above the circle is the target ID number (1-8). To the left of the target ID is the distance and to the right of the ID is the targets altitude. Maneuver your jet to place the target out front and close the distance.

AI planes will appear on the cockpit radar display as white triangles.

The target airspeed and altitude appears above and below each target triangle.

The AI plane you have targeted is the red one.

Close to within 1 nm of your target and the display de-clutters. You loose the target airspeed, index and altitude data because you are close enough to see the target now.

Place the cross over the target before you fire the gun.

We've given you 500 rounds even though the real F-35B gun pod only holds 220.

5.3 GUN A2G MODE

Toggling into 2D cockpit mode locks the pilot head camera forward and the Gun is in A2G (air to ground) mode for strafing ground targets.

One thing to look out for when strafing ground targets is called target fixation. Pilots can become fixated on the target and not notice the ground rushing up on them until it is too late. When this happens the valuable pilot and plane are lost and the target is rarely destroyed. This cannot happen in the real F-35 or in our AOA Simulations model.

A sub mode of the Auto GCAS system in this model monitors any ground strafing run and triggers an automatic recovery if you descend below 1,000 ft AGL.

Start your ground strafing runs from at least 10,000 ft AGL to give yourself time to center on the target and fire before you bust the 1,000 ft floor.

A sub mode of the FCS automatically suppresses yaw movement when the Gun in A2G mode and the jets nose is below the horizon. This helps concentrate your bullets on target during a ground strafing.

If you bust the floor the Auto GCAS system engages the autopilot in TF (Terrain Following) mode.

Once the jet is above 1,000 ft AGL again you can disengage the autopilot with a tap of the pitch trim switch.

If you run out of bullets during your ground strafing training runs you don't have to RTB to re-arm the gun. Just click on the RE-ARM touch screen button on the WEP display.

5.4 TRK (TARGET TRACK) AND IFR (IN-FLIGHT REFUELING) MODES

TRK mode is a separate stealthy way to keep track of AI planes in the simulator.

Stealthy because the weapon bay doors remain closed.

In TRK mode neither the gun nor missiles will fire from the jet.

5.4.1 Target Track / primary purpose SA

The primary purpose of TRK mode is to allow you to lock your eyes on a piece of sky that promises to contain an AI plane if only you flew closer.

You will "see" AI planes at far greater ranges with Target Track enabled, well beyond where you would otherwise see another airplane in the simulator.

You will also know exactly how far away that plane is, its altitude and which one of up to eight AI planes you are looking at long before you can actually see it in the simulator.

Knowing who is out there and where they are in relation to you is called SA.

5.4.2 Target Track / formation flight training

A second and very valuable use for Target Track is formation flying. Knowing the general location of an AI plane at long range enables you to fly an efficient intercept course and join up with the AI plane as flight lead while you fly formation as wingman.

5.4.3 Target Track / IFR training

Another use for Target Track is in-flight refueling training.

In-flight refuel probe extended

Use the techniques learned above in formation flying but choose a large transport type aircraft to join in formation.

With the IFR cockpit switch is in the "IFR OPEN" position to extend the probe all you have to do is stay within ~ 300 ft of the AI target plane and your jet will take on fuel.

The jet holds 14,000 lbs of fuel internally and in-flight refueling will stop automatically when the tanks are full.

The fact that the F-35 normally carries all its fuel and weapons internally and will only occasionally load external pylons and additional weapons means the jet flies around most of the time in a completely clean, low drag configuration. It has excellent endurance and range on internal fuel and therefore a limited need for EFTs (external fuel tanks).

EFT's have yet to make an appearance on any model of the real F-35A, B or C.

When more range for deployment or endurance on station is needed the availability of in-flight refueling has met the need.

We have not equipped F-35B 2.0 with EFTs. Legacy 1.0 code is still available should EFT's one day appear on an F-35. When that happens we will put out an update to our model.

5.4.4 "Virtual" IFR

A F-35B performing an in-flight refueling with a KC-130

This jet can also be refueled in the air without the difficulty of flying formation on an AI tanker. It only requires you to be able to hold altitude, vertical climb / descent rate and airspeed within certain not too difficult to maintain ranges and fuel will automatically flow into the jet when the IFR switch is flipped to "IFR OPEN."

1. Climb to either 20,000 or 30,000 ft MSL + / - 1,000 ft.

2. Vertical descent / climb rate between -1,000 and + 1,000 fpm

3. Maintain airspeed 300 knots +/- 20 knots

You have to admit that is a pretty generous envelope.

If you still find it too hard to stay within those parameters you can engage the autopilot and refuel with your arms folded across your chest while you watch the tanks fill.

No, you cannot text on your smart phone while in-flight refueling. There are limits.

5.5 WHERE IS THE AIRCRAFT CARRIER?

A sub mode of the R2c plug-in (section 1.4.16) when in ADVanced mode uses Target Track code to locate the default X-Plane aircraft carrier in the same way AI target planes are located and tracked using the pilot POV camera.

You have to be < 10 nm from the carrier before the pilot camera will lock on to the carrier.

Toggle from 3D to 2D cockpit modes if the carrier is to the side or behind you and you start to get disoriented. Once you are > 10 nm from the carrier R2c will automatically revert to normal.

5.6 A2A (MISSILE) MODE

A2A (Missile) mode is similar to TRK mode with the addition of a High PK (Probability of Kill) sub mode that keeps track of target range and azimuth left and right of your jets nose.

Out in front of your jet the high PK zone is a 60 deg wide wedge of pie (30 deg left to 30 deg right) with the tip of the pie starting 2 nm from the nose of your jet and the "crust" of the pie forming an arc 70 nm away. We call this pie in the sky.

Another high PK zone is 120 deg wide (60 left to 60 right), starting 5 nm in front of the jet and extending to 50 nm away. It looks lie a big piece of pie with a small bite off the tip.

The final PK zone is 180 deg wide (90 left to 90 right) starting 10 nm out and extending to 20 nm. This last zone is primarily for the externally carried AIM-9X imaging infrared guided missiles. It looks like half a pie with a big bite out of the middle.

When a target AI plane is within one of the zones the green target diamond will turn red to let you know you can fire a missile with a relatively higher probability of success verses firing a missile when the target diamond is green.

Missiles are expensive and most of the time you will only have the two internal AIM-120 radar guided missiles on board. You don't want to waste them taking unnecessary lo PK shots at targets that are out of range or too far outside the turning radius of your missile.

If you run out of missiles trying in vain to down an AI target plane you don't have to RTB to re-arm the jet. Just click on the RE-ARM touch screen button on the WEP display.

Missile performance / flight dynamics are weakness in X-Plane. I have to re-develop the flight model of each missile type very time the simulator gets a decimal number change.

X-Plane 11.50 was no different.

Fortunately, none of us are combat simulator authenticity fanatics. If we were, we would not be flying in X-Plane in the first place.

5.7 A2G (BOMB) MODE

5.7.1 Things you should know before you go

X-Plane is NOT a "combat simulator."

The bombs used on this model were marked as "GPS guided" in X-Plane's companion Plane-Maker program, even though some of the bombs hanging from the jet's wings are externally modeled as laser guided bombs. (F-35B CAS 4 x GBU-12 LGB's)

When the XP fire key data reference is triggered (when you release a bomb) our SASLplug-in code triggers the sim/weapons/GPS_lock_here command.

This is supposed to send the GPS coordinates of that point on the ground where the default X-Plane target camera cross hairs are focused.

There are a few assumptions going on here though.

1. Which camera? The weapons/TV guide camera? the EFIS camera? the HITS camera?

2. Does the camera have to be installed in the model for this feature to work?

For example: The feature works independent of the camera selection itself; "someplace out there in front of the jet if the camera were installed even though it is not."

This jet has the EFIS camera. Click the CAM tab to replace the radar screen with the camera during bomb runs to see if it helps your bombing accuracy. If it does then perhaps with this camera on GPS coordinates are being sent to the bomb at the moment it is released.

You can drop a bomb any time you want, except when the jet is on the ground, in the air with the landing gear down or between 4,000-4,500 and 5,000 and 5,500 ft AGL (radar altitude).

Those later altitudes are where I reset the fire key after an AUTO bomb drop at 5,000 ft AGL. The fire key data reference tends to get stuck in the ON position when triggered and needs to be reset by another trigger event. Releasing another bomb with the keyboard space bar would do the trick but that is not how we want to use our bombs.

This tutorial describes "dive bombing" targets, which is more fun than cruising high overhead and releasing a GPS guided bomb from level flight. If X-Plane could even do that it would be a combat simulator, of sorts.

This tutorial describes an AUTO release on Sea level targets without surrounding high hills or mountains.

For targets above sea level add 20,000 feet to the terrain elevation.

For targets in mount valley approach down the valley as crossing a ridge line will trigger the bomb to AUTO release when your radar altitude temporarily passes < 5,000 ft AGL.

5.7.2 Setup

Load the CAS version and turn GCAS off.

Enable R2c plug-in, ADVanced mode. This will enable smart camera logic to switch the pilot's head camera when you are in A2G mode. I will describe what happens further on when we switch the weapons system on.

Takeoff and climb to 20,000 feet. During the climb out the pilot's head camera will switch between the cockpit looking forward then pitch is < 30 degrees and the canopy frame camera at > 30 deg pitch.

Once at altitude set auto throttle airspeed .92 mach and engage auto throttle (AP = ON, no flight control servo actuators). This will free you from having to monitor your airspeed during the bomb run when you are focusing on lining up with your target and after bomb release when you are looking for the bomb to hit and do your BDA.

From 20,000 ft circle an area while rolling the jet left and right to look for potential targets to bomb. R2c will help you by swinging the pilot's head camera left and right as you roll the jet. The camera centers itself when you roll wings level, upright or inverted.

When you roll the jet inverted the pilot's head camera will bias "up" through the canopy "down" toward the ground to help you maintain ground awareness.

Look for easy to distinguish targets like a runway or airport building to start with.

When you have target located set up your approach.

Select Bomb mode by cycling up through the various weapons system modes from 0 = NAV to 1 = GUN, 2 = TRK, 3 = A2A and finally 4 = A2G.

In the HMD above 5,000 ft AGL the mode display will read A2G/MAN if roll is > 5 deg.

You can manually release a bomb but who knows where it will land?

Level the wings to < 5 deg and A2G/AUTO will display in the HMD.

In A2G mode the R2c plug-in behavior will slightly change. Instead of smoothly recentering the pilot's head camera when you roll out of a banked turn the camera will now lock forward when roll angle is < 90 degrees. I did this to eliminate any distractions during your bomb run caused by lateral camera motion. Steady makes for a better aim.

Below are the camera views in A2G mode.

1. The cockpit looking forward during your bomb run (pitch < 1 deg nose up, roll < 90)

2. The EOTS camera below the jet's nose looking aft immediately after the bomb run when you pull the jet's nose up to the horizon (pitch > 1 deg nose up, roll < 90). From this camera position you can watch for the bomb to impact the target and do your BDA (Bomb Damage Assessment).

3. The canopy frame camera looking back behind the jet during climb out after the bomb run (pitch > 30 deg nose up, roll < 90). In this view you can also study the target area as you climb out to reposition for another go at the target.

4. Rolling the jet more than 90 degrees puts you back into normal R2c behavior.

Align the jet's nose on the target from a distance of ~5 to 10 nm and start a shallow dive.

With the jets pitch < 1 deg nose up and roll < 60 the bomb "fall line" will appear in the HMD.

With the jets pitch < 1 deg nose up and roll < 5 a large green circle will appear in the HMD. This is the error circle for a bomb released at the current altitude. The circle will shrink in size as you get nearer the target.

A red ball near the bottom of the fall line will start to move up the line when you descend below 10,000 ft AGL (radar altitude).

Midway down the fall is a green ball with wings. Place this cue ball on your selected target.

When the red ball meats the green ball at 5,000 ft AGL a single bomb will automatically release from the jet.

The large green error circle will have shrunk to a much smaller green circle by the time you reach 5,000 AGL.

When the bomb auto releases the now smaller green circle will turn red and the word "DROP" will appear next to it (left side). It's time to ignore everything else and focus on getting the jet's nose up to the horizon. There is nothing you can do about that bomb now.

It is gone.

With the jet's nose > 1 deg above the horizon the pilot's head camera will auto switch to the EOTS camera below the jet's nose. The camera view is looking aft.

The bombs out on the wings (LGB or JSM) and in the internal weapons bay (SDB) are labeled on the camera view. Horizon bars, pitch ladder and your jet's radar altitude are also shown.

The labels for the bombs still on the jet are green.

The label of the bomb just release is yellow while the bomb is still falling.

The first bomb to come off the jet if you have external weapons is the one on the left wing outboard pylon. This will be on you right as you look back at the underside of the jet and wings.

To increase your chances of catching sight of the bomb impact keep the nose ~ 10-20 deg above the horizon and roll 30-45 degrees in the direction of the empty pylon. Roll left for the first bomb, right for the second, etc.

When the bomb stops falling (because it hit the ground?) the label disappears. Look for the explosion below the jet. How close to your aim point did the bomb hit? That is BDA.

Pulling the jet's nose up > 30 deg switches the pilot head camera to the canopy frame camera view looking aft.

Airspeed is displayed on the left, pitch attitude in the center and altitude on the right.

Varying you pitch attitude between < 30 and > 30 degree switches the camera between the cockpit forward and canopy frame aft views.

With the jet's nose > 1 deg above the horizon the pilot's head camera will auto switch to the EOTS camera below the jet's nose. The camera view is looking aft.

The bombs out on the wings (LGB or JSM) and in the internal weapons bay (SDB) are labeled on the camera view. Horizon bars, pitch ladder and your jet's radar altitude are also shown.

The labels for the bombs still on the jet are green.

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The first bomb to come off the jet if you have external weapons is the one on the left wing outboard pylon. This will be on you right as you look back at the underside of the jet and wings.

To increase your chances of catching sight of the bomb impact keep the nose ~ 10-20 deg above the horizon and roll 30-45 degrees in the direction of the empty pylon. Roll left for the first bomb, right for the second, etc.

When the bomb stops falling (because it hit the ground?) the label disappears. Look for the explosion below the jet. How close to your aim point did the bomb hit? That is BDA.

Pulling the jet's nose up > 30 deg switches the pilot head camera to the canopy framecamera view looking aft.

Airspeed is displayed on the left, pitch attitude in the center and altitude on the right.

Varying you pitch attitude between < 30 and > 30 degree switches the camera between the cockpit forward and canopy frame aft views.

A F-35B dropping a GBU-12 Paveway II

CHAPTER 6 - AIRCRAFT PERFORMANCE AND HANDLING

Now that you have the basics under control; various takeoff and landing modes: conventional, short and vertical, and basic navigation it is time to turn your attention to getting the maximum performance out of the jet.

6.1 MAX PERFORMANCE TAKEOFF AND CLIMB

The jet can takeoff in a very short distance using the after burner, especially with a reduce fuel load and no weapons except the gun pod and two internal AIM-120 air-to-air missiles.

When climbing out after an afterburner takeoff you can pitch the nose up >= 30 degrees and, with R2c in ADVance mode the pilot POV camera will automatically switch to the upper DAS camera and you can watch the runway drop away below you on your way to 30,000 ft.

Aircraft IAS, pitch attitude and altitude will be displayed in the HMD when looking aft.

At 30,000 the altitude display numbers will turn from green to red. That is your cue to roll the jet 180 degrees and pull the nose down to the horizon and accelerate through mach one.

6.2 MAXIMUM SPEED AT ALTITUDE

Descend to 30,000 ft as you accelerate and continue in afterburner out to mach 1.67

When you reach mach 1.67 the HMD speed display will start to flash, warning you of the limit you have reached.

The afterburner will automatically turn off to keep you from blasting way past the limit, though you will probably still keep accelerating slightly if you are in level flight.

Study the ENG/FUEL page to understand the thrust and fuel flow rates are associated with max speed flight at 30,000 ft.

Endurance and range on remaining fuel is displayed at the bottom of that page.

Roll the jet into a 90 deg bank turn and pull the stick to attain maximum G at 30,000 ft.

Note that the jet does not "pull" 7 G's at that altitude and airspeed.

Around 5 G's is all the real jet will do at this altitude.

6.3 RAPID DESCENT

The jet can (and should) be brought down fast from high altitude. This is a combat technique you need to master and every descent from high altitude it a training opportunity. You're not flying an airliner or corporate jet with paying customers to please. It is just you in the jet so max perform the machine at every opportunity.

From a level upright flight attitude roll the jet 180 degrees and pull the stick back.

R2c will swing the pilot POV camera around and point it at the ground. Continue to pull until the canopy arch comes into view and then roll the jet upright again.

The HMD "de-clutters" itself at extreme nose low pitch attitudes so you can concentrate on the greatest priority and threat, the ground, until you gradually bring the nose up.

With the nose of the jet pointing straight down at the ground reference the PCD in front of you for flight information.

As you raise the nose of the jet toward the horizon the HMD display information will start to reappear.

Level the jet at 15,000 ft AGL and prepare for a series of 360-degree maximum performance level turns. You will be exploring the relationship between airspeed, AOA (angle of attack) and maximum obtainable G's at this altitude.

You will also want to monitor engine thrust and fuel flow and their effect on calculated range and endurance as displayed on the ENG/FUEL page, just like you did up at 30K.

Roll the jet into a 90 deg bank turn and pull the stick to attain maximum G at 15,000 ft.

Note that the jet does pull up to 7 G's at this altitude but you have to have the afterburner enabled and maintain close to 500 knots IAS.

Also note that if you attempt to hold onto the G's your airspeed will bleed off until you run into the 22 deg AOA limit.

6.4 HIGH AOA AUDIO TONE

At that point the AOA limit tone will sound and roll authority will be restricted until you reduce the AOA to < 22 degrees.

6.5 AEROBATIC PERFORMANCE

The F-35 is fully aerobatic

You can perform any aerobatic maneuver in the jet including loops, aileron roll, tail slides and even "falling leaf" flat spins.

The FCS employs pitch, roll and yaw rate limiters to stabilize the jet if you fly it beyond the 22 deg AOA limit.

The jet is fully control able up to and beyond 90 degrees AOA.

It is best to explore this maneuvering capability for the first time with a generous altitude cushion below you so climb to at least 15,000 ft AGL before you start.

From straight and level flight at ~ 400 knots and 15,000 move the stick smartly and fully to the right until you hit the stop, then hold it there for at least one to two complete 360 degree rolls.

Note how the R2c plug-in commands the pilot POV camera.

The idea to replicate a little bit of the disorientation experienced in the real jet from a rapid roll maneuver while also indicating the direction of the roll and maintaining a ground reference.

Once you are wings level again pull the stick all the way back and enter a loop, relaxing back pressure on the stick when you are on your back looking down at the earth through the top of the canopy.

The white cord you see running down the center of the canopy is the emergency escape system detonator cord designed to shatter the canopy just before the ejection seat fires.

The cords location down the center helps you understand which side of the canopy you are looking through.

As you come down the second half of your loop increase back pressure on the stick until you pull up to level flight again at your loop entry altitude of 15,000.

6.6 HIGH AOA FLIGHT REGIME

Most pilots do not have a very good understanding of high AOA flight dynamics so, for these next few maneuvers I want you to deploy the X-Plane graphical *flight path string*

(Simulator drop down menu: View/Cycle 3-D Flight Path or default keyboard key "o").

This default X-Plane feature plays out a string behind the jet as it moves forward in flight. The string represents the actual path the jet has flown through the air and is not the same as the direction the nose of the jet is pointing.

Bring power back to idle thrust and pull the nose up to ~29-31 degrees above the horizon.

The R2c plug-in will keep the pilot POV camera in the cockpit < 30 deg theta (pitch attitude) and point the camera back through the aft facing DAS camera when > 30 deg.

Keep theta right around but just below 30 deg as the jet slows to stall speed and AOA climbs to the 22 deg limit.

When the high AOA tone sounds hold backpressure on the stick and pull the jet's nose pitch up past 30 deg.

Looking back through the aft DAS camera you will see the flight path string trailing out the back of the jet.

You can switch to an external view if you want to get a better look at and understanding of the jets pitch attitude verses flight path.

Newton's first law: "an object in motion tends to stay in motion" applies here. The string representing the path just flown by the jet also represent the jet going forward because the jet will tend to stay on the same path as it has just flown.

6.7 VELOCITY VECTOR PATH

This forward path is called the velocity vector.

The difference between the velocity vector and the jets nose pitch (theta) is AOA.

It takes a lot of power and pitch to slightly change the velocity vector at low speed.

Keep pulling the jets nose up, increasing AOA to 90 deg and note how the jet slows to almost no forward airspeed but instead begins to fall straight down.

At this point apply full forward stick and bring the nose of the jet down to the horizon.

With the jet falling straight down and the nose on the horizon kick in FULL rudder pedal and hold while the jet "cork screws" around its center of gravity and continues to fall.

Monitor heading in the HMD and enter opposite rudder to stop the rotation on a heading YOU choose.

Apply full throttle to exit the high AOA low speed regime and continue your flight.

FCS logic is working in the background to keep you out of trouble. For instance, if you had the afterburner disabled when you entered the high AOA flight regime the FCS logic will re-enable the AB below 10,000 ft to help you get out of a nose high / low speed situation.

Going back to the loops you flew earlier, now fly a series of loops one after another, with and with out the afterburner engaged to get a feel for how the jet performs and how much back stick pressure it takes to move the nose up past 22 deg AOA.

The high AOA tone aids you AOA SA without having to look at any cockpit or HMD display.

Eventually get to the point where you can do almost stationary back flips at the top of a loop and transition directly into a full rudder "falling leaf" spiral descent.

Bet you can't do that in any other aircraft.

CHAPTER 7 - AUTOPILOT

7.1 AP SWITCH

The autopilot panel sits in the upper right corner of the PCD.

Autopilot panel (top right of PCD)

Across the top, starting on the left is the AP touch switch.

This switch turns the autopilot on. It has 3 settings: AP (off), ON and AUTO.

When the AP letters are white the switch is OFF and no autopilot functions are active.

Click the switch once with the mouse to turn the autopilot ON and the letters turn green.

With the autopilot ON only the auto throttle is available. Flight control servo actuators are not active so you will have to hand fly the jet with the stick, but not the throttle.

With the autopilot ON you can use the pitch trim switch on your stick without fear of disengaging the auto throttle.

The final AP switch position is AUTO.

In AUTO the flight control servo actuators become active and you fly the aircraft through settings you input on the autopilot panel.

In AUTO mode bumping the pitch trim switch automatically disengages the autopilot.

Autopilot in AUTO mode with active servo actuators

7.2 SPD / ATR (AUTO THROTTLE) SWITCH

For auto throttle ONLY (no flight control servo actuators) do this:

With the autopilot ON click the white SPD touch switch.

The white SPD will change to green ATR

Auto throttle will maintain the speed entered into the autopilot but you must fly the jet.

With the autopilot in AUTO the auto throttle works the same way to maintain airspeed but the flight control servo actuators are active to control the jet.

7.3 APC (APPROACH POWER COMPENSATION) MODE

The default speed set for the auto throttle is 200 knots IAS, which is the normal traffic pattern and approach speed before APC mode takes over below 1,000 ft AGL.

To see how it works try flying around gear up at pattern altitude of 1,500-2,000 ft AGL with the autopilot ON and "200" selected as your preset ATH speed. When you turn base to final and descend to < 1,000 ft AGL the gear will automatically come down and the ATH will switch to APC mode.

APC maintains the best approach speed for your aircrafts current weight (empty + remaining fuel and weapons).

APC even adds a little power when you bank the jet because stall speeds increase with bank angle.

At 40 ft AGL APC automatically turns itself off so you can use the throttle during the landing flare to pull all the remaining power off or add full power to go around.

If you need a faster speed use your mouse on the down/up adjust switches below "200" to dial in a new speed for the auto throttle to maintain.

You can also click the small square button in the far lower left corner of your computer screen and pop up the preset auto throttle speed buttons.

These buttons allow you to quickly set or change the speed setting on the autopilot panel.

Your options are in knots IAS or Mach.

Choosing a Mach button automatically changes the KT/Mach setting on the autopilot panel to Mach, while choosing an IAS button changes it back to KT.

7.4 HDG (HEADING SELECT) SWITCH

Heading mode selected

This switch is synched with the NAV SOURCE switch located between the NAV radio frequency displays.

If the NAV SOURCE is Navigation radio 1 or 2 then this switch will display as NAV.

If the NAV SOURCE is GPS then this switch will display as GPS

When the autopilot is OFF these letters are white.

Clicking the NAV switch on its own will turn the autopilot ON (no servo actuators) and the white NAV will become a white HDG. The autopilot is in *heading mode* and will fly the magenta heading display number as soon as you switch the autopilot to AUTO.

Use the down/up adjustment switches on the autopilot control panel to change the magenta heading display number here and on the RDR map. The jet will turn as you change the heading *if* the autopilot is in AUTO.

Clicking the GPS switch on its own will turn the autopilot ON (no servo actuators) and the white GPS will become a green GPS. The autopilot is in *gps mode* and will fly the jet to the destination entered into the GPS system as soon as you switch the autopilot to AUTO.

7.5 LOC (LOCALIZER) SWITCH

When the LOC letters are white the system is OFF.

Localizer mode selected

This is the switch that tells the autopilot to follow a course sent to it from either of the Navigation radios or the GPS system.

Example: With the autopilot in NAV mode (explained above, autopilot in AUTO) and following the magenta heading course number enter a local VOR's frequency into Nav1.

Now select Nav1 as your NAV SOURCE, and then click the white LOC.

As soon as you click LOC it will change color. It will turn yellow if you are off course and green as soon as you capture the VOR on course signal.

Also note that **HDG** will change to a **NAV** and the jet will turn to a new course, either TO or FROM the VOR station, depending on the OBS1 setting (touch switch located below the RDR display).

Turning the OBS1 heading turns the jet now instead of the magenta heading adjust switch

Use the mouse to change the magenta heading now and watch the dashed magenta course line rotate on the RDR map. The jet does not respond because you are in *localizer mode*.

The localizer is also used to fly an ILS (instrument landing system) approach.

7.6 ILS (INSTRUMENT LANDING SYSTEM)

If you dial an ILS frequency in to Nav1 radio and select LOC the system will come on "armed" (**yellow**). When the system "captures" the ILS lateral beam the **yellow LOC** will turn green and the jet will turn to and follow the final approach course.

7.7 GS (GLIDE SLOPE) SWITCH

The glide slope switch is use when you are lined up for an instrument approach.

Glide slope can only be "captured" from below. This means you have to fly into the underside of the slope, preferably from level flight.

Somewhere out beyond the capture range of the localizer / glide slope beams get yourself lined up on a heading to intercept the approach course. Engage the autopilot-heading mode and click the LOC switch to "arm" the ILS. Then engage the GS switch.

If you are below the glide slope angle the GS will come on **yellow**, meaning the system is "armed."

When the autopilot "captures" the glide slope beam the **yellow GS** will turn green and the jet will begin to descend down the approach slope to the end of the runway.

7.8 VS (VERTICAL SPEED HOLD) SWITCH

Clicking the VS autopilot switch changes its color from white to green and engages the vertical speed hold system.

Clicking the VS switch "arms" the ALT (altitude hold) system as well.

Vertical climb speeds of a few hundred feet per minute up to 5,000 fpm can be dialed into the system and the jet will maintain that rate as long as you have enough power to maintain airspeed. Otherwise the jet will slow to stalling speed, stall and the autopilot will automatically disconnect.

Use VS in conjunction with ATR to avoid that embarrassment.

Use in conjunction with a preset altitude, either above your current altitude so the system can climb up to and then capture and hold that altitude or, set a lower altitude and the jet will descend, capture and hold the lower altitude.

Descent rates of up to -5,000 fpm can be dialed in.

7.9 PH (PITCH HOLD) SWITCH

To climb faster that 5,000 fpm click the PH touch switch and use the VS up switch to increase your climb rate as high as you like.

Use PH to control higher rate climbs in afterburner when you want the system to capture an altitude at the top of the climb.

Only positive climb rates are controlled by the PH function, not descent rates. There is another way to manage very fast descents but I will explain that a little further down.

7.10 ALT (ALTITUDE HOLD) SWITCH

The ALT switch is white when the system is OFF; yellow when waiting for the jet to arrive at a preset altitude or green when that altitude is "captured."

In normal use this switch is never clicked directly except in rare, unique situations.

Normally you will just use the altitude down / up control switches to set an altitude into the autopilot system and then allow the autopilot to "capture" that altitude after climbing or descending using the VS feature.

It those instances the ALT text is just a status display.

Clicking the switch enters the jets current altitude into the system but does not HOLD that altitude until you turn the AP switch to AUTO and engage the flight control servo actuators.

Clicking the ALT switch during a VS controlled climb or descent with the AP in AUTO will immediately stop the climb or decent at the altitude the jet was passing through at the moment you clicked the switch. The jet may there after may have to climb or descend to get back to that altitude depending how fast you were climbing or descending.

The altitude setting display has a rather unique feature enabled by SASL plug-in system lua coded logic. If you dial in an altitude you intend to descend to and that altitude is less than the

current altitude below the jet + 1,000 ft then the altitude number in the display window will turn from white to red. You need to add altitude to your setting or risk descending into the ground.

7.11 V NAV MODE STATUS DISPLAY

The V nav display in the upper right corner is a little bit of a space filler status display for any vertical navigation modes in operation.

7.12 RA MIN SWITCH (TERRAIN FOLLOWING MODE)

RA min doubles as a way of setting the minimum altitude for ILS missed approaches and setting the altitude the jet will fly at in TFR (terrain follow radar) mode.

Clicking the switch will change the text from white RA min to green TFR.

If you are cruising at 40,000 ft MSL and want to descend faster than the VS mode will allow (-5,000 fpm) then dial in a minimum safe altitude (white numbers, not red) and click the RA min switch to engage the TFR mode. The jet will descend under autopilot control at a VERY rapid rate and level out at your RA min altitude.

I use this method to descend through clouds that bottom out near the ground. There is nothing more exciting than breaking out of the clouds near the ground at 600 knots!

Terrain following at night is also great way to cure boredom.

FREQUENTLY ASKED QUESTIONS

Q1 I crashed and hear a loud, repeating alarm tone in the cockpit.

A1 Crashing the jet triggers the ELT (Emergency Locator Transmitter).

Q2 Why does the word "BURN" sometimes appear in the HMD? What's on fire?

A2 When you see that it means the afterburner is engaged.

Q3 Why does the word "THREAT" sometimes flash in the HMD

A3 When you see that it means your altitude is > 1,500 but < 15,000 ft AGL and your airspeed is < .80 Mach. You are in the heart of the MANPAD (Man Portable Air Defense) shoulder fired missile system engagement envelope. "THREAT" appears in the HMD.

MANPAD's can be fired at and optically track any aircraft the operator can visually acquire, even "stealth" aircraft like the F-35.

The MANPAD operator can stand on a hill and scan the horizon looking for you and fire a missile at you without having to acquire you on radar. The Mark 1 eyeball is enough technology to get the job done.

How to avoid MANPAD threats.

If you fly faster than Mach .80 the MANPAD operator is going to have a hard time visually detecting you with enough time remaining to aim and fire their missile at you before you are good and gone. They do not stand around with that heavy missile on their shoulder 24/7 expecting you to fly by at any moment. More than likely they are starring down at their cell phone / texting and expecting to hear you coming. By then it is too late.

If you stay below 1,500 ft you are lost in the background until it is too late. You'll fly by any threat before they see you.

If you stay above 15,000 ft AGL the relatively small rocket motor on any missile that can be lifted to a shoulder is not going to reach your altitude.

Avoid using the afterburner between the altitudes of 1,500 and 15,000 ft if your airspeed is already > .80 Mach. Using the afterburner when you are already going Mach .80+ is unnecessary and only makes you a hot, loud easier to detect target. "THREAT" appears in the HMD with afterburner use even though you are already going faster than .80 Mach.

Q4 How can I zoom the color moving map without popping the G1000 up or out?

Repeated clicks in the upper right corner of the map to zooms the map out while repeated clicks in the lower left corner zooms the map in.

Repeat clicks on the DCLTR text to clear the map of defining airspace lines and navigation icons.

CREDITS

Development team

- Fabrice Kauffmann, 3D models, animations, textures, LUA code, tutorial formatting, FMOD sounds
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