Top Mach Studios, LLC

F-22A Raptor Air Superiority Fighter for Microsoft Flight Simulator 2020

User Manual

For Software Release V1.1.9

Disclaimer – Although the digital aircraft model for which this manual is written resembles its real-world counterpart, neither the model nor this manual can or should be used as a source of real-world information about the operation or maintenance of the corresponding aircraft and is a work of fiction. Additionally, this package is not endorsed by or supported by the Lockheed Martin Corporation or its affiliates, or by the United States Air Force, or the Government of the United States of America.

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The F-22A Raptor Air Superiority Fighter

Brought to you by Top Mach Studios, LLC

The world's most advanced operational air superiority / air dominance fighter presents a challenge for any flight simulation developer. A passion project of ours, the Top Mach Studios team has dedicated over two years of research and development to the development of this model for MSFS 2020 and in doing so we've pushed the limits of what's possible in the game. We are proud to present this highly capable, highly detailed, and highly functional replica of the F-22A to the MSFS 2020 community. You'll find this aircraft model, our first effort to produce a premium quality aircraft for flight simulation, to be an absolute thrill and a true joy to fly in MSFS 2020. We hope you'll have at least as much fun flying the Raptor as much as we've had making it.

Top Mach Studios:

- Evan Burns – *Lead developer and programmer*
- Adam Burry – *3D modeling and visual effects*
- DakFly – *Flight physics modeling, lighting, sounds, visual effects, and documentation*

With contributions to 3D visual modeling by Wombii Actual
Contributions to visual effects and the amazing Starscream livery from Karl Derner (FlaminFenix)

Additional thanks and acknowledgements to:

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Cal Ernst
CGAviator

Thank you to the all of those members of the flight simulation community whose enthusiastic support, encouragement, and love of military aviation simulation kept us going. And a special thank you to our families and friends without whose support we couldn't have persevered to make this model a reality.

Minimum Hardware Recommendations

This F-22A model has high-detail modeling and textures as well as complex customized flight control and instrumentation coding that may not function correctly without sufficient computing resources. We highly recommend minimum system specifications that meet or exceed the following:

CPU: 3.2GHz quad core processor or better
GPU: at least 6Gb dedicated video memory, Nvidia 1060 GTX or AMD RX 580 or better recommended
RAM: 16.0Gb minimum
Hard Disk: 2.8Gb minimum hard disk space required for installation

A dedicated control input device such as a joystick, yoke, or HOTAS type control device with dedicated rudder controls or alternatively an Xbox type compatible controller is required. There is no keyboard only support for the primary model (there is a backup fully functional model included, identical in every way, called the No-FBW model, which does support keyboard control, but has somewhat degraded handling compared to the standard model).

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Installation

Please see installation instructions provided by the reseller from whom you purchased the software. See the section below on getting support if you need further assistance with installation or other technical assistance with your purchase.

Disclaimers About the Model and This User Manual

We've done our best to replicate the F-22A, within the limits of the information available to the public and within the limitations of Microsoft Flight Simulator 2020 (MSFS2020), however, we make no claims, representations, or warranties about the accuracy or validity of any modeled systems or capabilities, or of any statements made about the real world aircraft. This is not a true-to-life simulator of the F-22A, and any statements or programming choices we've made concerning performance, operations and procedures as incorporated in the model and described herein shall be considered fictional works. This is a "scale" digital model, or replica, of the F-22A, with information used in its creation taken only from published, publicly available sources, and with its only purpose to be as a source of entertainment, exclusively for customers of the MSFS2020 game environment, and is therefore not appropriate or intended for the purpose of training or simulation of real-world F-22A flight operations or systems familiarization. Additionally, this manual should only be used as a guide to using the Top Mach Studios, LLC model of the F-22A for MSFS2020 and is in no way adequate to serve as a manual or guide to the operation of the real-life F-22A and its systems, nor is it an adequate source of information for real-world operation and maintenance of aircraft sub-systems and components. Additionally, neither the F-22A model, nor this manual are endorsed by or supported by Lockheed Martin, or its subcontractors or affiliates in the development and production of the F-22A, nor by the United States Air Force or the Government of the United States of America.

Software Updates

Top Mach Studios will do its best to keep the product updated and resolve critical bugs as soon as possible. Updates are typically deployed as new installers/packages and will be available through the reseller channel from which you purchased the model. Installation of updates will depend on which point of purchase you used and the nature of the updates and instructions will be provided with each such update.

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Model Features and Capabilities:

Much about the F-22A is still classified; even basic details about the cockpit layout, instrumentation, and screens is still protected as United States Government secret information and privileged only to those

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with appropriate clearances. We've done our best, utilizing publicly available images, videos, graphics, statements, and specifications, to replicate what we know about the F-22A. However, regardless of any inaccuracies or omissions, we've rendered a highly capable and entertaining, and very realistic feeling model of the F-22A on the basis of the information available to us. Below is a list of many (but not all) of the various features and capabilities of this model.

Custom Programmed Simulated Fly-By-Wire control system for virtually carefree flight control

- Auto-trim / pitch control
- G-Limiter
- Roll rate limiter
- Yaw limiter
- Synthesized thrust vectoring performance and pitch maneuverability with smooth control responses up to 90 degrees angle of attack, and controllability at 20 knots or less.
- Highly resistant to departure from controlled flight throughout the flight envelope.
- Precision, stable high altitude flight control to 60,000 feet and above.
- Takeoff / Approach mode (landing gear down) ensures more docile control for virtually effortless handling during take-off and landing approaches.
- Low speed / high alpha aerobatic maneuvers possible; J-Turns, pedal turns, power loop, etc…

Highly detailed fully custom 3D cockpit modeling with:

- Highly detailed modeling and texturing of cockpit, control panel, and ICP/HUD module
- Detailed ejection seat model
- Highly detailed Head Up Display (HUD) based on Air Force specifications and real world F-22A primary HUD navigation mode display.
- Fully Functional SMFDs and PMFD (using fully customized instrumentation suite) including moving map, customized traffic display, fuel menu, stores management, etc…
- Fully functional and customized ICP module with many features and functions
- Canopy interior reflections and rain effects
- Most buttons, knobs, and switches are animated and many are functional.
- Full suite of essential autopilot and navigation controls.
- Functional engine management controls in SMFDs and in cockpit
- Full cockpit lighting and HUD lighting controls including normal lighting and simulated night vision goggle compatible lighting color.
- Customized airspeed and angle of attack gauges (to correct default game inaccuracies).
- Numerous additional customized screens and gauges with CAS messages and alerting system.
- "Hidden" G3000 navigation screen included to allow in-flight flight planning and course changes.

Detailed Custom 3D Exterior Model

- Highly detailed 3D exterior model.
- Custom texturing including metallic and non-metallic surface texturing effects
- Animation of all key flight control surfaces.
- Detailed and fully animated landing gear and extension / retraction sequence.
- Weapon bay door animations
- Optional stores configuration available to simulate loading and placement of 6 x AIM 120D and 2 x Aim 9X missiles (Non MSFS Marketplace version only).

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- Optionally displayed, detailed drop tank models to simulate 2 X 600 gallon external fuel loads.
- Custom dynamic visual effects including condensation and g-vapor effects, afterburner flame and lighting effects, engine starter flame / smoke, and others.
- Cold and dark visual modeling features (boarding ladder, remove before flight tags, etc…) that are user controlled.
- Thrust vectoring animations with animated afterburner flame effect.
- Pilot figure (can be optionally displayed when aircraft cold / dark).
- Custom canopy reflections and tinting
- Full exterior Lighting Systems include custom landing and taxi lighting, electroluminescent formation lighting, navigation lights, and beacons; all modeled after the actual aircraft, with correct lighting positions.
- Three detailed liveries (Langley, Hickam, and Elmendorf are represented).

Engine and Performance Modeling based on Lockheed Martin / USAF specifications

- Accurate weight and fuel quantities (includes additional fuel to simulate 2 x 600 gallon ferry drop tanks).
- Engine model tuned to realistic specifications for thrust and performance.
- Modeled fuel consumption in line with real world specifications in both dry and afterburning thrust.
- Drag and lift model tuned to estimated specifications.
- Mach 2.4+ maximum speed
- Mach 1.7+ supercruise capability
- Supersonic climb to high altitude
- Incredible acceleration rates at max throttle.
- Supersonic capability up to 60,000 feet and above.
- Service ceiling modeled to approx. 70,000 feet.
- Accurate fuel consumption and maximum range at all altitudes (not based on the default game turbine model, but customized to improve accuracy of turbine fuel consumption and thrust).

Real World Aircraft Description and Specifications

(Ref. Wikipedia, USAF, and Lockheed Martin**)**

The F-22A is a single-seat, twin-engine, all-weather stealth tactical fighter aircraft developed exclusively for the United States Air Force (USAF). The result of the USAF's Advanced Tactical Fighter (ATF) program, the aircraft was designed primarily as an air superiority fighter, but also has ground attack, electronic warfare, and signal intelligence capabilities. The prime contractor, Lockheed Martin, built most of the F-22's airframe and weapons systems and conducted final assembly, while Boeing provided the wings, aft fuselage, avionics integration, and training systems. The aircraft was variously designated F-22 and F/A-22 before it formally entered service in December 2005 as the F-22A.

USAF officials consider the F-22A a critical component of the service's tactical air power. The Collier Award winning F-22A’s unique combination of stealth, speed, agility, and situational awareness, combined with long-range air-to-air and air-to-ground weaponry, makes it the most capable air dominance fighter in the world. The F-22's high cruise speed and operating altitude compared to prior generation fighter aircraft improve the effectiveness of its sensors and weapon systems, and increase survivability against ground defenses such as surface-to-air missiles. The ability to supercruise, or sustain

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supersonic flight without using afterburners, allows it to intercept targets which subsonic aircraft would lack the speed to pursue and afterburner-dependent aircraft would lack the fuel to reach. The F-22's thrust and aerodynamics enable regular combat speeds in excess of Mach 1.5, without continuous use of afterburner, at 50,000 feet (15,000 m) or higher. The use of internal weapons bays permits the aircraft to maintain comparatively higher performance over most other combat-configured fighters due to a lack of parasitic drag from external stores.

The USAF had originally planned to buy a total of 750 F-22As. In 2009, the program was cut to 187 operational production aircraft due to high costs, a lack of clear air-to-air missions due to delays in competing Russian and Chinese fighter programs, a ban on exports, and development of the more versatile F-35. The last F-22A was delivered in 2012. The F-22A has been modernized during the course of its operational life to carry new weapons, adopt additional missions, and to build on its electronic warfare and battlefield situational awareness and communications capabilities.

General characteristics

- Crew: 1
- Length: 62 ft 1 in (18.92 m)
- Wingspan: 44 ft 6 in (13.56 m)
- Height: 16 ft 8 in (5.08 m)
- Wing area: 840 sq ft (78.04 m2)
- Aspect ratio: 2.36
- Airfoil: NACA 6 series airfoil
- Empty weight: 43,340 lb (19,700 kg)
- Gross weight: 64,840 lb (29,410 kg)
- Max takeoff weight: 83,500 lb (38,000 kg)
- Fuel capacity: 18,000 lb (8,200 kg) internally, or 26,000 lb (12,000 kg) with two 2× 600 US gal tanks
- Powerplant: 2 × Pratt & Whitney F119-PW-100 augmented turbofans, 25,000 lbf (116 kN) thrust each dry, 35,000 lbf (156 kN) thrust class with afterburner

Performance

- Maximum speed: Mach 2.25 (1,500 mph, 2,414 km/h) at altitude (some sources state M2.42 or greater, and others state an operational limit of approx. M1.9)
- Mach 1.21, 800 knots (921 mph; 1,482 km/h) at sea level
- Mach 1.7+ (1,220 mph, 1,963 km/h) supercruise at cruise altitudes
- Range: 1,600 nmi (1,800 mi, 3,000 km) or more with 2 external fuel tanks
- Combat radius: 460 nmi (530 mi, 850 km) clean with 100 nmi (115 mi, 185 km) in supercruise, 590 nmi (679 mi, 1,093 km) clean subsonic
- Ferry range: approx. 1,800 nmi (2,000 mi, 3,220 km) with two external fuel tanks
- Service ceiling: 65,000 ft (20,000 m)
- g limits: +9.0/−3.0
- Wing loading: 77.2 lb/sq ft (377 kg/m2)
- Thrust/weight: 1.08 (1.25 with loaded weight and 50% internal fuel)
- Armament
- Guns: 1× 20 mm (0.787 in) M61A2 Vulcan rotary cannon, 480 rounds
- Air-to-air mission loadout:

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6× AIM-120 AMRAAM
2× AIM-9 Sidewinder

- Air-to-ground mission loadout:
  2× 1,000 lb (450 kg) JDAM or 8× 250 lb (110 kg) GBU-39 Small Diameter Bombs
  2× AIM-120 AMRAAM
  2× AIM-9 Sidewinder
- Hardpoints: 4× under-wing pylon stations can be fitted to carry 600 U.S. gallon (2,270 L) drop tanks or weapons, each with a capacity of 5,000 lb (2,270 kg).

Avionics

- AN/APG-77 or AN/APG-77(V)1 radar: 125–150 miles (201–241 km) against 1 m2 (11 sq ft) targets (estimated range), 250 miles (400 km) in narrow beams
- AN/AAR-56 Missile Launch Detector (MLD)
- AN/ALR-94 radar warning receiver (RWR): 250 nautical miles (460 km) or more detection range
- Integrated CNI Avionics
- MJU-39/40 flares for protection against IR missiles

Sources for this data include Wikipedia, The United States Air Force, and Lockheed Martin, as well as public statements from test pilots and pilots of the F-22A in operational service, and various corroborating articles concerning aircraft capabilities and performance.

NOTAMS (REALLY IMPORTANT INFORMATION) FOR BEST ENJOYMENT OF THIS MODEL – READ THIS BEFORE TAKING OFF

Important concerns or known issues to be aware of before you fly.

Keyboard Only Users: Default / Primary Model vs No-FBW Model
The primary or main Raptor model cannot be flown (pitch, roll, or yaw) with keyboard control inputs – a dedicated controller or input device(s) must be used (joystick, game pad, yoke, etc…). However, If you are using a keyboard, or have other problems with your control devices that can't be resolved, we have provided a "No-FBW" model that relies upon the Asobo native FBW model found in the F/A-18 Super Hornet. This model has essentially the same performance capability as the primary F-22A model, but it is *not* nearly as capable of the aerobatic flight maneuvers described below and has several of the same issues inherent to the F/A-18 flight model. In a sense, you get two different flight models included with the Top Mach Studios Raptor, but if at all possible we encourage you acquire a stand-alone control device and use the primary model; it is a more refined, capable, and stable aircraft model.

Cold and Dark Startups
The aircraft engines can't be started when the aircraft is cold and dark until some of the visual features such as "remove before flight" tags, ladder, wheel chocks, etc… are hidden. This can be done from the PMFD screen once the battery is switched on, by going into the SIM menu. For more information on this please see the section in this manual concerning the Primary Multifunction Flight Display configuration screens.

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Modern flight model
Make sure you have the Flight Model in the game set to “Modern”. We have included an over-ride flag to prevent the model from reverting to “Legacy” performance, but still encourage you to ensure you use the Modern flight model setting to avoid any issues.

No Assistances
The flight model will not perform correctly or handle properly if you have set any of the “Piloting” options under the “Assistance Options” menu to anything other than “Hard”.

No AI Pilot
To achieve the performance characteristics of the model, the flight model and engines performance configurations do not work properly with the AI Pilot option – takeoffs and landings don’t work. We don’t recommend you try to use this feature with the Raptor. Autopilot functions can be used instead to manage the aircraft for long flights or while taking screen shots.

Eyepoint Settings
The Raptor has a small cockpit with a wide field of view setting in the default cockpit camera view to provide best / most realistic visibility out of the window while still being able to see a significant portion of the control panels. As a result, if you have made any prior adjustments to the default Cockpit Camera Height, Horizontal Position, or Zoom (all found under General Options -> Cameras), you may find the default eyepoint to be unusable (in some cases well outside of the cockpit). The default positions, that work for the Raptor, are 50% for Height, Horizontal Position, and Zoom.

Aerobatics – Independent Rudder Control
To perform several of the aerobatic maneuvers correctly, you must have an independent rudder control input device – keyboard inputs won’t work for this purpose unless you are using the No-FBW model (and aerobatics are significantly more difficult with the No-FBW flight model). Many control sticks or control pads have or can be configured to use a rudder control option (swivel, rocker switches, L/R buttons, etc…), but we find a set of rudder pedals to be the most effective and realistic way to control rudder inputs.

AMSL vs AMGL – Weather Presets and Engine Performance Bug
There is a bug that appeared after Sim Update 8 that effects high performance turbine engines and occurs when using weather presets (this issue is not found with Live weather). This bug degrades engine performance when flying over elevated terrain that is significantly above sea level. Under the Weather menu, Settings -> Altitude Calculation should be set to AMSL and not AMGL, or engine performance will be degraded when flying over higher elevation terrain and you will not achieve maximum performance of the aircraft.

Airspeed Indicator Differences
We have taken great pains to custom program a calibrated airspeed value for all instruments in the cockpit that is highly accurate. However, the game will report inaccurate airspeed when airspeed exceeds supersonic values at intermediate and high altitudes. Therefore, the cockpit KCAS values (as displayed on the HUD or other instruments that show airspeed value) will not match the value shown on

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the external HUD or other views of airspeed – those values will typically be significantly higher (inaccurately so) than what you will see in cockpit. Refer to the speeds reported in the cockpit when you are flying at supersonic speeds and intermediate to high altitudes (above 10,000 feet AMSL).

Angle of Attack Indicator Differences

The standard game angle of attack calculation is limited to around 70 degrees. Above this, the reported value will be incorrect or zero. We have custom programmed a correct angle of attack indicator for the Raptor and this is available in the in-cockpit head up display (HUD). When performing high alpha maneuvers it's best to rely upon the angle of attack indicator in the cockpit and not on the external chase camera HUD or other game native AoA references.

Manual Control Inputs While using Autopilot

In order for the autopilot functions to work, we disable the fly-by-wire module feature while autopilot Master control is activated. As a result, control limiters are disabled. If you make pitch or roll control inputs while autopilot is engaged the aircraft can easily exceed G-limits or other control limits and cause out of control situations, especially in the roll axis. As of this version, we have not found a solution to this problem short of writing our own autopilot system for the Raptor. This may be the subject of a future update, but for now, be careful not to make significant control inputs while using the autopilot.

Sound Volume

The external engine sounds are modeled to produce a very high sound output (it's a fighter jet, it's supposed to be LOUD). This can provide a visceral and immersive experience, but be careful to maintain a safe listening volume, particularly when using headphones or other over/in the ear sound output devices to avoid hearing damage. When in the cockpit, it may also be helpful to turn on the Headphone Simulation function to reduce the amount of ambient noise coming through your speakers / headphones when in the cockpit.

Auto-trim System

The Raptor model does not have a manual trim function for the standard primary edition or for the No-FBW model. The auto-trim system will automatically trim the aircraft pitch even at high angles of attack and will attempt to hold the commanded pitch value in most circumstances. This does not use the separate pitch trim function, but rather operates in a single channel using the primary elevator control. The aircraft can be controlled quite well with pitch control, but fine trim commands are not supported. For a subsequent update we may introduce this capability if there is sufficient demand for it.

Lighting System

The lighting system is customized such that the "L" key will not turn on or off lights in a realistic way. It is best to activate lights using the designated switches or controls in the cockpit. Additionally, the landing and taxi lights are programmed to the switch in the cockpit and won't activate via "L" key as expected. This is so these lights behave more like the real-life counterpart.

Auto-Flaps System

The Raptor model does not have a manual flaps system. All flaps settings are controlled automatically depending on airspeed, configuration (landing gear down or up), and angle of attack. There is no manual

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override modeled at this time. Any attempt to manually adjust flaps will not result in flaps settings changes and such commands will be ignored.

For the No-FBW model, the flaps should be left in the 0 / up position and no attempt should be made to manually deploy flaps. If flaps are deployed, the game will ignore the native fly by wire modeling and the plane will become overly sensitive in pitch, the auto-flaps won't deploy at correct speeds, and the aircraft will be more difficult to control.

G Load Buffet

The game has a built-in high G (gee) load buffet that oscillates the pitch controls and elevators up and down when g load exceeds approx. 6 g's. We have reduced the effect of this "feature" as much as we've been able to without damaging aircraft performance, but it's still noticeable, in particular at high-speeds with the aircraft at "max" G. Perhaps in future revisions we will find complete solution.

Freeware Versions of the F-22A

If you've previously installed our freeware model of the F-22A from flightsim.to (or elsewhere), you will need to remove it from your community folder before installing the premium edition. They are not compatible and if you attempt to launch a game session with both models installed you'll experience problems. We doubt you'll want to go back to the freeware version, but just in case, keep a backup.

However, if you want to do multi-player flights with a friend who hasn't purchased the premium version, you will be able to see them, and you'll see them flying in the premium edition model. They will see you flying in the freeware model.

A Word on MSFS 2020 Simulation Limitations and Limitations of this Model

The F-22A Raptor presents a variety of substantial challenges to any simulation developer and is arguably one of the most difficult aircraft to model and to simulate accurately in any flight simulation environment. The performance of the aircraft is unique because the maneuvering capabilities of the aircraft are enhanced by using its thrust vectoring engines and complex fly by wire systems to overcome many of the normal aerodynamic limitations of non-fly by wire, non-thrust vectoring aircraft. The avionics and systems are difficult (or impossible) to simulate due both to their extraordinary complexity and, more importantly, the lack of publicly available information about them (much about the Raptor is still classified). Additionally, specific to MSFS2020, there are a variety of limitations within the flight simulation engine that make developing a simulation of an extremely high performance super-maneuvering modern fighter aircraft even more challenging. While we've taken great pains to overcome a number of these limitations, we'll describe a handful of the most significant ones here and the impact on our simulation of the F-22A Raptor.

Thrust Vectoring Limitation: Presently there isn't support for simulation of dynamic thrust vectoring in MSFS2020. This puts some inherent restrictions on ultimate maneuvering capability and performance when simulating the F-22's unique low speed maneuvering and high speed sustained turning ability. We have synthesized as much "thrust vectoring" type maneuverability as possible with careful modifications to the flight physics model and proprietary coding of flight control systems logic, but with the lack of thrust vectoring simulation, the model won't perform quite like the real aircraft. While this model can easily perform most of the maneuvers you might see during an F-22A aerial demonstration flight, the real world aircraft can safely perform these maneuvers at somewhat lower airspeeds and lower altitudes, recover more quickly from post-stall maneuvering, and exhibits some better stability than we have been able to simulate. Additionally, the real world aircraft can fly at angles of attack in excess of 90

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degrees (where forward airspeed is essentially 0 knots) and still maintain control. This is not the case in MSFS and we have not found a means of achieving this with our modeling. Nonetheless, the model can be flown right to the limit with pitch and yaw control maintained at very low airspeeds and very high angles of attack.

Weapons and Combat Situational Awareness Systems: MSFS 2020 is a civilian simulator. Weapons systems and related avionics aren't natively supported. As such we don't simulate weapons systems including radar (other than a rudimentary display of data for multi-user and real-time traffic on the PMFD), radar warning receivers, functional weapons systems and weapons deployment, or tactical situational awareness systems. Even if we could, there is little to no public data available describing these systems specific to the F-22A in any detail, so any attempt to model these would be conjecture at best. There are loading options in the fuel and weight menu to simulate the weight and visual display of missiles (non-Marketplace editions) and also two optionally displayed external fuel tanks, but no functionality exists with respect to weapons or weapons deployment.

Cockpit and General Systems Overview

The premium edition of the F-22A Raptor incorporates a fully custom built suite of avionics to provide a high degree of functionality with respect to aircraft systems information display, navigation, and automation. We modeled these systems based on the limited amount of public information available about them and did our best to replicate the look of these avionics displays within the limitations of MSFS 2020. This should give this Raptor model, from the standpoint of general aircraft management and navigation, similar functionality to most of the default complex aircraft in MSFS 2020, but in a way that is generally more consistent with military systems, and specifically the F-22A. However, while this is a go places airplane model, it's not a procedures simulator and quite a few systems and functions that are found (or presumably found) in the real-world aircraft aren't represented in this model, both due to the lack of available information about how these are implemented and displayed in the Raptor cockpit, and the lack of underlying simulator support for modeling many of these systems.

The Raptor cockpit 3D model is a highly detailed 3D representation of the real-world Raptor cockpit, based on photographs, written descriptions, and illustrations. While not accurate in every respect, we took care to visually model as many of the key features of the cockpit as accurately as possible and animated almost all of the control inputs (switches, knobs, and dials) that we can find documentation about. However, this model does not attempt to replicate a number of the avionics and cockpit systems functionality of the real-world counterpart, in part due to lack of data, and in part due to lack of meaningfulness (the cabin air conditioning system switches for example are animated, but perform no relevant function for a "pilot" sitting in their gaming chair at home). In spite of these purposeful omissions, this model will still provide a highly immersive, functional, and endlessly entertaining flying simulation experience. The following reference guide will show you where the functional elements of the cockpit are found, where appropriate, how to use them in flight, and key procedures needed to operate the aircraft.

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F-22A Cockpit Overview

Welcome to the F-22A pilot's office. This is a high level summary of the key components of the cockpit. Each section of the cockpit will be described in more detail within this user guide.

1. Head Up Display (HUD)

2a. Left Tertiary Multi-Function Display (TMFD - left)

2b. Right Tertiary Multi-Function Display (TMFD - right)

3. ICP (Integrated Control Panel)

4. Secondary Multi-Function Displays (SMFDs)

5. Primary Multifunction Flight Display (PMFD)

6. Left Auxiliary Console

7. Left Console

8. Right Auxiliary Console

9. Right Console

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Head Up Display (HUD)

The Head Up Display provides the pilot with substantial information about the aircraft performance, attitude, position, and navigational references without having to look down into the cockpit. For this model, we've developed a fully customized HUD. While not modeled to replicate the Head Up Displays found in modern USAF fighter jets, many of the same basic features and information are found in the HUD in this model and greatly improve the simulator pilot's situational awareness and safety while performing demanding dynamic maneuvers or operating in poor flying conditions.

1. Current Heading and heading reference indicator

2. Autopilot heading reference / bug

3. Course deviation indicator (appears when a course selection is made in autopilot system)

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4. Current wind aloft bearing, speed, and direction pointer relative to aircraft

5. Vertical speed visual reference – a full circle indicates climbing or diving at or in excess of +/- 38,000 feet per minute.

6. Autopilot current altitude setting

7. Barometric altitude (above sea level). Needle moving clockwise indicates increasing altitude, counterclockwise indicates decreasing altitude. Each dot in the circle represents 100 feet of elevation.

8. Vertical velocity (climb or dive rate) in feet per minute

9. Radar altimeter (altitude above ground level - AGL)

10. Current steerpoint number, bearing, and distance in NM

11. Estimated time to steerpoint based on groundspeed (hours:minutes:seconds)

12. Bank angle indicator

13. Pitch ladder (in increments of 5 degrees pitch up or down)

14. Bank angle pointer and combination slip indicator

15. Artificial horizon indicator

16. Maximum g load attained during the current flight

17. Angle of Attack indicator in degrees (positive or –negative)

18. Current G (gee) level (airframe load factor).

19. Current Mach number (fraction or multiple of the speed of sound).

20. Current true airspeed in knots

21. Current Groundspeed (speed the aircraft is moving relative to the ground).

22. Acceleration or deceleration indicator.

23. Knots Calibrated Airspeed (KCAS). Primary airspeed indicator for the aircraft. Needle moving clockwise indicates increasing speed, counterclockwise indicates decreasing speed. Each dot in the circle represents 10 knots airspeed.

24. Autothrottle Airspeed / Mach Hold Reference: Will display Airspeed (IAS) or alternately (Mach) hold selection when toggled in the Autothrottle Speed Mode in Autopilot ICP page.

25. Flight Path Marker – shows the direction/vector of travel of the aircraft.

26. Approach angle indicator. This only shows if the aircraft is above or below the target angle of attack when the aircraft is on approach. Will only display when landing gear is down. Target angle of attack for final is 12 degrees AoA. If angle of attack is too low, a vertical line will appear above the climb/dive marker. If angle of attack is too high, a vertical line will appear below the climb/dive marker.

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27. Climb/Dive Marker (Airplane Reference Symbol): Shows where the aircraft nose is pointed.

ICP (Integrated Control Panel)

The integrated control panel (ICP), sometimes called the up-front control panel or UFCP, provides quick access to a wide array of functions and information about the F-22A. Without detailed references to the F-22A subsystems present in the ICP module, we've done our best to provide a variety of functions within the ICP in a way that seems plausible and highly functional and useful within MSFS 2020.

ICP Interface Overview:

1. Com 1 menu
2. Com 2 menu
3. Navigation radios menu
4. Steerpoint information menu
5. Set and select transponder (transponder is off by default)
6. Altimeter and altitude settings menu
7. HUD settings menu
8. Fuel, range, timer, temperatures, and other information
9. Autopilot menu page button
10. Confirms and commits (marks) the value entered into an ICP data entry field.
11. Cycles through ICP menu pages
12. Selection button(s) to select and activate the entry field to the right for data input (see item 15 below), if selectable. Additionally, the topmost selection button will typically navigate you back to a previous higher level page if you're working in a submenu.

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13. Current page / Total pages available in this menu.
14. Carat symbol indicates value can be selected for change by pressing the round select button. If a colon symbol appears, this indicates there is a subpage / submenu available (for most selections, some are inop).
15. This window shows the value being entered or changed, the currently active setting / selection, or page number depending on menu context and layout.
16. Numerical keypad entry button(s): use to enter values when value entry / selection option is enabled. For entries with zeros expected / preceding, such as 0.80 (like a Mach hold selection), enter "080". For entries of values with decimals expected in the value string, such as communications frequency 118.900, enter "11890" and the ICP will put the decimal in the correct place. UNDO is INOP. CLR erases the value entered.
17. Creates negative value when pressed before or after entering desired numerical value (only functional on for vertical speed hold).
18. Adjusts Com 1 listen volume
19. Adjusts Com 2 listen volume
20. HUD brightness control wheel
21. ICP backlight and LCD display brightness control wheel

Note: The DVR button has no function

ICP COM 1 and COM 2:

Set Com 1 and Com 2 radio Volume and Frequency.

ICP NAV: Nav 1 and Nav 2:

Cycle through navigation radio data and update volume and frequency. **Nav 1 and Nav 2:** Cycle through three pages of data for these radios – adjust frequency on page 1, volume on page 3. **TCN 1 and 2: INOP** - for display purposes only. **ADF:** shows ADF data; adjust frequency and volume on page 2. **ILS 1**

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and ILS 2: displays additional ILS/localizer/DME data when Nav 1 or Nav 2 are tuned to ILS/LOC frequencies.

ICP STPT:

Displays a variety of navigation and en route data for the currently active steerpoint (it is not possible to cycle through different steerpoints in the flight plan from the ICP). Steerpoints are entered via the flight plan in the flight planning screen in the game lobby, or by entering or modifying a flight plan using the Garmin G3000 flight planning widget that can be found by pressing the push button at the top of the left TMFD screen.

ICP IFF (Transponder Page):

Manually enter the transponder code at the bottom of the second page (squawk). Otherwise, select the transponder mode to employ. All modes are recognized by the sim, but the data transmitted with each

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mode is not 1:1 with real life as the sim doesn't support this – there for emulation purposes. By default, transponder is off at the start of each game session and must be turned on and tuned by the sim pilot.

ICP ALT:

Page 1 displays the barometric altimeter setting and adjustments (can also be adjusted in the right side TMFD) and displays and adjusts the mission altitude floor and related CAS (caution). Page 2 displays baro and radar altimeter data similar to / same as displayed on HUD

ICP HUD:

AA and AG options are for show only – no functionality. NAV is the default HUD mode (only HUD mode supported at this time). The "Caged" option will lock the pitch ladder when active (A) and the HUD will no longer display yaw motion via side to side movement of the pitch ladder.

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ICP OTHR:

Contains selectable options to change joker and bingo fuel warning settings (can also be adjusted in the right TMFD). Also contains a fuel submenu that also displays fuel total and total consumption rate, time to empty, and a remaining range estimate. Contains a Timer function. Contains a built in test menu subpage that is INOP other than displaying some submenu listings – just for show.

ICP A/P: Autopilot System:

Master – press to activate, "(A)" will display when on. Press again to de-active autopilot

SRC: Nav1/Nav2/GPS – selects the navigation data source to which the A/P will be slaved when the NAV hold is active.

A/T: When active "(A)", will set the autothrottle hold to the speed selected in the SPD: menu on A/P page 2. Set speed first before activating auto-throttle. Changes to speed are made from the SPD: menu on page 2 of the autopilot sub-system.

NAV: Activates / deactivates NAV hold and will slave to whichever NAV source is selected under the SRC: menu above.

APPROACH: Activates approach hold mode when an approach is programmed into the flight planner (e.g. RNAV approaches) or entered/activated using the in cockpit widget. Also works with ILS

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approaches (tune the respective NAV radio to an ILS/LOC frequency and then select the SRC: ILS1 (or 2) selection and turn on APPROACH mode to slave the autopilot to the radio beacon), NDB, and OBS assisted approaches.
BKCRS: on Page 2 - Activates Backcourse approach mode.
SPD: on Page 2 - select autothrottle speed and mode (IAS/KCAS or Mach hold).
HDG/OBS: on Page 2 – Activate HDG lock, Enter a heading or enter an OBS heading
ALT/VS: Activate Altitude hold or Vertical Speed hold and enter the respective altitude or vertical speed desired. Set altitude target before activating VS mode. To set a negative number for VS hold, enter the desired numerical value then press the rocker switch/button to the left of COM1 ICP button to enter the negative sign.

Primary Multifunction Flight Display

The Primary Multifunction Flight Display shows data about aircraft position, navigation symbology, multi-player and real-time live traffic, and relative terrain elevation. The PMFD also contains the screen(s) for management of several visual display elements for the model.

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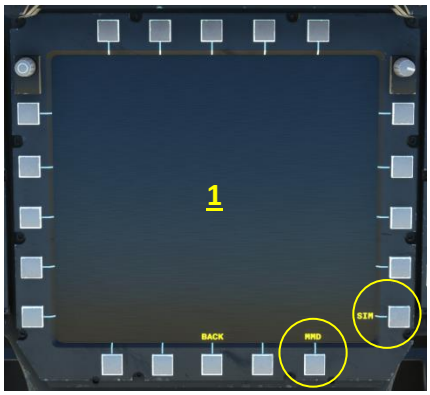
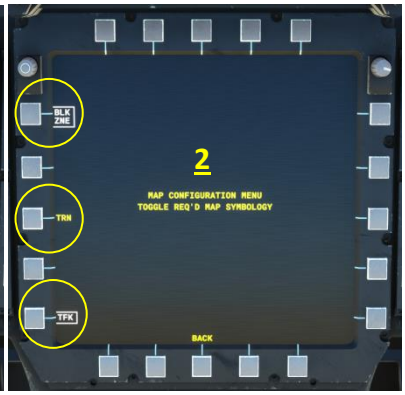
Elements of the PMFD MMD Display Screen:

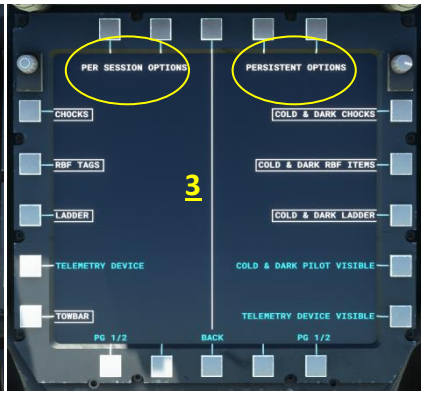
- Aircraft reference position symbol
- Standard airfield and navigation aid locations and ICAO names
- Heading and compass rose (arc format)
- Map range (to 2048 nautical miles) using RNG IN and RNG OUT selections
- Radar Range (Block Zone) overlay (for display / show purposes only)
- Live real world air traffic position, altitude, and airspeed vector lines.
- Live real world air traffic display speed vector adjustment knob (LDR selection)
- Optional moving terrain map overlay and relative elevation display (dynamically changes color based on aircraft relative elevation compared to surrounding terrain).
- Menu button to enter PFD menu screens (described below).

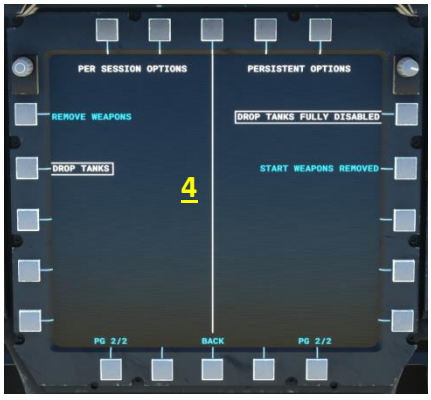
PMFD Configuration Screens

The PMFD has two distinct configuration screens; one is used for configuring the Moving Map Display with your preferences, and the other controls the visual display elements for the aircraft when cold and dark and the display and loading of weapons and drop tanks.









1. **PMFD Configuration Selection Screen:** You can reach this page by selecting “menu” from the main PMFD screen and you’ll find a screen with “MMD” and “CFG” options in green text; MMD will return you

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back to the main PMFD moving map display and CFG will open a page with yellow text with the option to configure the MMD or open the SIM aircraft configuration page. The BACK button will return you to the prior page where you can select to return to the MMD display or return to this page.

2. **MMD Configuration Page:** This page is reached by pressing MMD from the configuration page (in figure 1 above). From here you can select whether or not the moving map display will show the radar block zone overlay (the white "arrow" type shape), you can choose whether or not to show the moving map terrain overlay, and you can choose whether or not to show the real-time live traffic data. These options will be saved for future sessions (they are persistent) until you change them.

3. **SIM Configuration Page:** From the CFG page (figure 1) you can reach the SIM configuration page. This page is particularly important when starting up the aircraft from the cold and dark configuration (loaded onto the parking apron). The engines can't be started without disabling the wheel chocks, remove before flight (RBF) tags, Ladder, and tow bar (this can also be done by turning on the APU or pressing "Quick Start" in the ENG CTL page in the SMFDs. To turn these off in the current session, press the button to the left of each of the options under the "Per Session Options" showing a white box and white text and these items will be hidden from view. If you'd like to hide these options "permanently" so these items don't show up by default in subsequent game sessions, press the buttons for the items in white boxes and text under the "Persistent Options" menu and deselect all the ones you don't want. In case you were wondering, the Telemetry Device option refers to the Luneburg lens attached to the underside of the aircraft behind the landing gear. It looks like a small gray paint can hanging from under the aircraft. This device is attached to the aircraft to render it non-stealthy and visible to radar systems, useful for both flying (and staying visible to radar) through controlled airspace and for concealing the true radar signature of the aircraft.

4. **Drop Tank and Weapons Page(s):** By default the aircraft will load with weapons; for this release (non-Microsoft Marketplace versions only) we've limited the weapons load to the standard Air to Air mix of 2 Aim-9X Sidewinders, and 6 Aim-120D AMRAAM missiles. These are merely for "show" and have no function, but they will affect aircraft weight. However, you may notice that when the missiles are removed, the weight and loading menu doesn't reflect the change. This is a game bug. Have no fear, though, because the weight is being reduced and this can be seen in the weight debug menu, just not in the weight and loading page. You will also sometimes see the flight path marker will oscillate when the aircraft is sitting on the ground and you add and remove weapons from the aircraft, indicating a change in aircraft weight. To remove weapons, simply click on the Remove Weapons option so that it has a white box and the text is white. This will reduce aircraft weight by 2,640 pounds. If you want weapons to only load when you select them from the in-session menu and not by default, select the Start Weapons Removed option on page 2 of the persistent options menu (white box, white text).

Drop tank models will display automatically anytime the aircraft is loaded into the session with fuel loaded into the left and/or right auxiliary fuel tanks. Alternately, once in session you can also select the "Drop Tanks" option in the Per Session option to hide or display the tanks. If you've placed fuel in the external tanks and then remove the tanks using this option, fuel will be removed from the aircraft. Also,

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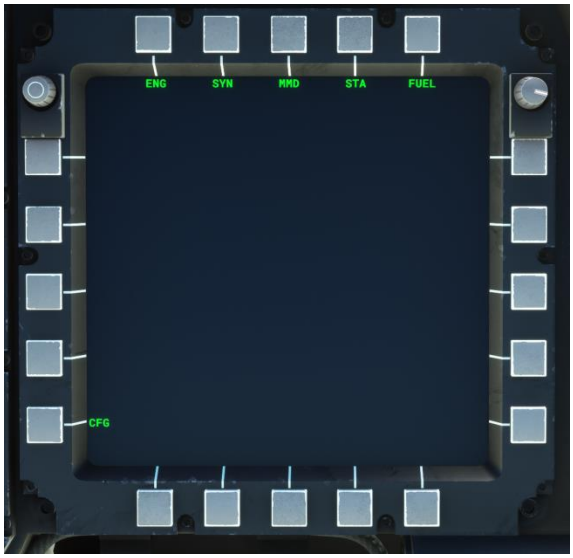
once in session, you can then add fuel to the auxiliary tanks if desired, but the drop tanks will not display – they will be hidden until you select the “Drop Tanks” option to show them again. If you wish to avoid having drop tanks displayed in future flight sessions, you can click the Drop Tanks Fully Disabled option (white box, white text) in the Persistent Options menu and the aircraft will only load with fuel in the left and right main tanks regardless of what you select in the aircraft selection menu in the game lobby; you can display the tanks within a given session by then selecting “Drop Tanks” in the Per Session options and you will need to manually add fuel from the weight and loading widget within the session.

Secondary Multifunction Flight Displays (SMFDs)

There are three “secondary” multifunction flight display screens in the F-22A. They display a variety of information relevant to aircraft systems, navigation, tactical and weapons system status, and defensive systems. In this model, we have omitted the tactical and defensive systems due to lack of information about these systems (most of these displays and systems are still classified military secrets), lack of support within MSFS 2020 for these types of systems, and prohibitions within the Microsoft Marketplace of weapons and weapon systems. However, we have provided several different customized information pages showing different aircraft system and performance data. These were modeled after screen shots and documentation from the real F-22A and we’ve attempted to be faithful to the look and feel of these screens.



Above you can see the various page options available in the MFDs; these options will display when you press the “menu” button in any of the MFD pages.

- Eng = Engine information Page
- Syn = Control position synoptic page
- MMD = Moving map display (very similar in function to the PMFD MMD)
- STA = Stores load-out page
- Fuel = Fuel load-out page
- CFG = configure Moving Map Display features (same as for PMFD)

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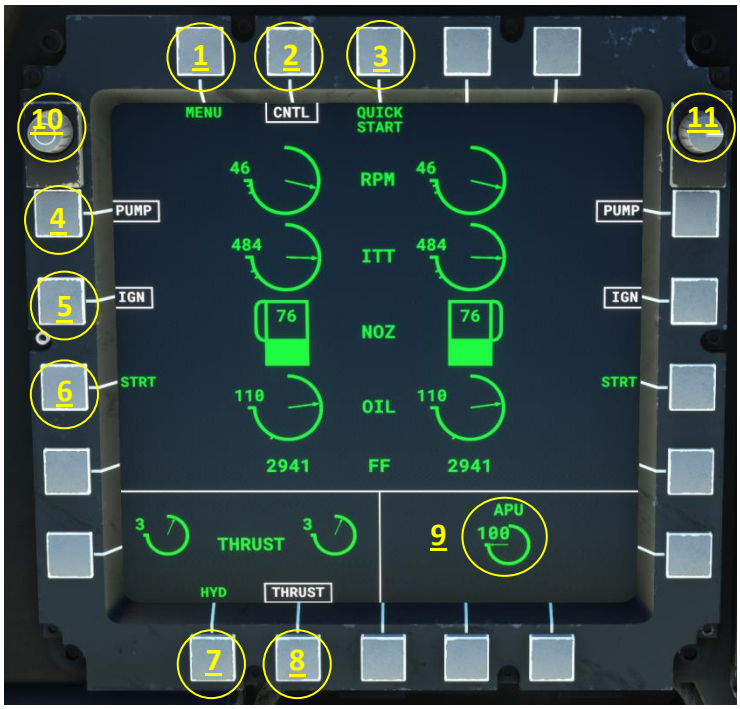
SMFD Engine Information Page:



The Engine Information Page displays critical information about engine performance as well as access to engine controls for startup and shutdown. Auxiliary Power Unit status is also displayed in this page.

1. SMFD Menu select button
2: Engine Controls page
3. Quick Start option – fires up the engines without having to run the checklists, other than turning battery on to enable SMFD displays. Generators will need to be turned on manually and APU turned off after engine start. See section about engine starts elsewhere in this manual.
4. Left engine fuel pump – must be on or engines won't start and/or will stop running. Engines can be shut down by turning off pumps.
5. Ignition – must be turned on prior to engine start.
6. Start switch. As referenced earlier, the engine select and start button on the left console can also be used. This is also built into this SMFD page as well – a redundant feature.
7. Hydraulic system pressure display
8. Engine thrust display (lbs thrust)
9. APU status. Must be on (above 80%) for engine starts.
10. Selector knob (no function within engine information page
11. Screen and backlight brightness knob

The information displayed by the page is relatively self explanatory, but here is a short explanation for each item:

- Engine RPM shows percent of max RPM for each engine.

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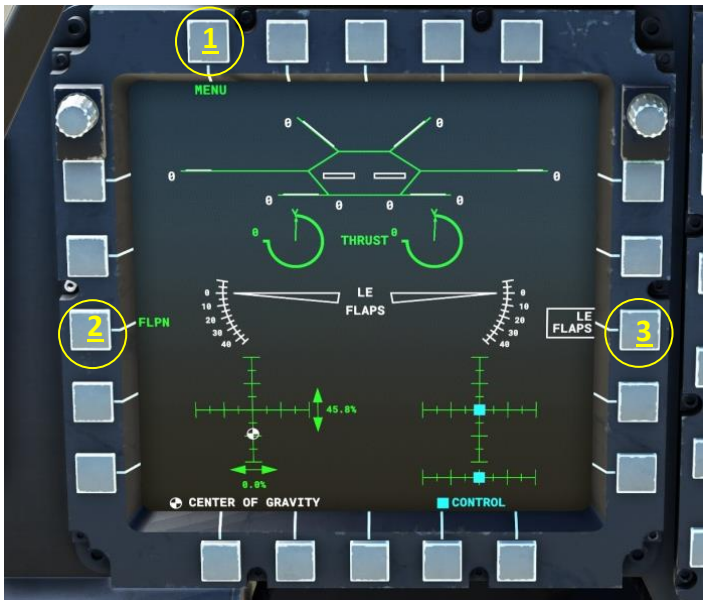
- ITT shows the interstage turbine temperature in degrees Celcius and is a key temperature measurement for the engine.
- The Nozzle position gauge shows the relative position of each engine exhaust nozzle, which opens and closes depending on the throttle setting. The nozzle gauge will turn yellow when afterburner is engaged.
- Oil temperature is displayed in degrees C.
- Fuel flow per engine is displayed in pounds per hour.

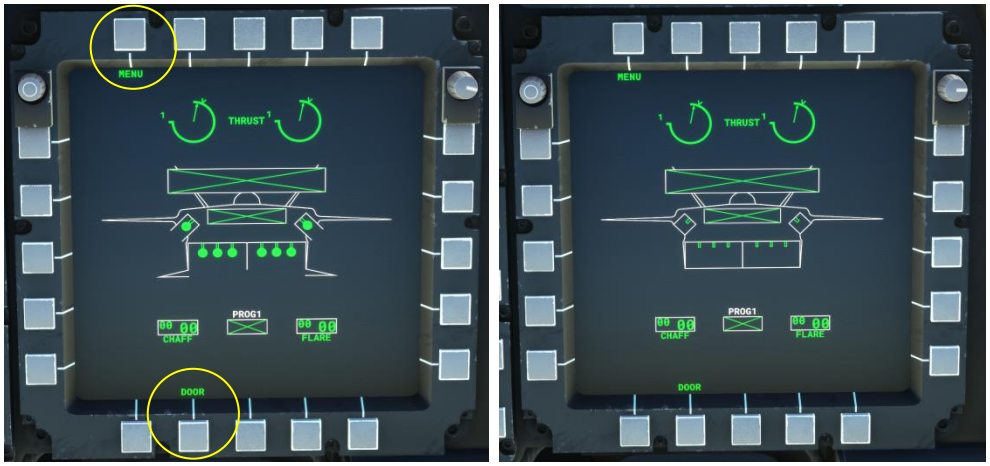
Aircraft Control Synoptic Page:



The page is used to display control positions, thrust, and center of gravity.

1. SMFD Menu select button
2: Select Flaperons position display (Trailing Edge Flaps)
3. Select Leading Edge Flaps position display

Aircraft Stores Page:



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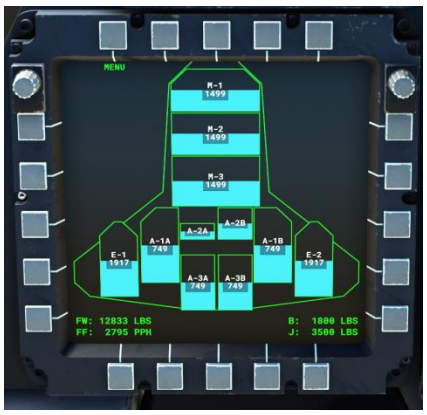
Page displays stores, when loaded via the PMFD SIM menu, represented by solid circles at each weapon station. The left graphic depicts the weapon load-out symbology with doors open. The right shows no weapons load-out and bay doors closed.

1. SMFD Menu select button

2: Opens weapons bay doors. On ground the weapon bay door animation takes about 10 seconds. In the air, the weapon bay door animations will take about 1.5 seconds.

Fuel Page:



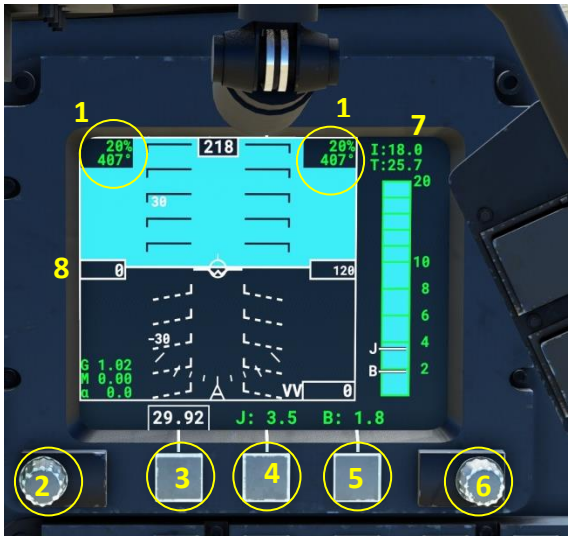
Page displays fuel loading, total weight, fuel flow, and bingo/joker fuel settings.

Bingo and Joker fuel settings are managed from the right TMFD or the Fuel menu under the ICP OTHR page.

Tertiary Multi-Function Displays (TMFDs)

The two displays on the upper right and left portion of the main panel are the TMFDs (see the cockpit reference diagram near the beginning of this manual). These are customized information screens that provide a significant amount of information to the pilot at a glance.

Right TMFD:



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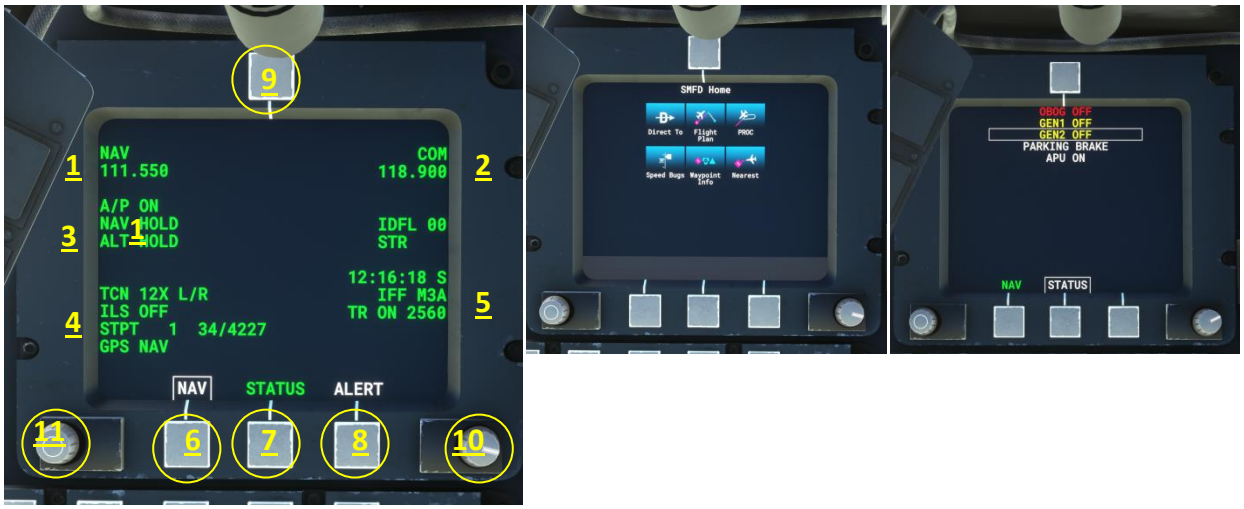
1: Engine RPM and ITT temp (Left and right engines respectively).
2: Value adjust knob – affects values selected with buttons 3, 4, and 5.
3: Altimeter barometer adjustment (Kollsman knob).
4: Joker fuel selector (mission low fuel caution).
5: Bingo fuel selector (mission low fuel warning – minimum fuel for return to base)
6. Display brightness knob
7. Fuel total: displays numerical internal (I) and total (T) fuel. The right side graphic bar shows total fuel less than 20,000 lbs, Joker, and Bingo fuel status. If fuel is below Joker threshold, the fuel bar graphic will display yellow. Below Bingo, and the fuel bar graphic will display red.
8. Attitude indicator and backup flight data information. This graphic displays similar data to the HUD and can be used to monitor key flight data while pilot's eyes are down in the cockpit and not looking through the HUD.

Left TMFD:



1. Nav 1 radio frequency active
2: Com 1 radio frequency active
3. Autopilot selections reference
4. TACAN (presently for display only – INOP), ILS status (On or Off – triggered by autopilot ILS / approach modes) and summary current steerpoint information.
5. Local time, IFF mode active, Transponder status (Off, On, Stby), and transponder frequency
6. Main TMFD page select button
7. Status / Alerts message page
8. Alerts message page (similar to button 7) – will change color and display the word "Alert" when there is an advisory, caution, or warning. Press Status or Alert button (7 or 8) to bring up the page of Alerts.
9. Flight planning screen (G3000 flight planner). This functions just as the G3000 flight planner screen does in the rest of MSFS2020 so we won't provide instructions on its use here, but it does integrate with the autopilot and instrumentation as expected.

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10. Brightness adjustment knob
11. Selection knob (doesn't serve much purpose in this screen but does "scroll" through the alerts list)

Left Console

The Left Console contains flight critical functions such as the throttle levers, generator switchs, apu, fuel, and lighting controls. The diagram above shows the functional dials, switches and knobs that are enabled in the model. If a switch, knob, or dial isn't numbered it is not animated nor functional.

1. Generator 1 and 2 Connect/Disconnect Switches: These should both be set to the Connect position at all times during normal flight / normal procedures.

2. APU Start / Off Switch: 2 positions "Start" and "Off" are modeled. Start will engage the APU, which will reach full power in 10 seconds. Off will turn off the APU.

3. Fuel dump switch. When switched to on will dump fuel at a rate of approx. 1000 pounds per minute, starting with the left external tank, followed by right external tank, followed by main tanks.

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4. External vs. Internal fuel selector – INOP – animated only.

5. Air to Air Refueling door open / close switch. Triggers the AAR door animation on the top of the aircraft behind the canopy.

6. Air to Air Refueling light switch. Illuminates the AAR lighting that projects aft of the AAR door and on the port itself. Will only be visible when AAR door switch is in the “AAR Open” position.

7. Navigation Lights Knob:

- ANTICOL will turn on the red omni-directional beacons near the upper and lower wing tips.
- POS/ANTICOL will turn on the omni-directional beacons, the solid red and green wing navigation lights, and the rear facing solid white navigation tail lights.
- POS FLASH will disable the red omni-directional beacons, and turn the red and green wing navigation lights and rear facing white navigation lights into flashing strobe lights, flashing approximately 1.5 times per second.
- POS will disable the red omni-directional beacons, and turn on the solid red and green wing navigation lights, and the rear facing solid white navigation tail lights.

8. Formation Lights Knob:

- The base knob, switched to NORM, will turn on the electro-luminescent exterior formation lights at the normal brightness setting. By default, formation lights are set to NORM.
- The base knob, switched to BRT, will turn on the electro-luminescent exterior formation lights at the maximum brightness setting.
- The smaller adjustment knob will increase or decrease the brightness level of the formation lights based on which main setting is selected. By default, formation lights brightness is set to 50%.

9. Console lighting mode switch: Switches between NVG compatible lighting (green) and Day or Normal lighting (white light) for the console text emissive and the flood lights on consoles and main panel. Does not affect emissive (backlight) lighting on most main panel flight display buttons and knobs (these stay in NVG mode).

10. Console Text Backlight Dial: Increases or decreases brightness of the text labels on switches, knobs, and dials, for right and left consoles and the auxiliary consoles. Text will be green when in NVG mode and white when in Day/Normal mode.

11. Main Panel Avionics Screens Brightness Dial: Increases brightness for TMFD, SMFD, and PMFD screen brightness for the entire main panel as well as the backlighting of buttons and other electroluminescent items. This dial will over-ride the individual brightness adjustment dials for each SMFD, TMFD, or PMFD. This control does not adjust brightness for the ICP module, which has independent lighting controls.

12. Console Flood Lights Dial: Increases and decreases brightness for the floodlights illuminating the left and right consoles and auxiliary consoles. Light will be green when in NVG mode and soft white when in Day/Normal mode.

13. Main Panel/Glareshield Flood Lights Dial: Increases and decreases brightness for the floodlights illuminating the main panel. Light will be green when in NVG mode and soft white when in Day/Normal mode.

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14. Lamp Test Switch – INOP – Animation only.

15. Throttle level and Toggle Throttle Visibility On/Off: Displays or hides the throttle control for better visibility of left console. When throttle is displayed, is animated and can be adjusted via mouse control (and of course via input device control).

16. Engine selector switch (FADEC): L = Engine 1, R = Engine 2

17. Engine Starter Switch: Select L or R using engine selector switch (FADEC) and then press the red button to start engines. Batt and APU on, Pump(s), and Ignition (IGN) must be on to start (see Engine CNTL menu in PMFD). For more detailed instructions please see the section on Engine Startup and Shutdown Procedures.

18. Flaps Manual Override Switch: INOP – Animation only

19. Rudder Trim Manual control: INOP – Animation only

20. FBW Module on / off switch. Default position is “On”. Turning this to “Off” will remove flight control limits and result in potentially unstable and unsafe aircraft handling. Please see the section below regarding the Fly-By-Wire System.

21. Ejection Seat Controls Handle. INOP – Animation only. For general reference, the control handle should be in the down or “armed” position during normal flight as this enables the ejection seat controls for emergency egress from the aircraft. Should be placed in the up or “Locked” position when the aircraft is parked and not in operation.

Fly-By-Wire System Overview

A unique feature of this model is the custom programmed fly by wire module that governs the flight control system for the aircraft. Without it the aircraft becomes very difficult to control and/or can be over-controlled very easily, resulting in airframe stress or loss of control. By default this system is on. However, if you disable this system, or it is not enabled by default for you, you will find the aircraft far less docile and much harder to fly smoothly. The switch should remain in the “up” or “on” position for this system to be enabled. Please ensure it stays in this position to avoid airframe overstress or out of control flight conditions. Pro-Tip: The fly-by-wire switch is set to keybind with the water rudder, if you want to experiment with flight with and without the Fly-by-wire system active and don’t want to have to look down in the cockpit to turn the system on and off.

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Left Auxiliary Console

The Left Auxiliary Console contains the all important landing gear handle as well as a handful of other important controls. Non-numbered switches, knobs, or dials, are not animated or functional.

1. Tail hook switch. In real life, the tail hook is not designed for carrier landings, but rather to catch onto barrier arresting equipment used in landing emergencies on land based runways. The hook may also be used to anchor the aircraft during engine run-up tests.

2.Parking Brake Set / Release Switch: “Park Brake” will set the brake, “Release” will release the brake. A CAS text indication will also display in the status page on the TMFD when the parking brake is in the set position.

3. Landing / Taxi Light Switch:

- LDG turns both landing and taxi lights on
- OFF turns both landing and taxi lights off
- TAXI turns the taxi light on
- The “L” key (nor any other keyboard or controller control binding set to enable lighting) will not activate or deactivate the landing or taxi lights. They must be controlled using the cockpit switch. This is due to a programming limitation within the game as we wanted to enable functionality that more closely matches real world aircraft landing and taxi lights functions.

4. Landing Gear Handle: Up for landing gear up and stowed, down for landing gear down.

5. Landing Gear Status:

- Green indicates gear is safely in the down and locked position.
- Red indicates the gear is in transit and/or is in an unsafe condition.
- Indicator off means gear is retracted and stowed safely.

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6. Weapons system arming switch: INOP – animation only. Default position is “SAFE”.

Right Console and Right Auxiliary Console

The Right Console and Right Auxiliary Console contain many controls that are not flight critical for this model, including environmental controls, radio controls, and others that we have chosen not to model for reasons of redundancy or lack of simulator functionality to support them.

1. Main Battery On/Off Switch: Should be in “on” position during normal flight / normal procedures.

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2. Environmental Control System panel. All INOP - switches, knobs, and dials are animation only

3. Toggle Side Stick Controller Visibility On or Off: Displays or hides the side stick controller for better visibility of right console.

4. Radio Volume Control panel: All INOP – all dials are animation only

5. AUX Comm panel: the LCD displays the COMM 1 frequency setting. All knobs and dials, *except* the brightness knob are INOP – animation only

6. AUX Comm LCD brightness control: Adjusts the brightness of the AUX Comm LCD display

7. Oxygen System control Panel: ALL knobs, switches, and dials are INOP, *except* the OBOGS switch.

8. OBOGS switch: The onboard oxygen generating system switch should be left in the "on" position. It serves no specific function in the game, but if left in the off position an "OBOG OFF" warning CAS will appear on the HUD and a warning text alert will display in the left TMFD Status page.

9. Encrypted / Secure communications switches: INOP – animations only

10. Canopy open/hold/close switch. Press switch located below the decal on the right side of the canopy next to the control stick. Switch can be pressed to open and close, or to suspend / hold the canopy open/close sequence.

Engine Startup and Shutdown Procedures

Engine Startup (Cold and Dark) – Full Procedure*:

- Check Parking Brake is on and check aircraft is clear of ground personnel, equipment, and debris
- Set Battery Switch to "On"
- If the remove before flight tags, wheel chocks, ladder, or towbar are present, select the "Menu" option on the PMFD, then select "CFG" and then select "Sim". From this menu, deselect these items from the left side menu options. Aircraft cannot be started cold/dark with these items in place and must be deselected/removed before aircraft can be started. Additionally, if ladder is in place, the canopy can't be closed. *If you wish to skip these steps*, you can simply turn on the APU at this point, which will hide the various ground protection equipment automatically.
- Close the canopy (if open)
- In the SMFD Engines Page, select the CNTL menu (engine control menu) - white box and text will show when selected.
- APU switch to "Start" –APU will quickly reach 100 percent power.
- In the engine control menu Select left engine "Pump" – white box and text will show when selected
- Select left engine "Ign" Ignition switch – white box and text will show when selected
- Select left engine "Start" – white box and text will show when selected. Left engine will begin the start sequence. Alternately, on the left console panel, the FADEC paddle switch just aft of the throttle quadrant can be moved to the left position, and the round red button next to the FADEC switch, marked "Motor", can be depressed to engage left engine starter.

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- To start the right engine, turn on “Pump”, “Ign” and “Start” (or alternately use the right FADEC switch position and red button push) to start the right engine.
- Once engines have reached 25% RPM, set Generator Switches 1 and 2 to “Connect” / the on position.
- Once the engines are running and generators connected, shut down the APU if it is no longer needed.
- Exit the engine control menu by pressing the “CNTL” button again.

*For fun, check the left side of the aircraft just after you hit the left engine start button for some cool visual effects.

Engine Startup (Cold and Dark) – Quick Start*:

We’ve created an engine quick start procedure to short cut most of the steps in the full procedure start up sequence.

- Check Parking Brake is on and check aircraft is clear of ground personnel, equipment, and debris
- Set Battery Switch to “On”
- Close the canopy
- In the SMFD Engines Page, select the CNTL menu (engine control menu) - white box and text will show when selected.
- Press the “Quick Start” button. APU and engine starter sequence will automatically start.
- The remove before flight tags, wheel chocks, ladder, or towbar, if present will be hidden as soon as the Quick Start button is selected – you will not need to hide these within the SIM configuration menu.
- Once engines have reached 25% RPM, set Generator Switches 1 and 2 to “Connect” - the on position.
- Once the engines are running and generators connected, shut down the APU if it is no longer needed.
- Exit the engine control menu by pressing the “CNTL” button again.

*For fun, check the left side of the aircraft just after you hit the quick start button for some cool visual effects.

Engine / Aircraft Shutdown:

- Set Parking Brake.
- Open the SMFD Engines Page
- Select the CNTL Menu
- Press “Pump” to deactivate the fuel pump for the respective engine to shut down (no longer showing white text and box when off).
- Press “Ign” to deactive the engine ignition system.
- Repeat the above steps for the other engine (if shutting down both engines)
- Disconnect the Generators
- Turn off APU (if running)
- Turn off Battery
- Turn lighting switches and other electronics to off positions, as needed

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Aircraft Handling and Performance Notes, Limits, and Game Settings:

Pitot Heat and Anti-Icing Equipment: Always on when the electrical system is running. You do not need to manually activate or deactivate these systems during flight.

Landing gear extension and speed limit: 290 KCAS – above this speed gear will not extend. At 310 KCAS the landing GEAR UNSAFE warning CAS message (crew alerting system) will come on. Reduce speed and retract gear.

Speed Limits: We have custom coded a highly accurate simulation of calibrated airspeed (KCAS) indication in response to the changes made in Sim Update 5, which introduced significant inaccuracies in reported airspeed values above the speed of sound and at high altitudes. This coding change is reflected in the cockpit instruments, *however* this is not reflected in the exterior Chase Camera HUD mode, and indicated airspeed will be significantly over-stated at high altitudes and supersonic speeds in the Chase Camera HUD. The aircraft's overspeed warning, based on the in-cockpit instruments, will come on at when the airspeed reported by the in cockpit instruments (HUD, TMFD, etc…) reaches 800 Knots (this speed equates to approximately Mach 1.21 at sea level, with increasing corresponding Mach number as altitude increases) and/or Mach 2.40, whichever comes first. mindful of your speed and thrust setting. If significantly exceeded, the aircraft will begin to buffet and, if Airframe Stress Damage is enabled in your settings, the flight will end shortly after onset of buffet. This is particularly important during low altitude operations, where the aircraft can easily exceed its maximum airspeed and resulting airframe stress limits. In case you were wondering, at 40,000 feet and in ISA conditions, the model will reach a little over Mach 2.6 if you ignore the overspeed warnings.

In real-world operation, we've read that the Raptor is likely limited to around Mach 1.9 to avoid erosion of the radar absorbing material (RAM) applied to the skin of the aircraft and heat stress damage to the composite wing leading edges. This also helps reduce the significant detectable heat signature caused by airframe heating as an aircraft approaches or exceeds Mach 2. As such we've set a caution alert when airspeed exceeds Mach 1.9. If you want to get an idea why the aircraft is limited to these speeds in practice, take a look a the Temp sub-menu in the ICP OTHR pages and watch what happens to aircraft temperature as speed increases above Mach 1.5.

An additional note: It is very easy to accelerate well beyond the limit airspeed for the airframe. We've created an alert so that if the aircraft is accelerating toward 800 knots (KCAS), at 770 knots, a visual "Airspeed" alert will display on the HUD to warn you that you are approaching the airspeed limit for the aircraft and you should reduce throttle, deploy speed brakes, or both.

G-Limiter: The simulated fly by wire system (if active) won't allow overstresses to the point of destroying the aircraft; the G-limiter will normally keep the aircraft under +10 Gs and -3Gs. But that doesn't mean the aircraft or the pilot is meant to be stressed to these limits with abandon. Don't bend the frame and the maintenance depot will thank you.

Flaps System: Flaps in real-world Raptors are automated in normal operation and adjust depending on the aircraft configuration, speed, and pilot inputs. This Raptor model does not have a manual flaps

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system. All flaps settings are controlled automatically depending on airspeed, configuration (landing gear down or up), and angle of attack. There is no manual override modeled at this time. Any attempt to manually adjust flaps will not result in flaps settings changes and such commands will be ignored.

During takeoff, the flaps setting will increase automatically as ground speed increases – lowering both the leading edge flaps and the trailing edge flaps to their optimum position for takeoff. Once airborne, as the aircraft speed increases, trailing and leading edge flaps deflection will decrease. When landing gear is raised, the trailing edge flaps will retract and be locked in place and only the leading edge flaps will deflect as airspeeds decrease and angle of attack increases.

During approach and landing, once the landing gear is lowered, the flaps will be lowered into optimum position as aircraft reaches target angle of attack (between 10 and 12 degrees aoa).

For the No-FBW model, the flaps should be left in the 0 / up position and no attempt should be made to manually deploy flaps. If flaps are deployed, the game will ignore the native fly by wire modeling and the plane will become overly sensitive in pitch, the auto-flaps won't deploy, and the aircraft more difficult to control.

Emergency procedures: We've made no attempt to simulate or replicate emergency procedures for the Raptor. You could refer to normal emergency procedures for typical modern fighter jets or turbine aircraft if you are attempting to simulate emergencies. However, there are a variety of CAS messages that will display in the left TMFD status and alerts page and, if a warning (a serious issue needing immediate attention) on the HUD.

Checklists: We have provided some basic checklists using the MSFS 2020 checklist system. There isn't published data on the F-22A pre-flight, engine start, takeoff, etc… checklists, so we've just provided some basic ones to help with pre-start and engine startup. We hope to add to these in subsequent updates.

Rudder Limits and Control Sensitivity: Rudder deflection is disabled above approximately 550 knots indicated airspeed and maneuvers like the knife edge pass can be performed. However, at present there is no mechanism in the flight model to offset roll induced by rudder input, so you will find you will need to provide some aileron deflection to counter yaw induced roll especially at lower airspeeds. Yaw damping is automatic – there is no need to turn yaw damping on or off in this model.

A word of caution: full rudder deflections combined with hard roll or pitch control surface deflections, can quickly induce a spin at any altitude (at low altitudes this can be fatal to the jet and/or your simulated pilot). You can attempt to counter with some opposite rudder, or just wait for the aircraft to re-stabilize, but best to simply avoid this circumstance.

GAME SETTINGS NOTE 1: Regarding rudder input controls, if you use rudder pedals or any other rudder input controller we strongly recommend you set your rudder sensitivity curve (found in the game Controls Options menu) setting to somewhere between -50 and -60 for your rudder input control. The rudder input in the game, at default settings, is very touchy or twitchy, and reducing the sensitivity curve will provide a much more easily managed rudder input and yaw control for all aircraft.

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GAME SETTINGS NOTE 2: Do not enable (or turn off if already enabled) the Take-Off Auto-Rudder option under the Assistance menu. Enabling this function may cause oscillation around the yaw axis at airspeeds above 600 knots indicated, although we've taken steps to reduce this effect with adjustments to the flight model. Auto-rudder is also not a realistic control setting for the aircraft. If you must enable this function, make sure to disable it after takeoff (and re-enable just before your approach and landing) to avoid this problem.

Aileron / Roll Control Sensitivity: The model is highly responsive in the roll axis and some sim pilots may find the default control sensitivity "twitchy" and find fine aileron control modulation difficult when in normal flight mode. If you find this to be the case we recommend a setting of between -20% and -30% for both positive and negative deflections for Axis-X (or whatever Axis correlates to aileron input for your controller) under the Sensitivity menu for your control stick or yoke (found under the Controls Options).

Takeoff and Approach Mode: When landing gear is extended, the simulated fly by wire system switches to a takeoff and approach mode that reduces roll and pitch rates by about 35% for more deliberate and docile handling.

Takeoff, Approach, and Landing: There are no verifiable references that we've found for the F-22A's various V speeds or the procedures for these phases of flight other than statements made from EMD testing discussing target angle of attack for landing and information taken from analysis of F-22A crash investigations. Takeoff, approach, and landing is a straightforward affair, and the flight control system in this model makes it all a lot easier.

Takeoff: For fully loaded (full fuel and internal weapons storage) takeoffs, apply max military (non-afterburning) or higher thrust. Statements from Raptor pilots indicate that typical takeoffs are performed in Mil thrust; afterburner is rarely used during takeoff as a way to conserve fuel. Rotate gently at approximately 140 knots (this will come very quickly at maximum power) and pull the nose up to between 10 to 12 degrees on the pitch ladder. Do not initiate the rotation at lower speeds or you may cause a loss of lift, tail strikes, and potentially damage or destroy the aircraft (which has in fact happened in real life). Do not pull hard or jerk back on the stick as the aircraft has a very powerful pitch control response even at low speeds and you can easily over-rotate the aircraft and cause a tail strike. For reference, the maximum pitch angle allowed is 15 degrees nose up attitude when wheels are on the ground or a tail strike will occur. Fully loaded (with external fuel and stores), the aircraft should lift off at approximately 170 knots at sea level ISA conditions (higher speed for hotter temperatures and lower for colder temperatures, as with all aircraft). Immediately retract the gear as soon as you have a confirmed positive rate of climb to avoid over-speeding the landing gear; the aircraft accelerates very quickly once airborne. As the aircraft takeoff weight decreases, the aircraft will have progressively lower rotation speeds and liftoff speeds, but the same take-off methodology should be used. In most cases you will want to retard the throttles shortly after takeoff to maintain your target climb profile speed and avoid over-accelerating. Flaps are automated and will deploy as the aircraft increases speed toward rotation and takeoff speeds. Trailing edge flaps will retract automatically when the landing gear is raised. Leading edge flaps are automated and will extend based on angle of attack and speed.

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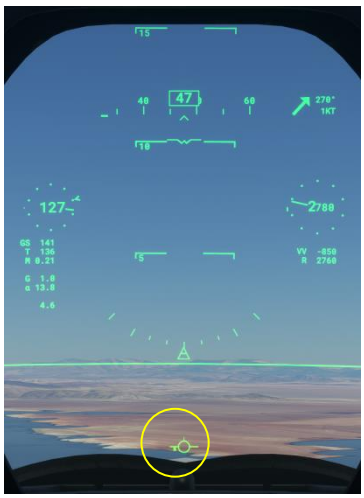
Approach and landing: We don't have much information or guidelines for initial approach and pattern speeds, but we assume these would be similar to the F-15 given the lift vs. weight ratio, general aerodynamic configuration, and twin engine configuration. Flaps are automatically deployed when landing gear is extended and will reach full deflection once you are at or near the target Angle of Attack. Final approach and landing should be done while maintaining approximately 12 degrees angle of attack (AoA) all the way to the runway (this was taken from pilot remarks in an article published during pre-production testing of the F-22A), with minimal need to execute a touchdown flare. On final, this is best accomplished in this model by keeping the nose at about 10 degrees on the pitch ladder, which will result in a descent rate of 400 and 500 feet per minute and this seems to correlate well with video footage of the F-22A on final approaches. If you use a lower angle of attack on final approach and landing, keep the pitch attitude shallower and speeds higher, but keep in mind this just wears out tires and brakes faster and will increase landing distances needed. As with any high performance high speed aircraft, ensure you have adequate time and distance to establish a stabilized approach with gear down, proper angle of attack, and stable thrust settings well before attempting to land. This is a fast, heavy airplane with a big wing, and it can be quite difficult to guide it to the touchdown markers if you are approaching too fast/slow, too high/low, or otherwise lined up incorrectly and not stabilized on approach. If you don't have it right, it's always better to execute a go around than to force a landing and cause possible damage the aircraft and/or the pilot. To help with maintaining the correct approach angle of attack, there is a small indicator line on the left side of the flight path marker that will appear when landing gear is down, that will extend above or below the horizontal cross line the marker when you are above or below the target AoA. Keep this marker on the line and you will be holding 12 degrees AoA.

AoA Too Low

AoA on Target

AoA Too High



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Adjust your thrust to keep the aircraft at the target angle of attack – don't chase the angle of attack with pitch changes – at the correct approach speed, the nose will typically be kept pitched up between 9 and 11 degrees on the climb pitch ladder to maintain the target AoA. The shallower the pitch angle maintained, the higher the speed needed to execute a landing at safe rate of descent. Approach and landing speeds will vary considerably depending on aircraft weight, air temperature, and if adjusting for gust values. At typical landing weight (post-mission with low fuel weight and minimal stores), this can usually be achieved at around 127 to 130 KCAS, but the best method is to maintain whatever combination of speed and pitch angle results in the target angle of attack for final approach and landing. So long as you maintain the correct angle of attack and a stable approach you should not have to manage the approach and landing based on any preset airspeed.

Landing and Landing Roll-out: Upon touchdown, deploy the airbrake and keep the nose up between 10 and 13 degrees on the pitch ladder to bleed off speed. Once the aircraft has decelerated to below 100 knots the nose will automatically drop toward to the runway; apply wheel brakes once the nose wheel is on the ground. Retract speed brakes once groundspeed is below 30 knots.

Cruise Profile and Range: There's no question that the Raptor is a gas guzzler. Its two engines can each consume close to 100,000 pounds of fuel per hour at maximum thrust and sea level. Without a close eye on fuel state and throttle setting, you can find yourself running low on fuel at an alarming rate, especially flying at low altitudes and high throttle settings. Even with an economical approach to throttle management, the two F119 engines consume a lot of fuel. The stated ferry range is only around 1740 nm with two external fuel tanks and a full internal fuel load (that's 26,000 pounds of JP-8) even with optimum fuel management and no unneeded stores or equipment. As with most turbine aircraft, the optimum cruise profile makes use of thin, cold air. At least for this model, best cruising altitudes are between 37,000 and 43,000 feet – starting lower when loaded with fuel and slowly climbing higher as fuel is burned off. Target cruise Mach number at these altitudes for this model is between 0.86 and 0.90 Mach, optimizing lift vs. drag. Climbing to cruise altitude burns a lot of fuel; expect to burn about 8% to 10% of a full fuel load, or about 2,500 pounds of fuel, to reach your initial cruise altitude. Best climb speed is between 300 and 350 knots until intercepting cruise Mach number (at which point, continue climbing while maintaining the cruise Mach number) and you'll want to get as quickly to high altitude as possible with that speed and without engaging afterburning thrust. Use of afterburner for any phase of flight will exact a significant range penalty. You can monitor your fuel consumption, estimated range, and endurance via the fuel submenu in the ICP.

Supercruise: Another unique capability and an interesting topic for the F-22A when it comes to aircraft range and performance is the ability to supercruise. This concept generates a lot of confusion and misguided information about the aircraft's capabilities. The F-22A was designed to accelerate to and maintain supersonic flight, at a target Mach number of 1.5, without having to use afterburning thrust, through a combination of optimized aerodynamics and high dry-thrust engines optimized for supersonic performance. This results in a far greater endurance at supersonic speeds than when using afterburner, and because the F-22A carries its offensive weapons stores internally, it is aerodynamically much more efficient than other aircraft that carry stores externally (which can limit performance to subsonic speeds,

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even with afterburning). However, just because the aircraft can cruise at supersonic speeds, doesn't mean this is as efficient as cruise flight at subsonic speeds. At optimal altitude, the aircraft still burns almost twice as much fuel per mile flown at Mach 1.6, when in supercruise, as it does at Mach 0.85. This is due to unavoidable supersonic drag penalties and engine efficiency decreases as the aircraft enters the supersonic flight regime. For this reason, even in the real world, the F-22A does not routinely "cruise" supersonically, unless training for or simulating combat profiles. Regardless, combined with stealthy design and coatings, this capability provides the F-22A with exceptional survivability due to its ability to enter and exit a highly contested battle space very quickly and with little chance of interception and improves the kinematics of its weapons. In addition to these advantages use of supercruise rather than afterburning also reduces heat signatures and the radar reflection from afterburner flame plumes which would otherwise greatly increase the chance of detection.

This model of the F-22A will supercruise, both accelerating to and maintaining supersonic speeds without afterburning thrust. The optimal altitude for maximum supercruise performance is between 30,000 and 40,000 feet where the aircraft can reach just over Mach 1.8 with Mil thrust in ISA conditions, however, engine efficiency increases with altitude, so 48,000 feet altitude or even higher will provide greater range when using the supercruise capability, at the expense of outright maximum speed. However, there is still a quite dramatic range penalty to accelerate to and maintain supersonic speeds, even without afterburner, compared to using subsonic cruise profiles, so you won't get the same kind of range performance from supercruise that you will from subsonic cruise flight. Not to mention, there aren't too many places in the real world where you are allowed to fly at supersonic speeds over populated areas.

Maneuvering Notes: The aircraft becomes G-limited by the flight control system G-limiter at around 340 KCAS (maxing out at around 9.5Gs) and rate of turn will slow as speed increases. At Max thrust, with the power and lift available in this model, at low altitude (less than 10,000 AMSL) the aircraft can accelerate, gaining airspeed, in a maximum G (9+ Gs) turn once speed is above approx. 400 KCAS. At maximum thrust and 50% internal fuel (9000 lbs or less), the aircraft can sustain a 3G+ turn at 45,000 feet while supersonic.

Camera settings for the Raptor: We recommend turning off camera shake in the Camera settings under General Options. At high angles of attack, and with the maneuvers this aircraft can perform, you won't be able to see the instrumentation or outside views as well with your "head" bobbing up and down – unless you like having that additional challenge.

A note about Frame Rate and Performance: The aircraft model handles best if you can maintain a frame rate of at least 20 frames per second. Below this and you may start to see some mild oscillation or other effects of the FBW system attempting to keep up with the processing cycles on your computer. In very dense scenery or with your graphics sliders maxed out, this will become more noticeable. The aircraft is still very fly-able, but you may see less smoothness in the performance.

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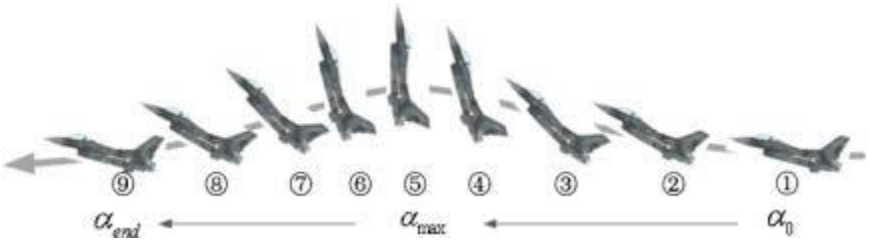
Aerobatic Flight And Maneuvering

In the real world, the F-22A is capable of performing some incredible and seemingly impossible maneuvers for an aircraft of its size and weight. This is due to the combination of aerodynamic design, fly-by-wire control system that makes hundreds of computations a second to keep the aircraft flying within the pilot's control (even while in the aircraft wing is stalled) at very high angles of attack, and thrust vectoring. This means that the aircraft systems, powerful engines, and thrust vectoring are compensating for a massive loss of lift as the aircraft enters the post-stall regime while still providing the pilot with control of the aircraft to perform maneuvers that allow the aircraft nose to be pointed at an enemy aircraft at speeds close to zero knots.

Top Mach Studios has made a substantial effort to model the aerodynamic stability and control authority to perform maneuvers in the post-stall or high alpha flight regime much like the real F-22A. While not all of the maneuvers can be performed within the exact same parameters as the real aircraft due to lack of true thrust vector simulation, most, if not all of the maneuvers you see performed by the real world F-22A at air shows can be performed within MSFS 2020. Below is an explanation of each maneuver and some general guidelines for how to perform them. To perform these maneuvers properly, you will need rudder input controls that are independent of pitch and roll controls. A set of rudder pedals would be ideal, but twist controls on joystick or separate rudder buttons on a controller should be sufficient.

Configuration: For all maneuvers described below we tested with a clean aircraft (no weapons or other store), and approx. 10,000 pounds fuel on board. A high wind component could also affect maneuver stability so caution is advised in high wind situations. You will need to make some adjustments if the aircraft is heavier (more speed, more altitude may be needed), and if aircraft is lighter you may have some more leeway with respect to speed and altitude.

Cobra:



Begin with altitude at least 500 AGL. In level flight (nose and wings level with horizon), with airspeed of approx. 250 knots and max power, make a medium to hard pull into the vertical, pushing the angle of attack approaching at or above 70 degrees. As soon as the nose is pointing at the vertical initiate a full forward stick movement to push the nose back down to level with the horizon – don't allow airspeed to bleed off too much or you will run out of available control authority to finish the pushover portion of the maneuver – the pushover maneuver should not be delayed once you have the nose in the vertical.

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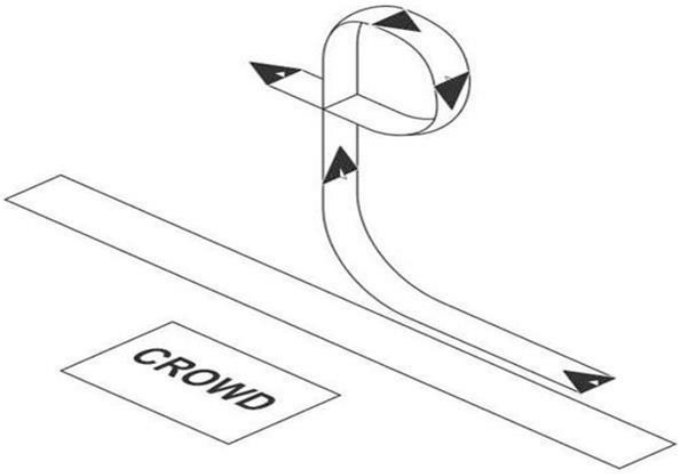
Power Loop:



Power Loop
F-22

Altitude at least 1500 AGL. Enter maneuver with nose and wings level with horizon. With airspeed of approx. 300 to 330 knots and max power, make a hard pull (stick to your lap) allowing the plane to pull all the way through the vertical, into the inverted, and back around until you are back level and upright (a vertical 360 degree loop). Maintain full stick back pressure all the way through the maneuver, releasing only when the nose reaches level with the horizon. Maintain max power to facilitate recovery from post-stall and maintain nose level with horizon.

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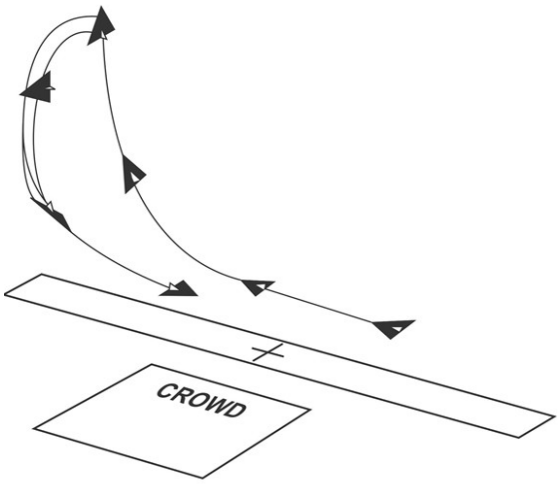
J-Turn:



J-Turn
F-22

This maneuver requires some altitude - at least 2500 AGL – to ensure room to recover. Maintain Max thrust for the duration of the maneuver. From nose and wings level with horizon, with airspeed of between 100 (can be a little less) and 180 knots, initiate a medium to hard pull into the vertical (at least 60 degrees nose up or higher). Making sure to keep the back stick pressure all the way through the maneuver to maintain high angle of attack, as the nose approaches the vertical and angle of attack exceeds 60 degrees, push rudder and aileron to full deflection in the direction of the desired yawing movement (right rudder right stick to go right, vice versa for left), again, maintaining stick back pressure for the entirety of the maneuver. For the Non-FBW, model aileron and rudder controls should be opposite one another with rudder in direction of desired spin direction and aileron opposite the desired spin. The aircraft will perform something like a hammerhead maneuver and the nose will yaw from the positive vertical to the negative vertical (and beyond if you continue to maintain control pressure). When the nose reaches the negative vertical (90 degrees down) release all stick inputs to arrest the maneuver. Allow the aircraft to build some airspeed (at least 100 knots) and begin a gentle pull to bring the nose level with the horizon taking care to keep angle of attack below 36 degrees to avoid excessive sink rate during recovery. It's best to practice from a higher altitude first to get the feel for this. In practice pilots will occasionally arrest the yaw / hammerhead movement before the nose reaches full negative pitch and will initiate a slow banking turn using pitch input to recover – allowing a safer recovery margin if altitude is too low.

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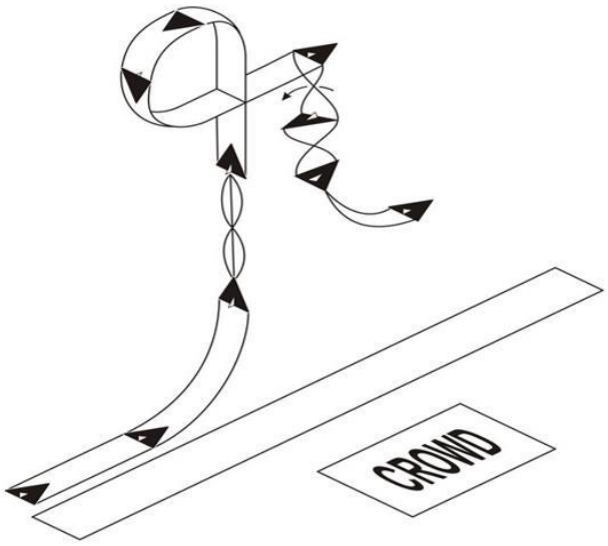
Pedal Turn:



Pedal Turn
F-22

This maneuver is similar to the J-Turn in execution but is done with the aircraft nose level with the horizon and angle of attack between 80 and 88 degrees (falling in a flat attitude almost straight down). It will look like a controlled flat spin when executed correctly. The easiest way to enter the maneuver is to climb vertically (nose at 80+ degrees vertical) with no roll or yaw input while maintaining Max thrust, targeting airspeed of approximately 250 to 300 knots. At 4000 feet AGL or higher, initiate a hard pull, bringing the aircraft around a 270 degree arc (3/4 of a high alpha loop) bringing the aircraft upright with nose level or slightly above the horizon as you begin the maneuver entry. As you reach level with the horizon, pull back the throttle from max thrust to Mil power or slightly less and continue to maintain full stick back pressure to maintain a high angle of attack. The KCAS airspeed indicator on the HUD should be close to 0 (or 0) and the angle of attack at least 80 degrees (*do not allow angle of attack to exceed 90 degrees during the maneuver*). Without delay and while maintaining full stick back pressure, enter full aileron and rudder input in the desired direction of the spin. For the Non-FBW, model aileron and rudder controls should be opposite one another with rudder in direction of desired spin direction and aileron opposite the desired spin. The aircraft will begin to spin slowly around the Z axis as long as you maintain stick back pressure and rudder and aileron input in the desired direction of spin. Continue the maneuver for a 360 degree turn. Maintain angle of attack above 80 degrees to maintain nose level or slightly below the horizon. Adding throttle will decrease angle of attack (increasing airspeed), reducing throttle will increase angle of attack (reducing airspeed). Loss of altitude is rapid and you must ensure that you begin your recovery no less than 2500’ AGL or you risk ground impact. To recover, release all stick and rudder input – to arrest unwanted spin momentum you can provide a small amount of rudder opposite the direction of spin. Increase throttle to max power and initiate recovery by gaining speed and pushing the nose down to bring angle of attack back below 36 degrees alpha.

Reverse the Pedal Turn Spin: For a bit more of a challenge, you can attempt to reverse the direction of

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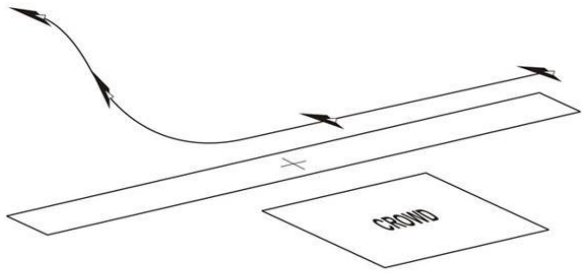
spin. To do so, maintain stick back pressure and reverse the aileron and rudder inputs while keeping airspeed close to 0 and angle of attack above 80 degrees. The nose will likely balloon a bit when this happens and you may find the nose will slice a bit through the horizon, but will eventually stabilize as long as angle of attack above 80 degrees is maintained. You'll need to start the hard pull over from the vertical to execute the maneuver at least 1000 feet higher than you would for the standard 360 degree pedal turn.

Slow Speed (High Alpha) Pass:



Slow Speed Pass
F-22

In air show demonstrations, the aircraft is brought to a low speed and around 900 feet AGL as the aircraft flies the show line (parallel to the crowd line). The aircraft is slowed, and while slowing is pitched up to approximately 35 degrees nose high and airspeed maintained at approximately 65 knots KCAS with altitude staying at 900' AGL. Thrust level will be at or near Mil power to hold this attitude. The angle of attack should be maintained at approx. 36 degrees and not allowed to increase above 40 degrees AoA to prevent unwanted sink rate or decreased above this resulting in climb away. The trick with this maneuver is to maintain consistent airspeed, angle of attack, and altitude to keep the aircraft in a stable attitude. It may be necessary to use small amounts of aileron input to keep the aircraft from yawing off from the desired attitude. To exit the maneuver, apply Max thrust until angle of attack is restored to less than 20 degrees AoA, push nose over to return to level flight and then reduce throttle avoid over-acceleration.

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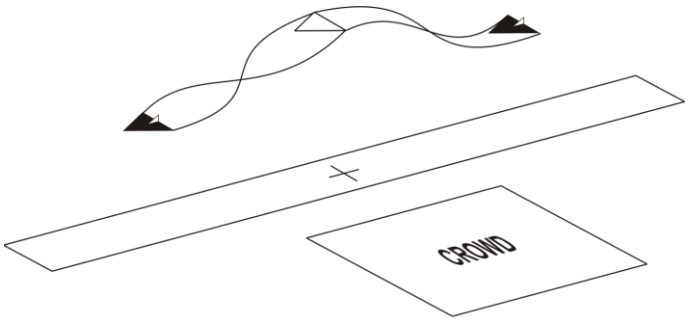
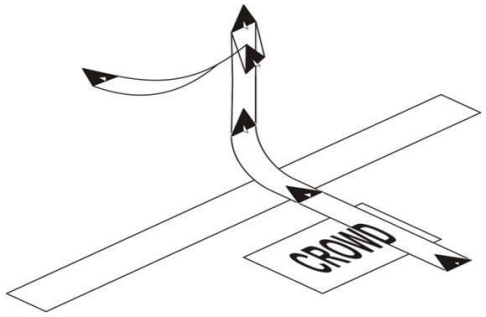
Loaded Roll:



Loaded Roll
F-22

Perform at least 1000 feet AGL. To initiate the loaded roll, bring airspeed to approx. 200 Knots KCAS and then advance throttle to Max thrust while pitching the nose up from level with horizon until angle of attack is around 30 to 35 degrees. Do not exceed this angle of attack or you will lose too much roll authority. Initiate a roll with a moderate amount of aileron input while maintaining enough stick back pressure to keep the angle of attack above 28 degrees throughout the roll (but no more than about 36 degrees). Recover after a 360 degree roll, reduce angle of attack and return the aircraft to level flight – reduce throttle to avoid over-acceleration out of the maneuver.

Tail Slide:



Tail Slide
F-22

The tail slide is the most difficult maneuver to perform correctly with the Top Mach Studios F-22A model. Begin the maneuver at no less than 1000’ AGL. Starting at straight and level at about 250 KCAS and Mil thrust. Pitch the nose up gently until nose is approximately 70 degrees nose high and reduce throttle until the aircraft begins to decelerate. Allow the aircraft to slow to the point where airspeed is 0 KCAS and the aircraft starts to sink, achieving no less than 3000’ AGL when airspeed reaches 0. While maintaining the nose high position, use throttle adjustments (you will need near Mil power) to ensure the aircraft doesn’t exceed a sink rate of approx. -5000 fpm. Use aileron to keep the nose pointed in the

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vertical. This is difficult because as the aircraft exceeds 90 degrees angle of attack it will want to slice left or right toward the horizon so you'll have to "balance" on the tail as the aircraft is sliding back toward the ground. When the aircraft reaches -5000 fpm, and/or you have lost about 300 to 400 feet of altitude from the apex of the maneuver, apply Max thrust until the aircraft achieves a positive forward velocity and then push the nose down toward the horizon and exit the maneuver.

Contact and Support Information

For support with your purchase, download, and installation, or to report issues with the model, please contact the reseller channel from which you purchased the product.

Justflight.com Purchases

For technical support (in English) please visit the support pages http://www.justflight.com/support on the Just Flight website.

As a Just Flight customer, you can get free technical support for any product purchased from Just Flight.

Top Mach Studios Online Resources:

Web Site: www.topmachstudios.com

Discord: https://discord.gg/uqpvKjZC6t

Facebook: https://www.facebook.com/TopMachStudios

Youtube: https://www.youtube.com/channel/UCla-LVq4xGHcuK6yQFCu1qw

Email non-support related inquiries to:
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