**F-22 Raptor**

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| **F-22 Raptor** |
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| F-22 Raptor |
| **Role** | [Stealth](http://en.wikipedia.org/wiki/Stealth_aircraft) [Air superiority fighter](http://en.wikipedia.org/wiki/Air_superiority_fighter) |
| **National origin** | [United States](http://en.wikipedia.org/wiki/United_States) |
| **Manufacturer** | [Lockheed Martin Aeronautics](http://en.wikipedia.org/wiki/Lockheed_Martin_Aeronautics)[Boeing Integrated Defense Systems](http://en.wikipedia.org/wiki/Boeing_Integrated_Defense_Systems) |
| **First flight** | YF-22: 29 September 1990F-22: 7 September 1997 |
| **Introduction** | 15 December 2005 |
| **Status** | In service |
| **Primary user** | [United States Air Force](http://en.wikipedia.org/wiki/United_States_Air_Force) |
| **Number built** | 141 as of May 2009 |
| **Program cost** | [US$](http://en.wikipedia.org/wiki/United_States_dollar)65 billion |
| **Unit cost** | US$137.5 million (2008 flyaway cost)  |
| **Variants** | [X-44 MANTA](http://en.wikipedia.org/wiki/X-44_MANTA)[FB-22](http://en.wikipedia.org/wiki/FB-22) |

The **Lockheed Martin/Boeing F-22 Raptor** is a [fifth-generation](http://en.wikipedia.org/wiki/Fifth_generation_jet_fighter) [fighter aircraft](http://en.wikipedia.org/wiki/Fighter_aircraft) that uses [stealth technology](http://en.wikipedia.org/wiki/Stealth_technology). It was designed primarily as an [air superiority fighter](http://en.wikipedia.org/wiki/Air_superiority_fighter), but has additional capabilities that include [ground attack](http://en.wikipedia.org/wiki/Ground_attack_aircraft), [electronic warfare](http://en.wikipedia.org/wiki/Electronic_warfare), and [signals intelligence](http://en.wikipedia.org/wiki/SIGINT) roles. [Lockheed Martin Aeronautics](http://en.wikipedia.org/wiki/Lockheed_Martin_Aeronautics) is the prime contractor and is responsible for the majority of the airframe, weapon systems and final assembly of the F-22. Program partner [Boeing Integrated Defense Systems](http://en.wikipedia.org/wiki/Boeing_Integrated_Defense_Systems) provides the wings, aft fuselage, avionics integration, and all of the pilot and maintenance training systems.

The aircraft was variously designated **F-22** and **F/A-22** during the years prior to formally entering USAF service in December 2005 as the **F-22A**. Despite a protracted and costly development period, the [United States Air Force](http://en.wikipedia.org/wiki/United_States_Air_Force) considers the F-22 a critical component for the future of US tactical airpower, and claims that the aircraft cannot be matched by any known or projected fighter, while Lockheed Martin claims that the Raptor's combination of stealth, speed, agility, precision and situational awareness combined with air-to-air and air-to-ground combat capabilities, makes it the best overall fighter in the world. Air Chief Marshal [Angus Houston](http://en.wikipedia.org/wiki/Angus_Houston), Chief of the [Australian Defense Force](http://en.wikipedia.org/wiki/Australian_Defence_Force), said in 2004 that the "F-22 will be the most outstanding fighter plane ever built." In April 2009 the [US Department of Defense](http://en.wikipedia.org/wiki/US_Department_of_Defense) proposed to cease placing new orders, subject to Congressional approval, for a final procurement tally of 187 Raptors. Congress will have to decide if more F-22 funding is added in the 2010 budget.

**Development**

In 1981 the United States Air Force (USAF) developed a requirement for a new air superiority fighter, the [Advanced Tactical Fighter](http://en.wikipedia.org/wiki/Advanced_Tactical_Fighter) (ATF), to replace the capability of the [F-15 Eagle](http://en.wikipedia.org/wiki/F-15_Eagle), primarily the F-15A, B, C and D variants. ATF was a demonstration and validation program undertaken by the USAF to develop a next-generation air superiority fighter to counter emerging worldwide threats, including development and proliferation of Soviet-era [Su-27 "Flanker"](http://en.wikipedia.org/wiki/Sukhoi_Su-27)-class fighter aircraft. It was envisaged that the ATF would incorporate emerging technologies including advanced alloys and [composite materials](http://en.wikipedia.org/wiki/Composite_material), advanced [fly-by-wire](http://en.wikipedia.org/wiki/Aircraft_flight_control_systems#Fly-by-wire) flight control systems, higher power propulsion systems, and low-observable/[stealth technology](http://en.wikipedia.org/wiki/Stealth_technology).

A [request for proposal](http://en.wikipedia.org/wiki/Request_for_proposal) (RFP) was issued in July 1986, and two contractor teams, [Lockheed](http://en.wikipedia.org/wiki/Lockheed_Corporation)/[Boeing](http://en.wikipedia.org/wiki/Boeing)/[General Dynamics](http://en.wikipedia.org/wiki/General_Dynamics) and [Northrop](http://en.wikipedia.org/wiki/Northrop)/[McDonnell Douglas](http://en.wikipedia.org/wiki/McDonnell_Douglas) were selected in October 1986 to undertake a 50-month demonstration/validation phase, culminating in the flight test of two prototypes, the YF-22 and the [YF-23](http://en.wikipedia.org/wiki/Northrop_YF-23), respectively.

On 23 April 1991 the USAF ended the design and test flight competition by announcing Lockheed's YF-22 as the winner. It was anticipated at the time that 650 aircraft would be ordered.

**Into production**

The first operational F-22 Raptor is painted at the Lockheed Martin assembly plant at Marietta, Georgia

The YF-22 was modified for the production F-22. The [differences](http://en.wikipedia.org/wiki/F-22_Raptor#Airframe#Airframe) between the YF-22 and the F-22 include relocation of cockpit, structural changes, and many other smaller changes.

The first production F-22 was delivered to [Nellis Air Force Base](http://en.wikipedia.org/wiki/Nellis_Air_Force_Base), [Nevada](http://en.wikipedia.org/wiki/Nevada), on 14 January 2003 and "Dedicated Initial Operational Test and Evaluation" commenced on 27 October 2003. By 2004, 51 Raptors had been delivered.

In 2006, the Raptor's development team, composed of [Lockheed Martin](http://en.wikipedia.org/wiki/Lockheed_Martin) and over 1,000 other companies, plus the [United States Air Force](http://en.wikipedia.org/wiki/United_States_Air_Force), won the [Collier Trophy](http://en.wikipedia.org/wiki/Collier_Trophy), American aviation's most prestigious award. The U.S. Air Force will acquire F-22s that are to be divided among seven active duty combat squadrons, and jointly flown and maintained by three integrated [Air Force Reserve Command](http://en.wikipedia.org/wiki/Air_Force_Reserve_Command) and [Air National Guard](http://en.wikipedia.org/wiki/Air_National_Guard) fighter squadrons.

In August 2007, the United States Air Force signed a $5 billion, multi-year contract with Lockheed Martin that will extend production to 2011, and as of 2008, F-22 Raptors are being procured at the rate of 20 per year.

In a ceremony on 29 August 2007, Lockheed Martin reached its "100th F-22 Raptor" milestone, delivering AF Serial No. 05-4100.

**Procurement**

Two F-22s during flight testing, the upper one being the first EMD F-22, "Raptor 01".

The United States Air Force originally planned to order 750 ATFs, with production beginning in 1994; however, the 1990 Major Aircraft Review altered the plan to 648 aircraft beginning in 1996. The goal changed again in 1994, when it became 442 aircraft entering service in 2003 or 2004, but a 1997 [Department of Defense](http://en.wikipedia.org/wiki/United_States_Department_of_Defense) report put the purchase at 339. In 2003, the Air Force said that the existing congressional cost cap limited the purchase to 277. By 2006, the Pentagon said it will buy 183 aircraft, which would save $15 billion but raise the cost of each aircraft, and this plan has been *de facto* approved by Congress in the form of a multi-year procurement plan, which still holds open the possibility for new orders past that point. The total cost of the program by 2006 was $62 billion.

In April 2006, the cost of the F-22 was assessed by the Government Accountability Office to be $361 million per aircraft. This cost reflects the F-22 total program cost, divided by the number of fighters the Air Force is programmed to buy; and which has so far invested $28 billion in the Raptor's research, development and testing. That money, referred to as a "[sunk cost](http://en.wikipedia.org/wiki/Sunk_cost)", is already spent and is separate from money used for future decision-making, including procuring a copy of the jet. The Unit Procurement Cost was estimated at $177.6 million in 2006 based on a production run of 181 airframes. This unit cost will decrease if total production is higher. This cost includes $3.233 billion already spent on research and development by 2006.

By the time all 183 fighters have been purchased, $34 billion will have been spent on actual procurement, resulting in a total program cost of $62 billion or about $339 million per aircraft. The [incremental cost](http://en.wikipedia.org/wiki/Marginal_cost) for one additional F-22 is around $138 million; decreasing with larger volumes.

F-22 Raptors line up for refueling in their first official deployment, October 2005.

On 31 July 2007, Lockheed Martin received a multiyear contract for 60 F-22s worth a total of US$7.3 billion. The contract brought the number of F-22s on order to 183 and extended production through 2011. Restarting production would greatly increase costs; building 75 more would cost an estimated $70 million extra per unit.

**Ban on exports**

The opportunity for export is currently non-existent because the export sale of the F-22 is barred by American federal law. Most current customers for U.S. fighters are either acquiring earlier designs like the F-15 or F-16, or else are waiting to acquire the [F-35 Lightning II](http://en.wikipedia.org/wiki/F-35_Lightning_II) (the Joint Strike Fighter), which contains technology from the F-22 but is designed to be cheaper, more flexible, and available for export from the start. The F-35 will not be as nimble as the F-22 or fly as high or as fast, but its radar and avionics will be more advanced.

The Japanese government reportedly showed interest in buying F-22s in its Replacement-Fighter program for the [Japan Air Self-Defense Force](http://en.wikipedia.org/wiki/Japan_Air_Self-Defense_Force) (JASDF). If it were to occur, it would most likely involve a "watered-down" export variant while still retaining most of its advanced [avionics](http://en.wikipedia.org/wiki/Avionics) and [stealth](http://en.wikipedia.org/wiki/Stealth_technology) characteristics. However, such a proposal would still need approval from the Pentagon, State Department and Congress. In addition the high per aircraft costs and the very high operating expenses would require a lifting of the popular 1 percent of GDP military budget ceiling in Japan. On 9 June 2009, Japanese Defense Minister [Yasukazu Hamada](http://en.wikipedia.org/wiki/Yasukazu_Hamada) said that Japan still seeks the F-22.

[Israeli Air Force](http://en.wikipedia.org/wiki/Israeli_Air_Force) (IAF) chief procurement officer Brigadier-General Ze'ev Snir said that, "The IAF would be happy to equip itself with 24 F-22s, but the problem at this time is the US refusal to sell the aircraft, and its $200 million price tag."

Some Australian politicians and defense commentators have proposed that Australia purchase F-22s instead of the F-35. In 2006, the [Australian Labor Party](http://en.wikipedia.org/wiki/Australian_Labor_Party) supported this proposal on the grounds that the F-22 is a proven, highly capable aircraft, while the F-35 is still under development. However, the [Howard government](http://en.wikipedia.org/wiki/John_Howard) ruled out purchase of the F-22, on the grounds that it is unlikely to be released for export, and does not have sufficient ground/[maritime](http://en.wikipedia.org/wiki/Maritime) strike capacity.

The US Congress upheld the ban on F-22 Raptor foreign sales during a joint conference on 27 September 2006. After talks in Washington in December 2006, the [US DoD](http://en.wikipedia.org/wiki/United_States_Department_of_Defense) reported the F-22 would not be available for foreign sale.

In 2007, the Australian government ordered a review of plans to procure the F-35 and [F/A-18E/F Super Hornet](http://en.wikipedia.org/wiki/F/A-18E/F_Super_Hornet). This review will include an evaluation of the F-22's suitability for Australia; moreover, then Defense Minister [Joel Fitzgibbon](http://en.wikipedia.org/wiki/Joel_Fitzgibbon) stated: "I intend to pursue American politicians for access to the Raptor". In February 2008, U.S. Defense Secretary [Robert Gates](http://en.wikipedia.org/wiki/Robert_Gates) said he had no objection to sale of the Raptor to Australia, but Congress would have to change the law.

**Further procurement and proposed end of production**

Two F-22A Raptors in close trail formation

During the two-month grounding of nearly 700 older F-15s in November and December 2007, some US Senators demanded that Deputy Secretary of Defense [Gordon England](http://en.wikipedia.org/wiki/Gordon_England) release three government reports that support additional F-22 Raptors beyond the planned 183 jets. The USAF has requested that the F-22 remain in production after the 183 planned fighters. This was believed at the time to have been a response to the grounding of F-15A-D fighters.

In January 2008, the Pentagon announced that it would ask Congress for funds to buy additional F-22s to replace other aircraft lost in combat, and proposed that $497 million that would have been used to shut down the F-22 line instead be used to buy four more F-22s, keeping open the production line beyond 2011 and providing the next Presidential administration the option to buy even more F-22s. The funds earmarked for the line shutdown, however, were directed by Pentagon Comptroller Tina W. Jonas on 17 December 2007, to be used to fund repairs to the [F-15](http://en.wikipedia.org/wiki/F-15) fleet caused by the worldwide grounding of that aircraft in November 2007. This diversion had the same effect of postponing the decision to shut down the F-22 production line until at least 2009.

An F-22 executes a transonic flyby over the aircraft carrier [USS *Stennis*](http://en.wikipedia.org/wiki/USS_John_C._Stennis_%28CVN-74%29)

On 24 September 2008, US Congress passed a defense spending bill with funding for F-22 long lead items for future production.

On 12 November 2008, the Pentagon released $50 million of the $140 million approved by Congress to buy parts for an additional four aircraft, thus leaving the Raptor program in the hands of the incoming Obama Administration. Additional funds to complete the four aircraft were provided in a war supplemental bill, for a total of 187 F-22s procured.

On 6 April 2009, as part of the 2010 Pentagon budget announcement, Secretary of Defense Gates called for production of the F-22 to be phased out by fiscal year 2011, leaving the USAF with 187 fighters. F-35 acquisition would be accelerated.

On 17 June 2009 the House Armed Services Committee inserted $368.8 million in the budget markup as a down payment for a further 12 F-22s in FY 2011.

On 21 July 2009, the [United States Senate](http://en.wikipedia.org/wiki/United_States_Senate) voted in favor of ending F-22 production. The House had budgeted for an additional 12 aircraft. The two versions of the 2010 budget must now be resolved in conference before facing President Obama who has threatened to veto any additional aircraft.

**Upgrades**

On 5 January 2001, Raptor 4005 flew with the Block 3.0 software, which was the first combat-capable avionics version.

In June 2009, Increment 3.1 was tested at Edwards Air Force Base. This provided the F-22 a basic ground attack capability through Synthetic Aperture Radar mapping, Electronic Attack and the GBU-39 Small Diameter Bomb. The F-22 Raptor Increment 3.1 Modification Team with the 412th Test Wing received the Chief of Staff Team Excellence Award for upgrading 149 Raptors.

The next step will be Increment 3.2 with an advanced SDB capability and the ability to use the [AIM-9X Sidewinder](http://en.wikipedia.org/wiki/AIM-9X_Sidewinder#AIM-9X) and [AIM-120D AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM) missiles. However, the F-22 will still lack a [helmet mounted cueing system](http://en.wikipedia.org/wiki/Helmet_mounted_display) and associated sensors to allow the aircraft to take advantage of the AIM-9X's high off-boresight capability. *Defense Daily* reported that the [Joint Helmet Mounted Cueing System](http://en.wikipedia.org/wiki/Joint_Helmet_Mounted_Cueing_System) was deferred on the F-22 because of maintenance overhead. If this system is later implemented it will use the AIM-9X's own seeker as the off-boresight sensor to find targets.

Upgrading the first 183 jets to the 3.2 upgrade is estimated to cost $8 billion. In May 2009, Gen. Norton A. Schwartz and Air Force Secretary Michael B. Donley gave testimony to Congress that this would be paid for through the early retirement of legacy fighters. Increment 3.2 is expected to be fielded in FY15 and it will also include the [Multifunction Advanced Data Link](http://en.wikipedia.org/wiki/Multifunction_Advanced_Data_Link) that will tie together future U.S. penetration forces of stealth aircraft and unmanned platforms.

In July 2009 the USAF announced that three business jets had been deployed with the interim [Battlefield Airborne Communications Node](http://en.wikipedia.org/wiki/Battlefield_Airborne_Communications_Node) (BACN) to allow communication between F-22s and other platforms, until MADL is installed.

"The current F-22A modernization plan will result in 34 Block 20 aircraft used for test and training, 63 combat-coded Block 30s fielded with Increment 3.1, 83 combat-coded Block 35s fielded with Increment 3.2, and 3 Edwards AFB-test coded aircraft. Consideration is also being given to upgrade the 63 Block 30s to the most capable Block 35 configuration."

**Design**

**Characteristics**

F-22 Raptor displaying its [F119-PW-100](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F119) engines on full afterburner during flight testing.

The F-22 is a [fifth generation](http://en.wikipedia.org/wiki/Fifth_generation_jet_fighter) fighter that is considered a fourth-generation [stealth aircraft](http://en.wikipedia.org/wiki/Stealth_aircraft) by the USAF. Its dual [afterburning](http://en.wikipedia.org/wiki/Afterburner) [Pratt & Whitney F119-PW-100](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F119) [turbofans](http://en.wikipedia.org/wiki/Turbofan) incorporate [pitch axis](http://en.wikipedia.org/wiki/Flight_dynamics) [thrust vectoring](http://en.wikipedia.org/wiki/Thrust_vectoring), with a range of ±20 degrees. The maximum thrust is [classified](http://en.wikipedia.org/wiki/Classified_information_in_the_United_States), though most sources place it at about 35,000 [lbf](http://en.wikipedia.org/wiki/Pound-force) (156 kN) per engine. Maximum speed, without external weapons, is estimated to be [Mach](http://en.wikipedia.org/wiki/Mach_%28speed%29) 1.82 in [super cruise](http://en.wikipedia.org/wiki/Supercruise) mode; as demonstrated by [General John P. Jumper](http://en.wikipedia.org/wiki/John_P._Jumper), former US Air Force Chief of Staff, when his Raptor exceeded Mach 1.7 without afterburners on 13 January 2005. With afterburners, it is "greater than Mach 2.0" (1,317 mph, 2,120 km/h), according to Lockheed Martin; however, the Raptor can easily exceed its design speed limits, particularly at low altitudes, with max-speed alerts to help prevent the pilot from exceeding them. Former Lockheed F-22 chief test pilot Paul Metz stated that the Raptor has a fixed inlet; but while the absence of variable intake ramps may theoretically make speeds greater than Mach 2.0 unreachable, there is no evidence to prove this. Such ramps would be used to prevent engine surge resulting in a [compressor stall](http://en.wikipedia.org/wiki/Compressor_stall), but the intake itself may be designed to prevent this. Metz has also stated that the F-22 has a top speed greater than 1,600 mph (Mach 2.42) and its climb rate is faster than the [F-15 Eagle](http://en.wikipedia.org/wiki/F-15_Eagle) due to advances in engine technology, despite the F-15's thrust-to-weight ratio of about 1.2:1, with the F-22 having a ratio closer to 1:1. The US Air Force claims that the Raptor cannot be matched by any known or projected fighter, and Lockheed Martin claims that, "the F-22 is the only aircraft that blends super cruise speed, super-agility, stealth and sensor fusion into a single air dominance platform."

A [KC-10 Extender](http://en.wikipedia.org/wiki/KC-10_Extender) (top) [refuels](http://en.wikipedia.org/wiki/Aerial_refueling) an F-22 Raptor.

The true top-speed of the F-22 is unknown to the general public. The ability of the airframe to withstand the stress and heat is a further key factor, especially in an aircraft using as many [polymers](http://en.wikipedia.org/wiki/Polymers) as the F-22. However, while some aircraft are faster on paper, the internal carriage of its standard combat load allows the aircraft to reach comparatively higher performance with a heavy load over other modern aircraft due to its lack of drag from external stores. It is one of only a handful of aircraft that can sustain [supersonic](http://en.wikipedia.org/wiki/Supersonic) flight without the use of afterburner augmented thrust (and its associated high fuel usage). This ability is now termed [super cruise](http://en.wikipedia.org/wiki/Supercruise). This allows the aircraft to hit time critical, fleeting or mobile targets that a subsonic aircraft would not have the speed to reach and an afterburner dependent aircraft would not have the fuel to reach.

The F-22 is highly maneuverable, at both supersonic and [subsonic](http://en.wikipedia.org/wiki/Speed_of_sound) speeds. It is extremely [departure-resistant](http://en.wikipedia.org/wiki/Departure_resistance), enabling it to remain controllable at extreme pilot inputs. The Raptor's thrust vectoring nozzles allow the aircraft to turn tightly, and perform extremely high alpha ([angle of attack](http://en.wikipedia.org/wiki/Angle_of_attack)) maneuvers such as the [Herbst maneuver](http://en.wikipedia.org/wiki/Herbst_maneuver) (or J-turn), [Pugachev's Cobra](http://en.wikipedia.org/wiki/Pugachev%27s_Cobra), and the [Kulbit](http://en.wikipedia.org/wiki/Kulbit), though the J-Turn is more useful in combat. The F-22 is also capable of maintaining a constant angle of attack of over 60°, yet still having some control of roll. During June 2006 exercises in [Alaska](http://en.wikipedia.org/wiki/Alaska), F-22 pilots demonstrated that cruise altitude has a significant effect on combat performance, and routinely attributed their altitude advantage as a major factor in achieving an unblemished kill ratio against other US fighters and 4th/4.5th generation fighters.

**Avionics**

The F-22's avionics include [BAE Systems E&IS](http://en.wikipedia.org/wiki/BAE_Systems_Electronics_and_Integrated_Solutions) [radar warning receiver](http://en.wikipedia.org/wiki/Radar_warning_receiver) (RWR) AN/ALR-94, AN/AAR 56 Infra-Red and Ultra-Violet MAWS (Missile Approach Warning System) and the [Northrop Grumman](http://en.wikipedia.org/wiki/Northrop_Grumman) [AN/APG-77](http://en.wikipedia.org/wiki/AN/APG-77) [Active Electronically Scanned Array](http://en.wikipedia.org/wiki/Active_Electronically_Scanned_Array) (AESA) radar. The AN/APG-77 has both long-range target acquisition and [low probability of interception](http://en.wikipedia.org/wiki/Low_Probability_of_Intercept) of its own signals by enemy aircraft.

The AN/ALR-94 is a passive receiver system capable of detecting the radar signals in the environment. Composed of more than 30 antennas smoothly blended into the wings and fuselage that provide all around coverage plus azimuth and elevation information in the forward sector, it is described by Tom Burbage, the former head of the F-22 program at Lockheed Martin, as "the most technically complex piece of equipment on the aircraft." With greater range (250+ [nmi](http://en.wikipedia.org/wiki/Nautical_mile)) than the radar, it enables the F-22 to limit its own radar emission which might otherwise compromise its stealth. As the target approaches, AN/ALR-94 can cue the AN/APG-77 radar to keep track of its motion with a narrow beam, which can be as focused as 2**°** by 2**°** in azimuth and elevation.

The AN/APG-77 AESA radar, designed for air-superiority and strike operations, features a low-observable, active-aperture, electronically-scanned array that can track multiple targets in all kinds of weather. The AN/APG-77 changes frequencies more than 1,000 times per second to reduce the chance of being intercepted. The radar can also focus its emissions to overload enemy sensors, giving the aircraft an electronic-attack capability.

The AN/APG-77 AESA radar

The radar's information is processed by two [Raytheon](http://en.wikipedia.org/wiki/Raytheon) Common Integrated Processor (CIP)s. Each CIP operates at 10.5 billion [instructions per second](http://en.wikipedia.org/wiki/Instructions_per_second) and has 300 [megabytes](http://en.wikipedia.org/wiki/Megabyte) of memory. Information can be gathered from the radar and other onboard and offboard systems, filtered by the CIP, and offered in easy-to-digest ways on several cockpit displays, enabling the pilot to remain on top of complicated situations. The Raptor’s software is composed of over 1.7 million [lines of code](http://en.wikipedia.org/wiki/Source_lines_of_code), most of which concerns processing data from the radar. The radar has an estimated range of 125-150 miles, though planned upgrades will allow a range of 250 miles (400 km) or more in narrow beams. In 2007, tests carried out by Northrop Grumman, Lockheed Martin, and [L-3 Communications](http://en.wikipedia.org/wiki/L-3_Communications) enabled the [AESA](http://en.wikipedia.org/wiki/Active_Electronically_Scanned_Array) system of a Raptor to act like a [WiFi](http://en.wikipedia.org/wiki/Wi-Fi) access point, able to transmit data at 548 [Megabit](http://en.wikipedia.org/wiki/Megabit)/sec and receive at [Gigabit](http://en.wikipedia.org/wiki/Gigabit) speed; far faster than the current [Link 16](http://en.wikipedia.org/wiki/Link_16) system used by US and allied aircraft, which transfers data at just over 1 Megabit/sec.

The F-22 has several unique functions for an aircraft of its size and role. For instance, it has threat detection and identification capability along the lines of that available on the [RC-135 Rivet Joint](http://en.wikipedia.org/wiki/Boeing_RC-135#RC-135V.2FW_Rivet_Joint). While the F-22's equipment isn't as powerful or sophisticated, because of its stealth, it can be typically hundreds of miles closer to the battlefield, which often compensates for the reduced capability.

The F-22 is capable of functioning as a "mini-[AWACS](http://en.wikipedia.org/wiki/Airborne_Warning_and_Control_System)." Though reduced in capability compared to dedicated airframes such as the [E-3 Sentry](http://en.wikipedia.org/wiki/E-3_Sentry), as with its threat identification capability, the F-22's forward presence is often of benefit. The system allows the F-22 to designate targets for cooperating F-15s and F-16s, and even determine if two friendly aircraft are targeting the same enemy aircraft, thus enabling one of them to choose a different target. It is often able to identify targets "sometimes many times quicker than the AWACS."

The F-22's [low probability of intercept](http://en.wikipedia.org/wiki/Low_probability_of_intercept) radar is being given a high-bandwidth data transmission capability, to allow it to be used in a "broadband" role to permit high-speed relaying of data between friendly transmitters and receivers in the area. The F-22 can already pass data to other F-22s, resulting in considerably reduced radio "chatter".

The [IEEE-1394B](http://en.wikipedia.org/wiki/FireWire) data bus, developed for the F-22, was derived from the commercial IEEE-1394 "FireWire" bus system, often used on personal computers. The same data bus is employed by the subsequent [F-35 Lightning II](http://en.wikipedia.org/wiki/F-35_Lightning_II) fighter.

**Cockpit**

Cockpit of the F-22, showing instruments and heads up display.

The [F-22 cockpit](http://en.wikipedia.org/wiki/F-22_cockpit) is a [glass cockpit](http://en.wikipedia.org/wiki/Glass_cockpit) design without any traditional analog flight instruments and represents a marked improvement on the cockpit design of previous advanced aircraft. The leading features of the F-22 cockpit include simple and rapid start-up, highly developed [HMI](http://en.wikipedia.org/wiki/Human-Machine_Interface), light helmet, large [anthropometric](http://en.wikipedia.org/wiki/Anthropometry) accommodation and highly integrated warning system. Other main features include the large single-piece canopy, side stick and improved life support systems.

All internal displays are designed to be used with night vision goggles because the aircraft lacks optical or IR vision devices.

**Airframe**

The YF-22A prototype and production F-22A are sometimes confused in pictures, often at angles where it is difficult to see certain features. Several small design changes were made from the YF-22 to the F-22A. The swept-back angle on the wing's leading edge was decreased from 48 degrees to 42 degrees, while the vertical stabilizer area was decreased 20%. To improve pilot visibility, the canopy was moved forward 7 inches (178 mm) and the engine intakes were moved rearward 14 inches (356 mm). The shape of the wing and [stabilator](http://en.wikipedia.org/wiki/Stabilator) trailing edges was refined to improve aerodynamics, strength, and stealth characteristics. Also, the vertical stabilizer was shifted rearward. The airframe also features three internal weapons bays on the bottom and sides of the fuselage.

**Armament**

An F-22 fires an [AIM-120 AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM).

The Raptor has internal weapons bays that can carry a maximum of six missiles or four bombs in the center bay, and one missile in each side bay. Carrying missiles and bombs internally maintains its [stealth](http://en.wikipedia.org/wiki/Stealth) capability and maintains lower drag resulting in higher top speeds and longer combat ranges. Launching missiles requires opening the weapons bay doors for less than a second, while the missiles are pushed clear of the airframe by hydraulic arms. This reduces the Raptor's chance of detection by enemy radar systems due to launched ordnance. The aircraft can also carry such air-to-surface weapons as bombs with the [Joint Direct Attack Munition](http://en.wikipedia.org/wiki/Joint_Direct_Attack_Munition) (JDAM) guidance system, and the new [Small-Diameter Bomb](http://en.wikipedia.org/wiki/Small-Diameter_Bomb) (SDB), but not laser designated weapons as it lacks the F-35's stealthy designator. The Raptor carries an [M61A2 Vulcan](http://en.wikipedia.org/wiki/M61_Vulcan) 20 mm [rotary cannon](http://en.wikipedia.org/wiki/Gatling_gun), also with a trap door, in the right wing root. The M61A2 is a last ditch weapon, and carries 480 rounds; enough ammunition for approximately five seconds of sustained fire. The opening for the cannon's firing barrel is covered by a door when not in use to maintain stealth. The F-22 has been able to close to gun range in training dogfights without being detected, which can be necessary when missiles are depleted.

The Raptor's very high sustained cruise speed and operational altitude add significantly to the effective range of both air-to-air and air-to-surface munitions. These factors may be the rationale behind the USAF's decision not to pursue long-range, high-energy air-to-air missiles such as the [MBDA Meteor](http://en.wikipedia.org/wiki/MBDA_Meteor). However, the USAF plans to procure the [AIM-120D AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM), which is reported to have a 50% increase in range compared to the AIM-120C. The Raptor launch platform provides additional energy to the missile which helps improve the range of air-to-ground ordnance. While specific figures remain classified, it is expected that JDAMs employed by F-22s will have twice or more the effective range of munitions dropped by legacy platforms. In testing, a Raptor dropped a 1,000 lb (450 kg) JDAM from 50,000 feet (15,000 m), while cruising at Mach 1.5, striking a moving target 24 miles (39 km) away. The SDB, as employed from the F-22, should see even greater increases in effective range, due to the improved lift to drag ratio of these weapons. The AIM-120 is the primary missile and the AIM-9 Sidewinder is the short-range missile.

An F-22 releases a [JDAM](http://en.wikipedia.org/wiki/Joint_Direct_Attack_Munition) from its center internal bay while flying at supersonic speed.

While in its air-superiority configuration the F-22 carries its weapons internally, it is not limited to this option. The wings include four [hardpoints](http://en.wikipedia.org/wiki/Hardpoint), each rated to handle 5,000 lb (2,300 kg). Each hardpoint has a pylon that can carry a detachable 600 gallon fuel tank or a rail launcher that holds two air-air missiles. However, use of external stores compromises the F-22's stealth, and has a detrimental effect on maneuverability, speed, and range (unless external fuel is carried). The two inner hardpoints are "plumbed" for external fuel tanks. These hardpoints allow the mounting pylons to be jettisoned in flight so the fighter can regain its stealth after exhausting external stores. Research is currently being conducted to develop stealth ordnance pod and pylon. Such a pod would comprise a low observable shape and carry its weapons internally, then would open when launching a missile or dropping a bomb. The pod and pylon could be detached when no longer needed. This system would allow the F-22 to carry its maximum ordnance load while remaining stealthy with a loss of maneuverability.

**Stealth**

To maintain stealth, the F-22 carries its weapons in internal bays, here shown open.

Although several recent Western fighter aircraft are less detectable on radar than previous designs using techniques such as [radar absorbent material](http://en.wikipedia.org/wiki/Radar_absorbent_material)-coated S-shaped intake ducts that shield the compressor fan from reflecting radar waves, the F-22 design placed a much higher degree of importance on low observance throughout the entire spectrum of sensors including radar signature, visual, infrared, acoustic, and radio frequency.

The [stealth](http://en.wikipedia.org/wiki/Stealth_technology) of the F-22 is due to a combination of factors, including the overall shape of the aircraft, the use of radar absorbent material (RAM), and attention to detail such as hinges and pilot helmets that could provide a radar return. However, reduced radar cross section is only one of five facets that designers addressed to create a stealth design in the F-22. The F-22 has also been designed to disguise its infrared emissions to make it harder to detect by [infrared homing](http://en.wikipedia.org/wiki/Infrared_homing) ("heat seeking") [surface-to-air](http://en.wikipedia.org/wiki/Surface-to-air_missile) or [air-to-air missiles](http://en.wikipedia.org/wiki/Air-to-air_missiles). Designers also made the aircraft less visible to the naked eye, and controlled radio and noise emissions. The Raptor has an under bay carrier made for hiding heat from missile threats, like surface-to-air missiles.

The F-22 apparently relies less on maintenance-intensive radar absorbent material and coatings than previous stealth designs like the [F-117](http://en.wikipedia.org/wiki/F-117_Nighthawk). These materials caused deployment problems due to their susceptibility to adverse weather conditions. Unlike the [B-2](http://en.wikipedia.org/wiki/B-2_Spirit), which requires climate-controlled hangars, the F-22 can undergo repairs on the flight line or in a normal hangar. Furthermore, the F-22 has a warning system (called "Signature Assessment System" or "SAS") which presents warning indicators when routine wear-and-tear have degraded the aircraft's radar signature to the point of requiring more substantial repairs. The exact [radar cross section](http://en.wikipedia.org/wiki/Radar_cross_section) of the F-22 remains classified. In early 2009 Lockheed Martin released information on the F-22, showing it to have a radar cross section from certain critical angles of -40 [dBsm](http://en.wikipedia.org/wiki/Decibel#Radar) — the equivalent radar reflection of a "steel marble". However, the stealth features of the F-22 require additional maintenance work that decreases their mission capability rate to approximately 62-70%.

The effectiveness of this emphasis on stealth characteristics during the F-22 design process is difficult to measure. While its radar cross-section is almost nonexistent, this is merely a static measurement of the aircraft's frontal or side area and is valid only for a radar source in a stationary location relative to the aircraft. As soon as the F-22 maneuvers, it exposes a different set of angles and a greater surface area to any radar, increasing its visibility. Furthermore, the use of stealth contouring and radar absorbent material are chiefly effective against [high-frequency radars](http://en.wikipedia.org/w/index.php?title=High-frequency_radar&action=edit&redlink=1), the type usually found on other aircraft. [Low-frequency radars](http://en.wikipedia.org/wiki/Low-frequency_radar), including weather radars and warning stations in areas of the former Soviet Union, are less affected by stealth characteristics and are more capable of detecting some of the aircraft employing them.

**External lighting**

The aircraft has integral position and anti-collision lighting (including strobes) on the wings, compatible with stealth requirements, supplied by [Goodrich Corporation](http://en.wikipedia.org/wiki/Goodrich_Corporation). The low voltage electroluminescent formation lights are located on the aircraft at critical positions for night flight operations (on both sides of the forward fuselage under the chin, on the tip of the upper left and right wings, and on the outside of both vertical stabilizers). There are similar air refueling lights on the butterfly doors that cover the air refueling receptacle.

**Operational history**

The [27th Fighter Squadron](http://en.wikipedia.org/wiki/27th_Fighter_Squadron) at [Langley Air Force Base](http://en.wikipedia.org/wiki/Langley_Air_Force_Base) was the first squadron to receive the F-22.

The prototype YF-22 won a fly-off competition against the Northrop/[McDonnell-Douglas](http://en.wikipedia.org/wiki/McDonnell-Douglas) [YF-23](http://en.wikipedia.org/wiki/Northrop_YF-23) for the Advanced Tactical Fighter contract.

**Designation and name changes**

The YF-22 was originally given the unofficial name *"Lightning II"*, after the [World War II](http://en.wikipedia.org/wiki/World_War_II) fighter [P-38](http://en.wikipedia.org/wiki/P-38), by Lockheed, which persisted until the mid-1990s when the USAF officially named the aircraft "Raptor". For a short while, the aircraft was also dubbed "SuperStar" and "Rapier". The F-35 later received the *Lightning II* name on 7 July 2006. The production model was formally named F-22 "Raptor" when the first production-representative aircraft was unveiled on 9 April 1997 at Lockheed Georgia Co., [Marietta](http://en.wikipedia.org/wiki/Marietta%2C_Georgia), [Georgia](http://en.wikipedia.org/wiki/Georgia_%28U.S._state%29). The first flight occurred on 7 September 1997.

In September 2002, Air Force leaders changed the Raptor’s designation to F/A-22. The new designation, which mimicked that of the Navy’s [F/A-18 Hornet](http://en.wikipedia.org/wiki/F/A-18_Hornet), was intended to highlight plans to give the Raptor a ground-attack capability amid intense debate over the relevance of the expensive air-superiority jet. This was later changed back to simply F-22 on 12 December 2005. On 15 December 2005, the F-22A entered service.

**Testing**

An F-22 refuels from a [KC-135](http://en.wikipedia.org/wiki/KC-135_Stratotanker) during testing; the attachment on the back top is for a spin recovery chute.

Flight testing of the F-22 began in 1997. Raptor 4001 was retired and sent to [Wright-Patterson AFB](http://en.wikipedia.org/wiki/Wright-Patterson_Air_Force_Base) to be fired at for testing the fighter's survivability. Usable parts of 4001 would be used to make a new F-22. Another engineering and manufacturing development (EMD) F-22 was also retired and likely to be sent to be rebuilt. A testing aircraft was converted to a maintenance trainer at [Tyndall AFB](http://en.wikipedia.org/wiki/Tyndall_Air_Force_Base).

On 3 May 2006, a report was released detailing a problem with a forward titanium boom on the aircraft that was not properly heat treated. Officials are still investigating the problem which was caused by the boom portion not being subjected to high temperatures in the factory for long enough, causing the boom to be less [ductile](http://en.wikipedia.org/wiki/Ductile) than specified and potentially shortening the lives of the first 80 or so F-22s. Work is underway to restore them to full life expectancy. In April 2006, the F-22 fleet underwent modifications at [Hill AFB](http://en.wikipedia.org/wiki/Hill_Air_Force_Base), and at [Edwards AFB](http://en.wikipedia.org/wiki/Edwards_Air_Force_Base) near [Palmdale, California](http://en.wikipedia.org/wiki/Palmdale%2C_California).

**Service history**

An F-22 near [Langley AFB](http://en.wikipedia.org/wiki/Langley_AFB), [Virginia](http://en.wikipedia.org/wiki/Virginia) in 2005

On 15 December 2005 the USAF announced that the Raptor had reached its Initial Operational Capability (IOC).

During Exercise [Northern Edge](http://en.wikipedia.org/wiki/Northern_Edge) in Alaska in June 2006, 12 F-22s of the 94th FS downed 108 adversaries with no losses in simulated combat exercises. In two weeks of exercises, the Raptor-led Blue Force amassed 241 kills against two losses in air-to-air combat, and neither Blue Force loss was an F-22.

An F-22 observes as an [F-15 Eagle](http://en.wikipedia.org/wiki/F-15_Eagle) banks left. The F-22 is slated to replace the F-15C/D.

This was followed with the Raptor's first participation in a [Red Flag](http://en.wikipedia.org/wiki/Red_Flag_%28USAF%29) exercise. 14 F-22s of the 94th FS supported attacking Blue Force strike packages as well as engaging in close air support sorties themselves in Red Flag 07-1 between 3 February and 16 February 2007. Against designed superior numbers of [Red Force Aggressor](http://en.wikipedia.org/wiki/Aggressor_squadron) F-15s and F-16s, it established air dominance using eight aircraft during day missions and six at night, reportedly defeating the Aggressors quickly and efficiently, even though the exercise [rules of engagement](http://en.wikipedia.org/wiki/Rules_of_engagement) allowed for four to five Red Force regenerations of losses but none to Blue Force. Further, no sorties were missed because of maintenance or other failures, and only one Raptor was adjudged lost against the virtual annihilation of the defending force. When their ordnance was expended, the F-22s remained in the exercise area providing electronic surveillance to the Blue Forces.

While attempting its first overseas deployment to the [Kadena Air Base](http://en.wikipedia.org/wiki/Kadena_Air_Base) in Okinawa, Japan, on 11 February 2007, a group of six Raptors flying from [Hickam AFB](http://en.wikipedia.org/wiki/Hickam_AFB), Hawaii experienced multiple computer crashes coincident with their crossing of the 180th meridian of [longitude](http://en.wikipedia.org/wiki/Longitude) (the [International Date Line](http://en.wikipedia.org/wiki/International_Date_Line)). The computer failures included at least navigation (completely lost) and communication. The fighters were able to return to Hawaii by following their [tankers](http://en.wikipedia.org/wiki/Aerial_refueling) in good weather. The error was fixed within 48 hours and the F-22s continued their journey to Kadena.

An F-22 from [Elmendorf AFB](http://en.wikipedia.org/wiki/Elmendorf_AFB), Alaska intercepting a Russian [Tupolev Tu-95](http://en.wikipedia.org/wiki/Tupolev_Tu-95) near Alaskan airspace

F-22A Raptors of the 90th Fighter Squadron performed their first intercept of two Russian [Tu-95MS 'Bear-H'](http://en.wikipedia.org/wiki/Tupolev_Tu-95) bombers in Alaska, on 22 November 2007. This was the first time that F-22s had been called to support a NORAD mission.

On 12 December 2007, General [John D.W. Corley](http://en.wikipedia.org/wiki/John_D.W._Corley), USAF, Commander of [Air Combat Command](http://en.wikipedia.org/wiki/Air_Combat_Command), officially declared the F-22s of the integrated active duty [1st Fighter Wing](http://en.wikipedia.org/wiki/1st_Fighter_Wing) and [Virginia Air National Guard](http://en.wikipedia.org/wiki/Virginia_Air_National_Guard) [192d Fighter Wing](http://en.wikipedia.org/wiki/192d_Fighter_Wing) fully operational, three years after the first Raptor arrived at [Langley Air Force Base](http://en.wikipedia.org/wiki/Langley_Air_Force_Base), Virginia. This was followed from 13 April to 19 April 2008 by an Operational Readiness Inspection (ORI) of the integrated wing in which it received an "excellent" rating in all categories while scoring a simulated kill-ratio of 221-0. The first pair of Raptors assigned to the [49th Fighter Wing](http://en.wikipedia.org/wiki/49th_Fighter_Wing) became operational at [Holloman Air Force Base](http://en.wikipedia.org/wiki/Holloman_Air_Force_Base), [New Mexico](http://en.wikipedia.org/wiki/New_Mexico), on 2 June.

On 28 August 2008, an F-22 from the 411th Flight Test Squadron performed in the first ever air-to-air refueling of an aircraft using synthetic jet fuel. The test was a part of the wider USAF effort to qualify all of its aircraft to use the fuel, a 50/50 mix of [JP-8](http://en.wikipedia.org/wiki/JP-8) and a [Fischer-Tropsch process](http://en.wikipedia.org/wiki/Fischer-Tropsch_process)-produced, [natural gas](http://en.wikipedia.org/wiki/Natural_gas)-based fuel. For the tests, no modifications were made to the F-22 nor the [KC-135 Stratotanker](http://en.wikipedia.org/wiki/KC-135_Stratotanker) which performed the refueling.

On 22 July 2009, the [United States Senate](http://en.wikipedia.org/wiki/United_States_Senate) voted to end F-22 production at 187 fighters. The extreme economic burden of the Raptor was cited, with arguments that since it is not used in [Iraq](http://en.wikipedia.org/wiki/Iraq) or [Afghanistan](http://en.wikipedia.org/wiki/Afghanistan), the further costs are unnecessary. [Defense Secretary](http://en.wikipedia.org/wiki/Defense_Secretary) [Robert Gates](http://en.wikipedia.org/wiki/Robert_Gates) announced in April that the military would shift more funding towards intelligence and personnel, rather than hardware only suitable for fighting major wars like the F-22, specifically stating that

The F-22, to be blunt, does not make much sense anyplace else in the spectrum of conflict. Nonetheless, supporters of the F-22 lately have promoted its use for an ever expanding list of potential missions. These range from protecting the homeland from seaborne cruise missiles to, as one retired general recommended on TV, using F-22s to go after Somali pirates who in many cases are teenagers with AK-47s – a job we already know is better done at much less cost by three Navy SEALs. These are examples of how far-fetched some of the arguments have become for a program that has cost $65 billion – and counting – to produce 187 aircraft, not to mention the thousands of uniformed Air Force positions that were sacrificed to help pay for it.

**Maintenance**

In January 2007, it was reported that the F-22 maintained a 97% sortie rate (flying 102 out of 105 tasked sorties) while amassing a 144-to-zero kill ratio during "Northern Edge" air-to-air exercises held in Alaska, the first large-scale exercise in which the Raptor participated. Lt. Col. Wade Tolliver, the squadron commander of the 27th FS from Langley AFB commented on the upkeep and reliability of the Raptor's RAM during simulated combat conditions, stating "the stealth coatings are not as fragile as they were in earlier stealth aircraft. It isn't damaged by a rain storm and it can stand the wear and tear of combat without degradation."

In July 2009, the Air Force reported that the F-22 requires more than 30 hours of maintenance for every flight hour, while the Office of the Secretary of Defense puts that figure at 34 hours of maintenance per single hour of flight. The aircraft's radar-absorbing metallic skin is the principal cause of its maintenance troubles, with skin repairs accounting for more than half of the maintenance. Another source of maintenance problems is that many components require custom hand-fitting and are not interchangeable. The canopy visibility has declined more rapidly than expected, with refurbishments at 331 flight hours, on average, instead of the required 800 hours. Pentagon officials respond that measuring flying costs for aircraft fleets that have not reached 100,000 flying hours is premature. They say improvements have been made since 2008, and the F-22s are on track to meet key performance parameters by 2010. [*Air Force Magazine*](http://en.wikipedia.org/wiki/Air_Force_Magazine) reported that the *Washington Post* article's 55% capable rate was incorrect and that mission capable rates have been climbing, and by late June stood at 62.9%. And the [Air Force Association](http://en.wikipedia.org/wiki/Air_Force_Association) states that the current mission capable rate is 70%.

**Variants**

Under the Navy Advanced Tactical Fighter (NATF) program, a carrier-borne variant of the F-22 with [swing-wings](http://en.wikipedia.org/wiki/Variable-sweep_wing) was proposed for the [U.S. Navy](http://en.wikipedia.org/wiki/United_States_Navy) to replace the [F-14 Tomcat](http://en.wikipedia.org/wiki/F-14_Tomcat), though the program was subsequently cancelled in 1993. A two-seat F-22B trainer variant was planned, but was cut in 1996 to save development costs.

Another more recent proposal is the [FB-22](http://en.wikipedia.org/wiki/FB-22), which would be used as a deep strike bomber for the USAF, but there has yet to be any word on whether the USAF plans further development of the program. Also, the [X-44 MANTA](http://en.wikipedia.org/wiki/X-44_MANTA), short for *multi-axis, no-tail aircraft*, was a planned experimental aircraft based on the F-22 with enhanced [thrust vectoring](http://en.wikipedia.org/wiki/Thrust_vectoring) controls and no aerodynamic backup (i.e. the aircraft is controlled solely by thrust vectoring, without rudders, ailerons, or elevators). Funding for the program was halted in 2000.

**Operators**

F-22A Raptor from [Tyndall AFB](http://en.wikipedia.org/wiki/Tyndall_AFB), [Florida](http://en.wikipedia.org/wiki/Florida) cruising over the [Florida Panhandle](http://en.wikipedia.org/wiki/Florida_Panhandle).

An F-22 landing at [Holloman AFB](http://en.wikipedia.org/wiki/Holloman_AFB), [New Mexico](http://en.wikipedia.org/wiki/New_Mexico)

An F-22 belonging to the 433rd Weapons Squadron at [Nellis AFB](http://en.wikipedia.org/wiki/Nellis_AFB), [Nevada](http://en.wikipedia.org/wiki/Nevada)

An F-22, based at [Elmendorf AFB](http://en.wikipedia.org/wiki/Elmendorf_AFB), [Alaska](http://en.wikipedia.org/wiki/Alaska), over mountain terrain

The United States is the only operator of the aircraft, with the [United States Air Force](http://en.wikipedia.org/wiki/United_States_Air_Force) having 139 F-22s in its active inventory as of May 2009. These are operated by the following commands.

* [Air Education and Training Command](http://en.wikipedia.org/wiki/Air_Education_and_Training_Command)
	+ [325th Fighter Wing](http://en.wikipedia.org/wiki/325th_Fighter_Wing), [Tyndall Air Force Base](http://en.wikipedia.org/wiki/Tyndall_Air_Force_Base), [Florida](http://en.wikipedia.org/wiki/Florida)
		- [43d Fighter Squadron](http://en.wikipedia.org/wiki/43d_Fighter_Squadron) - The first squadron to operate the F-22 and continues to serve as the Formal Training Unit. Known as the "Hornets", the 43d was re-activated at Tyndall in 2002.
* [Air Combat Command](http://en.wikipedia.org/wiki/Air_Combat_Command)
	+ [1st Fighter Wing](http://en.wikipedia.org/wiki/1st_Fighter_Wing), [Langley Air Force Base](http://en.wikipedia.org/wiki/Langley_Air_Force_Base), [Virginia](http://en.wikipedia.org/wiki/Virginia)
		- [27th Fighter Squadron](http://en.wikipedia.org/wiki/27th_Fighter_Squadron) - The first combat F-22 squadron. Began conversion in December 2005 after and flew the first operational mission (January 2006 in support of [Operation Noble Eagle](http://en.wikipedia.org/wiki/Operation_Noble_Eagle)).
		- [94th Fighter Squadron](http://en.wikipedia.org/wiki/94th_Fighter_Squadron)
	+ [49th Fighter Wing](http://en.wikipedia.org/wiki/49th_Fighter_Wing), [Holloman AFB](http://en.wikipedia.org/wiki/Holloman_Air_Force_Base), [New Mexico](http://en.wikipedia.org/wiki/New_Mexico)
		- [7th Fighter Squadron](http://en.wikipedia.org/wiki/7th_Fighter_Squadron)
		- [8th Fighter Squadron](http://en.wikipedia.org/wiki/8th_Fighter_Squadron)
	+ [53d Wing](http://en.wikipedia.org/wiki/53d_Wing), [Eglin Air Force Base](http://en.wikipedia.org/wiki/Eglin_Air_Force_Base), [Florida](http://en.wikipedia.org/wiki/Florida)
		- [422d Test and Evaluation Squadron](http://en.wikipedia.org/wiki/422d_Test_and_Evaluation_Squadron) - The "Green Bats" are responsible for operational testing, tactics development and evaluation for the F-22.
	+ [57th Wing](http://en.wikipedia.org/wiki/57th_Wing), [Nellis Air Force Base](http://en.wikipedia.org/wiki/Nellis_Air_Force_Base), [Nevada](http://en.wikipedia.org/wiki/Nevada)
		- [433d Weapons Squadron](http://en.wikipedia.org/w/index.php?title=433d_Weapons_Squadron&action=edit&redlink=1)
* [Air Force Materiel Command](http://en.wikipedia.org/wiki/Air_Force_Materiel_Command)
	+ [412th Test Wing](http://en.wikipedia.org/wiki/412th_Test_Wing), [Edwards Air Force Base](http://en.wikipedia.org/wiki/Edwards_Air_Force_Base), [California](http://en.wikipedia.org/wiki/California)
		- [411th Flight Test Squadron](http://en.wikipedia.org/wiki/411th_Flight_Test_Squadron) - Conducted competition between YF-22 and YF-23 from 1989-1991.
		- [412th Flight Test Squadron](http://en.wikipedia.org/wiki/412th_Flight_Test_Squadron) - Conducts developmental tests of F-22 enhancements and modernization.
* [Pacific Air Forces](http://en.wikipedia.org/wiki/Pacific_Air_Forces)
	+ [3d Wing](http://en.wikipedia.org/wiki/3d_Wing), [Elmendorf Air Force Base](http://en.wikipedia.org/wiki/Elmendorf_Air_Force_Base), [Alaska](http://en.wikipedia.org/wiki/Alaska)
		- [90th Fighter Squadron](http://en.wikipedia.org/wiki/90th_Fighter_Squadron) - Converted from F-15Es; first F-22A arrived 8 August 2007.
		- [525th Fighter Squadron](http://en.wikipedia.org/wiki/525th_Fighter_Squadron)
	+ [477th Fighter Group](http://en.wikipedia.org/wiki/477th_Fighter_Group), Elmendorf AFB, Alaska. [Air Force Reserve Command](http://en.wikipedia.org/wiki/Air_Force_Reserve_Command) (AFRC) unit.
		- [302d Fighter Squadron](http://en.wikipedia.org/wiki/302d_Fighter_Squadron) Associate AFRC squadron to the 3 WG.
* [Air National Guard](http://en.wikipedia.org/wiki/Air_National_Guard)
	+ [192d Fighter Wing](http://en.wikipedia.org/wiki/192d_Fighter_Wing) - Langley AFB, Virginia.
		- [149th Fighter Squadron](http://en.wikipedia.org/wiki/149th_Fighter_Squadron) - Associate ANG squadron to the 1 FW.

Future bases and units will include:

* [154th Wing](http://en.wikipedia.org/wiki/154th_Wing), [Hickam AFB](http://en.wikipedia.org/wiki/Hickam_Air_Force_Base), [Hawaii](http://en.wikipedia.org/wiki/Hawaii) (2009/2010)
	+ [199th Fighter Squadron](http://en.wikipedia.org/wiki/199th_Fighter_Squadron), [Hawaii Air National Guard](http://en.wikipedia.org/wiki/Hawaii_Air_National_Guard)
	+ [531st Fighter Squadron](http://en.wikipedia.org/wiki/531st_Fighter_Squadron), Hickam AFB, Hawaii. Associate squadron to the 199 FS.
* [44th Fighter Group](http://en.wikipedia.org/w/index.php?title=44th_Fighter_Group&action=edit&redlink=1), [Holloman AFB](http://en.wikipedia.org/wiki/Holloman_AFB), [New Mexico](http://en.wikipedia.org/wiki/New_Mexico); Air Force Reserve Command (AFRC)
	+ [301st Fighter Squadron](http://en.wikipedia.org/wiki/301st_Fighter_Squadron) Associate AFRC squadron to the 49 FW.

**Accidents**

In April 1992 the first YF-22 crashed while landing at [Edwards Air Force Base](http://en.wikipedia.org/wiki/Edwards_Air_Force_Base), California. The test pilot Tom Morgenfeld escaped without injury. The cause of the crash was found to be a flight control [software error](http://en.wikipedia.org/wiki/Software_error) that failed to prevent a [pilot-induced oscillation](http://en.wikipedia.org/wiki/Pilot-induced_oscillation).

The first crash of a production F-22 occurred during [takeoff](http://en.wikipedia.org/wiki/Takeoff) at [Nellis Air Force Base](http://en.wikipedia.org/wiki/Nellis_Air_Force_Base) on 20 December 2004, in which the pilot ejected safely prior to impact. The crash investigation revealed that a brief interruption in power during an engine shutdown prior to flight caused a malfunction in the flight-control system; consequently, the aircraft design was corrected to avoid the problem. All USAF F-22s were grounded for two weeks after the crash, but resumed operations after a review was completed.

On 25 March 2009 an F-22 crashed 35 miles northeast of [Edwards Air Force Base](http://en.wikipedia.org/wiki/Edwards_Air_Force_Base) during a [test flight](http://en.wikipedia.org/wiki/Test_flight), resulting in the death of Lockheed test pilot [David P. Cooley](http://en.wikipedia.org/wiki/David_P._Cooley). The aircraft was from the [411th Flight Test Squadron](http://en.wikipedia.org/wiki/411th_Flight_Test_Squadron). The *Washington Post* reported that the crash happened during a bombing test.

**Aircraft on display**

The [National Museum of the United States Air Force](http://en.wikipedia.org/wiki/National_Museum_of_the_United_States_Air_Force), on 30 April 2007, announced that EMD Raptor 91-4003 would be put on display later in 2007 in the space being occupied by the YF-22. The Museum publicly unveiled its Raptor 91-4003 display on 18 January 2008.

**Specifications (F-22 Raptor)**

*Data from* USAF, F-22 Raptor Team web site, Lockheed Martin, [*Aviation Week*](http://en.wikipedia.org/wiki/Aviation_Week_%26_Space_Technology), and *Journal of Electronic Defense*

**General characteristics**

* Crew: 1
* Length: 62 ft 1 in (18.90 m)
* [Wingspan](http://en.wikipedia.org/wiki/Wingspan): 44 ft 6 in (13.56 m)
* Height: 16 ft 8 in (5.08 m)
* Wing area: 840 ft² (78.04 m²)
* [Airfoil](http://en.wikipedia.org/wiki/Airfoil): [NACA 64A?05.92](http://en.wikipedia.org/wiki/NACA_airfoil) root, NACA 64A?04.29 tip
* Empty weight: 43,430 [lb](http://en.wikipedia.org/wiki/Pound_%28mass%29) (19,700 kg)
* Loaded weight: 64,460 lb (29,300 kg)
* [Max takeoff weight](http://en.wikipedia.org/wiki/Maximum_Takeoff_Weight): 83,500 lb (38,000 kg)
* Powerplant: 2× [Pratt & Whitney F119-PW-100](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F119) Pitch Thrust vectoring [turbofans](http://en.wikipedia.org/wiki/Turbofan), 35,000+ lb (156+ kN) each
* Fuel capacity: 18,000 lb (8,200 kg) internally, or 26,000 lb (11,900 kg) with two external fuel tanks

**Performance**

* [Maximum speed](http://en.wikipedia.org/wiki/V_speeds#Vno):
	+ At altitude: [Mach](http://en.wikipedia.org/wiki/Mach_number) 2.25 (1,500 mph, 2,410 km/h)
	+ [Supercruise](http://en.wikipedia.org/wiki/Supercruise): Mach 1.82 (1,220 mph, 1,963 km/h)
* [Range](http://en.wikipedia.org/wiki/Range_%28aircraft%29): 1,600 nmi (1,840 mi, 2,960 km) with 2 external fuel tanks
* Combat radius: 410 nmi (471 mi, 759 km)
* [Ferry range](http://en.wikipedia.org/wiki/Ferry_range): 2,000 mi (1,738 [nmi](http://en.wikipedia.org/wiki/Nautical_mile), 3,219 km)
* [Service ceiling](http://en.wikipedia.org/wiki/Ceiling_%28aeronautics%29): 65,000 ft (19,812 m)
* [Wing loading](http://en.wikipedia.org/wiki/Wing_loading): 77 lb/ft² (375 kg/m²)
* [Thrust/weight](http://en.wikipedia.org/wiki/Thrust-to-weight_ratio): 1.08 (1.26 with loaded weight & 50% fuel)
* Maximum *g*-load: -3.0/+9.0 g

USAF poster overview of key features and armament.

**Armament**

* **Guns:** 1× [20 mm (0.787 in)](http://en.wikipedia.org/wiki/20_mm_caliber) [M61A2 Vulcan](http://en.wikipedia.org/wiki/M61_Vulcan) [gatling gun](http://en.wikipedia.org/wiki/Gatling_gun) in starboard wing root, 480 rounds
* **Air to air loadout:**
	+ 6× [AIM-120 AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM)
	+ 2× [AIM-9 Sidewinder](http://en.wikipedia.org/wiki/AIM-9_Sidewinder)
* **Air to ground loadout:**
	+ 2× [AIM-120 AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM) *and*
	+ 2× [AIM-9 Sidewinder](http://en.wikipedia.org/wiki/AIM-9_Sidewinder) *for* [*self-protection*](http://en.wikipedia.org/wiki/Air_to_air_combat)*, and one of the following:*
		- 2× 1,000 lb (450 kg) [JDAM](http://en.wikipedia.org/wiki/Joint_Direct_Attack_Munition) *or*
		- 2× [Wind Corrected Munitions Dispensers](http://en.wikipedia.org/wiki/Wind_Corrected_Munitions_Dispenser) (WCMDs) *or*
		- 8× 250 lb (110 kg) [GBU-39 Small Diameter Bombs](http://en.wikipedia.org/wiki/GBU-39_Small_Diameter_Bomb)
* [Hardpoints](http://en.wikipedia.org/wiki/Hardpoint)**:** 4× under-wing pylon stations can be fitted to carry 600 US [gallon](http://en.wikipedia.org/wiki/Gallon) *Sargent Fletcher* [drop tanks](http://en.wikipedia.org/wiki/Drop_tank) *or* weapons, each with a capacity of 5,000 lb (2,268 kg).

**Avionics**

* RWR ([Radar warning receiver](http://en.wikipedia.org/wiki/Radar_warning_receiver)): 250 [nmi](http://en.wikipedia.org/wiki/Nautical_mile) (463 km) or more
* [Radar](http://en.wikipedia.org/wiki/Radar): 125-150 miles (200-240 km) against 1 m2 (11 sq ft) targets (estimated range)

**Popular culture**

The F-22 has been featured in numerous books, such as [Tom Clancy](http://en.wikipedia.org/wiki/Tom_Clancy)'s [*Debt of Honor*](http://en.wikipedia.org/wiki/Debt_of_Honor) (1994) and *Fighter Wing* (1995) as well as Clive Cussler's [*Dark Watch*](http://en.wikipedia.org/wiki/Dark_Watch) (2005) and Daymon Andrews' *The Sword and the Star: Temple Mount* (2008).

The Raptor has appeared in movies as well. Despite appearing in the 2003 Hulk film, the F-22 made its major [Hollywood](http://en.wikipedia.org/wiki/Hollywood) debut in the 2007 film [*Transformers*](http://en.wikipedia.org/wiki/Transformers_%28film%29) as the form taken by the [Decepticon](http://en.wikipedia.org/wiki/Decepticon#2007_movie) character [Starscream](http://en.wikipedia.org/wiki/Starscream#2007_Transformers_film) in addition to numerous USAF fighters that engaged during the initial and climactic battles. The movie crew was allowed to film actual Raptors in flight, unlike previous [computer-generated](http://en.wikipedia.org/wiki/Computer-generated) appearances, because of the military's support of director [Michael Bay](http://en.wikipedia.org/wiki/Michael_Bay). The Raptors were filmed at Edwards Air Force Base.

**See also**

|  |  |
| --- | --- |
|  | [***United States Air Force portal***](http://en.wikipedia.org/wiki/Portal%3AUnited_States_Air_Force) |

* [Fifth generation jet fighter](http://en.wikipedia.org/wiki/Fifth_generation_jet_fighter)
* [Military-Industrial Complex](http://en.wikipedia.org/wiki/Military-Industrial_Complex)

**Related development**

* [FB-22](http://en.wikipedia.org/wiki/FB-22)
* [F-35 Lightning II](http://en.wikipedia.org/wiki/F-35_Lightning_II)
* [X-44 MANTA](http://en.wikipedia.org/wiki/X-44_MANTA)

**Comparable aircraft**

* [Northrop YF-23](http://en.wikipedia.org/wiki/Northrop_YF-23)

**Related lists**

* [List of fighter aircraft](http://en.wikipedia.org/wiki/List_of_fighter_aircraft)
* [List of Lockheed aircraft](http://en.wikipedia.org/wiki/List_of_Lockheed_aircraft)
* [List of military aircraft of the United States](http://en.wikipedia.org/wiki/List_of_military_aircraft_of_the_United_States)