**F-35 Lightning II**

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*"Joint Strike Fighter" redirects here. For other uses, see* [*Joint Strike Fighter (disambiguation)*](http://en.wikipedia.org/wiki/Joint_Strike_Fighter_(disambiguation))*.*

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| **F-35 Lightning II** | |
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| An F-35 Lightning II, marked AA-1, lands on 23 October 2008 at [Edwards Air Force Base](http://en.wikipedia.org/wiki/Edwards_Air_Force_Base). | |
| **Role** | [Stealth](http://en.wikipedia.org/wiki/Stealth_aircraft) [multirole fighter](http://en.wikipedia.org/wiki/Multirole_combat_aircraft) |
| **First flight** | 15 December 2006 |
| **Introduction** | 2012 (Marines IOC) 2016 (scheduled) |
| **Status** | Under development / pre-production |
| **Produced** | 2003–present |
| **Number built** | 13 flight-test aircraft;  15 [LRIP](http://en.wikipedia.org/wiki/Low_rate_initial_production) aircraft on order. |
| **Unit cost** | [US$](http://en.wikipedia.org/wiki/US$)83 million (flyaway cost in Then-Year dollars) |
| **Developed from** | [Lockheed Martin X-35](http://en.wikipedia.org/wiki/Lockheed_Martin_X-35) |

The **Lockheed Martin F-35 Lightning II** is a [fifth-generation](http://en.wikipedia.org/wiki/Fifth_generation_jet_fighter), single-seat, single-engine, [stealth](http://en.wikipedia.org/wiki/Stealth_aircraft) [multirole fighter](http://en.wikipedia.org/wiki/Multirole_combat_aircraft), that can perform [close air support](http://en.wikipedia.org/wiki/Close_air_support), [tactical bombing](http://en.wikipedia.org/wiki/Tactical_bombing), and [air defense](http://en.wikipedia.org/wiki/Aerial_warfare) missions. The F-35 has three different models; one is the [conventional takeoff and landing](http://en.wikipedia.org/wiki/CTOL) variant, the second is [short takeoff and vertical-landing](http://en.wikipedia.org/wiki/STOVL) variant, and the third is a [carrier](http://en.wikipedia.org/wiki/CATOBAR)-based variant.

The F-35 is descended from the [X-35](http://en.wikipedia.org/wiki/Lockheed_Martin_X-35), the product of the [Joint Strike Fighter](http://en.wikipedia.org/wiki/Joint_Strike_Fighter_Program) (JSF) program. Its development is being principally funded by the [United States](http://en.wikipedia.org/wiki/United_States) and the [United Kingdom](http://en.wikipedia.org/wiki/United_Kingdom), with other partner governments providing additional funding. It is being designed and built by an aerospace industry team led by [Lockheed Martin](http://en.wikipedia.org/wiki/Lockheed_Martin) with [Northrop Grumman](http://en.wikipedia.org/wiki/Northrop_Grumman) and [BAE Systems](http://en.wikipedia.org/wiki/BAE_Systems) as major partners. Demonstrator aircraft flew in 2000, with the [first flight](http://en.wikipedia.org/wiki/Maiden_flight) on 15 December 2006.

**Development**

**JSF Program history**

Main article: [Joint Strike Fighter Program](http://en.wikipedia.org/wiki/Joint_Strike_Fighter_Program)

**Requirement**



An F-35 wind tunnel testing model in the [Arnold Engineering Development Center](http://en.wikipedia.org/wiki/Arnold_Engineering_Development_Center)'s 16-foot transonic [wind tunnel](http://en.wikipedia.org/wiki/Wind_tunnel)

The JSF program was designed to replace the U.S. military's [F-16](http://en.wikipedia.org/wiki/F-16_Fighting_Falcon), [A-10](http://en.wikipedia.org/wiki/A-10_Thunderbolt_II), [F/A-18](http://en.wikipedia.org/wiki/F/A-18_Hornet) (excluding F/A-18E/F) and [AV-8B](http://en.wikipedia.org/wiki/AV-8_Harrier_II) tactical fighter aircraft. To keep development, production, and operating costs down, a common design was planned in three variants that share 80% of their parts:

* F-35A, conventional takeoff and landing ([CTOL](http://en.wikipedia.org/wiki/CTOL)) variant.
* F-35B, short-takeoff and vertical-landing ([STOVL](http://en.wikipedia.org/wiki/STOVL)) variant.
* F-35C, carrier-based [CATOBAR](http://en.wikipedia.org/wiki/CATOBAR) (CV) variant.

The F-35 is intended to be the world's premier strike aircraft through 2040, with close- and long-range air-to-air capability second only to that of the [F-22 Raptor](http://en.wikipedia.org/wiki/F-22_Raptor). The F-35 is required to be four times more effective than existing fighters in air-to-air combat, eight times more effective in air-to-ground combat, and three times more effective in reconnaissance and suppression of air defenses – all while having better range and requiring less logistics support.

With takeoff weights up to 60,000 lb (27,000 kg), the F-35 is considerably heavier than the lightweight fighters it replaces. In empty and maximum gross weights, it more closely resembles the single-seat, single-engine [F-105 Thunderchief](http://en.wikipedia.org/wiki/F-105_Thunderchief) which was the largest single-engine fighter of the Vietnam era.

**Origins and selection**

The Joint Strike Fighter evolved out of several requirements for a common fighter to replace existing types. The actual JSF development contract was signed on 16 November 1996.

The contract for System Development and Demonstration (SDD) was awarded on 26 October 2001 to Lockheed Martin, whose X-35 beat the [Boeing X-32](http://en.wikipedia.org/wiki/Boeing_X-32). According to Department of Defense officials and British [Minister of Defense Procurement](http://en.wikipedia.org/wiki/William_Bach) Lord Bach, the X-35 consistently outperformed the X-32, although both met or exceeded requirements. The designation of the fighter as "F-35" came as a surprise to Lockheed, which had been referring to the aircraft in-house by the designation "F-24".

**Design phase**



F-35 Lightning II [USAF](http://en.wikipedia.org/wiki/USAF) video

The F-35B STOVL variant was in danger of missing performance requirements in 2004 because it weighed too much – reportedly, by 2,200 [pounds](http://en.wikipedia.org/wiki/Pound_(mass)) (1,000 kg) or 8 percent. In response, Lockheed Martin added engine thrust and shed more than a ton by thinning the aircraft's skin; shrinking the weapons bay and vertical stabilizers; rerouting some thrust from the roll-post outlets to the main nozzle; and redesigning the wing-mate joint, portions of the electrical system, and the portion of the aircraft immediately behind the [cockpit](http://en.wikipedia.org/wiki/Cockpit_(aviation)).

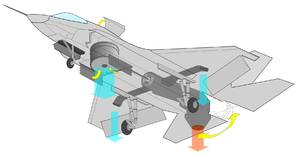
On 7 July 2006, the US Air Force officially announced the name of the F-35: Lightning II, in honor of Lockheed's [World War II](http://en.wikipedia.org/wiki/World_War_II)-era twin-prop [P-38 Lightning](http://en.wikipedia.org/wiki/P-38_Lightning) and the [Cold War](http://en.wikipedia.org/wiki/Cold_War)-era jet, the [English Electric Lightning](http://en.wikipedia.org/wiki/English_Electric_Lightning). [English Electric Company](http://en.wikipedia.org/wiki/English_Electric_Company)'s aircraft division was a predecessor of F-35 partner [BAE Systems](http://en.wikipedia.org/wiki/BAE_Systems). Lightning II was also an early company name for the aircraft that became the [F-22 Raptor](http://en.wikipedia.org/wiki/F-22_Raptor).

On 6 April 2009, US Secretary of Defense [Robert Gates](http://en.wikipedia.org/wiki/Robert_Gates) proposed speeding up production for the US to buy 2,443 F-35s.

On 21 April 2009 media reports, citing [Pentagon](http://en.wikipedia.org/wiki/Pentagon) sources, said that during 2007 and 2008, computer spies managed to copy and siphon off several terabytes of data related to F-35's design and the electronics systems, potentially enabling the development of defense systems against the aircraft. However, Lockheed Martin has rejected suggestions that the project has been compromised, saying that it "does not believe any classified information had been stolen".

On 9 November 2009, Ashton Carter, undersecretary of defense for acquisition, technology and logistics, acknowledged that the Pentagon "joint estimate team" (JET) had found possible future cost and schedule overruns in the project and that he would be holding meetings to attempt to avoid these.

**Design**



F-35's thrust vectoring nozzle and lift fan



The F-35A being towed to its inauguration ceremony on 7 July 2006

The F-35 appears to be a smaller, slightly more conventional, single-engine sibling of the sleeker, twin-engine [F-22 Raptor](http://en.wikipedia.org/wiki/F-22_Raptor), and indeed drew elements from it. The exhaust duct design was inspired by the [General Dynamics](http://en.wikipedia.org/wiki/General_Dynamics) Model 200 design, which was proposed for a 1972 supersonic VTOL fighter requirement for the [Sea Control Ship](http://en.wikipedia.org/wiki/Sea_Control_Ship). For specialized development of the F-35B STOVL variant, [Lockheed](http://en.wikipedia.org/wiki/Lockheed_Corporation) consulted with the [Yakovlev Design Bureau](http://en.wikipedia.org/wiki/Yakovlev_Design_Bureau), purchasing design data from their development of the [Yakovlev Yak-141 "Freestyle"](http://en.wikipedia.org/wiki/Yakovlev_Yak-141). Although several experimental designs have been built and tested since the 1960s including the Navy's unsuccessful [Rockwell XFV-12](http://en.wikipedia.org/wiki/Rockwell_XFV-12), the F-35B is to be the first operational supersonic STOVL fighter.

The F-35 is designed to be America's "premier surface-to-air missile killer and is uniquely equipped for this mission with cutting edge processing power, [synthetic aperture radar](http://en.wikipedia.org/wiki/Synthetic_aperture_radar) integration techniques, and advanced target recognition."

Some improvements over current-generation fighter aircraft are:

* Durable, low-maintenance [stealth technology](http://en.wikipedia.org/wiki/Stealth_technology);
* Integrated avionics and sensor fusion that combine information from off- and onboard sensors to increase the [pilot's](http://en.wikipedia.org/wiki/Aviator) situational awareness and improve target identification and weapon delivery, and to relay information quickly to other command and control (C2) nodes;
* High speed data networking including [IEEE 1394b](http://en.wikipedia.org/wiki/IEEE_1394_interface#FireWire_800_.28IEEE_1394b-2002.29) and [Fiber Channel](http://en.wikipedia.org/wiki/Fibre_Channel).
* The Autonomic Logistics Global Sustainment (ALGS), Autonomic Logistics Information System (ALIS) and Computerized Maintenance Management System (CMMS) help ensure aircraft uptime with minimal maintenance manpower.

The [Teen Series](http://en.wikipedia.org/wiki/Teen_Series) of fighters (F-15, F-16, F/A-18) were notable for always carrying large external fuel tanks, but as a stealth aircraft the F-35 must fly most missions on internal fuel. Unlike the F-16 and F/A-18, the F-35 lacks leading edge extensions (LEX) and instead uses stealth-friendly [chines](http://en.wikipedia.org/wiki/Leading_edge_extension#Chines) for vortex lift in the same fashion as the [SR-71 Blackbird](http://en.wikipedia.org/wiki/SR-71_Blackbird). The small bumps just forward of the engine air intakes form part of the diverterless supersonic inlet (DSI) which is a simpler, lighter and stealthier means to ensure high-quality airflow to the engine over a wide range of conditions.

**Cockpit**

The F-35 features a full-panel-width "panoramic cockpit display" (PCD), with dimensions of 20 by 8 inches (50 by 20 centimeters). A cockpit speech-recognition system ([Direct Voice Input](http://en.wikipedia.org/wiki/Direct_Voice_Input)) is planned to improve the pilot's ability to operate the aircraft over the current-generation interface. The F-35 will be the first US operational fixed-wing aircraft to use this system, although similar systems have been used in [AV-8B](http://en.wikipedia.org/wiki/AV-8B) and trailed in previous US jets, particularly the [F-16 VISTA](http://en.wikipedia.org/wiki/F-16_VISTA). In development the system has been integrated by Adacel Systems Inc with the speech recognition module supplied by SRI International. The pilot flies the aircraft by means of a right-hand [side stick](http://en.wikipedia.org/wiki/Side-stick) and left-hand throttle.

A helmet-mounted display system (HMDS) will be fitted to all models of the F-35. A helmet-mounted cueing system is already in service with the F-15s, F-16s and F/A-18s. While some fighters have offered HMDS along with a [head up display](http://en.wikipedia.org/wiki/Head_up_display) (HUD), this will be the first time in several decades that a front-line tactical jet fighter has been designed to not carry a HUD.

The [Martin-Baker](http://en.wikipedia.org/wiki/Martin-Baker) US16E [ejection seat](http://en.wikipedia.org/wiki/Ejection_seat) is used in all F-35 variants. The US16E seat design balances major performance requirements, including safe-terrain-clearance limits, pilot-load limits, and pilot size. It uses a twin-catapult system that is housed in side rails.

**Sensors and avionics**



Electro-optical target system (EOTS) under the nose of a mockup of the F-35.

The F-35 includes an advanced, powerful sensor suite. The main sensor on board the F-35 is its [AN/APG-81](http://en.wikipedia.org/wiki/APG-81) [AESA](http://en.wikipedia.org/wiki/AESA)-radar, designed by [Northrop Grumman Electronic Systems](http://en.wikipedia.org/wiki/Northrop_Grumman_Electronic_Systems). It is augmented by the Electro-Optical Targeting System (EOTS) mounted under the nose of the aircraft, designed by Lockheed Martin. This gives the same capabilities as the [Lockheed Martin Sniper XR](http://en.wikipedia.org/wiki/Lockheed_Martin_Sniper_XR) without compromising the aircraft's stealth. A version of the EOTS will also be used by the [General Atomics Avenger](http://en.wikipedia.org/wiki/General_Atomics_Avenger).

Six additional passive infrared sensors are distributed over the aircraft as part of Northrop Grumman's AN/AAQ-37 distributed aperture system (DAS), which acts as a missile warning system, reports missile launch locations, detects and tracks approaching aircraft spherically around the F-35, and replaces traditional night vision goggles for night operations and navigation. All DAS functions are performed simultaneously, in every direction, at all times. The F-35's AN/ASQ-239 (Barracuda) Electronic Warfare systems are designed by BAE and include Northrop Grumman components. The communications, navigation and identification (CNI) suite is designed by Northrop Grumman and includes the [Multifunction Advanced Data Link](http://en.wikipedia.org/wiki/Multifunction_Advanced_Data_Link) (MADL). The F-35 will be the first jet fighter that has sensor fusion that combines both radio frequency and IR tracking for continuous target detection and identification in all directions which is shared via MADL to other platforms without compromising their low observability.

Unlike older generations of aircraft, such as the F-22, all software for the F-35 is written in [C++](http://en.wikipedia.org/wiki/C%2B%2B) for faster code development. The [Integrity DO-178B](http://en.wikipedia.org/wiki/Integrity_(operating_system)#INTEGRITY-178B) real-time operating system (RTOS) from [Green Hills Software](http://en.wikipedia.org/wiki/Green_Hills_Software) runs on [COTS](http://en.wikipedia.org/wiki/COTS) Freescale PowerPC processors.

**Engines**

The F-35's main engine is the [Pratt & Whitney F135](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F135). The [General Electric/Rolls-Royce F136](http://en.wikipedia.org/wiki/General_Electric/Rolls-Royce_F136) is being developed as an alternate engine. The STOVL versions of both powerplants use the [Rolls-Royce LiftSystem](http://en.wikipedia.org/wiki/Rolls-Royce_LiftSystem), patented by Lockheed Martin and built by Rolls-Royce. This system is more like the Russian [Yak-141](http://en.wikipedia.org/wiki/Yakovlev_Yak-141) and German [VJ 101D/E](http://en.wikipedia.org/wiki/EWR_VJ_101)than the preceding generation of STOVL designs, such as the [Harrier Jump Jet](http://en.wikipedia.org/wiki/Harrier_Jump_Jet) in which all of the lifting air went through the main fan of the [Rolls-Royce Pegasus](http://en.wikipedia.org/wiki/Rolls-Royce_Pegasus) engine.

The LiftSystem is composed of a lift fan, drive shaft, two roll posts and a "Three Bearing Swivel Module" (3BSM). The 3BSM is a [thrust vectoring](http://en.wikipedia.org/wiki/Thrust_vectoring) nozzle which allows the main engine exhaust to be deflected downward at the tail of the aircraft. The lift fan near the front of the aircraft provides a counter-balancing thrust. Somewhat like a vertically mounted [turboprop](http://en.wikipedia.org/wiki/Turboprop) within the forward fuselage, the lift fan is powered by the engine's low-pressure (LP) turbine via a drive shaft and gearbox. Roll control during slow flight is achieved by diverting pressurized air from the LP turbine through wing mounted thrust nozzles called Roll Posts.

The F-35B lift fan achieves the same 'flow multiplier' effect as the Harrier's huge, but supersonically impractical, main fan. Like lift engines, this added machinery is just deadweight during horizontal flight but provides a net increase in payload capacity during vertical flight. The cool exhaust of the fan also reduces the amount of hot, high-velocity air that is projected downward during vertical takeoff (which can damage runways and aircraft carrier decks). Though complicated and risky, the lift system has been made to work to the satisfaction of DOD officials.

To date, F-136 funding has come at the expense of other parts of the program, reducing the number of aircraft built and increasing their costs. However, the F-136 team has claimed that their engine has a greater temperature margin which may prove critical for VTOL operations in hot, high altitude conditions.

**Armament**



Weapons bay on a [mock-up](http://en.wikipedia.org/wiki/Mock-up) of the F-35.

The F-35 includes a [GAU-22/A](http://en.wikipedia.org/wiki/GAU-12_Equalizer) four-barrel [25mm](http://en.wikipedia.org/wiki/25_mm_caliber) cannon. The cannon will be mounted internally with 180 rounds in the F-35A and fitted as an external pod with 220 rounds in the F-35B and F-35C. The gun pod for the B and C variants will have stealth features. This pod could be used for different equipment in the future, such as EW, reconnaissance equipment, or possibly a rearward facing radar.

Internally (current planned weapons for integration), up to two air-to-air missiles and two air-to-air or air-to-ground weapons (up to two 2,000 lb bombs in A and C models (BRU-68); two 1,000 lb bombs in the B model (BRU-67)) can be carried in the bomb bays. These could be [AIM-120 AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM), [AIM-132 ASRAAM](http://en.wikipedia.org/wiki/AIM-132_ASRAAM), the [Joint Direct Attack Munition](http://en.wikipedia.org/wiki/Joint_Direct_Attack_Munition) (JDAM) – up to 2,000 lb (910 kg), the [Joint Standoff Weapon](http://en.wikipedia.org/wiki/AGM-154_Joint_Standoff_Weapon) (JSOW), [Small Diameter Bombs](http://en.wikipedia.org/wiki/GBU-39_Small_Diameter_Bomb) (SDB) – a maximum of four in each bay (Three per bay in F-35B), the [Brimstone](http://en.wikipedia.org/wiki/Brimstone_missile) anti-armor missiles, and Cluster Munitions (WCMD). The [MBDA Meteor](http://en.wikipedia.org/wiki/MBDA_Meteor) air-to-air missile is currently being adapted to fit internally in the missile spots and may be integrated into the F-35. The UK had originally planned to put up to four AIM-132 ASRAAM internally but this has been changed to carry 2 internal and 2 external ASRAAMs. It has also been stated by a Lockheed executive that the internal bay will eventually be modified to accept up to 6 AMRAAMs.

At the expense of being more detectable by radar, many more missiles, bombs and fuel tanks can be attached on four wing pylons and two near wingtip positions. The two wingtip locations can only carry [AIM-9X Sidewinder](http://en.wikipedia.org/wiki/AIM-9_Sidewinder#AIM-9X). The other pylons can carry the AIM-120 AMRAAM, [Storm Shadow](http://en.wikipedia.org/wiki/Storm_Shadow), [AGM-158 Joint Air to Surface Stand-off Missile](http://en.wikipedia.org/wiki/AGM-158_JASSM) (JASSM) cruise missiles, guided bombs, 480-gallon and 600-gallon fuel tanks. An air-to-air load of eight AIM-120s and two AIM-9s is conceivable using internal and external weapons stations, as well as a configuration of six 2,000 lb bombs, two AIM-120s and two AIM-9s. With its payload capability, the F-35 can carry more air-to-air and air-to-ground weapons than legacy fighters it is to replace as well as the [F-22 Raptor](http://en.wikipedia.org/wiki/F-22_Raptor). Solid-state lasers were being developed as optional weapons for the F-35 as of 2002.

**Helmet-Mounted Display System**

Rather than maneuvering with thrust vectoring, or canards to line up the target directly ahead of the aircraft, like [4.5 Generation jet fighters](http://en.wikipedia.org/wiki/Fighter_aircraft#4.5th_generation_jet_fighters_.281990s_to_the_present.29), the F-35 does not need to point at the target to hit it. It uses combined radio frequency and infrared (SAIRST) [situational awareness](http://en.wikipedia.org/wiki/Situational_awareness) to continually track all nearby aircraft, the pilot's helmet-mounted display system (HMDS) for displaying and selecting targets, and High Off-Boresight (HOBS) weapons. The helmet system replaces the dashboard-mounted head-up display used in previous generation fighters. As Northrop Grumman puts it "maneuvering is irrelevant".

The [OODA loop](http://en.wikipedia.org/wiki/OODA_loop) has been decisive in air-to-air combat since at least the start of the jet age. Stealth and advanced sensors give the F-35 the edge in observation, automated target tracking gives the edge in orientation, sensor fusion simplifies decision making and the aircraft's controls allow action against targets without having to look away from them.

**Concerns over performance**

Concerns about the F-35's performance have resulted partially from reports of RAND simulations where numerous Russian [Sukhoi](http://en.wikipedia.org/wiki/Sukhoi) fighters defeat a handful of F-35s by denying tanker refueling. As a result of these issues, then Australian defense minister [Joel Fitzgibbon](http://en.wikipedia.org/wiki/Joel_Fitzgibbon) requested a formal briefing from the [Australian Department of Defense](http://en.wikipedia.org/wiki/Department_of_Defence_(Australia)) on the computer simulation. This briefing stated that the reports of the simulation were inaccurate and that it did not compare the F-35's performance against that of other aircraft.

RAND has applied the same tanker-denial scenario against the F-22 Raptor and seems to favor a new medium-bomber design.

The criticism of the F-35 has been dismissed by the Pentagon and manufacturer. The USAF has conducted an analysis of the F-35's air-to-air performance against all 4th generation fighter aircraft currently available, and has found the F-35 to be at least four times more effective. Maj Gen Charles R. Davis, USAF, the F-35 program executive officer, has stated that the "F-35 enjoys a significant Combat Loss Exchange Ratio advantage over the current and future air-to-air threats, to include Sukhois". The Russian, Indian, Chinese, and other air forces operate [Sukhoi Su-27/30](http://en.wikipedia.org/wiki/Sukhoi_Su-27) fighters.

**Manufacturing responsibilities**

[Lockheed Martin Aeronautics](http://en.wikipedia.org/wiki/Lockheed_Martin_Aeronautics) is the prime contractor and performs aircraft final assembly, overall system integration, mission system, and provides forward fuselage, wings and flight controls system. [Northrop Grumman](http://en.wikipedia.org/wiki/Northrop_Grumman) provides [Active Electronically Scanned Array](http://en.wikipedia.org/wiki/Active_Electronically_Scanned_Array) (AESA) radar, Infrared Distributed Aperture System (DAS), Communications, Navigation, Identification (CNI), center fuselage, weapons bay, and arrestor gear. [BAE Systems](http://en.wikipedia.org/wiki/BAE_Systems) provides aft fuselage and empennages, horizontal and vertical tails, crew life support and escape systems, [Electronic warfare](http://en.wikipedia.org/wiki/Electronic_warfare) systems, fuel system, and Flight Control Software (FCS1). [Alenia](http://en.wikipedia.org/wiki/Alenia_Aeronautica) will perform final assembly for Italy and, according to an Alenia executive, assembly of all European aircraft with the exception of Turkey and the United Kingdom.

In July 2009, a lawsuit by a former F-35 software worker against Lockheed Martin concerning the safety and quality of its software was unsealed. The lawsuit states that the software for the jet may be unsafe because standards are not being followed.

On 24 November 2009, Jon Schreiber said that the United States will not share the software codes for the F-35 with its allies.

**Next Generation Jammer**

The USMC is considering replacing their EA-6B Prowler Electronic Attack aircraft with F-35s that have stealthy jammer pods attached.

On 30 September 2008, the United States Navy outlined the basic requirements of the NGJ and stated that the design must be modular and open. The Navy has selected four companies to submit designs for the Next Generation Jammer.

**Operational history**

**Testing**

On 19 February 2006, the first F-35A (designated AA-1) was rolled out in [Fort Worth, Texas](http://en.wikipedia.org/wiki/Fort_Worth,_Texas). The aircraft underwent extensive ground testing at [Naval Air Station Fort Worth Joint Reserve Base](http://en.wikipedia.org/wiki/Naval_Air_Station_Fort_Worth_Joint_Reserve_Base), adjacent to Lockheed Martin's Fort Worth manufacturing facility, in fall 2006. On 15 September 2006 the first engine run of the [F135](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F135) afterburning turbofan was conducted in an airframe, with the tests completed on 18 September after a static run with full afterburner. The engine runs were the first time that the F-35 was completely functional on its own power systems. On 15 December 2006, the F-35A completed its maiden flight.

On 3 May 2007, electrical arcing inside an electrical-hydraulic control unit forced the aircraft to make an emergency landing. It was grounded until 7 December, when test pilot Jon Beesley flew a 55-minute test flight.

A unique feature of the test program is the use of the so-called [Lockheed CATBird](http://en.wikipedia.org/wiki/Lockheed_CATBird) avionic testbed, a highly modified [Boeing 737-300](http://en.wikipedia.org/wiki/Boeing_737), inside of which are racks holding all of F-35's avionics, as well as a complete F-35 cockpit.

On 31 January 2008 at Fort Worth, Texas, Lt Col James "Flipper" Kromberg of the U.S. Air Force became the first military service pilot to evaluate the F-35, taking the aircraft through a series of maneuvers on its 26th flight.

On 12 March 2008, the first F-35A (designated AA-1) began [aerial refueling](http://en.wikipedia.org/wiki/Aerial_refueling) testing on its 34th test flight. Another milestone was reached on 13 November 2008, when the AA-1 flew supersonic for the first time. A speed of Mach 1.05 was reached at 30,000 feet (9,144 meters), including four transitions through the sound barrier, and a total of eight minutes in supersonic flight.

On 11 June 2008, after extensive ground testing, the first F-35B (designated BF-1) made its maiden flight at Fort Worth. The flight, which featured a conventional takeoff, was piloted by BAE Systems' test pilot Graham Tomlinson. The BF-1 is the second of 19 System Development and Demonstration (SDD) F-35s, and the first to use new weight-optimized design features that will apply to all future F-35s.

On 19 December 2008, Lockheed Martin rolled out the first weight-optimized F-35A (designated AF-1). It is the first F-35 to be produced at a full-rate production speed – the [assembly line](http://en.wikipedia.org/wiki/Assembly_line) moves at 50 inches (127 centimeters) per hour – and is structurally identical to final production F-35As that will be delivered starting in 2010.

As of 5 January 2009, six F-35s are complete, including AF-1 and AG-1, and 17 are in production. "Thirteen of the 17 in production are pre-production test aircraft, and all of those will be finished in 2009," said John R. Kent, acting manager of F-35 Lightning II Communications at Lockheed Martin Aeronautics Company. "The other four are the first production-model planes, and the first of those will be delivered in 2010 to the U.S. Air Force, and will go to Eglin."

The F-35 testing program completed "just under 100 sorties and about as many hours in 2.5 years" as of June 2009 according Defense Technology International. To meet the current target date of mid-2014 for completion of operational testing, the test program "will have to go from the slowest to the fastest in history".Furthermore: "The GAO also reports that the goal set for FY2009 was 317 flights; as of mid-May, however, fewer than 30 test flights had been performed this year."

In 2009 the Pentagon's Joint Estimate Team (JET) reported to the Congress that their estimate was that the F-35 program was two years behind the latest public schedule.

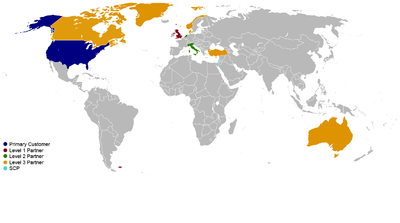
In March 2009, the United States Government Accountability Office reported that the JSF program office "noted that JSF’s technical, software, production processes, and testing maturity are tracking to plan and substantially exceeding standards set in past programs. The manufacturing fit and quality of the jets are unprecedented and production processes are improving with each jet."

**Environmental concerns**

In late 2008 the Air Force revealed that the F-35 would be about twice as loud at takeoff as the [F-15 Eagle](http://en.wikipedia.org/wiki/F-15_Eagle) and up to four times as loud upon landing. As a result, residents near [Davis-Monthan Air Force Base](http://en.wikipedia.org/wiki/Davis-Monthan_Air_Force_Base), Arizona and [Eglin Air Force Base](http://en.wikipedia.org/wiki/Eglin_Air_Force_Base), Florida, possible homes of the jet, have requested that the Air Force conduct environmental impact studies concerning the F-35's noise levels. The city of [Valparaiso, Florida](http://en.wikipedia.org/wiki/Valparaiso,_Florida), adjacent to Eglin AFB, threatened in February 2009 to sue the Air Force over the impending arrival of the F-35s. However, it was reported in March 2009 that testing by Lockheed Martin and the Royal Australian Air Force revealed that the F-35 was not as loud as first reported, being "only about as noisy as an [F-16](http://en.wikipedia.org/wiki/F-16) fitted with a Pratt & Whitney F100-PW-200 engine" and "quieter than the Lockheed Martin F-22 Raptor and the Boeing F/A-18E/F Super Hornet."

**International participation**

While the United States is the primary customer and financial backer, the United Kingdom, Italy, the Netherlands, Canada, Turkey, Australia, Norway and Denmark have agreed to contribute [US$](http://en.wikipedia.org/wiki/United_States_dollar)4.375 billion toward the development costs of the program. Total development costs are estimated at more than US$40 billion (underwritten largely by the United States), while the purchase of an estimated 2,400 planes is expected to cost an additional US$200 billion. The nine major partner nations plan to acquire over 3,100 F-35s through 2035, making the F-35 one of the most numerous jet fighters.



Participant nations:  
     Primary customer: [USA](http://en.wikipedia.org/wiki/USA)      Level 1 partner: [UK](http://en.wikipedia.org/wiki/UK)      Level 2 partner: [Italy](http://en.wikipedia.org/wiki/Italy) and [The Netherlands](http://en.wikipedia.org/wiki/The_Netherlands)      Level 3 partner: [Canada](http://en.wikipedia.org/wiki/Canada), [Turkey](http://en.wikipedia.org/wiki/Turkey), [Australia](http://en.wikipedia.org/wiki/Australia), [Norway](http://en.wikipedia.org/wiki/Norway) and [Denmark](http://en.wikipedia.org/wiki/Denmark)      Security Cooperative Participants (SCP): [Israel](http://en.wikipedia.org/wiki/Israel) and [Singapore](http://en.wikipedia.org/wiki/Singapore)

There are three levels of international participation. The levels generally reflect the financial stake in the program, the amount of technology transfer and subcontracts open for bid by national companies, and the order in which countries can obtain production aircraft. The United Kingdom is the sole "Level 1" partner, contributing US$2.5 billion, which was about 10% of the planned development costs under the 1995 [Memorandum of Understanding](http://en.wikipedia.org/wiki/Memorandum_of_Understanding) that brought the UK into the project. Level 2 partners are [Italy](http://en.wikipedia.org/wiki/Italy), which is contributing US$1 billion; and the [Netherlands](http://en.wikipedia.org/wiki/Netherlands), US$800 million. Level 3 partners are [Canada](http://en.wikipedia.org/wiki/Canada), US$475 million; [Turkey](http://en.wikipedia.org/wiki/Turkey), US$195 million; [Australia](http://en.wikipedia.org/wiki/Australia), US$144 million; [Norway](http://en.wikipedia.org/wiki/Norway), US$122 million and [Denmark](http://en.wikipedia.org/wiki/Denmark), US$110 [million](http://en.wikipedia.org/wiki/Million). [Israel](http://en.wikipedia.org/wiki/Israel) and [Singapore](http://en.wikipedia.org/wiki/Singapore) have joined as Security Cooperative Participants (SCP).

Some of the partner countries have wavered in their public commitment to the JSF program, hinting or warning that unless they receive more subcontracts or technology transfer, they will forsake JSF for the [Eurofighter Typhoon](http://en.wikipedia.org/wiki/Eurofighter_Typhoon), [Saab JAS 39 Gripen](http://en.wikipedia.org/wiki/JAS_39_Gripen), [Dassault Rafale](http://en.wikipedia.org/wiki/Dassault_Rafale) or simply upgrade their existing aircraft. Furthermore, F-35 export competitiveness has been hurt by international buyers finding either its export variant too costly per unit or "watered down". While the F-16E/F costs $50 million per export copy, the F-35 is likely to cost between $65–120 million.

**United Kingdom**

Main article: [Joint Combat Aircraft](http://en.wikipedia.org/wiki/Joint_Combat_Aircraft)

The [United Kingdom](http://en.wikipedia.org/wiki/United_Kingdom) planned to acquire 138 F-35Bs as of December 2006 for the [Royal Air Force](http://en.wikipedia.org/wiki/Royal_Air_Force) and the [Royal Navy](http://en.wikipedia.org/wiki/Royal_Navy). But speculation mounts in 2009 that they may switch from the F-35B to the F-35C model, with its greater range and payload the UK would require fewer aircraft and save about $25 million for each aircraft ordered.

The UK became increasingly frustrated by a lack of U.S. commitment to grant access to the technology that would allow the UK to maintain and upgrade its F-35s without US involvement. This is understood to relate mainly to the software for the aircraft. For five years, British officials sought an [ITAR](http://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations) waiver to secure greater technology transfer. This request, which had the blessing of the Bush administration, was repeatedly blocked by U.S. Representative [Henry Hyde](http://en.wikipedia.org/wiki/Henry_Hyde), who said that the UK needed to tighten its laws protecting against the unauthorized transfer of the most advanced U.S. technology to third parties.

On 27 May 2006, President [George W. Bush](http://en.wikipedia.org/wiki/George_W._Bush) and Prime Minister [Tony Blair](http://en.wikipedia.org/wiki/Tony_Blair) announced that "Both governments agree that the UK will have the ability to successfully operate, upgrade, employ, and maintain the Joint Strike Fighter such that the UK retains operational sovereignty over the aircraft." On 12 December 2006, Lord Drayson signed an agreement which met the UK's demands for further participation, i.e., access to software source code and operational sovereignty. The agreement allows "an unbroken British chain of command" for operation of the aircraft. Drayson said Britain would "not be required to have a US citizen in our own operational chain of command".Drayson also said, however, that Britain is still considering an unspecified "Plan B" alternative to buying the Joint Strike Fighter.

On 25 July 2007, the Ministry of Defense confirmed that they have placed orders for the two new aircraft carriers of the [*Queen Elizabeth* class](http://en.wikipedia.org/wiki/Queen_Elizabeth_class_aircraft_carrier) that will allow the purchase of the F-35B variant. On 2 May 2008, however, the [*Washington Post*](http://en.wikipedia.org/wiki/The_Washington_Post) reported that an [Inspector General](http://en.wikipedia.org/wiki/Inspector_General)'s report chided the U.S. Department of Defense's Defense Security Service for failing to ensure that BAE Systems was exercising appropriate controls over access to sensitive technologies, while both BAE and Lockheed Martin denied that any technology had been compromised.

On 18 March 2009, Defense Secretary [John Hutton](http://en.wikipedia.org/wiki/John_Hutton_(Labour_MP)) announced the MoD had agreed to purchase three test F-35s. And on 22 December 2009, financial approval for the purchase of the third aircraft was given.

**Italy**

As of October 2008, [Italy](http://en.wikipedia.org/wiki/Italy) planned to acquire 131 of the planes: 109 F-35As and 22 F-35Bs. On 7 October 2008, Italy announced it will not participate in initial F-35 testing and evaluation, and will not purchase test aircraft. The Navy plans to use the F-35Bs on their new [Cavour](http://en.wikipedia.org/wiki/Italian_aircraft_carrier_Cavour_(550)) [STOVL](http://en.wikipedia.org/wiki/STOVL) Carrier.

**Netherlands**

The [Netherlands](http://en.wikipedia.org/wiki/Netherlands) has plans to acquire 85 F-35As for the [Royal Netherlands Air Force](http://en.wikipedia.org/wiki/Royal_Netherlands_Air_Force). The aircraft will replace an aging fleet of Lockheed Martin [F-16](http://en.wikipedia.org/wiki/F-16)AM. The Dutch government expects the costs to be €5.5 billion for the initial purchase and €9.1 billion for 30 years of service. On 19 November 2007, in the Dutch Parliament, the Secretary of Defense was questioned about the JSF delay, technical problems and rising costs. However, on 29 February 2008, the [executive council](http://en.wikipedia.org/wiki/Council_of_Ministers_of_the_Netherlands) of the [Dutch government](http://en.wikipedia.org/wiki/Politics_of_the_Netherlands) decided to go ahead with the purchase of two test aircraft and a MOU was signed. On 7 September 2008 Dutch television show "Reporter" reports that counter orders are lagging behind compared to promises and that an active lobby by the Royal Netherlands Air Force has manipulated the Dutch government into participating in the project.

**Canada**

Canada has been involved in the Joint Strike Fighter Program from its beginning, investing US$10 million to be an "informed partner" during the evaluation process. Once Lockheed Martin was selected as the primary contractor for the JSF program, Canada elected to become a level 3 participant along with Norway, Denmark, Turkey, and Australia on the JSF project. An additional US$100 million from the Canadian [Department of National Defense](http://en.wikipedia.org/wiki/Department_of_National_Defence_(Canada)) (DND) over 10 years and another $50 million from [Industry Canada](http://en.wikipedia.org/wiki/Industry_Canada) were dedicated in 2002, making them an early participant of the JSF program.

Canada's rationale for joining the JSF project was not due to an urgent need to replace Canada's fleet of [CF-18 Hornets](http://en.wikipedia.org/wiki/CF-18_Hornet); instead, it was driven primarily by economics. Through Canadian government investment in the JSF project, Canadian companies were allowed to compete for contracts within the JSF project, as there were fears that being shut out from industrial participation in such a large program would severely damage the Canadian aviation industry. Joining also furthered Canadian access to information regarding the F-35 as a possible contender when it eventually plans to replace the CF-18 Hornet fleet. Improved interoperability with major allies allowed the DND to gain insight on leading edge practices in composites, manufacturing and logistics, and offered the ability to recoup some investment if the government did decide to purchase the F-35.

As a result of the Canadian government investment in the JSF project, 144 contracts were awarded to Canadian companies, universities, and government facilities. Financially, the contracts are valued at US$490 million for the period 2002 to 2012, with an expected value of US$1.1 billion from current contracts in the period between 2013 and 2023, and a total potential estimated value of Canadian JSF involvement from US$4.8 billion to US$6.8 billion.

**Turkey**

On 12 July 2002, [Turkey](http://en.wikipedia.org/wiki/Turkey) became the seventh international partner in the JSF Project, joining the United Kingdom, Italy, the Netherlands, Canada, Denmark and Norway. On 25 January 2007, Turkey signed a [memorandum of understanding](http://en.wikipedia.org/wiki/Memorandum_of_understanding) (MoU) for involvement in F-35 production. The [Turkish Air Force](http://en.wikipedia.org/wiki/Turkish_Air_Force) is planning to initially order 116 F-35A "CTOL/Air Force versions" at a reported cost of $11 billion. It is reported that the aircraft will be produced under license in Turkey by the [Turkish Aerospace Industries](http://en.wikipedia.org/wiki/Turkish_Aerospace_Industries) (TAI).

A Letter of Intent (LOI) was signed between [TAI](http://en.wikipedia.org/wiki/Turkish_Aerospace_Industries) and Northrop Grumman ISS (NGISS) International on 6 February 2007. With the LOI, TAI becomes the second source for the F-35 Lightning II center fuselage during the JSF Signing. The number of center fuselages to be produced by Turkish Aerospace Industries will be determined depending on the number of F-35s Turkey will procure and the number of F-35s to be produced worldwide. The LOI represents a potential value in excess of $3 billion. Northrop Grumman currently produces all F-35 center fuselages at its F-35 assembly facility in [Palmdale, California](http://en.wikipedia.org/wiki/Palmdale,_California).

TAI of Turkey is one of the two international suppliers to Northrop Grumman (the other being Denmark). On 10 December 2007, the Turkish Aerospace Industries, Inc. (TAI) was authorized by the Northrop Grumman to commence fabricating subassemblies for the first two F-35 production aircraft. The subassemblies – composite components and aircraft access doors – will be used in the F-35 center fuselage, a major section of the aircraft being produced by Northrop Grumman, a principal member of the Lockheed Martin-led F-35 global industry team.

It is also anticipated that TAI after 2013 will also produce 100% of the F-35 under license from Lockheed Martin Corporation, as was also the case with the F-16 Fighting Falcon program Peace Onyx I and II. Turkey also intends to incorporate in the future several Turkish designed and manufactured electronic systems into the F-35 platform.

Murad Bayar, head of the Undersecretariat for Defense Industries, has said that Turkey may increase its order to 120 aircraft instead of purchasing [Eurofighter Typhoons](http://en.wikipedia.org/wiki/Eurofighter_Typhoon).

**Australia**



Australia's then-Minister for Defense [Dr. Brendan Nelson](http://en.wikipedia.org/wiki/Brendan_Nelson) signing the JSF Production, Sustainment and Follow-on Development Memorandum of Understanding in December 2006

Australia is participating in the F-35's development, and is expected that overall, 72 or more F-35As will be ordered to replace the [Royal Australian Air Force's](http://en.wikipedia.org/wiki/Royal_Australian_Air_Force) (RAAF's) [F/A-18 Hornet](http://en.wikipedia.org/wiki/F/A-18_Hornet) aircraft.

The [Australian Government](http://en.wikipedia.org/wiki/Australian_Government) announced that it would buy into the F-35's development on 22 June 2002. This decision ended the competition to replace Australia's F/A-18 and [F-111](http://en.wikipedia.org/wiki/General_Dynamics_F-111) aircraft before it formally began, with other aircraft manufacturers being advised that it would not be worth submitting proposals. The Government argued that joining the F-35 program at an early stage would allow Australia to influence the F-35's development, provide the Government with information on the aircraft's suitability, and generate savings of over $600 million if an order for F-35s is eventually placed. Australia formally signed up to the F-35 Systems Development and Demonstration phase as a Level 3 participant on 30 October 2002.

In November 2006, satisfied with the F-35's progress to date, the Government gave 'first pass' initial approval to the project under which F-35s will be acquired, with a decision on whether to order the aircraft being scheduled for late 2008. Following this initial approval, on 13 December 2006 Australia signed the JSF Production, Sustainment and Follow-on Development Memorandum of Understanding which commits Australia to the next phase of the F-35's development. In October 2006, the deputy chief of the Air Force, Air Vice Marshal John Blackburn, publicly stated that the RAAF had considered suitable aircraft which could be acquired if the F-35 was delayed, but that such aircraft were not believed to be necessary on the basis of the F-35 program's progress at the time.

Concerns over the F-35s delivery schedule developed in Australia during 2007. In February the [Minister for Defense](http://en.wikipedia.org/wiki/Minister_for_Defence_(Australia)) announced that a risk mitigation strategy which involved obtaining F/A-18F Hornets was being developed to prevent a gap in the RAAF's air combat capability if the F-35 program was delayed. This strategy was adopted, and an order for 24 F/A-18Fs was announced on 6 March 2007. These aircraft are scheduled to enter service with the RAAF in 2010 and be fully operational by 2012.

Following the [2007 Australian Federal Election](http://en.wikipedia.org/wiki/Australian_federal_election,_2007), the new [Australian Labor Party](http://en.wikipedia.org/wiki/Australian_Labor_Party) Government launched an inquiry into the replacement of the RAAF's air combat capability. The party had expressed concerns over the F-35's adequacy while it was in opposition, and proposed acquiring [F-22s](http://en.wikipedia.org/wiki/F-22_Raptor) to replace or supplement the RAAF's F-35 force. An approach was made to the U.S. Government for F-22s in early 2008, but was not successful as these aircraft are not available for export. In April 2008 it was reported that the air combat review had found that the F-35 was the most suitable aircraft for Australia. In October 2008 it was reported that the Australian Government may order 75 F-35s instead of the 100 originally (and still officially) planned, due to the impact of the [global financial crisis](http://en.wikipedia.org/wiki/Financial_crisis_of_2007%E2%80%932008) and a large long-term funding gap in the Defense budget. The Government's [Defense white paper](http://en.wikipedia.org/wiki/Defending_Australia_in_the_Asia_Pacific_Century:_Force_2030) released in April 2009 argued for a purchase of up to 100 F-35s, however.

There has been much debate in Australia over whether the F-35 is the most suitable aircraft for the RAAF. It has been claimed that the F-35's performance is inferior to Russian-built fighters operated by countries near Australia (such as the Su-27 and Su-30 in [Indonesia](http://en.wikipedia.org/wiki/Indonesian_National_Air_Force)), that it cannot meet the RAAF's long-range strike requirement, and that further delays to the F-35 program may result in the RAAF experiencing a shortage of combat aircraft. The RAAF believes that the F-35 will meet Australia's needs however, and both of Australia's major political parties currently support the development and purchase of the aircraft (though differences remain on the deadline and the number of aircraft).

On 21 August 2009, it was reported that the RAAF would get two F-35s for testing in 2014 and that the initial squadron would be delayed until 2017.

On 11 September 2009, Air Marshall Mark Binskin said that a fourth squadron of F-35s for the RAAF would be imperative. On 25 November 2009, Australia committed to placing a first order for 14 aircraft at a cost of [AUD](http://en.wikipedia.org/wiki/AUD)3.2 billion with deliveries to begin in 2014.

**Norway**

Norway participates in the F-35 program as a Level 3 partner in the System Development and Demonstration phase with a view to enabling its industry to compete for industrial opportunities. Norwegian National Deputy Rune Fagerli, the country's sole representative on the Joint Strike Fighter program, told SPACE.com the Norwegian Royal Ministry of Defense has pledged $125 million in preparations to replace a fleet of F-16 jets that have about 12 years left of operation. "By getting involved here, on the ground level, we can try and address the needs of Norway into this capable fighter early," said Fagerli, a colonel. In Norway, F-16s are fitted with drag chutes because of wet, slippery runways. International cooperation to aircraft development could also yield aircraft from cooperating nations that fit well together during combat. Fagerli also mentioned that Norwegian pilots currently fly missions over Afghanistan in F-16s alongside Danish and Dutch aviators.

Norway has several times threatened to put their support on hold unless substantial guarantees for an increased industrial share is provided. Despite this Norway has signed all the Memoranda of Understanding, including the latest one detailing the future production phase of the JSF program. They have, however, indicated that they will increase and strengthen their cooperation with both competitors of the JSF, the Typhoon and the Gripen.

The F-35 was evaluated along with [JAS 39 Gripen](http://en.wikipedia.org/wiki/JAS_39_Gripen) by the Norwegian Future Combat Aircraft Capability Project as a replacement for the F-16s currently in-service. On 20 November 2008, the government released a statement saying it will support buying F-35s for the [Royal Norwegian Air Force](http://en.wikipedia.org/wiki/Royal_Norwegian_Air_Force) instead of the Saab Gripen NG.

The Norwegian Air Force has decided to develop the [Joint Strike Missile](http://en.wikipedia.org/wiki/Joint_Strike_Missile) for the F-35 and other aircraft.

**Denmark**

Denmark has joined the Joint Strike Fighter program as a Level 3 partner and the [Royal Danish Air Force](http://en.wikipedia.org/wiki/Royal_Danish_Air_Force) is considering the replacement of 48 of its aging F-16 fighters with next generation aircraft.

**Security Cooperative Participants (SCP)**

**Israel**

In 2003, [Israel](http://en.wikipedia.org/wiki/Israel) signed a formal letter of agreement, worth almost $20 million, to join the System Development and Demonstration (SDD) effort for the F-35 as a "security cooperation participant" (SCP). The [Israeli Air Force](http://en.wikipedia.org/wiki/Israeli_Air_Force) (IAF) stated in 2006 that the F-35 is a key part of IAF's recapitalization plans, and that Israel intends to buy over 100 F-35A fighters at an estimated cost of over $5 billion to replace their F-16s over time. Israel was reinstated as a partner in the development of the F-35 on 31 July 2006, after Israeli participation was put on hold following the [Chinese arms deal crisis](http://en.wikipedia.org/wiki/People%27s_Republic_of_China_%E2%80%93_Israel_relations#Controversies).

On 16 November 2006, Yaakov Katz, of The Jerusalem Post reported that if no jet fighters were delivered to Israel between the last batch of F-16s in 2007 and the first F-35s in 2014 then the Israeli air force would decline in numbers as older fighters wore out and were retired.

On 3 September 2007, [IDF](http://en.wikipedia.org/wiki/Israel_Defense_Forces) Chief of General Staff Lt.-Gen. Gabi Ashkenazi announced the purchase of a squadron of F-35s which Israel will begin receiving in 2014. However, U.S. defense officials later agreed to allow Israel to receive the fighters as early as 2012. The price of each F-35 is expected to reach $70–80 million.

[*The Jerusalem Post*](http://en.wikipedia.org/wiki/The_Jerusalem_Post) reports that the Pentagon has agreed to supply the F-35A variant to Israel as early as 2012, instead of in 2014 or 2015. This would make Israel one of the first nations to receive the aircraft, and very possibly the first foreign nation. Previous objections to Israel’s installation of its own technology in the F-35 – as it has done with every US fighter it has received – were also reportedly overcome. At present, the only Israeli technology in the standard version will be the JSF HMDS helmet-mounted display system, designed in cooperation with [Elbit Systems](http://en.wikipedia.org/wiki/Elbit_Systems). Israel also asked to manufacture F-35 aircraft locally at a 1:2 ratio, but the reports did not indicate whether that request was granted. On 30 September 2008, the US DoD reported that Israel has requested to purchase 25 F-35As with options to buy up to 50 F-35As or F-35Bs.

On 24 June 2009, *The Jerusalem Post* reported that an understanding had been reached on "the main basic issues". These include Israeli electronics and the ability to maintain the aircraft independently and that deliveries could start as early as 2014.

On 10 July 2009, the Israeli Air Force submitted an official Letter of Request (LOR) to the Pentagon to purchase its first squadron of 25 F-35As.

On 8 September 2009, *The Jerusalem Post* reported that negotiations had bogged down again over Israeli insistence that they be given sufficient technical details to enable them to equip the aircraft with their own technologies and repair them independently. And on 4 November 2009 it reported that a likely failure to sign a contract for 25 aircraft by the start of 2010 would delay the deliveries one or two years past the 2014 target date.

[Haaretz](http://en.wikipedia.org/wiki/Haaretz) has reported disaffection by Israeli defense firms over what will be their minimal contributions to "the largest procurement program in IDF history."

**Singapore**

In February 2003, Singapore joined the JSF program's System Design and Development (SDD) Phase, as a Security Co-operation Participant (SCP).

**Potential exports**

The F-35 is a possible future offer to the [Indian Air Force](http://en.wikipedia.org/wiki/Indian_Air_Force) as of July 2007. This has been interpreted as part of a tactic to sell the [F-16](http://en.wikipedia.org/wiki/F-16_Fighting_Falcon) as a multirole fighter to the IAF, as part of its [competition](http://en.wikipedia.org/wiki/Indian_MRCA_Competition) to acquire 126 new fighters. [Lockheed Martin](http://en.wikipedia.org/wiki/Lockheed_Martin) formally expressed its interest to sell F-35s to India. It is also known that the [Indian Navy](http://en.wikipedia.org/wiki/Indian_Navy) has shown interest in buying the F-35B.

The [Brazilian Air Force](http://en.wikipedia.org/wiki/Brazilian_Air_Force) recently has added the F-35 Joint Strike Fighter to the list of aircraft under consideration for its relaunched new fighter procurement, called F-X2. The F-35 replaces the F-16, which was in contention for the previous F-X BR program, shelved in 2003 and finally abandoned in 2006. Lockheed Martin did not offer the F-35 and instead bid the F-16BR in 2008.

The [Finnish Air Force](http://en.wikipedia.org/wiki/Finnish_Air_Force) has expressed its interest in the F-35, and other "advanced aircraft", as the replacement for its F-18C Hornets. An eventual purchase decision would be taken around 2015.

The future [Spanish Navy](http://en.wikipedia.org/wiki/Spanish_Navy) ship [Juan Carlos I (L61)](http://en.wikipedia.org/wiki/Juan_Carlos_I_(L61)) is adapted to carry JSF and AV-8B Harrier.

Lockheed Martin is offering the F-35 to the [Hellenic Air Force](http://en.wikipedia.org/wiki/Hellenic_Air_Force) as F-4E Peace Icarus 2000 and F-16C/D Block 30 replacement.

[Taiwan](http://en.wikipedia.org/wiki/Republic_of_China) has requested to buy the F-35 from the US. However this has been rejected by the US in fear of a critical response from [China](http://en.wikipedia.org/wiki/China). In March 2009 Taiwan again was looking to buy U.S. fifth-generation fighter jets featuring stealth and vertical takeoff capabilities.

The United States has asked Japan for a billion yen for basic information about the F-35 and is only willing to disclose information about the F-35's stealth features after Japan commits to the purchase. The Japanese Defense Ministry is likely to include a request for the fighter in its 2011 budget, but coalition politics may delay this for a year.

South Korea will most likely buy 60 F-35s for the third stage of its F-X program.

**Variants**

The F-35 is planned to be built in three different versions to suit the needs of its various users.

**F-35A**



F-35 Lightning II over [Eglin Air Force Base](http://en.wikipedia.org/wiki/Eglin_Air_Force_Base)

The F-35A is the conventional takeoff and landing ([CTOL](http://en.wikipedia.org/wiki/CTOL)) variant intended for the US Air Force and other air forces. It is the smallest, lightest F-35 version and is the only variant equipped with an internal cannon, the GAU-22/A. This [25 mm](http://en.wikipedia.org/wiki/25_mm_caliber) cannon is a development of the [GAU-12](http://en.wikipedia.org/wiki/GAU-12_Equalizer) carried by the USMC's [AV-8B Harrier II](http://en.wikipedia.org/wiki/AV-8B_Harrier_II). It is designed for increased effectiveness compared to the [20 mm](http://en.wikipedia.org/wiki/20_mm) [M61 Vulcan](http://en.wikipedia.org/wiki/M61_Vulcan) cannon carried by other USAF fighters.

The F-35A is expected to match the F-16 in maneuverability, instantaneous and sustained high-g performance, and outperform it in stealth, payload, range on internal fuel, avionics, operational effectiveness, supportability and survivability. It also has an internal laser designator and infrared sensors, equivalent to the Sniper XR pod carried by the F-16, but built in to remain stealthy.

The A variant is primarily intended to replace the USAF's [F-16 Fighting Falcon](http://en.wikipedia.org/wiki/F-16_Fighting_Falcon), beginning in 2013, and replace the [A-10 Thunderbolt II](http://en.wikipedia.org/wiki/A-10_Thunderbolt_II) starting in 2028.

**F-35B**



The F135 engine with lift fan, roll posts, and rear vectoring nozzle, as designed for the F-35B, at the [Paris Air Show](http://en.wikipedia.org/wiki/Paris_Air_Show), 2007

The F-35B is the short takeoff and vertical landing ([STOVL](http://en.wikipedia.org/wiki/STOVL)) variant of the aircraft. Similar in size to the A variant, the B sacrifices some fuel volume to make room for the vertical flight system. Takeoffs and landing with vertical flight systems are by far the riskiest, and in the end, a decisive factor in design. Like the [AV-8B Harrier II](http://en.wikipedia.org/wiki/AV-8B_Harrier_II), the B's guns will be carried in a ventral pod. Whereas F-35A is stressed to 9 g, the F-35B is stressed to 7 g. Unlike the other variants, the F-35B has no landing hook; the "STOVL/HOOK" button in the cockpit initiates conversion instead of dropping the hook.

The [British](http://en.wikipedia.org/wiki/United_Kingdom) [Royal Air Force](http://en.wikipedia.org/wiki/Royal_Air_Force) and [Royal Navy](http://en.wikipedia.org/wiki/Royal_Navy) plan to use this variant to replace their [Harrier GR7/GR9s](http://en.wikipedia.org/wiki/BAE_Harrier_II). The [United States Marine Corps](http://en.wikipedia.org/wiki/United_States_Marine_Corps) intends to purchase 340 F-35Bs to replace all current inventories of the [F/A-18 Hornet](http://en.wikipedia.org/wiki/F/A-18_Hornet) (A, B, C and D-models), and [AV-8B Harrier II](http://en.wikipedia.org/wiki/AV-8B_Harrier_II) in the [fighter](http://en.wikipedia.org/wiki/Fighter_aircraft), and [attack](http://en.wikipedia.org/wiki/Ground-attack_aircraft) roles. The USMC is investigating an [electronic warfare](http://en.wikipedia.org/wiki/Electronic_warfare) role for the F-35B to replace the service's [EA-6B Prowlers](http://en.wikipedia.org/wiki/EA-6B_Prowler).

One of the British requirements was that the F-35B design should have a Ship-borne Rolling and Vertical Landing (SRVL) mode so that wing lift could be added to powered lift to increase the maximum landing weight of carried weapons.

The U.S. Marines are investigating the use of the SRVL method to operate F-35Bs from CVNs without disrupting carrier operations as the landing method uses the same pattern of approach as wire arrested landings. However the aircraft is able to "bring back" 2 x 1K JDAM, 2 x AIM-120 and reserve fuel to a vertical landing.

The F-35B was unveiled at Lockheed's Fort Worth plant on 18 December 2007, and the first test flight was on 11 June 2008. The B variant is expected to be available beginning in 2012.

**F-35C**

The F-35C carrier variant will have a larger, folding wing and larger control surfaces for improved low-speed control, and stronger landing gear and hook for the stresses of [carrier](http://en.wikipedia.org/wiki/Aircraft_carrier) landings. The larger wing area allows for decreased landing speed, increased range and payload, with twice the range on internal fuel compared with the [F/A-18C Hornet](http://en.wikipedia.org/wiki/F/A-18_Hornet), achieving much the same goal as the heavier [F/A-18E/F Super Hornet](http://en.wikipedia.org/wiki/F/A-18E/F_Super_Hornet).

The [United States Navy](http://en.wikipedia.org/wiki/United_States_Navy) will be the sole user for the carrier variant. It intends to buy 480 F-35Cs to replace the F/A-18A, B, C, and D Hornets. The F-35C will also serve as a stealthier complement to the Super Hornet. On 27 June 2007, the carrier variant completed its Air System Critical Design Review (CDR). This allows the first two functional prototype F-35C units to be produced. The C variant is expected to be available beginning in 2014. The first production F-35C was rolled out on 29 July 2009.

**Specifications (F-35A Lightning II)**

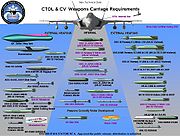
|  |  |
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| **External images** | |
| ***F-35B Lightning II cutaway illustration*** | |
|  | [Hi-res cutaway of F-35B Lightning II STOVL by](http://www.flightglobal.com/airspace/photos/militaryaviation1946-2006cutaways/images/11683/lockheed-f-35-jsf-cutaway.jpg) [Flight Global](http://en.wikipedia.org/wiki/Flight_Global), 2006. |



The first of 15 pre-production F-35s



A Pratt and Whitney F135 engine undergoes altitude testing at the [Arnold Engineering Development Center](http://en.wikipedia.org/wiki/Arnold_Engineering_Development_Center).



F-35A and F-35C armament

*Data from* Lockheed Martin specifications, F-35 Program brief, F-35 JSF Statistics

**General characteristics**

* **Crew:** 1
* **Length:** 51.4 ft (15.67 m)
* [**Wingspan**](http://en.wikipedia.org/wiki/Wingspan)**:** 35 ft (10.7 m)
* **Height:** 14.2 ft (4.33 m)
* **Wing area:** 460 ft², (42.7 m²)
* **Empty weight:** 29,300 lb (13,300 kg)
* **Loaded weight:** 44,400 lb (20,100 kg)
* [**Max takeoff weight**](http://en.wikipedia.org/wiki/Maximum_Takeoff_Weight)**:** 70,000 lb (31,800 kg)
* **Powerplant:** 1× [Pratt & Whitney F135](http://en.wikipedia.org/wiki/Pratt_%26_Whitney_F135) afterburning [turbofan](http://en.wikipedia.org/wiki/Turbofan)
  + **Dry thrust:** 28,000 lbf (125 kN)
  + **Thrust with** [**afterburner**](http://en.wikipedia.org/wiki/Afterburner)**:** 43,000 [lbf](http://en.wikipedia.org/wiki/Pound-force) (191 kN)
* **Internal fuel:** 18,480 lb (8,382 kg)

**Performance**

* [**Maximum speed**](http://en.wikipedia.org/wiki/V_speeds#Vno)**:** [Mach](http://en.wikipedia.org/wiki/Mach_number) 1.67 (1,283 mph, 2,065 km/h)
* [**Range**](http://en.wikipedia.org/wiki/Range_(aircraft))**:** 1,200 [nmi](http://en.wikipedia.org/wiki/Nautical_mile) (2,220 km) on internal fuel
* [**Combat radius**](http://en.wikipedia.org/wiki/Combat_radius)**:** 610 nmi (1,110 km) on internal fuel
* [**Service ceiling**](http://en.wikipedia.org/wiki/Ceiling_(aeronautics))**:** 60,000 ft (18,288 m)
* [**Rate of climb**](http://en.wikipedia.org/wiki/Rate_of_climb)**:** [classified](http://en.wikipedia.org/wiki/Classified_information_in_the_United_States) (not publicly available)
* [**Wing loading**](http://en.wikipedia.org/wiki/Wing_loading)**:** 91.4 lb/ft² (446 kg/m²)
* [**Thrust/weight**](http://en.wikipedia.org/wiki/Thrust-to-weight_ratio)**:**
  + **With full fuel:** 0.84
  + **With 50% fuel:** 1.04 B:
* ***g*-Limits:** 9 *g*

**Armament**

* **Guns:** 1 × [GAU-22/A](http://en.wikipedia.org/wiki/GAU-12_Equalizer) [25 mm (0.984 in)](http://en.wikipedia.org/wiki/25_mm_caliber) cannon  internally with 180 rounds
* [**Hardpoints**](http://en.wikipedia.org/wiki/Hardpoint)**:** 6× external pylons on wings with a capacity of 15,000 lb (6,800 kg) and 2× internal bays with 2 pylons each for a total weapons payload of 18,000 lb, with provisions to carry combinations of:
  + **Missiles:**
    - **Air-to-air**: [AIM-120 AMRAAM](http://en.wikipedia.org/wiki/AIM-120_AMRAAM), [AIM-132 ASRAAM](http://en.wikipedia.org/wiki/AIM-132_ASRAAM), [AIM-9X Sidewinder](http://en.wikipedia.org/wiki/AIM-9X_Sidewinder#AIM-9X)
    - **Air-to-ground**: [AGM-154 JSOW](http://en.wikipedia.org/wiki/AGM-154_JSOW), [AGM-158 JASSM](http://en.wikipedia.org/wiki/AGM-158_JASSM)
  + **Bombs:**
    - [Mark 84](http://en.wikipedia.org/wiki/Mark_84_bomb), [Mark 83](http://en.wikipedia.org/wiki/Mark_83_bomb) and [Mark 82](http://en.wikipedia.org/wiki/Mark_82_bomb) GP bombs
    - [Mk.20 Rockeye II](http://en.wikipedia.org/wiki/CBU-100) cluster bomb
    - [Wind Corrected Munitions Dispenser](http://en.wikipedia.org/wiki/Wind_Corrected_Munitions_Dispenser) capable
    - [Paveway](http://en.wikipedia.org/wiki/Paveway)-series laser-guided bombs
    - [Small Diameter Bomb](http://en.wikipedia.org/wiki/Small_Diameter_Bomb) (SDB)
    - [JDAM](http://en.wikipedia.org/wiki/JDAM)-series
    - A future nuclear weapon

**Avionics**  
[AN/APG-81](http://en.wikipedia.org/wiki/AN/APG-81)

**Differences for B and C variants**

1. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-201#cite_ref-201) B: 51.3 ft (15.6 m) C: 51 ft 6 in (15.7 m)
2. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-202#cite_ref-202) B is same span, C is 43 ft (13.1 m)
3. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-203#cite_ref-203) B is the same, C: 14.9 ft (4.54 m)
4. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-204#cite_ref-204) B the same, C: 668 ft² (62.1 m²)
5. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-205#cite_ref-205) B: 32,000 lb (14,500 kg) C: 34,800 lb (15,800 kg)
6. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-206#cite_ref-206) C is same, B: 60,000 lb (27,000 kg)
7. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-208#cite_ref-208) F-35B: 14,003 lb (6,352 kg); F-35C: 20,085 lb (9,110 kg)
8. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-210#cite_ref-210) B: 900 nmi (1,670 km); C: 1,400 nmi (2,520 km)
9. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-212#cite_ref-212) B: 500 nmi (910 km); C: 640 nmi (1,150 km)
10. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-214#cite_ref-214) B: 0.86; C: 0.77
11. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-215#cite_ref-215) 1.02; C: 0.95
12. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-216#cite_ref-216) F-35B: 7.5 *g*, F-35C: 7.5 *g*
13. [**^**](http://en.wikipedia.org/wiki/F-35_Lightning_II#cite_ref-217#cite_ref-217) fitted as an external pod with 220 rounds in the F-35B and F-35C

**Media**

|  |  |  |
| --- | --- | --- |
| X-35 video with transition to VTOL configuration, hover, take off in STOVL configuration, in-flight re-fueling, vertical hover and landing. | Test firing of F-35 gun. | Vertical landing |

**See also**

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

**Related development**

* [Lockheed Martin X-35](http://en.wikipedia.org/wiki/Lockheed_Martin_X-35)
* [F-22 Raptor](http://en.wikipedia.org/wiki/F-22_Raptor)

**Comparable aircraft**

* [Sukhoi PAK FA](http://en.wikipedia.org/wiki/Sukhoi_PAK_FA)

**Related lists**

* [List of fighter aircraft](http://en.wikipedia.org/wiki/List_of_fighter_aircraft)
* [List of active United States military aircraft](http://en.wikipedia.org/wiki/List_of_active_United_States_military_aircraft)