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Lockheed Martin/Boeing F-22 Raptor

Outlook

- Last F-22 ordered by the U.S. Air Force rolled off production line in December 2011
- Efforts in Congress to extend production failed in face of veto threat by White House
- Export prohibited by U.S. law

Orientation

Description. Twin-engine, single-seat fighter.

Sponsor. USAF Aeronautical Systems Division, Advanced Tactical Fighter Office.

Status. In production.

Total Produced. Two prototypes, nine engineering and manufacturing development (EMD) aircraft, eight

production-representative test vehicles, and 177 production aircraft through 2011.

Application. Air superiority land-based fighter / interceptor with a limited ground attack capability.

Price Range. Flyaway unit cost \$150.4 million in 2009 dollars (2009 is the last year the F-22 was procured).

Contractors

Prime

Lockheed Martin Corp	http://www.lockheedmartin.com , 6801 Rockledge Dr, Bethesda, MD 20817 United States, Tel: + 1 (301) 897-6000, Fax: + 1 (301) 897-6704, Prime
Boeing	http://www.boeing.com , 100 N Riverside, Chicago, IL 60606 United States, Tel: + 1 (312) 544-2000, Fax: + 1 (312) 544-2082, Second Prime

Subcontractor

Aerojet	http://www.aerojet.com , PO Box 1036, Highland Industrial Park, Camden, AR 71711-1036 United States, Tel: + 1 (870) 574-0610 (Forward Boom Ship Set)
Argo-Tech Corp	http://www.argo-tech.com , 23555 Euclid Ave, Cleveland, OH 44117-0798 United States,

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	Tel: + 1 (216) 692-5803, Fax: + 1 (216) 692-5293 (Fuel Boost Pumps)
BAE Systems Inc, Electronic Solutions	http://www.baesystems.com/Businesses/ElectronicSolutions/ , 65 Spit Brook Rd, Nashua, NH 03061-0868 United States, Tel: + 1 (603) 885-4321, Fax: + 1 (603) 885-2772 (ALR-94 - INEWS F-22 EW Suite; Electronic Countermeasures System with GE; Intraflight Datalink Antenna for ICNIA from Lockheed)
BAE Systems Inc, Electronic Solutions	http://www.baesystems.com/Businesses/ElectronicSolutions/ , 164 Totowa Rd, Wayne, NJ 07474-0975 United States, Tel: + 1 (973) 633-4290 (Intraflight Datalink for ICNIA from TRW)
Boeing Defense, Space & Security	http://www.boeing.com/bds/ , PO Box 516, St Louis, MO 63166 United States, Tel: + 1 (314) 232-0232, Fax: + 1 (314) 777-1096 (Wings and Aft Fuselage)
Concorde Battery Corp	2009 San Bernardino Rd, West Covina, CA 91790 United States, Tel: + 1 (626) 813-1234, Fax: + 1 (626) 813-1235 (OEM Battery)
Curtiss-Wright Corp	http://www.curtisswright.com , 10 Waterview Blvd, 2nd Fl, Parsippany, NJ 07054 United States, Tel: + 1 (973) 541-3700, Fax: + 1 (973) 541-3699 (Leading Edge Flap Actuator)
El du Pont de Nemours & Co	http://www2.dupont.com/DuPont_Home/en_US/ , 1007 Market St, Wilmington, DE 19898-0001 United States, Tel: + 1 (302) 774-1000 (High Temperature Thermoplastic Material)
Eaton Aerospace - Hydraulic Systems Division	http://www.aerospace.eaton.com , 5353 Highland Dr, Jackson, MS 39206-3449 United States, Tel: + 1 (601) 981-2811, Fax: + 1 (601) 987-5255 (Auxiliary Hydraulic Pump; Engine-Driven Hydraulic Pump)
GE - Aviation	http://www.geae.com , 1 Neumann Way, Cincinnati, OH 45215-6301 United States, Tel: + 1 (513) 243-2000 (F120-GE-100)
Goodrich Corp	http://www.goodrich.com , Four Coliseum Centre, 2730 W Tyvola Rd, Charlotte, NC 28217-4578 United States, Tel: + 1 (704) 423-7000, Fax: + 1 (704) 423-7002, Email: corporate.communications@goodrich.com (Landing Gear)
Hamilton Sundstrand	http://www.hamiltonsundstrand.com , 4747 Harrison Ave, PO Box 7002, Rockford, IL 61125-7002 United States, Tel: + 1 (815) 226-6000 (Main Engine Fuel Pump & Oil Cooler)
Harris Corp	http://www.harris.com , 1025 W NASA Blvd, Melbourne, FL 32919-0001 United States, Tel: + 1 (321) 727-9100, Fax: + 1 (321) 727-9646, Email: webmaster@harris.com (Avionics Bus Interface Module)
Helmets Ltd	Moat Factory, Wheathampstead, St Albans, AL4 81T United Kingdom, Tel: + 44 582834211, Fax: + 44 582834210 (Oxygen Mask; Lightweight Helmet; Chemical Biological Protective Hood; Goggles)
Honeywell Aerospace, Defense Avionics Systems	http://www.honeywell.com/sites/aero/Avionics_Electronics.htm , 699 Route 46, Teterboro, NJ 07068 United States, Tel: + 1 (201) 393-3924 (Advanced Integrated Maintenance System)
Honeywell Aerospace Yeovil	http://www.honeywell.com/sites/aero/ , Bunford Ln, Yeovil, BA20 2YD Somerset, United Kingdom, Tel: + 44 1935 457 181, Fax: + 44 1935 427 600, Email: sales.yeovil@honeywell.com (Integrated Breathing Regulator from Boeing; Onboard Oxygen Generator)
ITT Exelis Inc	http://www.exelisinc.com , 1650 Tysons Blvd, Suite 1700, McLean, VA 22102 United States, Tel: + 1 (703) 790-6300, Fax: + 1 (703) 790-6360 (LAU-142 Missile Rail Launcher; LAU-142/A AMRAAM Vertical Ejection Launcher)
Kaman Aerospace Corp	http://www.kamanaero.com , Old Windsor Rd, PO Box 2, Bloomfield, CT 06002-0002 United States, Tel: + 1 (860) 242-4461, Fax: + 1 (860) 243-7514 (Hat Stiffener; Gun Breech Screen)
Kavlico Corp	http://www.kavlico.com , 14501 Princeton Ave, Moorpark, CA 93021-9707 United States, Tel: + 1 (805) 523-2000, Fax: + 1 (805) 523-7125, Email: info@kavlico.com. (Linear Variable Differential Transformer)
Kidde Aerospace and Defense	http://www.kiddeaerospace.com , 4200 Airport Dr NW, Wilson, NC 27896-9643 United States, Tel: + 1 (252) 237-7004, Fax: + 1 (252) 246-7181 (Thermal Fire & Overheat Protection System with Fenwall)
Lockheed Martin Aeronautics Co	http://www.lockheedmartin.com/aeronautics/ , 86 S Cobb Dr, Marietta, GA 30063 United States, Tel: + 1 (770) 494-4411, Fax: + 1 (770) 494-6263 (Forward Fuselage; Cockpit; Display; Flight Control System Integration)
Loud Engineering &	1055 E Francis St, Ontario, CA 91761 United States, Tel: + 1 (909) 947-1313,

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Manufacturing	Fax: + 1 (909) 947-0532, Email: sales@loudeng.com (Landing Gear)
Northrop Grumman Aerospace Systems, Space Systems	http://www.as.northropgrumman.com , 1 Space Park, Redondo Beach, CA 90278 United States, Tel: + 1 (310) 812-4321, Fax: + 1 (310) 813-7548 (ICNIA)
Northrop Grumman Electronic Systems	http://www.es.northropgrumman.com , 1580-A W Nursery Rd, Linthicum, MD 21090 United States, Tel: + 1 (800) 443-9219, Email: ES_Communications@ngc.com (APG-77 with Raytheon Space & Airborne Systems)
Northrop Grumman Electronic Systems, Navigation Systems Division	http://www.es.northropgrumman.com/by_division/navigationssystemsf/ , 21240 Burbank Blvd, M/S W8, Woodland Hills, CA 91367-6675 United States, Tel: + 1 (818) 715-2470, Fax: + 1 (818) 715-3368 (Inertial Reference System [IRS])
Optical Imaging Systems Inc	1896 Barrett St, Troy, MI 48084 United States, Tel: + 1 (313) 362-2738 (Color Active Matrix LCD)
Parker Aerospace Hydraulic Systems Division	http://www.parker.com , 2220 Palmer Ave, Kalamazoo, MI 49001-4165 United States, Tel: + 1 (269) 384-3400, Fax: + 1 (269) 384-3862 (Flight Control Actuator)
Quadrax Corp	300 High Point Ave, Portsmouth, RI 02871 United States, Tel: + 1 (401) 683-6600, Fax: + 1 (401) 683-6606 (Structural Thermoplastic Composite Material)
Raytheon Space & Airborne Systems	http://www.raytheon.com/businesses/rsas , 2000 E El Segundo Blvd, El Segundo, CA 90245 United States, Tel: + 1 (310) 647-1000, Fax: + 1 (310) 647-0734, Email: SAS_Comms_PA@raytheon.com (APG-77 with Northrop Grumman Electronic Systems; Common Integrated Processor)
Rockwell Collins Inc	http://www.rockwellcollins.com , 400 Collins Rd NE, Cedar Rapids, IA 52498-0001 United States, Tel: + 1 (319) 295-1000, Fax: + 1 (319) 295-5429 (Communication & Navigation & IFF - CNI; Global Positioning System [GPS] Receiver from TRW; L-Band Receiver from TRW; UHF/VHF Transceiver from TRW; Antenna; Direction Finding Synthesizer)
SELEX Galileo Ltd	http://www.selexgalileo.com , Christopher Martin Rd, Basildon, SS14 3EL Essex, United Kingdom, Tel: + 44 1268 522 822, Fax: + 44 1268 883 140 (Digital Electronic Flight Control System; Head-Up Display [HUD]; Side-Stick Transducer)
Sierracin Corp	http://www.sierracin.com , 12780 San Fernando Rd, Sylmar, CA 91342-3796 United States, Tel: + 1 (818) 362-6711, Fax: + 1 (818) 362-0603 (Coated Canopy)

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Lockheed Martin/Boeing F-22

Source: U.S. Air Force

Lockheed Martin/Boeing F-22 Raptor

Technical Data

Design Features. The F-22A is swept-winged with blended engine intake/wing leading edge root extension. Wingtips are double clipped at the tip and outer trailing edge. Tail features twin, clipped-tip horizontal stabilizers and twin, highly canted vertical stabilizers. Incorporates advanced fiber-optic and digital electronic flight and weapon control systems. Production aircraft have 35 percent composite materials content. All weapons carried internally.

	<u>Metric</u>	<u>U.S.</u>
Dimensions		
Overall length	18.9 m	62.0 ft
Overall height (approx)	5.1 m	16.7 ft
Wing span	13.6 m	44.5 ft
Weight (estimates)		
Weight (empty)	19,700 kg	43,340 lb
Maximum takeoff weight	38,000 kg	83,500 lb
Maximum internal fuel load	8,200 kg	18,000 lb
Performance		
Maximum cruise speed w/o afterburners	Mach 1.5+	Mach 1.5+
Maximum dash speed	Mach 2+	Mach 2+
Combat radius (estimated)	2,177 km	1,350 nm
Maximum ferry range with external tanks	2,580 km	1,600 nm

Propulsion

F-22A (2) UTC Pratt & Whitney F119-PW-100 advanced turbofan engines rated 155.7 kN (35,000 lbst) each with full augmentation. Maximum dry thrust is estimated at 97.9 kN (22,000 lbst) each. Engines are equipped with two-dimensional thrust vectoring nozzles.

Armament

Normal air-to-air mission – Four AIM-120 AMRAAMs and four AIM-9 Sidewinders, or eight AIM-120 AMRAAMs. Single nose-mounted derivative of the M61A1 20mm Gatling gun. Currently, the F-22 has the ability to employ up to two 1,000-pound GBU-32 Joint Direct Attack Munitions. Aircraft with the Increment 3.1 upgrade will be able to employ the GBU-39 Small Diameter Bomb in a supersonic drop.

Accommodation

F-22A – Single-seat. The program has no two-seat variant.

Variants/Upgrades

F-22A. Lockheed froze the aircraft's design in 1992. Changes from the Dem/Val aircraft include a decrease in leading edge sweep from 48° to 42°, and a greater wingtip span to house sensors by incorporating a rearward-extended tip-clipped trailing edge.

The nose has an ogival shape, as opposed to the conical design of the YF-22A. Composite materials comprise 35 percent of the aircraft, as opposed to 23 percent for the Dem/Val aircraft.

FB-22. To meet a potential USAF requirement for an interim strike platform, Lockheed Martin has proposed

an FB-22 "regional bomber" derivative of its F-22 fighter featuring a stretched fuselage for additional fuel capacity, an enlarged weapons bay, and an all-new and much larger delta wing. The FB-22 may also be fitted with GE/Rolls-Royce F136 engines.

Several design configurations have been explored, offering various degrees of commonality with the baseline F-22. However, at least for now the USAF appears to be looking at a "clean sheet" design for a new bomber to fill the interim strike requirement.

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Program Review

Background. The Lockheed F-22A is the USAF's next-generation air superiority fighter. It has much greater range, payload, time on station, and agility than the F-15 and F-16, and is the first fighter developed from the outset for the maximum capability to detect, target, and kill opposing aircraft at beyond-visual ranges while having the ultimate in close-in dog-fight capabilities. No other aircraft has this combination of characteristics.

Program Criticized on Costs, Delays

The program has come under increasing scrutiny, primarily due to cost overruns and schedule slippage, and in 2002, both the Lockheed Martin and USAF management teams were replaced. Escalating costs were blamed on a fin buffet problem and avionics instability. These problems led to an extension of the aircraft's development phase and to a further reduction in the planned acquisition to 277 units.

Design Fixes Implemented

In late 2003, the Air Force stated that the fin buffet problem had been resolved and that the avionics instability issues were being cleared up.

The aircraft entered its initial operational test and evaluation phase in April 2004, and completed it in September. Initial Operational Capability was achieved in December 2005.

Program Cut

In December 2004, the DoD cut the planned F-22 procurement from 277 to 175 production-standard aircraft, of which 116 had been procured through FY06. In its FY07 budget documents, the Air Force requested a multiyear buy of 20 aircraft in each of fiscal years 2008, 2009, and 2010, which Congress later approved.

Structural Flaws Reported

In mid-2006, the Air Force began a \$1 billion structural retrofit program to address issues with the mid-fuselage, wing leading edge, forward and aft booms, and engine bay. According to the USAF, these were not design flaws, but rather faulty manufacturing processes on the part of one or more subcontractors.

The F-22 reached Full Operational Capability in December 2007. Reaching that milestone means F-22 squadrons are now fully combat-ready and can be deployed for global engagements. A series of upgrades are planned to bring a large portion of the first 100 aircraft produced to a multirole configuration common with aircraft produced subsequently.

At the end of its production run, the F-22 line will have turned out 37 Block 10 F-22s, which includes production-representative test vehicles, and which are not combat-coded. The combat-coded portion of the F-22 fleet includes two groups of aircraft: 63 Block 30 and 87 Block 35 aircraft. The Block 30 aircraft are to receive the Increment 3.1 capability upgrade, which includes, among other modifications, addition of an air-to-ground and electronic attack mode for the APG-77 radar and integration of the GBU-39 Small Diameter Bomb. The F-22 will be able to carry eight SDBs, but the pilot will only be able to employ two at a time.

The Block 35 aircraft will get, in addition to the 3.1 upgrade, the Increment 3.2 package, which adds integration of the Raytheon AIM-120D and AIM-9X air-to-air missiles, an automatic ground collision avoidance system, and a multifunction advanced datalink. It is possible that the Air Force will eventually upgrade all combat-coded aircraft to the Block 35 standard.

Future upgrade programs will depend on securing funding and overcoming whatever technical issues arise.

Fleet Grounded

Flight operations of the F-22 fleet were suspended on May 3, 2011 as a safety precaution after 12 separate reported incidents where pilots experienced hypoxia-like symptoms during flight. The U.S. Air Force said the incidents occurred over a three-year period beginning in April 2008.

During the flying ban, the Air Force instituted a series of inspections, training on life support systems, and continued data collection to mitigate the risk of flying the aircraft with an oxygen generating system that officials worried could be flawed.

Related News

Pentagon to Spend \$7.4 Billion Upgrading F-22 Fleet – The U.S. Department of Defense awarded a new \$7.4 billion contract to upgrade its fleet of F-22 fighters to Lockheed Martin Corp. The contract announcement did not specify the systems that will be upgraded, but rather spoke broadly of upgrades to existing requirements,

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incorporating changes to meet new DoD requirements, adding capabilities, and enhancing performance of the aircraft. The new contract is not in addition to earlier modification/retrofit contracts, but rather supersedes them with a new, broader contract. (U.S. Department of Defense, 11/11)

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Funding

U.S. FUNDING

	FY09 QTY	FY09 AMT	FY10 QTY	FY10 AMT	FY11 QTY	FY11 AMT	FY12 (Req) QTY	FY12 (Req) AMT
F-22 Proc.	24	3,497.8	0	93.2	0	158.0	0	104.1
Adv. Proc.		138.6		0.0		0.0		0.0
Mods		322.5		176.7	0	492.2	0	232.0
PE#0604239F		-		-		-		
PE#0207138F (RDT&E)		579.7		559.5	0	576.3	0	718.4
Total	24	4,538.6	0	829.4	0	1,226.5	0	1,054.5

All \$ are in millions.

Note: FY09 advance procurement does not include funds obligated by congressional authorization in later budget action. Funding for four Raptors under the FY09 supplemental funding bill is also not included. RDT&E line PE#0207138F covers research and development for modifications to the aircraft. Advance procurement spending for FY09 applies to four Raptors in FY09 supplemental.

Contracts/Orders & Options

Contractor	Award (\$ millions)	Date/Description
Lockheed Martin	7,400	Nov 2011 – Contract raising price ceiling of existing Raptor Enhancement Development and Integration contract to \$7.4 billion from prior, unspecified price limit. The REDI contract was signed in 2002 and covers system upgrades to existing requirements, add new capabilities, and enhance performance. The new contract was needed to allow upgrades in FY12.
Lockheed Martin	7.2	Oct 2011 – Contract modification for the F-22 structural maintenance and repair team.
Lockheed Martin	24.4	Sep 2011 – Contract modification for the F-22 program to provide sustained engineering and depot partnering task associated with non-destructive inspection organic capability, hypoxia root cause analysis, titanium crack growth, site activation, slider seals, and radar cross section turntable.
Lockheed Martin	726.6	Feb 2011 – Contract modification for the calendar year 2011 sustainment of F-22 aircraft.
Lockheed Martin	15.2	Oct 2010 – Contract modification for procurement of the installation of reliability and maintainability maturation program and engineering change proposals on the fielded F-22 aircraft.
Lockheed Martin	568.5	Mar 2010 – Contract to provide incremental funding for the original F-22 weapons system undefinitized contract action modification awarded on Dec 15, 2009 to authorize and fund the Structural Retrofit Program II and the Reliability and Maintainability Maturation Program.
Lockheed Martin	N/A	Nov 2008 – Lot 10 advanced procurement contract for four F-22s, with option for an additional 16 aircraft.
Lockheed Martin	5,049.7	Jul 2007 – Multi-year, firm-fixed-price contract with economic price adjustment and cost-plus-fixed-fee contract modification for 60 aircraft covering Lots 7, 8, and 9. Work was to be completed by 2011.

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Contractor	Award (\$ millions)	Date/Description
Lockheed Martin	1,046.2	Nov 2006 – Firm-fixed-price contract modification to cover the cost of 23 F-22 aircraft and one F-22 replacement test aircraft. This award supported the F-22 Lot 6 full production contract. Work was to be completed by 2010.

N/A = Not Available

Timetable

Month	Year	Major Development
Nov	1981	MENS approved by Defense Resource Board
Sep	1983	Technology and concept development contracts awarded
Oct	1986	Lockheed, Northrop awarded demonstration/validation contracts
Sep	1990	First flight of YF-22
Dec	1990	Completion of dem/val
Apr	1991	Lockheed/General Dynamics/Boeing/Pratt & Whitney selected to build ATF
Aug	1991	EMD contract issued
Sep	1997	Prototype first flight
Aug	2001	Low-rate production decision
Jan	2003	First production delivery
Mar	2005	Full-rate production decision
Dec	2005	Initial Operational Capability
Dec	2007	Full Operational Capability
Dec	2011	Final F-22 rolls off production line
	2012	Projected final deliveries

Worldwide Distribution/Inventories

Operator	Designation	Quantity
United States Air Force	F-22	185

Forecast Rationale

The last F-22 Lockheed Martin built for the U.S. Air Force rolled off the manufacturer's Marietta, Georgia assembly line in the middle of December, 2011. The U.S. Air Force will take delivery of the last F-22 in 2012, but by that time the production line will already be silent.

The service procured its last aircraft in the FY09 budget, and the Obama administration opposes any extension of F-22 production, arguing that the threats facing the U.S. military could be addressed by the current program requirements and the addition of the Lockheed Martin F-35 Lightning II/Joint Strike Fighter to the Air Force's fleet over the long term.

There was little public outrage over the decision that the F-22 program be discontinued when it was announced

in April 2009. The F-22 suffers from the public's perception that it is too expensive and that the F-35 will be a cheaper substitute. Combat operations in Iraq and Afghanistan did not require the use of the F-22's stealth or advanced air-to-air capabilities. Older designs in the U.S. arsenal – the F-16s, F-15Es, and F/A-18s – were better equipped for ground-support missions than the new F-22. The F-22 had a substantial constituency in Congress that supported its further production, but the political momentum was with the administration.

The Pentagon already has an expensive upgrade program underway to add various capabilities to the F-22 fleet in service. These aircraft will serve as a "silver bullet" force used on the opening days of future conflicts to attain air superiority and hit high value targets.

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New stealth designs in development in Russia and China have raised the question of whether F-22 production should be restarted, but there is no chance of that happening. Any effort to restart production would lead to a push to substantially redesign the F-22 to update its avionics architecture and add new systems featuring technology developed for the F-35. Projected costs would skyrocket, and the idea would be shelved.

According to the General Accountability Office (GAO), the estimated total cost of the program as of early 2011 was \$77.4 billion, including \$39.2 billion in research and development costs and \$37.6 in procurement costs.

Federal law prohibits export of the F-22, so there are no export orders for the aircraft. Even if the ban was lifted, the potential market for the aircraft is small due to the aircraft's high cost and limited multirole capabilities. Japan and Israel have both expressed serious interest in acquiring the F-22, but the only movement from the U.S. side has been to offer the possibility of a stripped-down "export" version of the aircraft that would lack some of the capabilities that most interest the two nations.

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