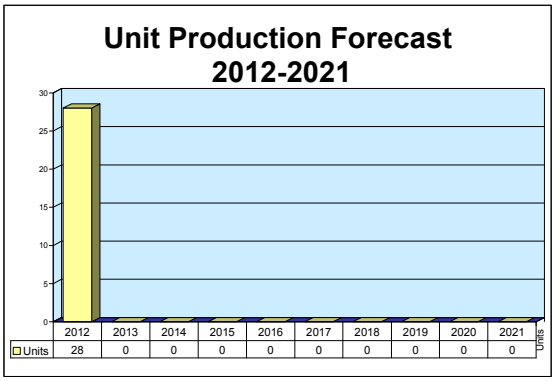
Pratt & Whitney F119

Outlook

- Last spare F119 expected to be delivered in late 2012
- USAF to buy out F119 production tooling
- Total engine production estimated at 500, including spares



Orientation

Description. Twin-spool, low-bypass-ratio, augmented military turbofan engine of approximately 35,000 lbst (155.7 kN).

Sponsor. The U.S. Department of Defense, Washington, DC, through the U.S. Air Force, Air Force Materiel Command, Aeronautical Systems Center, and Wright-Patterson AFB, Ohio, is the sponsor of F119/ATFE RDT&E and hardware fabrication/testing.

Application. Military fighter/attack aircraft.

Power Class. 35,000 lbst (155.6 kN) class, with full augmentation. Maximum dry thrust is approximately 22,000 lbst (97.8 kN).

Status. In production for the F-22.

Total Produced. As of February 2012, an estimated 472 F119 engines were built.

Model Variant	Thrust Rating	Application	Units per Airframe
F119-PW-100	35,000 lbst (155.6 kN)	Lockheed Martin F-22 Raptor	2

Price Range. Estimated in 2012 dollars at $9-$10 million.

Competition. Outside the Russian Federation, the only other combat aircraft engines within the F119's thrust class are the Pratt & Whitney F100 and the General Electric F110-GE-132, both of which are a generation behind the F119 technologically, despite their potential to equal F119's augmented thrust level with further development.

In the Russian Federation, engines that compete with the F119 are the Aviadvigatel D-30F6 at about 34,170 lbst (151.9 kN) and the Saturn Al-41F at about 44,000 lbst (195.7 kN).

Contractors

Prime

Pratt & Whitney	http://www.pratt-whitney.com, 400 Main St, East Hartford, CT 06108 United States, Tel: + 1 (860) 565-4321, Email: info@pw.utc.com, Prime

Pratt & Whitney F119

Subcontractor

ABA Industries Inc	http://www.herouxdevtek.com, 10260 US 19 N, Pinellas Park, FL 33782-3416 United States, Tel: + 1 (727) 546-3571, Fax: + 1 (727) 545-9003 (Convergent Flap)
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)
Honeywell Aerospace	http://www.honeywell.com/sites/aero/, 717 N Bendix Dr, South Bend, IN 46620 United States, Tel: + 1 (574) 231-3000 (Engine Control)
Howmet Castings, Corporate Machining	http://www.alcoa.com, 145 Price Rd, Winsted Industrial Park, Winsted, CT 06098 United States, Tel: + 1 (860) 379-3314, Fax: + 1 (860) 379-4239 (Blade, Stage 1 LP)
Precision Castparts Corp	http://www.precast.com, 4650 SW Macadam Ave, Suite 440, Portland, OR 97239-4262 United States, Tel: + 1 (503) 417-4800, Fax: + 1 (503) 417-4817, Email: info@precastcorp.com (Turbine Blade Casting - Stages 1 & 2)
Semco Instruments Inc	11505 Vanowen St, North Hollywood, CA 91605 United States (Exhaust Gas Temperature & Pressure Sensor)
Unison Engine Components - Terre Haute	http://www.unisonenginecomponents.com, 333 S Third St, Terre Haute, IN 47807 United States, Tel: + 1 (812) 234-1591, Fax: + 1 (812) 235-5210 (Transition Duct)
Unison Industries	http://www.unisonindustries.com, 7575 Baymeadows Way, Jacksonville, FL 32256 United States, Tel: + 1 (904) 739-4000, Fax: + 1 (904) 739-4093 (Igniter Plug)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call + 1 (203) 426-0800.

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Design Features

Fan. The three-stage fan has wide-chord unshrouded hollow fan blades. It is diffusion-bonded from machined titanium halves, which are linear-friction welded to the disk just prior to final machining. The fan pressure is estimated at 4:1; the bypass ratio is estimated at 0.45:1.

Compressor. The engine's six-stage axial-flow design features low-aspect, high-stage-load compressor blades. Overall pressure ratio estimated at 35:1. The engine has Alloy C high-strength, burn-resistant titanium compressor stators.

Combustor. A single, fully annular combustor that uses FloatWall™ technology for improved structural integrity and cooling. The FloatWall combustor features thermally isolated panels of oxidation-resistant, high-quantity cobalt material.

HP Turbine. A single-stage high-pressure turbine with single-crystal blades.

LP Turbine. A single-stage low-pressure turbine that rotates in the opposite direction of the HP turbine.

Nozzle. A two-dimensional vectoring convergent / divergent nozzle is standard. Alloy C is used for the nozzle. The nozzle vectors thrust 20° up and down for improved aircraft agility. The nozzle is manufactured at P&W's West Palm Beach facility.

Accessories. An advanced fourth-generation Full Authority Digital Engine Control (FADEC) system is standard (dual-redundant digital engine controls – two units per engine, two computers per unit).

Dimensions. Approximate dimensions and weight of the F119:

	Metric Units	U.S. Units
Length	4,826 mm	190 in
Diameter	1,143 mm	45 in
Weight, dry	1,360 kg	3,000 lb

Performance. Other than the augmented thrust rating, the F119's performance parameters have not been released.

Pratt & Whitney F119

F119-PW-100

Source: Pratt & Whitney

Variants/Upgrades

F119-PW-100. In October 1983, General Electric and Pratt & Whitney signed 50-month, $202.75 million contracts to develop demonstrator engines for the advanced tactical fighter (ATF) program, renamed the Joint Advanced Fighter Engine (JAFE) program. The F119-PW-100 engine was developed under this program.

The Pratt engine was designated the PW5000 internally by P&W, and the F119 by the USAF. It is a conventional, twin-spool turbofan incorporating advanced materials, with a much lower parts and stage count (3+6+1+1) than its F100 predecessor (3+10+2+2); it also features digital electronic engine control. Pratt & Whitney was selected for full-scale development on the same day the Lockheed team was awarded the ATF work in April 1991.

CAESAR. An F119 variant called CAESAR (Component and Engine Structural Assessment Research) is being collectively developed by P&W, Wright Laboratories, and the F-22 System Program Office. CAESAR is being created for high-endurance testing of advanced engine technologies. The demonstrator features an F119 core shell made up of the F119's HP compressor, combustor, and HP turbine. Several components are scheduled to be tested under this program. Among them are the compressor blades, which contain varying mixes of gamma-titanium-aluminide alloy made by P&W, Allison, GE, and Rolls-Royce. The material, not the aerodynamics, is the focus in this case, with the goal of engine weight reduction. Advanced HP turbine components will also be tested, including vanes made of Allison's Lamilloy material, as well as P&W's Super Vane and Super Blade cooling techniques. In addition, an F119 fan and nozzle could eventually be used in the program. Other components that could be tested include an advanced aerodynamic fan and spherical convergent flap nozzle (SCFN) configuration to boost engine performance and reduce fuel consumption.

The CAESAR program was formally launched in 1992. Core tests were conducted at the Arnold Engine Development Center in 1996 and 1997. P&W received a $13.5 million contract from the Air Force in 1992, but Pratt also intended to make a large private investment in the program.

SE614. The SE614 is a roughly 33,000-35,000 lbst (146.8-155.7 kN) F119 derivative of the Lockheed Martin JSF demonstrator. The engine's enlarged two-stage fan drives a shaft-linked lift-fan system operated by a clutch and a bevel gearbox. With an additional stage, the fan is also driven via a shaft to the low-pressure turbine. Main-engine, fan-bleed air runs the Rolls-developed low-speed, roll-control exhaust nozzles outboard on each wing. Additional air for the JSF119 is provided during lift operation through an inlet that opens behind the liftfan doors atop the fuselage.

Two SE614 models were produced for demonstration: the JSF119-614C for Lockheed Martin's CTOL JSF variant and the JSF119-614S for Lockheed Martin's V/STOVL JSF variant.

SE611. This is a 35,000-lbst (155.7-kN) F119 derivative engine for the Boeing JSF demonstrators; its fan has been enlarged by 20 percent to boost airflow. The low-pressure section is completely redesigned from the F119-PW-100 standard, with one additional stage added to the low-pressure turbine to drive the bigger fan.

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The two SE611 models produced for demonstration were the JSF119-611C for Boeing's conventional takeoff and landing (CTOL) JSF variant, and the JSF119-611S for Boeing's vertical short takeoff and landing (V/STOVL) JSF variant.

XTE-66. Pratt & Whitney began test-running the XTE-66 prototype of its PW7000 next-generation fighter engine in February 1999. The XTE-66 is to be used as the basis for growth of the F119 engines used on the F-22 and JSF. The XTE-66 is based on the XTC-66 core, which was successfully demonstrated in 1998 under the Advanced Technology Engine Gas Generator segment of the U.S. DoD's Integrated High Performance Turbine Engine Technology (IHPTET) effort.

The twin-spool XTE-66 has an advanced two-stage fan and a vaneless LPT that rotates opposite the core. The HP spool rotates at up to 22,000 rpm in one direction, while the LP spool turns at 10,000 rpm in the opposite direction. The net result is expected to be a 50 percent thrust-to-weight improvement over the F119.

Program Review

Background. As a part of the U.S. Air Force's Advanced Tactical Fighter (ATF) program, the Advanced Technology Fighter Engine (ATFE) program was intended to provide the most advanced, cost-effective, mission-effective powerplant for next-generation USAF fighter aircraft.

Goals of the ATFE project were initially set as:

- Sustained supersonic cruise speed
- STOL capability
- Stealth, or reduced infrared and radar signatures
- Reduction in life-cycle costs of at least 25 percent
- Reduction in parts count from present-day fighter engines of 40-60 percent
- Increase in thrust-weight ratio of 20 percent
- Three-fold increase in durability
- Improvement in parts life over current engines

Among other goals of the USAF project was a 30-50 percent reduction in fuel flow at dry supersonic cruise thrust. That capability will translate to an 8-10 percent reduction in specific fuel consumption (SFC). The dry SFC is expected to be approximately 0.61 lb/hr/lbst (17.28 mg/Ns), and maximum SFC, 2.35 lb/hr/lbst (66.57 mg/Ns).

The technology base of the ATFE comprises various USAF engine programs under the overall IHPTET umbrella, including the Advanced Technology Engine Gas Generator (ATEGG), Aircraft Propulsion Subsystem/System Integration (APSI), Joint Turbine Advanced Gas Generator (JTAGG), Modern Technology Demonstrator Engine (MTDE), and Advanced Turbine Technology Applications Program (ATTAP), as well as RDT&E done by the USAF and USN.

Design Program. Pratt's F119-PW-100 engine is a straightforward design turbofan with a bypass ratio of 0.2:1, a minimum determined by the desired augmentation ratio and need to cool the afterburner. It will employ a dual-redundant Full Authority Digital Engine Control (FADEC) system. While GE took a somewhat unorthodox design approach, Pratt chose to concentrate on such concepts as simplicity, durability, and maintainability.

P&W and GE worked on what is now called the "shingled combustor." Pratt's designation for the high-temperature-capable burner is FloatWall. Static hot section parts in both demonstrator combustors are made of ceramic or carbon/carbon materials with ceramic material turbine high-pressure seals. Single-crystal blades and vanes are used in the turbine sections. Pratt may have also used eutectic materials in the turbine section of its engine, and ceramics in non-rotating seals and some non-structural components as well. HIP-ed powder metal materials may have also been employed in the manufacture of both engines' turbine blades.

The F119 and F120 feature two-dimensional, convergent/divergent nozzles with thrust reverse capability. The F119 uses Rapid Solidification Rate Plasma Deposition components and new nickel-titanium materials in turbine discs. Augmenter liners and nozzles are made of graphite/polymide, or carbon/carbon materials. The GE F120 engine is a variable-cycle unit. It has triplex-redundant, full-digital electronic control.0

Lockheed/Boeing F-22 ATF Program. Two teams, Lockheed/General Dynamics/Boeing and Northrop/McDonnell Douglas, responded to the USAF's call for teaming arrangements on the Advanced Tactical Fighter effort. Both aircraft had an approximate T-O weight of 50,000 pounds (22,680 kg), a combat radius of 1,350 nautical miles (2,177 km), and a maximum dash speed of 1,700 knots (3,148 km/h). Each of the contractor teams fabricated three demonstration / validation (dem/val) aircraft. One aircraft from each team was rolled out in the June-July 1990 timeframe. The Lockheed team's aircraft prototype was designated

the YF-22A, and the Northrop team's aircraft was designated the YF-23A.

Both the YF119-powered YF-23 prototype and the YF120-powered YF-22 made their initial flights in September-October 1990.

In April 1991, the Lockheed-led team won the competition, with the production-standard model designated F-22A; P&W won the engine competition.

Lockheed froze the design of the F-22 in December 1992 after several structural changes. Composite materials make up 35 percent of the aircraft, as opposed to 23 percent for the dem/val aircraft. The single-seat aircraft's T-O weight is now 60,000 pounds (27,216 kg); the aircraft has a maximum speed of Mach 2.5+ and a combat radius of 1,350 nautical miles (2,177 kg).

The FB-22 is an unofficial designation of the in-house version studied by Lockheed but not yet approved by the USAF. The FB-22 would have a 30 percent structural and 90 percent avionics commonality with the F-22. The aircraft variant would have triple the range and ordnance payload, and feature a fuselage plug. While seemingly an appealing aircraft model, it has not attracted any DoD interest.

Initial plans for production of a two-seat, F-22B operational conversion aircraft were shelved in July 1996.

The USAF initially sought 750 ATF aircraft to replace its McDonnell Douglas F-15s. But due to budget cuts and force reductions, the number of aircraft needed has steadily fallen, dropping from 648, then to 438, and finally to 339 aircraft in 1997 after the Quadrennial Review. The total then dropped to 276 F-22 aircraft – enough, it was thought, to allow the USAF to extend the testing program aimed at solving its software abnormalities while remaining under the production cost cap imposed by Congress.

However, at the end of December 2004, the trade and lay press began reporting a DoD-approved proposal to cut F-22 procurement back to 180 aircraft. The White House was urging all agencies to cut spending requests from the FY06 budget because of mounting deficits and the uncertain costs of continuing operations in Iraq. To this end, production was capped at 187 aircraft, and the last airframes and engines are expected to be produced in 2012.

The USAF awarded Boeing and Lockheed Martin funding in 1995 to identify F-22 variations. The companies identified Suppression of Enemy Air defense (SEAD), reconnaissance/surveillance, and strategic attack/interdiction versions as reasonably simple F-22 variant possibilities. The manufacturers have also held talks with the DoD in hopes of obtaining clearance to offer an export version, primarily for current overseas F-15 operators.

Other Applications. The USAF, operating without a seemingly serious funding limitation, has been searching for an inexpensive aircraft/air vehicle with fast global attack capability.

Possible airframes that have been mentioned are a new, much larger unmanned combat aircraft, and a version of the venerable B-1 Bomber – re-engined with F119s – that could attain a Mach 2.0+ speed. The service has expressed interest in designs for an interim capability. The plan would be to attain Initial Operational Capability by 2015 and Full Operational Capability by 2020.

Meanwhile, Boeing has come forth with a unique offering: a B-1R (i.e., a B-1 "regional") model equipped with F119 engines, which would allow the aircraft to fly at Mach 2.0 while achieving a combat mission radius of 3,000 nautical miles.

Funding

Funding for the F-22 engine is included in PE#0604239F, F-22 EMD, Project 4069, Advanced Tactical Fighter FSD.

U.S. FUNDING

	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT	FY09 QTY	FY09 AMT
RDT&E								
PE#0604239F Total Program	-	341.7	-	427.4		743.5		666.8
Procurement								
Aircraft Procurement: Engine Accessories, Shipsets	-24	19.5	-29	20.3	20		20	

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	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT	FY09 QTY	FY09 AMT
Modification (P-1M)								
F22014 F119 Engine Modification	-	12	-	39.7		33.7		27.0

Note: Amounts are in millions of 2005 dollars.

The USAF identifies the following data in its February 2006/2007 budget estimates for **Aircraft Procurement** (Air Force, Volume II, Budget Activity 01, Combat Aircraft, Item No. 02, P-1 Line Item Nomenclature: F-22 (Raptor)). Note that engine totals and unit costs are for single engines.

F119 ENGINE PROCUREMENT

Engine Quantity	Unit Cost ($ millions)	RFP Issue Date	Award Date	Date of First Delivery
4	14.125	Dec 1997	Dec 1998	Feb 2001
20	10.853	Jan 1999	Sep 2001	Mar 2002
26	10.547	May 2000	Jan 2002	Mar 2003
42	10.630	Nov 2001	Apr 2003	Mar 2004
44	10.408	Aug 2002	Nov 2003	Mar 2005
48	10.470	Aug 2003	Nov 2004	Mar 2006
48	10.391	Oct 2005	Apr 2007	Mar 2007
58	10.910	Oct 2006	Apr 2007	Mar 2008

USAF data for **Engine Modification** are identified in February 2006/2007 budget estimates for Aircraft Procurement (Air Force/Aircraft Modifications, P-1 Item Nomenclature: F-22).

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
P&W	1,300.0	Jul 2007 – A $1.3 billion contract to provide F119 engines for 60 F-22 Raptor fighters, bringing the total aircraft buy to 183. The engine contract was for deliveries in 2008, 2009, and 2010.
P&W	599.6	May 2005 – Firm-fixed-price (FFP) contract to provide 42 LRIP F119 engines and field training to support F-22 LRIP. At the time, $512.7 million of the funding had been obligated. Work was completed by Jan 2006. USAF Aeronautical Systems Center, Wright-Patterson AFB, OH, was the contracting agency. (F33657-02-C-2011)
P&W	10.0	Mar 2005 – FFP and cost-plus-fixed-fee contract to provide for advance procurement of 48 Lot 6 F119 engines and associated equipment. At the time, $4,185,496 of the funding had been obligated. Work was completed by Jan 2008. USAF Aeronautical Systems Center, Wright-Patterson AFB, OH, was the contracting agency. (FA8611-05-C-2851)

Timetable

Month	Year	Major Development
Nov	1981	Mission Element Need Statement approved by Defense Resources Board
Sep	1983	USAF awards GE and P&W 50-month development contracts
4Q	1985	GE37, PW5000 component tests
2Q/3Q	1986	GE37 designated YF120 by USAF; PW5000 designated YF119 by USAF
Oct	1986	First Pratt demonstrator engine tested
May	1987	First GE demonstrator engine tested
May	1988	GE 2-D nozzle thrust vectoring demonstrated
1Q	FY89	Preliminary Design Review of development engines (Milestone II)
Jul	1989	First sea-level test of F119

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Month	Year	Major Development
End	1989	First prototype engines delivered to USAF
Aug	1990	P&W-powered YF-23A makes initial flight (August 27)
Nov	1990	P&W-powered YF-22A makes initial flight
Apr	1991	F119-powered YF-22A chosen as USAF ATF winner
	FY92	Termination of naval ATF program
Feb	1993	P&W starts F119-100 ground tests
Jul	1996	First F119 flight-test engine completed
Mar	1997	Preliminary Design Review of JSF119
Jun	1997	First flight of F-22A with F119 EMD engine
Nov	1997	USAF Critical Design Review of JSF119
Jun	1998	Initial testing of SE611 and SE614 JSF engines
Oct	1999	USAF certification of F119-PW-100; P&W/Rolls-Royce sign MoA for Rolls' STOVL lift system for JSF119
Oct	2001	F-22 EMD contract awarded
Mar	2003	Support System Release approval granted by USAF
	2005	F-22 high-rate production decision
Dec	2004	Plan announced to shrink the F-22 program to 180 aircraft
Dec	2005	F-22 FOC planned
Jul	2007	P&W awarded $1.3 billion contract to produce engines for 60 F-22 fighters
	2014	Projected end of F119 production

Worldwide Distribution/Inventories

As of February 2012, an estimated 472 F119-PW-100 engines were built. All engines are assumed to be in service and in the inventory of the **U.S.** regardless of their military end-use location worldwide.

Forecast Rationale

With production completed on Lockheed Martin's F-22 Raptor fighter, Pratt & Whitney has no other applications for the F119 and will produce the remaining 28 of 39 total spare engines in 2012 for the U.S. Air Force. The last of these engines is expected to be built in November 2012, after which the line will transition to sustainment of the 500 or so F119s built for the USAF.

A contract for production shutdown will be awarded in April 2012; subsequent to that, the USAF will take possession of all production tooling. Pratt will keep tooling necessary for sustainment purposes to support the 500 or so engines built for the F-22 fleet.

Japan had been a potential customer for the F-22, but technology transfer restrictions from the U.S. Congress meant the Japanese F-22 would not have the same capabilities as the U.S. model. This fact may have influenced Japan's decision to purchase the Lockheed Martin F-35, which was announced in December 2011.

Overall, we estimate F119 production at 28 engines during the 10-year forecast period.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence			Speculative			
	Thru 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Pratt & Whitney												
F119 -PW-100 Military <> United States <> F-22												
Note: 2012 spares production												
	11	28	0	0	0	0	0	0	0	0	0	28
Total	11	28	0	0	0	0	0	0	0	0	0	28