

# F-22 Raptor

The history of the one and only  
active fifth generation fighter aircraft

By

CODE ONE



**Pratt & Whitney**  
A United Technologies Company

# Part 1

## **From ATF (Advanced Tactical Fighter) to Raptor 01 first flight**

Cheers went up from the several hundred engineers, designers, team members, mechanics, and Air Force officials watching from the ramp—plus the 5,000 or so interested people looking on from behind the fence at the end of the runway—as Raptor 4001, the first F-22 air dominance fighter, took to the skies for the first time on 7 September 1997.

Vinny Devino, who had led the effort to refine the design of the Raptor from the prototype YF-22 to the production F-22A, said what many people were thinking: “The F-22 is flying. Everything else is now a target.” The first flight was the dawn of a completely new generation of fighter aircraft—one that is stealthy, maneuverable, and lethal. A long road led to that Sunday morning flight in 1997. The US Air Force identified a requirement in 1981 for a new air superiority fighter to replace the F-15 which then had been in service for just seven years.

The competitors in the Advanced Tactical Fighter competition were selected on Halloween in 1987. The YF-22 and YF-23 prototypes were flown in 1990, and the Lockheed-Boeing-General Dynamics team won the ATF contest in 1991.

After nearly 44,000 wind tunnel test hours, 13,000 material sample tests, six years of development, and a trio of program rephasings mandated by Congress, the F-22 was finally airborne.

Wearing his lucky Super Chicken T-shirt under his flight suit, chief test pilot Paul Metz pulled the Raptor’s nose up and quickly gained speed and altitude, even with the landing gear down. Jon Beesley, flying the safety chase aircraft, put his F-16 in afterburner to keep up with the Raptor.

After two circuits on a triangular route around north Georgia, Metz touched down fifty-eight minutes later. As he rolled up the taxiway, he turned the jet slightly, tapped the brakes, and the jet bowed to the appreciative crowd. The maiden flight was the first of 3,496 flights and 7,616 test hours to come in the F-22’s engineering and manufacturing development phase. The Air Force would declare the F-22 operational in 2005.

This first half of a two-part F-22 chronology covers the major program events from those first studies to that first flight in 1997. The second half, which will appear in the next issue, will cover the test program and history of the Raptor through the delivery of the final F-22 Raptor 195 to the US Air Force.

## Time line

### 1981 – 1997

#### 1981

November: US Air Force formally identifies a requirement for a new air superiority fighter to replace the F-15.

#### 1983

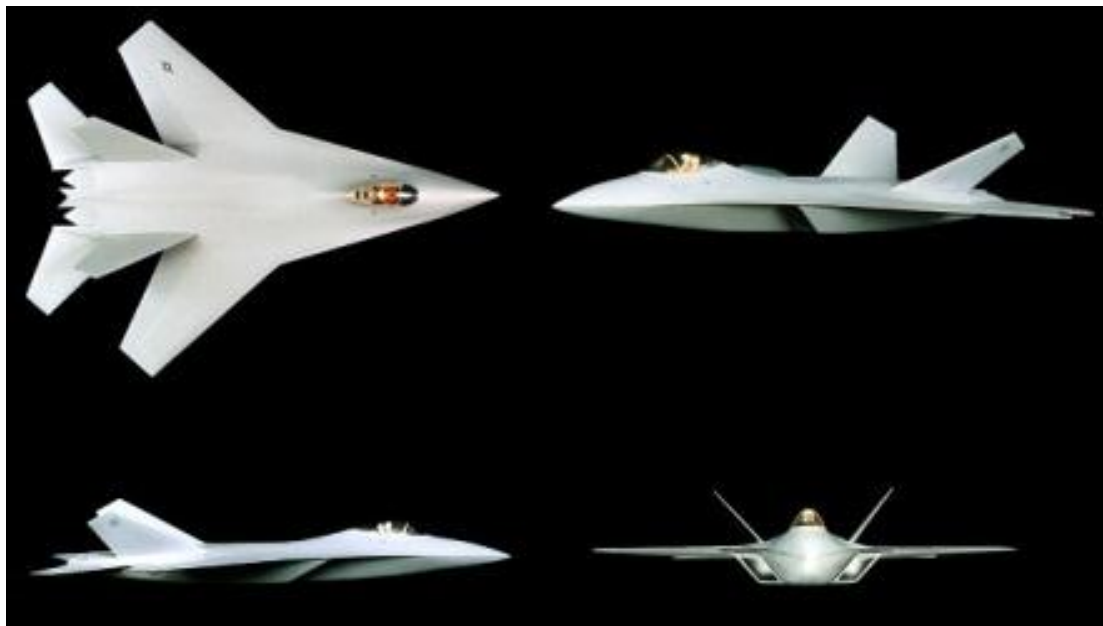
May: Pratt & Whitney initiates design of the PW5000 engine, later designated F119.

September: US Air Force awards concept definition contracts to seven aircraft manufacturers for the Advanced Tactical Fighter. Engine demonstration/validation, or dem/val, contracts are awarded to Pratt & Whitney and General Electric.

#### 1985

September: US Air Force issues the formal ATF request for proposal.  
Pratt & Whitney fabricates the first YF119 engine parts.

October: The Lockheed proposal design configuration is frozen (Model 090P).



*The Lockheed proposal design configuration is frozen. The associated design, called Model 090P, had a streamlined nose, trapezoidal wing planform with positive sweep on both the leading and trailing edges, and four tail surfaces (two horizontal and two vertical). The large vertical tails were canted outwards. The leading and trailing edge sweep angles of all of the surfaces were aligned at common angles. The design had a wide strake that ran in a straight line from the wing leading edge outboard of the inlets to the point of the nose*

November: US Air Force issues more stringent stealth goals for the ATF designs.

## 1986

May: Secretary of the Air Force Edward Aldridge announces that the ATF dem/val phase must include prototype aircraft, engines, and avionics as a result of guidelines established by the Packard Commission, the federal government commission created to study several areas of management functionality within the Department of Defense.

June: US Air Force awards contracts to Pratt & Whitney and General Electric for the ATF prototype engines, which are designated YF119-PW-100 and YF120-GE-100, respectively.

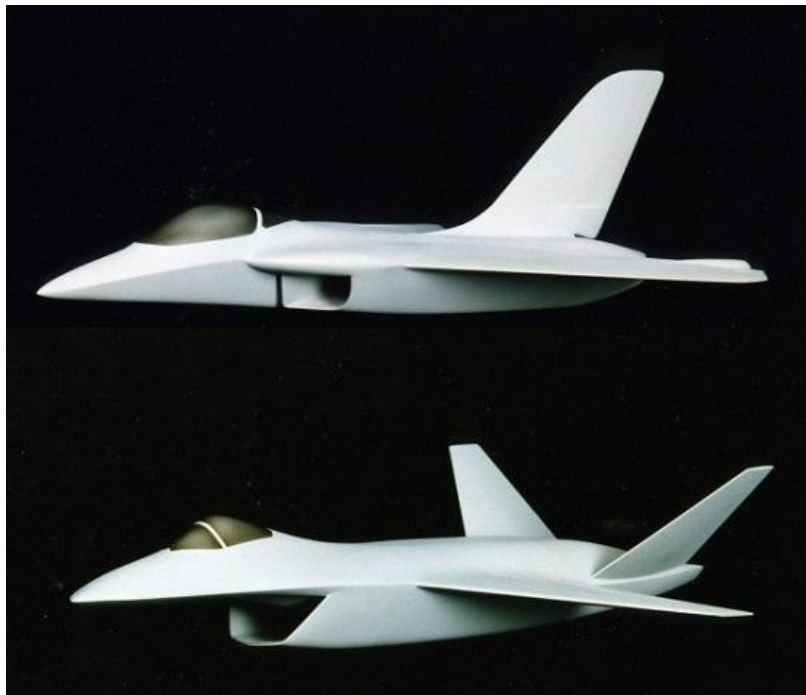
June: Lockheed's proposed prototype configuration (Lockheed Model 090P) is frozen.

August: Lockheed, Boeing, and General Dynamics sign a memorandum of understanding for a teaming agreement.

September: Assembly begins on the first YF119-PW-100 engine, which begins ground testing the following month.

31 October: The Lockheed-Boeing-General Dynamics team and the Northrop-McDonnell Douglas teams are the two contractors selected to participate in the dem/val phase of the ATF program.

3 November: Lockheed, Boeing, and General Dynamics representatives meet for the first time as partners at Lockheed Skunk Works facilities in Burbank, California. Each company briefs its design approach. (The design by General Dynamics is shown at the top).



**1987**

10 July: The original design of the YF-22, Configuration 1095, is determined to be technically and competitively unacceptable by the contractor team.

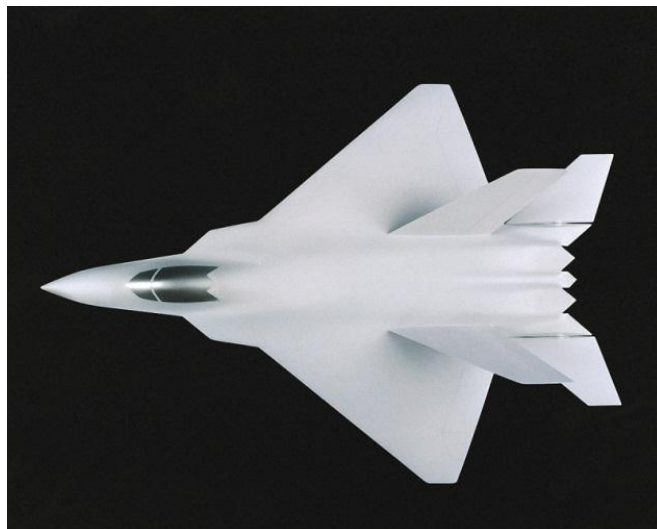


13 July: The team begins developing a new configuration.

17 July: Initial tests of the YF-22 avionics are carried out on the team's Airborne Flying Laboratory, a Boeing 757.

October:

A new configuration for the YF-22 with a diamond wing and four tails (Configuration 614) is selected.



November: Tail arrangement for the new configuration is modified. The tail arrangement of Configuration 615 was rearranged to produce Configuration 631 of the Lockheed-General Dynamics-Boeing design for the Advanced Tactical Fighter





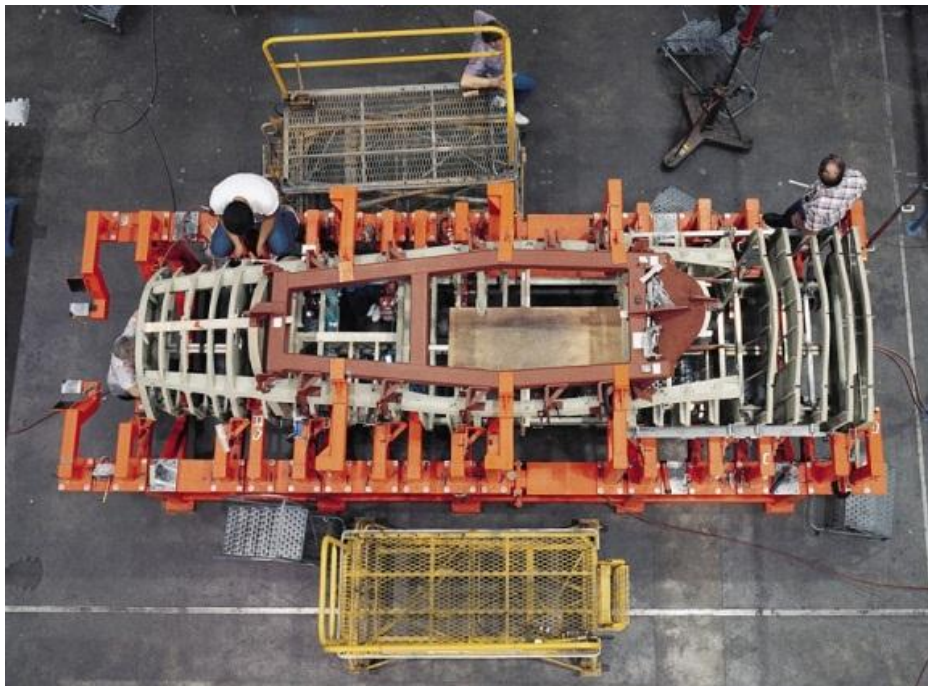
**1988**

April: First drawings are released for YF-22 production. Additional changes are made to the configuration to reduce supersonic drag. The first bulkhead is rough cut.

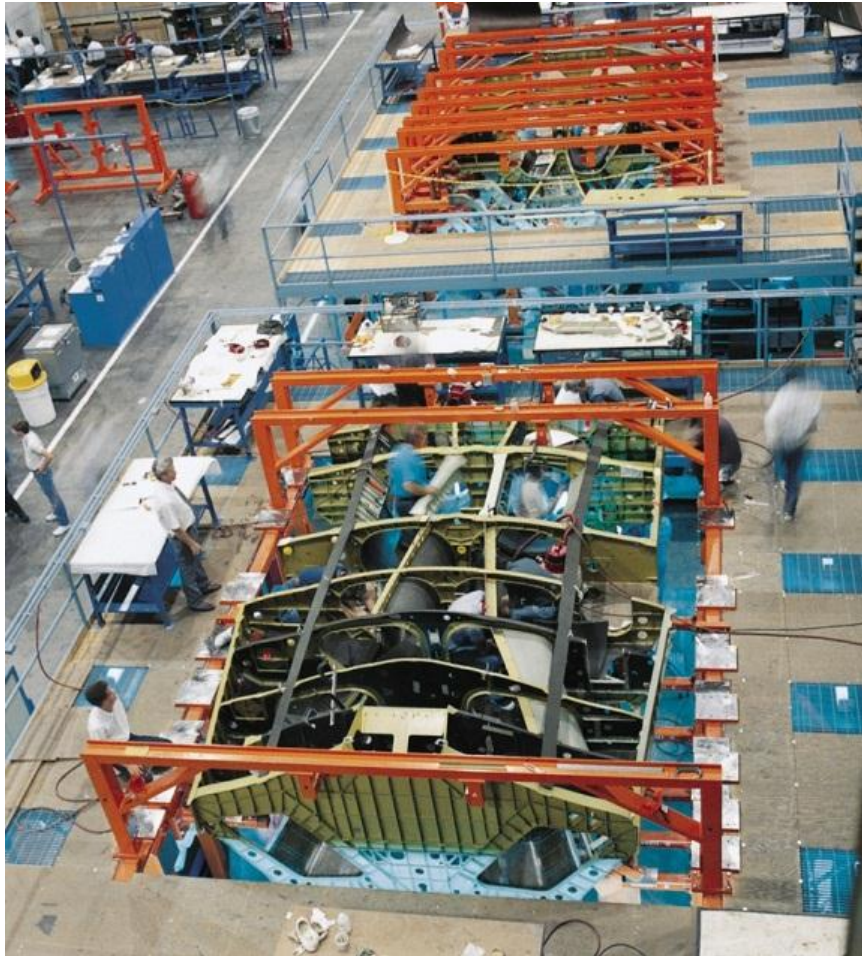
May: The F-22 forebody and aft fuselage are redesigned.

**1989**

Construction of major sections for two prototypes takes place at Boeing in Seattle, Washington; General Dynamics in Fort Worth, Texas; and Lockheed in Palmdale, California.







**1990**

13 January: Final assembly of the first YF-22 prototype begins in Palmdale.



April: Final assembly of the second YF-22 prototype begins.

8 June: Pratt & Whitney delivers its first flyable prototype YF119 engine to Lockheed.

17 July: Pratt & Whitney delivers its second flyable prototype engine to Lockheed.

August: Prototype YF119 engine YF604-2 completes accelerated mission testing. The prototype YF119 engine YF605-1 also completes flight clearance testing for the YF-22 at Arnold Engineering and Development Center in Tennessee. Also in this month, the F-22 aircraft configuration for the Engineering and Manufacturing Development, or EMD, proposal is frozen.

29 August:  
YF-22A is unveiled  
in ceremonies at  
Lockheed Plant 10  
in Palmdale. This  
first Prototype Air  
Vehicle, called  
PAV-1, is powered  
by two General  
Electric YF120-GE-  
100 turbofan  
engines.



29 September:  
Lockheed test pilot  
Dave Ferguson  
makes the first  
flight of the YF-22  
when he ferries the  
aircraft from  
Palmdale to the Air  
Force Flight Test  
Center at Edwards  
AFB, California.







*Lockheed test pilot Dave Ferguson just before the first flight of the YF-22*

25 October: Maj. Mark Shackelford becomes the first Air Force pilot to fly the YF-22 prototype. This flight also marks the first time the YF-22 is flown at supersonic speeds.

26 October:  
First aerial  
refueling of  
the YF-22  
takes place.  
Fuel is  
supplied  
from a  
KC-135  
tanker.



29 October: Pratt & Whitney delivers its third flyable prototype YF119 engine to Lockheed. (The engine is used as a spare.)

30 October: Lockheed test pilot Tom Morgenfeld completes the first flight of the number two YF-22 prototype in a flight from Palmdale to Edwards. This aircraft, called PAV-2, is powered by two Pratt & Whitney YF119-PW-100 turbofan engines.



3 November: YF-22 ability to supercruise, or fly at sustained supersonic speeds without afterburners, is demonstrated for the first time on PAV-1.

15 November: The General Electric-powered YF-22's thrust vectoring capability is demonstrated for the first time.

23 November: The Pratt & Whitney-powered YF-22 demonstrates its supercruise capability for the first time.

28 November: General Dynamics test pilot Jon Beesley, flying PAV-2, fires an AIM-9 Sidewinder over the range at the Naval Weapons Center at China Lake, California. This is the first live missile firing in the entire ATF program.



1 December: Pratt & Whitney-powered YF-22's thrust vectoring capability is demonstrated for the first time.

10 December: High angle-of-attack testing begins. All tests are conducted with PAV-1, which is equipped with a spin recovery chute.

11 December:  
YF-22s are  
flown in  
formation for  
the first time.





17 December: YF-22 high angle-of-attack testing is completed on the eighty-seventh anniversary of the Wright Brothers' first flight. The YF-22 attains an unprecedented sixty-degree angle-of-attack attitude and remains in full control.



20 December: Lockheed test pilot Tom Morgenfeld fires an unarmed AIM-120 missile from PAV-2 over the Pacific Missile Test Range at Point Mugu, California.



28 December: YF-22 achieves a maximum speed greater than Mach 2.

28 December:  
Flight test  
portion of the  
dem/val  
phase ends  
with the two  
YF-22s  
accumulating  
a total of 91.6  
hours in  
seventy-four  
flights.



31 December: The Lockheed-Boeing-General Dynamics team submits its ATF proposal to the Air Force. Including the required copies, the proposal totals 20,000 pages and weighs about 4,500 pounds.

## **1991**

3 January: Lockheed-Boeing-General Dynamics team makes its oral summary presentation to the Air Force.

January: F-22 program offices relocate from Burbank, California, to Marietta, Georgia.

22 April: Air Force Secretary Dr. Donald Rice announces the number of ATFs to be procured will be reduced from 750 to 648 aircraft as a result of declining defense budgets.

23 April: Air Force Secretary Dr. Donald Rice announces at a Pentagon briefing that the F-22 and the Pratt & Whitney F119 engine are the winners in the ATF competition. He says the F-22/F119 combination offers "clearly better capability with lower cost, thereby providing the Air Force with a true best value."

June: PAV-1 is flown aboard a Lockheed C-5 to Andrews AFB, Maryland, to participate in the Air Force's Stealth Week, an informational exhibit for congress and the media. The YF-22 is displayed with a Lockheed F-117 Nighthawk stealth attack aircraft and a B-2 Spirit bomber.

23 June:  
PAV-1 is  
flown to  
Marietta  
aboard a C-5.  
This YF-22,  
which will  
not be flown  
again, will  
primarily be  
used as an  
engineering  
mockup.



2 August: US Air Force awards the Lockheed-Boeing-General Dynamics team a \$9.55 billion contract to begin Engineering and Manufacturing Development phase of the F-22 program. Eleven flyable aircraft (nine single-seat F-22As and two tandem-seat F-22Bs), one static test, and one fatigue test airframe are to be built under this contract. Pratt & Whitney will build thirty-three flightworthy engines under a separate \$1.4 billion contract for engine development.

September: PAV-2 is trucked from Edwards AFB to Palmdale, where additional test equipment was installed. It is trucked back to Edwards in October.

30 October:  
Flight testing of  
PAV-2 resumes at  
the Air Force  
Flight Test Center  
at Edwards AFB.  
Lockheed pilot  
Tom Morgenfeld  
makes a 1.6-hour  
sortie. Test points  
include functional  
checks, handling  
qualities, and  
gathering  
aerodynamic  
loads data.





13 November: Ground is broken in Marietta for the L-22 building, the new office home of the F-22 program. The building covers nearly 217,000 square feet.

16 December: External design of the F-22 is frozen, allowing wind tunnel and radar cross-section models to be built, internal design to be completed, and manufacturing tooling to be prepared.

## **1992**

10 January: Pratt & Whitney-powered YF-22 prototype surpasses the number of hours flown by PAV-1 (52.8) during dem/val, accumulating fifty-three hours total flight time and completing post-contract award flight test.

21 January: PAV-2 sorties surpass the total sorties flown in PAV-1 during dem/val with forty-four flights completed during the two flight test phases. During this second phase of flight testing, the YF-22 is KC-10 tanker qualified.



11 April: Air Force Lt. Col. Jay Jabour makes the thirty-second test sortie in PAV-2 since the resumption of flight test in October 1991. The second YF-22 had then been flown more times during the second test phase than it was during dem/val.

25 April: The YF-22 experiences a series of pitch oscillations at roughly forty feet above the runway upon returning to Edwards AFB after a test flight. With landing gear retracted, the aircraft hits the runway, slides 8,000 feet, and burns. Although no longer flightworthy, the external damage is later repaired, and the YF-22 is flown aboard a C-5 to the Rome Air Development Center at Griffiss AFB, New York, where it undergoes a series of antenna tests. PAV-2 had been flown on seventy test flights for a total of more than 100 hours.

4 June: The F-22 design review update is completed.

June: Critical Design Reviews are held for all F119 EMD test engine components. These thorough reviews of the engine mark completion of the detailed design phase of the program and ensure readiness of F119 to proceed to fabrication and assembly.

October: Live-fire testing of F-22 components begins to validate that the aircraft can withstand battle-induced damage and return safely to base.

22 October: The Air Force releases its investigative report on the YF-22 accident.

17 December: First F119 EMD engine goes to test.

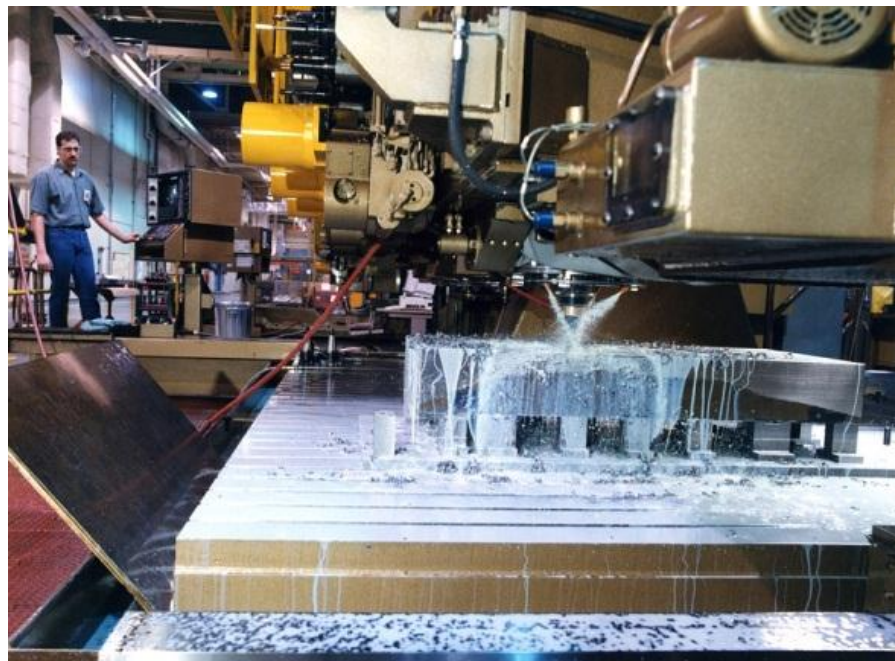
## 1993

January: The F-22 EMD program schedule is rephased as a result of a fiscal year 1993 funding shortfall. Key events in the development process now occur anywhere from six to eighteen months later than originally scheduled. The rephasing also reduces the number of aircraft to be built during EMD from eleven to nine (which still includes two F-22B tandem-seat trainers). The F119 engine program is also rephased. Pratt & Whitney is to build twenty-seven (rather than thirty-three) flightworthy EMD engines.

1 March: Lockheed Corporation completes the acquisition of General Dynamics Fort Worth Division. This \$1.5 billion purchase (announced in December) increases Lockheed's majority share of the F-22 program from thirty-five percent to 67.5 percent. Boeing's share of the program remains unchanged at 32.5 percent.

30 April: F-22 air vehicle Preliminary Design Review is completed to conclude the third and final phase of preliminary design work. The final development phase, detailed design, now begins.

8 December: Albert Ferara, a milling machine operator at Boeing Defense and Space Group in Kent, Washington, begins fabricating the first part of the first flyable F-22. The part, which is made of titanium, is one of eight forward boom keelson panels that will comprise one section of the aft fuselage.



## 1994

10 February: US Air Force announces that the number of production F-22s to be procured will be reduced from 648 to 442 as a result of the continuing downsizing of the US military.

4 March: F-22 Air Force-industry design team identifies shortfalls in the aircraft's radar cross-section signature through a new computer modeling technique. The fixes involve reducing the number of drain holes on the bottom of the aircraft and combining access panels. The shortfalls are mitigated by late spring.

6 October: Charles Wilkey, a milling machine operator at Lockheed Aeronautical Systems Company in Marietta, Georgia, begins fabricating the first part Lockheed is building for the first flyable F-22. The aluminum part is an engine inlet duct frame segment.



November: Acquisition of long-lead-time hardware for the first F119 flight test engine is initiated.

9 December: A third rephase of the F-22 program begins after Secretary of Defense William Perry announces a ten percent reduction in the FY1996 research and development funding. The reduction is part of an overall \$8 billion in budget changes to seven DOD modernization programs.



December: Lockheed Fort Worth Company in Fort Worth, Texas, begins fabricating the first graphite composite parts for the first mid fuselage of the first flyable F-22. Also, Pratt & Whitney's F119 test engine FX622 completes high-cycle fatigue testing at West Palm Beach, Florida.



## 1995

24 February: The formal portion of the F-22 air vehicle Critical Design Review is completed, marking the end of the detailed design phase of the program and ensuring fabrication and assembly readiness of the F-22.

15 March: Lockheed Corporation and Martin Marietta complete a "merger of equals" with the combined enterprise named Lockheed Martin Corporation. Lockheed Aeronautical Systems Company in Marietta becomes Lockheed Martin Aeronautical Systems, and Lockheed Fort Worth Company becomes Lockheed Martin Tactical Aircraft Systems.

20 April: US Air Force awards the Lockheed-Boeing team a \$9.5 million, twenty-four month study contract to explore derivatives to the F-22 aircraft. Pratt & Whitney is awarded a separate \$500,000 contract to explore improved F119 performance. The Air Force later curtails the studies.

27 June: Assembly of the first flyable F-22 begins as workers load the first mid fuselage bulkhead into an assembly fixture at Lockheed Martin Tactical Aircraft Systems in Fort Worth. This milestone is achieved ahead of schedule.

July: Wind tunnel testing of the F-22 configuration is completed. Twenty-three models are tested in fourteen facilities in the United States and in one facility in Germany during the wind tunnel test program that began in 1991. A total of 16,930 test hours were completed.

July: Pratt & Whitney's redesigned F119 turbine demonstrates improved fuel efficiency and eliminates turbine blade vibratory stress.

4 October: Assembly of the first flyable F-22 begins at Boeing Military Airplanes as workers load parts for the aft fuselage into an assembly fixture.

2 November:  
Assembly of the first flyable F-22 begins at Lockheed Martin Aeronautical Systems in Marietta as workers load parts for the nose landing gear wheel well into an assembly fixture.



## 1996

17 January: Boeing begins assembly of the first shipset of wings for the first flyable F-22. Left wing assembly begins first.

February: Tests of the flight control laws begin in the Variable Stability In-flight Simulator Aircraft, or VISTA, a highly modified F-16D that, through a sophisticated control system, can emulate the flight characteristics of another airplane while in flight. These tests, which take place over upstate New York, are done in two sessions that end in May.

6 May: Pratt & Whitney begins assembly of the first flight test F119 engine at its facilities in Middletown, Connecticut.

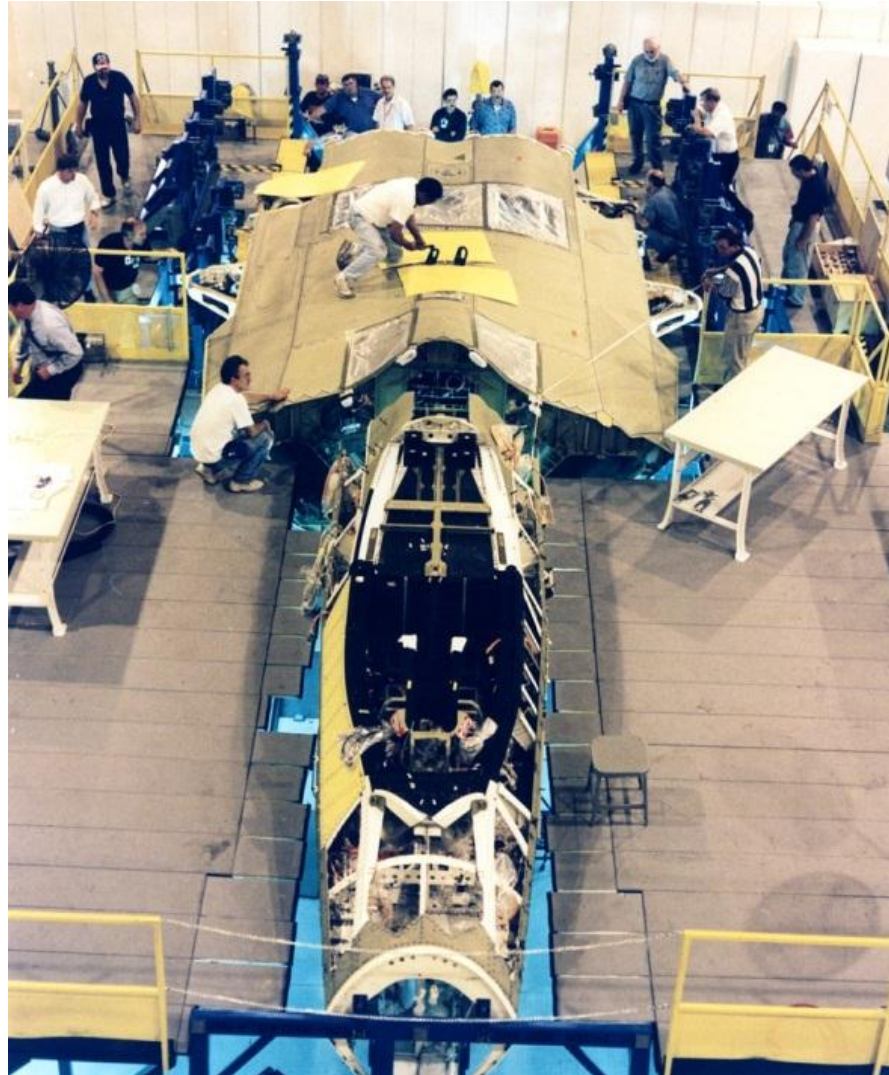
10 July: Pratt & Whitney conducts a Last Bolt ceremony at Middletown, to recognize the completion of the first flight test F119 engine.

10 July: F-22 airframe team receives formal notification from the US Air Force that defers the requirement for design and development of the two-seat F-22B.

The two planned EMD F-22s will now be replaced by two single-seat F-22As, making all nine EMD F-22s single-seat models.

29 August: Lockheed Martin Tactical Aircraft Systems in Fort Worth holds a tri-ceremony to commemorate the completion of the mid fuselage for the first flyable F-22, mating of the mid fuselage for Ship 2, and loading of the first mid fuselage assembly for Ship 3.

6 September: The mid fuselage for the first flyable F-22 (first called Ship 1, then later called 4001 to denote its company construction number) arrives in Marietta after a three-day truck trip from Lockheed Martin Tactical Aircraft Systems in Fort Worth. Forward-to-mid fuselage mate operations then begin. The fuselage comes complete with a Texas state flag draped over it.



24 September: Pratt & Whitney announces the first flight test F119-PW-100 engine has been delivered to the Air Force. It is taken to Arnold AFB, Tennessee, for testing and then delivered to Lockheed Martin Aeronautical Systems in Marietta.

1 October: Northrop Grumman (formerly Westinghouse) announces that the first developmental AN/APG-77, the electronically steered, active element, phased-array radar to be used in the F-22, begins system-level integration and test.

8 October: First flight test F119 engine is delivered to Lockheed Martin Aeronautical Systems in Marietta. The engine arrives via truck.



16 October: The aft fuselage for the first flyable F-22 arrives in Marietta and mate operations begin. The aft fuselage, which had a Washington state flag draped over it, is flown from Seattle on board a C-5 Galaxy.



27 October: Completed fuselage of the first F-22 is lifted from the body mate tool to the wing mate tool.

9 November: Wings for the first flyable F-22 arrive in Marietta from Seattle and mate operations are completed two days later.

20 December: Electrical power is applied to the F-22 for the first time.

## 1997

21 January: The left vertical stabilizer is installed on the first F-22.

24 January: First F119 engine is fit-checked into the first F-22.

6 February: The right vertical stabilizer is installed on the first F-22.

17 February: F119 engine endurance testing is completed.

6 March: The first F-22, now nearly complete, is towed from the final assembly area in the B-1 building at Lockheed Martin Aeronautical Systems in Marietta to the newly constructed B-22 engine noise attenuation facility (called a hush house) where it will undergo fueling operations and engine runs.



31 March: F119-PW-100 engine is granted Initial Flight Release.

9 April: Dubbed The Spirit of America, the first F-22 is publicly unveiled in ceremonies at Lockheed Martin Aeronautical Systems in Marietta. During the ceremony, the fighter is given its official nickname—**Raptor**.



25–26 April: The YF-22 prototype that had been used as an engineering tool in Marietta is displayed at the Air Force's Golden Air Tattoo at Nellis AFB, Nevada. The aircraft is shown in the colors and marking of the Air Force's Fighter Weapons School. It is later delivered to the Air Force Museum at Wright-Patterson AFB, Ohio.





22 May: Boeing completes safety-of-flight testing of the F-22 pilot life-support system.

June: The Flying Test Bed, the converted 757 airliner that will be used to support F-22 avionics development, arrives in Seattle. The aircraft, which had been modified in Wichita, Kansas, sports an F-22 integrated into its forebody.



31 July: Chief test pilot Paul Metz runs the F119 engines installed in Raptor 4001 to full afterburner for the first time.





7 September: Chief test pilot Paul Metz makes the first flight of the F-22 from Dobbins ARB in Marietta, taking off at 10:18 a.m. and lifting off at 140 knots in military power. The aircraft reaches an altitude of 15,000 feet in less than three minutes and is put through a series of engine transients and handling characteristics tests. Metz then climbs to 20,000 feet and retracts the landing gear and flies formation with two F-16 safety chase aircraft piloted by Lockheed Martin test pilot Jon Beesley and US Air Force Lt. Col. Steve Rainey. Metz lands at Dobbins after a fifty-eight minute flight.



*Chief test pilot Paul Metz gives a thumbs up before getting into the F-22 for its first flight.*