Cleared Vertical!

X-35B: Ready

For STOVL Testing

STRIKE FORCE

Vertical Takeoffs Initiate X-35B STOVL Flights

Straight up will be the first move for the Lockheed Martin X-35B, as the Joint Strike Fighter test team begins the demonstrator's short takeoff, vertical landing (STOVL) takeoff and landing tests this summer. Initial testing will take place over a specially designed hover pit – a large rectangular basin with special ducting that pulls away the propulsion system's downward rush of air and engine exhaust – at Lockheed Martin's Palmdale, Calif., facility.

The Lockheed Martin JSF team completed installation of the X-35B's flight-ready propulsion system – including the shaft-driven lift fan and engine – on May 12. X-35B chief test pilot Simon Hargreaves began operating the flight-ready system in the aircraft on May 24.

The X-35B is shown here during hover pit testing (and before the tails were repainted) earlier this spring. The open lift fan doors, open auxiliary inlet doors, and the downturned engine exhaust nozzle can be seen clearly.

The government JSF Program Office completed a first flight readiness review of the X-35B on May 22 and 23 in preparation for the beginning of STOVL flight testing. Engineering groups from the JSF Program Office, an independent review team, and a joint service safety review board met with the Lockheed Martin-led X-35 team to review engineering and test results of all X-35B STOVL development work, as well as plans for the STOVL flight-test program.

Taxi tests have already confirmed that jet-plume proximity to the aircraft inlets is minimal, which is an important factor in making slow landings later in the test program.

In the first "flight" test, which is imminent as this issue of Strike Force went to press, Hargreaves will engage the shaft-driven lift fan (SDLF) propulsion system at full power in the heavily loaded X-35B. The "no-go VTO" (vertical takeoff), in which the aircraft's nosewheel is lifted off, but otherwise remains on the ground, is designed to confirm overall controllability in an unrestrained condition.

In subsequent sorties, Hargreaves, a veteran Harrier pilot, will lift the X-35B into the air at increasingly higher hover altitudes to calibrate the net amount of vertical lift being generated.

Following hovers of 20 to 50 feet, the taxi tests will begin to confirm jet-plume proximity to the aircraft inlets, which is an important factor for making slow landings later in the test program. The team will mix in some conventional flights to ensure the X-35B retains the outstanding up-and-away characteristics demonstrated by pilots flying the X-35A (this same aircraft before it was modified to the STOVL configuration) last fall.

Testing will quickly transition to Air Force Flight Test Center at nearby Edwards AFB, where the aircraft will undergo envelope expansion tests of semi-jetborne flights at around 9,000 to 10,000 feet altitude. During the tests, the X-35B test program will build down from conventional airspeeds to slow jetborne flight. Ultimately, the plane will undergo short takeoffs and full conversions down to hovers and vertical landings. High-speed work is also on the test schedule.

Current plans call for a cross-country flight to the Naval Air Warfare Center's Aircraft Division at NAS Patuxent River, Md., where sea level testing will be completed later in the test program. The X-35B's STOVL testing is scheduled to be completed by August.

JSF Engine Agreement Signed

Officials from Pratt & Whitney, General Electric Aircraft Engines, and the Air Force and Navy acquisition executives on June 6 signed an agreement to work together to assure that both companies' engines will be physically and functionally interchangeable across all three variants of the JSF aircraft.

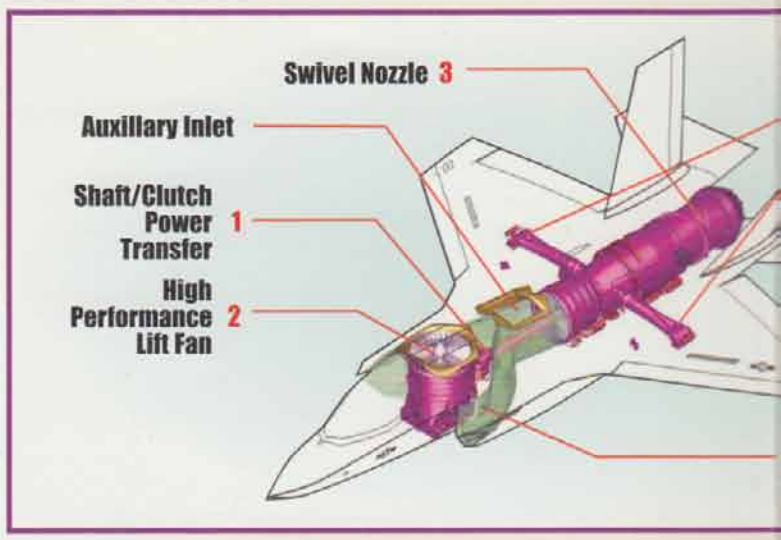
Pratt &Whitney's JSF119 engine was selected by both JSF weapons system competitors to power their competing demonstrator aircraft designs. The engine, a derivative of the F119 engine powering the F-22 Raptor, currently has accrued approximately 150 hours of flight test performance in all JSF candidate aircraft variants.

General Electric's JSF F120 engine is a derivative of the F120 engine originally developed for the YF-22 and YF-23 Advanced Technology Fighter prototypes, and is being further developed to power the JSF aircraft in the future.

It has been the plan of the U.S. Department of Defense to compete the two engines starting in approximately 2011 during the production phase of the JSF program.

A JSF Program Office (JPO)/P&W/GEAE team has been established to integrate the management structure and technical processes necessary to assure engine interchangeability. This includes participation by GE representatives on P&W-led integrated product teams for those propulsion system components that will be common to the JSF119 and F120 engines.

The Ups and Downs of th



The X-35B, designed to meet U.S. Marine Corps and Royal Navy/Royal Air Force requirements, fe a drive shaft from the engine 1 turns a counterrotating lift fan 2 that produces tremendous cool at landing (STOVL) operations. The front-mounted fan works in concert with a thrust vectoring ro control nozzles 4 to produce nearly 40,000 pounds of lifting power. Powered flight lift and control roll control posts, and the engine), which operates with fewer nozzles than legacy systems now and nozzles. The Pratt & Whitney JSF119-611 engine is based on the F-22's powerplant. The shaf government-monitored durability mission tests, demonstrating full rea

Completing the Hat Trick

by Tom JSF Pr

We now ready to begin the third and final (and what most people would say is the most difficult) phase of our Joint Strike Fighter flight test program – the short takeoff and vertical landing demonstration. We fully expect our X-35B to pick up right where the X-35A left off – after all, it is the same airframe.

The Lockheed Martin-led team expects to conduct its first STOVL test series in what's called a press up to hover. We will clear our hover maneuver to validate the X-35B's jetborne handling qualities. Once testing of this maneuver is completed, we will expand our flight envelope by backing down from conventional, or wingborne, flight into the transition to hovering flight.

After initial flight envelope expansion is completed at Edwards AFB, Calif., we are planning to transition our test program to NAS Patuxent River, Md., to conduct sea level flight demonstrations. This would provide an additional demonstration of our aircraft's capabilities during shipboard operations.

While all this is going on, another part of our team is continuing to support development of our engineering and manufacturing development (EMD) phase proposal. This activity is very intense and will continue into early July.

Once we complet X-35B, like the larger- The government's cur flight demonstration

The governmen will determine whic

our technical issues ar processes are tracking ready, and our staffing buildup after contract

This team is work reality. With a little lu

X-35 Flight Test Summary

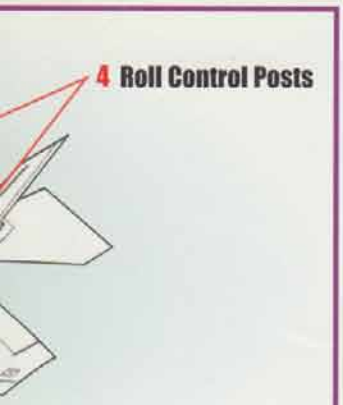
(As of 16 June 2001)

X-35A[1] (CTOL):	27 Flights;	27.4 Hours
X-35B (STOVL):	Shaft-driven lift fan installed; Ground testing completed; Flight testing resumes in June;	
X-35C (CV):	73 Flights[2];	58 Hours
Total	100 Flights;	85.4 Hours

[1] *Conventional takeoff and landing variant testing completed. Aircraft converted into X-35B short takeoff, vertical landing demonstrator.*

[2] *Carrier variant testing completed. Totals include 38 flights at Edwards AFB, Calif., and one ferry flight (split into two segments) from Edwards to NAS Patuxent River, Md. Aircraft now in storage.*

e X-35B



atures a unique propulsion system in which r lifting force during short takeoff, vertical ar engine nozzle **3** *and underwing lateral s provided by these four devices (fan, two n service. Rolls-Royce produces the fan t-driven lift fan system recently completed ired reliability.*

a Burbage,
ogram General Manager

e all of our flight test objectives, the winged X-35C, will be put in storage. rent cut off date to submit STOVL est data is August 15th.

's downselect decision, which h of the two JSF competitors is to ultimately build nearly 4,000 combat aircraft for the U.S. Air Force, Navy, Marine Corps, Royal Navy and Air Force – and quite likely a number of other countries – is currently scheduled for the fall.

In the meantime, a third activity we are working on is to ensure that the total Lockheed Martin/Northrop Grumman/BAE SYSTEMS team (along with our subcontractors) are ready to conduct EMD if we are chosen. This current activity is very intense and is centered on ensuring e considered low risk, our tools and to our start date, our facilities are plans are in place to support a rapid award.

ing very hard to make the dream a ck, it will all come together this fall.

From the Cockpit *by Simon Hargreaves, X-35B Chief Test Pilot*

Late last November, the X-35A was flown for the final time to conclude a tremendously successful flight test program. The X-35A, the Lockheed Martin/Northrop Grumman/BAE SYSTEMS Team's conventional takeoff and landing (CTOL) demonstrator, showed the outstanding handling qualities, performance, and reliability of the team's basic design during its 27 flights. On that last sortie, after a brief supersonic run over the Air Force Flight Test Center's range, Chief Test Pilot Tom Morgenfeld brought the aircraft safely 'home' to Lockheed Martin's facility at Palmdale, Calif.

Since then, the ship has undergone a metamorphosis. Earlier this year, it emerged from the hangar as the X-35B – our short takeoff, vertical landing (STOVL) demonstrator. In the cockpit virtually nothing has changed; only the addition of a thrust vector lever (TVL) outboard of the throttle indicates that this is now a revolutionary new tactical STOVL fighter. This one small cockpit addition belies the changes that have occurred under the skin of the aircraft.

The basic airframe has remained untouched and many subsystems and the CTOL flight control system remain identical to the A-model, but the Pratt & Whitney F119 engine has been augmented by addition of a shaft, clutch, gearbox, and a lift fan.

This shaft-driven lift fan (SDLF) propulsion system is the first of its kind. The system produces an enormous amount of STOVL thrust without great penalty to the ground environment and, crucially, provides the potential for future growth. This is an important factor in an aircraft that is likely to be in service for upwards of 30 years.

Since the aircraft has become the X-35B, we have been working steadily and confidently toward the first flight – a vertical takeoff, hover, and vertical landing – which is now imminent. That's right, the first ever flight of this aircraft will be straight into the hover from a VTO!

One of the myths we had to overcome was that a SDLF was somehow 'too complex' to ever achieve an acceptable level of reliability. Well, since the historic ground run on February 22 when the lift fan was coupled to the engine for the first time, we have completed a further 40 engagements, at all the power settings we will ever require in flight.

I am completely confident the system is now mature and reliable enough for us to start in-air conversions.

Engine start and system checks are identical to the CTOL airplane and there is absolutely no sensation in the cockpit that the shaft is turning, which it does whenever the engine is running because the clutch is on the lift fan end of the shaft.

The STOVL system is engaged by moving the thrust vector lever out of a detent. (This will change in the production aircraft to further simplify the cockpit.) The lift fan spins up with an absolute minimum of fuss or drama. The fact it feels so unremarkable makes it, in fact, a remarkable event.

With the fan engaged there is no additional vibration, for example, and noise levels are unchanged. The engine note changes slightly with the addition of a characteristic low whine, but other than that, there is nothing in the cockpit to indicate that you are now sitting just in front of the most powerful single-engined propulsion system ever incorporated into an airplane.

With the aircraft safely tied to the ground, we have run the propulsion system at full power to measure the thrust achieved and have completed all the necessary system checks before flight. The cockpit environment remains benign, even with the massive amount of thrust being developed just behind the canopy. The thrust vectoring nozzles move smoothly and predictably and you can feel it trying to move against the restraints.

From all my time in the simulator and my few hours flying the X-35A and X-35C, I am confident that this airplane will have excellent handling qualities in jet-borne and semi-jetborne flight, as well as through the vertical-to-horizontal conversion process.

From the first hovers at Palmdale, the test team will rapidly expand the flight envelope to encompass conversions, decelerating transitions to the hover, and landing and takeoff at a variety of speeds. The event that will clearly demonstrate the enormous potential of the Lockheed Martin JSF design is a short takeoff, acceleration to supersonic speed at altitude, and return for a vertical landing.

STRIKE FORCE
LOCKHEED MARTIN JSF TEAM NEWSLETTER
Volume 1 • Number 2 *June 2001*

On the Front: *The X-35A has been converted into the X-35B short takeoff, vertical landing demonstrator and as can be seen from its open lift fan doors (top and bottom, directly behind the cockpit), open auxiliary inlet doors (on the top in the middle of the fuselage), and the downturned engine exhaust nozzle, it is ready for its first flight, which will consist of a vertical takeoff, hover, and vertical landing. That first "hop" is imminent as this issue went to press.*

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