F-35 Lightning II status and future prospects

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Activities at Lockheed Martin's Fort Worth facilities have steadily increased over the past year as more than a dozen F-35 jets have taken shape on the production line. But there are some signs that things are shifting into a new gear at the Texas manufacturer. F-16.net recently met with Lockheed Martin for a brief. Here is the update.

After a couple of months on the ground for modifications the BF-2 jet has been back in the air flying multiple weekly test sorties. BF-1 is also flying again after a period of modifications and a trip back to the hover pit in preparation for the upcoming STOVL transition flights. Both jets will shortly transfer to the Naval Air Station Pawtuxet River for this important stage in the flight testing.

The first Navy variant, the CF-1, has been delivered and will join the six jets currently on the flight line while AF-1, the first weight optimized CTOL airframe, is due for its first flight next month. BF-3 has successfully completed a series of ground tests, which included a full complement of under wing weapon stores, "ahead of schedule and close to predictions" and is also scheduled for its first flight within weeks.

AF-2, AF-3 and BF-4, the first mission-systems aircraft, are expected to fly before years end. AA-1, the first flyable test aircraft, was ferried to Edwards Air Force Base last week. It will then head off to China Lake Naval Weapons Testing Center for live firing exercises to test the aircraft's survivability. The jet is not expected to be fly worthy after this. The F-35 is also on track to deliver its 5th generation stealth promise. Recent test results on the Highly Accurate Low Observable (HALO) full scale model show that signatures closely match the expected levels.

While returning to flight has been important, Lockheed Martin is in no hurry to rush the test flights prematurely. "The flights will ramp up in the coming months, but this year our main focus is to get all the SDD planes delivered on schedule and then 2010 and 2011 will be when the flights really get going", F-35 Program Executive Vice President Tom Burbage explains. "We would have liked to see that happen a little bit sooner", Burbage adds, "but we have a good margin in place for dealing with flight test issues without affecting the overall schedule". "We are confident that we will meet the IOC dates".

Compared to some legacy programs the F-35 is in a favorable position. "We have completed the structural static tests in a mere 350 days". "And without a major problem", Burbage adds. In comparison, the F-22 took about 1000 days, or almost three years, which is more typical for legacy programs. Because of this the F-35 can open up the flight envelope sooner than the jets before it. "We don't have to wait for the structural testing and then slowly expand the envelope", says Burbage. In addition, all the flyable production representative aircraft - the so called SDD vehicles - can fully explore the flight envelope, giving the flight test program more flexibility in the flying schedule.

From a design point of view Lockheed Martin has taken numerous preemptive steps based on the experience gained from previous programs. For instance the F-35s twin vertical tails are designed to deal effectively with the excessive flutter which occurs from strong air vortices generated at high G's and angles of attack. These vortices have a very good -- and quite deliberate – function; to increase lift and reduce drag which greatly assists maneuverability. The F-35 lacks the distinctive leading edge extensions (LEX) found on the F-16 and F-18 jets. On the F-35 this important function is provided by the carefully shaped engine cowls and -- to a lesser degree -- the chinned forward fuselage, and is a good example of how aerodynamic design tools have come a very long way since the days of the venerable YF-16. These vortices are usually not a problem for single tail designs, like the F-16, as they split on either side of the tail, but twin tails puts them right in the airflow's path causing flutter. "This can severely reduce the tail's structural life span, as seen in some legacy programs", Burbage explains. "We have prepared for that".

Another example of preemptive measures is found on the folding wing section on the F-35C carrier model. Jets flying in the transonic regime are prone to a phenomenon called "accelerated stall". One way this can occur is in a steep, high G turn where asymmetric shock formation can cause one wing to loose lift -- or stalling -- forcing the plane into a roll, and possibly a spin. Wing drop problems has plagued some earlier fighter programs and due to the inherently unpredictable nature of transonic airflows modern computer tools and wind tunnel procedures are still not refined enough to accurately predict airflows in these cases. As a practical solution Lockheed Martin designers have mounted an aerodynamic spoiler towards the leading edge of the folding wing. In case of a wing drop the spoiler pops up interfering

with the airflow and restoring control. This is simply a precautionary step; if the problem does not show up during flight testing, the spoilers will be removed on the production planes. A simple procedure when compared to the extensive task of having to redesign the wing. This kind of "lessons learned" from earlier programs is an essential condition for the F-35 program. "We have tried to think of every possible problem that might occur and taken steps to prevent them", Burbage explains.

With regards to aircraft capabilities, Lockheed Martin confirms that the Infrared Search and Track (IRST) capability is slated for Block 3, the first fully mission capable F-35. "It's a fully functional capability", says Lockheed Martins's Vice President for Business Development Steve O'Bryan. "It includes sensor fused input from both the Electro-Optical Distributed Aperture System and Electo-Optical Targeting System sensors", often just called the EODAS and EOTS. Combined with the Helmet Mounted Display and High Off-Bore sight weapons it enables the F-35 to engage multiple aerial and surface targets simultaneously in a 360 degree sector around the aircraft. It's a unique capability in the fighter world today -- and the foreseeable future.

Looking towards future block upgrades there are several interesting items on the horizon. The AN/ASQ-239 electronic warfare (EW) suite is a major part of the F-35s "protective bubble" and Lockheed Martin is already looking ahead. Fuselage space is allocated for avionics growth and the embedded EW antenna compartments located in the wing sections have room for future expansions. It depends on customer demands. Alternatively the F-35s missionized gun pod could be used to expand the F-35s electronic capabilities. "The gun pod is already there, and it's stealthy, so we see a potential for different types of equipment", says O'Bryan. That could include EW equipment, a reconnaissance pod or even side and aft-looking AESA radar, adding to the F-35's range of powerful capabilities.

It's an interesting prospect. Recall that the F-22 has allocated growth space for AESA modules in the forward fuselage side cheeks. Across the Atlantic, the Swedes and Europeans are considering a less novel, but still useful, "swash plate" antenna approach for the JAS Gripen and Eurofighter jets. This allows the AESA antenna to rotate and cover a wider field. The F-35's AESA antenna is fixed at an inclined angle giving it a reasonable side coverage, but still falls short of a dedicated side-looking capability. Putting a radar in the gun pod would extend the capabilities well beyond currently planned systems. The extra wide coverage would come in handy. Not just for common radar modes like search and track, but also such tasks as mid-course missile guidance at greater angles giving a pilot more freedom to maneuver after missile launch. A swash plate approach was considered early on in the JSF program, but Lockheed Martin found that it would seriously impact stealth performance. "An antenna pointing in all directions is a big source of reflections in the forward aspect, so we needed to avoid that", O'Bryan explains.

The F-35 will link up with other stealthy aircraft, such as the B-2 and F-22, through its stealthy Multi-functional Advanced Data Link (MADL). In addition the F-35 supports a number of formats, such as Link-16, for communication with other combat assets. Link-16 usage would in some cases be restricted in order to maintain the aircraft's stealth cover. This is not a big problem for such tasks as missile updates as an undetected F-35 would be well inside the opponent's "kill chain". It would essentially deny the opponent's situational awareness, thus his ability to respond, requiring fewer, if any, missile updates on its way to the target. Lockheed Martin won't confirm plans for a stealthy weapons link in the future, but such a capability seems likely based on the anticipated threat scenario in the post 2020 time frame.

Another reason for Lockheed Martin's fixed AESA antenna approach is the reduced weight and complexity compared to a mechanical gimbaled system. This translates into less maintenance and cost. Due to its exceptional reliability the AESA antenna is, in fact, expected to outlast the aircraft's 30 year or 8000 hour service life. Furthermore; the nose cone is sealed to optimize the F-35's stealth signature. The sealing can be removed and reapplied with "relative ease" if needed, but this will only be done in rare cases, such as major upgrades.

Also planned is a Directional Infrared Countermeasures (DIRCM) capability. This is for a notional Block 5 upgrade with fielding possibly in the 2017-2018 time frame. The system would provide active protection against inbound missiles detected by the F-35s infrared sensors. "The exact type of system is not yet decided", O'Bryan explains, "but proposed solutions include a laser". A laser beam would target an inbound missile's seeker head, breaking its target lock or even destroying it. Lockheed Martin envisions two small laser turrets; one underneath and one atop the F-35s fuselage, giving full spherical coverage. "A laser is a natural choice because the technology is ready and relatively cheap to implement", O'Bryan says. Stealth would not be compromised. Such a laser would have other uses as well. "The laser could be pointed in any direction, taking ranging measurements or painting targets for other combat units". This would increase the F-35's flexibility on the battlefield.

Lockheed Martin's interest in lasers goes even further. Under study as potential growth capabilities are high speed laser communications and LIDAR (Laser Detection and Ranging). The latter could be used for 3D mapping of the ground or airborne targets while laser comm could beam the large amounts of data quickly to other tactical assets. This could involve the EOTS sensor underneath the nose of the aircraft which already implements a laser range finder and a laser spot tracker.

Research on a high power solid-state laser is continuing outside the SDD program. This would employ a laser of at least 100 KW effect capable of damaging or destroying tactical assets at useful distances. That work is being done by Lockheed Martin's Advanced Development programs, generally known as Skunk Works, and involves several other companies. The laser would be powered by a generator located in the lift-fan bay on the F-35B STOVL variant and driven by the engine. Testing would likely begin sometime in the middle of the next decade.

Weapons integration is an important aspect of the SDD phase. Several of the European JSF partner nations have acquired or are planning acquisition of the MBDA Meteor and IRIS-T missiles which may be considered for integration in follow-on development. Lockheed Martin informs that digital fit checks have been made to assess initial physical fit. Related to this, Norway funded a preliminary study in 2003 on the integration of IRIS-T and is actively consulting with Lockheed Martin in the development of the Joint Strike Missile through Kongsberg Defence & Aerospace (KDA). The missiles would be carried internally in the weapon bays or the under wing stations. Norway has yet to make a decision on which missiles to acquire for the F-35.

Development of a stealthy air-to-air pylon has been brought up from time to time. This would allow for reduced signatures when carrying missiles on the wing stations. But the project appears to have been put on ice for the time being. O'Bryan informs that the project is currently not funded. What is being studied, however, is a 6 air-to-air missile capability in the internal weapons bays, which would substantially increase the F-35's stealthy fire power.

Interestingly, sketches of the F-35 early in the program depicted weapon stations 1 and 11 located on wingtip rails, but this was later changed. As the design matured the wing chord at the tips was reduced enough to make rails impractical, so they were moved inboard to their current location on the outer wing section.

Also mentioned in the F-35 block road map are "range and propulsion improvements". Increased thrust is one possibility. Lockheed Martin informs that the engine inlets are designed with a considerable margin for growth anticipating higher air flow requirements in the future.

The F-35's future looks impressive. Having prospects for up to 6000 aircraft spanning almost three decades of production, its modernization potential lacks any equal in the aviation world. With the U.S. remaining a tier one operator it is destined to provide a steady stream of state of the art technology and know-how for any allied air force choosing to invest in this 5th generation fighter.