F-35 Joint Strike Fighter (JSF)

Executive Summary

- The high level of concurrency of production, development, and test created several challenges for the program and the Services:
  - Preparing to begin flight training at the integrated training center with immature aircraft
  - Developing and resourcing structural modification plans for early production aircraft to meet service life and operational requirements
  - Developing and resourcing configuration upgrade plans to achieve final Block 3 capability
- The flight rate in flight sciences testing for all variants in 2011 matched or exceeded the new, restructured flight test plan for 2011. Measurements of progress based on test points accomplished indicate mixed results for flight sciences of the three variants: both the F-35B Short Take-Off/Vertical-Landing (STOVL) variant and the F-35A Conventional Take-Off and Landing (CTOL) variant are behind schedule (9 and 11 percent, respectively), and the F-35C Carrier Variant (CV) is 32 percent ahead.
- Very limited mission systems software flight testing took place in 2011. Additionally, concurrency between development and testing of mission systems blocks of capability is growing and this growth in concurrency increases risk. Development, integration, and flight testing of the most complex elements of mission systems lie ahead.
- In October 2011, the program successfully conducted initial amphibious ship trials with STOVL aircraft in accordance with the new, restructured plan for 2011; however, significant work and flight tests remain to verify and incorporate modifications to STOVL aircraft required to correct known STOVL deficiencies and prepare the system for operational use.
- Although it is early in the program, current reliability and maintainability data indicate more attention is needed in these areas to achieve an operationally suitable system.
- The program completed full-up system-level (FUSL) testing of the first flight test aircraft, as required under the LFT&E plan. Test results confirmed the ability of the airplane to isolate ballistic damage to targeted components, validating the robustness of both the flight control and electrical power systems. Nonetheless, live fire tests and analyses showed the fuel tank inerting system is incapable of providing protection from threat-induced fuel tank explosions during some critical segments of combat missions when the aircraft is most likely to be hit. The program is redesigning the system. Upon completion, the redesigned system will be evaluated to determine if it provides the required protection.

Actual versus Planned Test Flights and Points through November 2011

		ALL VARIANTS ALL TESTING		STOVL ONLY FLIGHT SCIENCES		CTOL ONLY FLIGHT SCIENCES		CV ONLY FLIGHT SCIENCES		MISSION SYSTEMS (MS)			OTHER MS TEST ACTIVITY
		Flights	Points	Flights	Points	Flights	Points	Flights	Points	Flights	Block 0.5 Points	Block 1.0 Points	Points[1]
CY11	ACTUAL	915	6,079	308	1,972	264	1,710	154	1,355	189	116	183	743
	PLANNED	812	5,509	268	2,175	263	1,925	148	1,023	133	111	125	150
Cumulative[2]	ACTUAL	1,371	11,612	564	4,848	426	3,474	181	2,151	200	203	183	753
	PLANNED	1,252	11,042	563	5,051	349	3,689	179	1,819	161	198	125	160
Estimated Quantities Remaining[3]		4,207	48,044	1,437	15,045	827	10,257	1,002	12,442	941	185	1,108	1,862
											8,438[4]		

Notes:
1. Other test activity requiring mission systems aircraft that was not mission systems software capability verification (i.e. maturity flights, survivability measurements).
2. Due to re-baselining in early 2011, "planned" test points are equal to the actual test points for activity prior to 2011.
3. Estimates of tests remaining include only the required number of successful flights and baseline test points. Discovery, regression, and re-fly factors are not included.
4. Mission systems estimate includes total remaining Test Points to complete System Design and Development test plans for Blocks 0.5 through Block 3.0.

System

- The F-35 Joint Strike Fighter (JSF) program is a tri-Service, multi-national, single-seat, single-engine family of strike aircraft consisting of three variants:
  - F-35A Conventional Take-Off and Landing (CTOL)
  - F-35B Short Take-Off/Vertical-Landing (STOVL)
  - F-35C Aircraft Carrier Variant (CV)
- It is designed to survive in an advanced threat (year 2012 and beyond) environment using numerous advanced capabilities. It is also designed to have improved lethality in this environment compared to legacy multi-role aircraft.
- Using an Active Electronically Scanned Array (AESA) radar and other sensors, the F-35 is intended to employ precision-guided bombs such as the Joint Direct Attack Munition and Joint Standoff Weapon, AIM-120C radar-guided air-to-air missiles, and AIM-9 infrared-guided air-to-air missiles.
- The program provides mission capability in three increments: Block 1 (initial training), Block 2 (advanced), and Block 3 (full).
- The F-35 is under development by a partnership of countries: the United States, Great Britain, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway.

Mission

- A force equipped with F-35 units should permit the combatant commander to attack targets day or night, in all weather, in highly defended areas of joint operations.
- Targets include fixed and mobile land targets, enemy surface units at sea, and air threats, including advanced cruise missiles.

Major Contractor

Lockheed Martin, Aeronautics Division, Advanced Development Programs – Fort Worth, Texas

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Activity

Test Strategy, Planning, and Resourcing

- The program applied the recommendations of last year's Technical Baseline Review (TBR) to the System Design and Development (SDD) phase test and verification plans. The program established a new integrated master schedule for the 2011 calendar year, and rebaselined all test metrics beginning January 2011.
- In November 2011, the program implemented the changes to the SDD flight test schedule recommended by the TBR. These changes included lowering planned flight rates, increasing planned downtime for modifications of test aircraft, changing roles for some SDD test aircraft, adding production aircraft as developmental test aircraft, lengthening software development spans, increasing the number of flights dedicated to weapons integration, and adding sustainment support for flight test.
- Throughout 2011, the program developed a new integrated master schedule (IMS) for the remainder of SDD. In December 2011, the program incorporated the new SDD flight test schedule (which included the TBR recommendations) in the new, draft IMS. The final IMS is expected to be available in early 2012.

F-35 Flight Test

F-35A Flight Sciences, Flight Test with AF-1, AF-2, and AF-4 Test Aircraft

- The program achieved the full complement of planned F-35A flight sciences SDD test aircraft with the delivery of aircraft AF-4 in January 2011. F-35A flight sciences testing focused on expansion of the flight envelope in transonic and supersonic flight regimes, improving handling qualities by reducing the impact of transonic roll-off, and accomplishing the test points required for the initial training capability flight clearance.
- As of the end of November 2011, the test team was able to accomplish the planned sortie rate of 7.7 flights per aircraft per month (264 flights accomplished, 263 planned). However, the number of test points accomplished lagged the planned baseline productivity by 11 percent (1,710 test points accomplished of 1,925 planned). The program discovered a test point metrics accounting error in November and adjusted the CY11 planning numbers accordingly. The error caused a projection of an additional 590 F-35A flight sciences test points than were actually called for in the test plans for 2011.
- In addition to the content of the approved baseline test plans, the program discovered requirements for additional testing. The test team accomplished an additional 358 test points per the program's flight test request process, which is the formal process for adding flight tests that are not part of the existing, approved test plan.

F-35B Flight Sciences, Flight Test with BF-1, BF-2, BF-3, BF-4, and BF-5 Test Aircraft

- In accordance with the post-TBR re-planning guidance, the program modified two mission systems F-35B test aircraft, BF-4 and BF-5, as flight sciences aircraft and modified the original three flight sciences test aircraft (BF-1, BF-2, and BF-3) to improve their STOVL-mode capabilities and instrumentation. BF-4 and BF-5 may accomplish either type of testing: flight sciences or mission systems. In 2011, BF-4 and BF-5 focused on flight sciences. This brought the number of F-35B flight science test aircraft to five, which is the full complement in the new plan.
- F-35B flight sciences focused on preparation for the first developmental test trials on a large deck amphibious ship, which began on October 3, 2011, as planned in the new master schedule for 2011. The test team also worked to

expand the flight envelope for F-35B pilot training (planned to begin in early 2012), conducted air refueling testing, and surveyed handling characteristics in transonic flight regimes.
- As of the end of November 2011, the test team was able to exceed the planned flight rate of 5.1 flights per aircraft per month, exceeding the total flight goal by 15 percent (308 flights accomplished, 268 required). By the end of November 2011, overall test point progress against planned baseline productivity was slightly behind (9 percent). The program also identified additional F-35B flight sciences test requirements and accomplished 213 of these test points added by flight test requests.

F-35C Flight Sciences, Flight Test with CF-1, CF-2, and CF-3 Test Aircraft
- The production team delivered test aircraft CF-2 and CF-3 to the Patuxent River, Maryland, test center in May and June 2011, respectively. CF-3 is primarily a mission systems test aircraft, but is capable of limited flight sciences activity, such as ship trials. The program plans to deliver the final F-35C flight sciences aircraft, CF-5, in late 2012.
- F-35C flight sciences focused on preparing for and executing carrier landing and catapult launch testing in the simulated carrier environment at the Lakehurst, New Jersey, test facility. The test team also began envelope expansion in the transonic regime, weapons bay environment testing, and evaluation of handling qualities with weapons bay doors open.
- As of November 2011, the test team exceeded the planned flight rate of 4.3 flights per aircraft per month, accomplishing 154 flights against a planned total of 148. Test point production exceeded the goal by 32 percent. The program also identified additional flight test requirements for F-35C flight sciences and accomplished 132 of these points added by flight test requests.

Mission Systems, Flight Tests with AF-3, AF-6, and AF-7 Test Aircraft and Software Development Progress
- The program successfully added F-35A production lot 1 aircraft AF-6 and AF-7 as mission systems test assets at the Edwards flight test center, California, in June and May 2011, respectively. Because the program plans for these aircraft to eventually be operational test aircraft, they contain instrumentation that makes them useful as mission systems test aircraft. This brings the total number of dedicated mission systems test aircraft at present to three; this number may be augmented by aircraft BF-4 and BF-5 at the Patuxent River test center, as they have a primary role as F-35B flight sciences assets. For example, aircraft BF-4 accomplished eight mission systems flights early in the year before entering modifications for F-35B flight sciences ship trials. The program plans to provide three more operational test aircraft from production lots 3 and 4 to the mission systems test fleet – F-35B aircraft BF-17 and BF-18 (in late 2012) and F-35C aircraft CF-8 (in early 2013).
- The test team attempted mission systems test points needed for acceptance and delivery of the lot 2 and lot 3 aircraft to the training center. The test team also accomplished other flight test activity requiring the use of mission systems aircraft, such as signature tests and "maturity" flights designed to determine the readiness of the F-35A air vehicle for the start of pilot training.
- As of the end of November 2011, mission systems test aircraft exceeded the planned flight rate of 5.2 flights per aircraft per month by 42 percent. The team exceeded the combined Block 0.5 and Block 1 test point goal of 236 by 27 percent. The program identified additional mission systems flight test requirements and accomplished 67 of these points added by flight test requests. The team had not completed any of the 60 Block 2 flight test points, which the program intended to begin in November 2011.
- Block 0.5, Block 1A, and Block 1B Initial Training Capability for Lot 2 and Lot 3 Aircraft
  - **Block 0.5.** Most of the Block 0.5 test points (78 percent) remained to be accomplished after the end of 2010. In 2011, the test team planned to accomplish 130 of the 301 remaining Block 0.5 test points concurrently with Block 1 testing. Block 1 capability has two parts: Block 1A for lot 2 aircraft and Block 1B for lot 3 aircraft (retrofit to lot 2).
  - **Block 1A.** The program and the Air Force determined that the initial Block 1A capability and the F-35A air vehicle required additional testing and deficiency resolution in order to be suitable for unmonitored flight at the training center. Early in 2011, plans for the airworthiness certification process initially anticipated that 200 to 400 hours would need to be accumulated in order to have sufficient flight hours to facilitate a maturity decision. The Edwards test team added a "maturity" flight test plan and used the instrumented lot 1 mission systems test aircraft, AF-6 and AF-7, which were delivered in May (five months later than previously planned), to accomplish these flights. The results of these flights, along with other flight test data, are inputs to the Air Force's airworthiness decision and official military flight release for the lot 2 aircraft at the training center. Through mid-October 2011, the test team accomplished 34 F-35A maturity flights flown in the initial training syllabus mission profile, accumulating 58.6 hours on AF-6 and AF-7 combined. Between early July and early November, an additional 10 sorties and 19.9 hours were flown in AF-6 and AF-7 with the initial Block 1A software configuration in flights accomplishing other mission systems flight test objectives. By the end of November 2011, the program accumulated a total of 44 sorties and 78.5 hours on the Block 1A software in the F-35A air vehicle for consideration in the Air Force airworthiness decision.
  - **Block 1B.** Software integration tasks for Block 1B mission capability were 90 percent complete by the end of September 2011 when it began flight test, three months late based on the new plan. This increment includes new functionality for sensor fusion, electronic

warfare, and onboard imagery, as well as system security provisions. As of the end of November 2011, less than half of the Block 1B capabilities (12 of 35) had met full lot 3 production contract verification requirements for aircraft delivery. Five of the remaining capabilities were under consideration to be deleted from the requirements since they were associated with weapons capabilities not available until lot 5 in the new IMS. The remaining 18 capabilities have some degree of variance from the expected performance.
  - Tests of two systems integral to Block 1 (and later) capability, the Identification Friend-or-Foe Interrogator (IFFI) and the laser in the Electro-Optical Targeting System experienced delays in 2011. This was due to delays in obtaining clearances from the government agencies that oversee their use. While limited testing of the IFFI system has been conducted off-shore in non-restricted airspace, clearance for testing in national airspace (planned for May) had not been received as of this report. Clearance for testing the laser did not occur until November, while testing was planned to start in June 2011. These delays affected the ability of the test team to accomplish the 192 Block 1 test points assigned for laser and IFFI testing during the year.
- Block 2 and Block 3 Software Development Progress
  - The program intends to provide Block 2 capability for production lot 4 and lot 5 aircraft; lot 4 aircraft should begin to deliver in mid-2012. In the new plan, the program intends Block 2 to contain the first mission systems combat capability – including weapons employment, electronic attack, and interoperability.
  - Concurrent with Block 1 development and integration, the program began integration of initial Block 2A software using the Cooperative Avionics Test Bed (CATB) in early October 2011. The development team augmented the mission systems integration lab, which was busy supporting Block 1 tasks, with the CATB as an integration resource. The new plan calls for the beginning of Block 2A flight test on F-35 mission systems aircraft before the end of November 2011. However, initial Block 2 integration task execution has fallen behind the new plan, having completed approximately half of the planned schedule, and leaving approximately 70 percent of integration tasks to go.
  - Block 3 development is slightly behind the new plan with only 30 percent of initial Block 3 having completed the development phase. In the new plan, the program simplified Block 3 to two production releases instead of three in prior planning and schedules. The program plans the first release, Block 3i, to contain no substantive increase in functions or capability. It will re-host the final Block 2 capability on the upgraded "Technical Refresh 2" processor hardware set. The program intends Block 3i capability for production lot 6 and lot 7 aircraft. Block 3f, the final increment, includes new capability. The program intends to deliver Block 3f for IOT&E and the final lots of low-rate production.

Modeling and Simulation

Verification Simulation (VSIM)

- The program determined that the man-in-the-loop verification simulation that will meet the operational test agencies' intended use would be located at Marietta, Georgia, for both Block 2 and Block 3 testing.
- The contractor worked through validation of the requirements of the simulated battlespace environment and the F-35 own-ship modeling with the program office, the verification team, and the JSF Operational Test Team.
- The Lockheed Martin VSIM verification and validation team provided inputs to the Block 2 flight test plan that will begin execution in late 2011. The program continues to work to source the data that will be needed to validate this simulation for operational testing.
- The program began a technical assessment of simulation validation challenges that have been identified by the operational test community, and is exploring these in a series of detailed technical reviews that began in 2011 and will continue into 2012.

Other Models and Corporate Labs

- Of the 28 models and simulations currently planned to support verification of the F-35, the program office has accredited four. In 2011, the program accredited use of the finite element models contained in the National Aeronautics and Space Administration (NASA) Structural Analysis (NASTRAN) model in verification of F-35 structures. NASTRAN solves large structural stress analysis problems and predicts strength and durability. The program plans to accredit two more models before the end of 2011.
- The changes to the program master schedule enabled several accreditation need dates to move from 2011 to later years. About half of the models and simulation in the verification plan must be accredited in the next 24 months, with the remainder due between 2014-2016.

Static Structural and Durability Testing

- The program halted F-35B durability testing at the end of last year when a wing carry-through bulkhead cracked before 2,000 hours of airframe life. The required airframe lifetime is 8,000 hours. Repair of the bulkhead on the test article was completed in November 2011, and F-35B durability testing is scheduled to restart in January 2012.
- Following the bulkhead crack in the F-35B test article, analysis verified the existence of numerous other life-limited parts on all three variants. The program began developing plans to correct these deficiencies in existing aircraft by repair/modifications, and designing changes to the production process. The most significant of these in terms of complexity, aircraft downtime, and difficulty of the modification required for existing aircraft is the forward wing root rib on the F-35A and F-35B aircraft.

All production aircraft in the first five lots will need the modification before these aircraft reach 1,000 hours.

- The program also halted F-35A durability testing after the F-35B bulkhead crack and restarted it at the end of May 2011. The test article restarted testing in November 2011, after completing inspections subsequent to accomplishing 3,000 effective flight hours of testing. During the second 1,000-hour block of testing, the wing root rib failed, as predicted. The test team is able to continue airframe fatigue testing in the near-term, while analysis determines when and how to repair the test article.
- F-35C structural testing completed all structural test objectives in August 2011, including planned "drop tests" in preparation for simulated carrier trials. Durability testing is scheduled to begin in Spring 2012.

Training System

- The program continued to develop training systems for use at the Integrated Training Center, Eglin AFB, Florida. The Air Force's training command approved courseware and the syllabus for the initial familiarization flight training (a six-mission syllabus) portion of the F-35A transition syllabus. From July through October, the six F-35A lot 2 aircraft ferried to Eglin on a one-time ferry-flight clearance from the production plant in Fort Worth, Texas. The aircraft have been used for verification of Joint Technical Data – the technical directives delineating F-35 maintenance and servicing procedures – while awaiting the military flight release permitting unmonitored flight.
- The program worked with the Air Force's airworthiness authority to determine the data requirements for the military flight release needed to begin flying production aircraft at the training center. Engineering teams cannot monitor these aircraft like they can flight test aircraft. Though planned to be complete by August, the military flight release had not occurred by the end of November 2011. At the time of this report, the program and the Air Force were in the process of examining numerous risks in starting unmonitored flight and training relatively early in, and concurrent with, development. The program and the Air Force have stated an intention to follow an event-driven plan to start training.
- In August 2010, the JSF Program Executive Officer (PEO) asked the JSF Operational Test Team to assess the initial training mission capability intended for the integrated training center. The JSF Operational Test Team developed an Operational Utility Evaluation (OUE) plan and submitted it for approval to DOT&E. In October 2011, DOT&E identified the need to resolve specific safety-related deficiencies in the F-35A and sustainment systems, as well as the need to build-up maturity in the air system, before the OUE test plan would be approved.

Air System-Ship Integration and Ship Suitability Testing

- **F-35B.** The program accomplished the first of two STOVL developmental test ship trials on the USS *Wasp* in October with test aircraft BF-2 and BF-4. The testing focused on developing initial short take-offs and vertical landings in the initial flight envelopes for deck operations, performing initial ship compatibility assessments, and collecting environmental data from instrumented ship locations. Seventy-two short take-offs and vertical landings were completed during the 19-day deployment in conditions of up to 33 knots of wind-over-deck and 10 knots of starboard crosswind. Some standard deck operations and maintenance activities were demonstrated, including fueling and defueling, aircraft tiedown, jacking, tire replacement, augmenter boost pump and door actuator replacements, and hydraulic servicing. Environmental data were collected to assess thermal stress to landing sites and shielded areas, and acoustic effects to ship personnel. Current plans place the second set of trials in August 2013.
- **F-35C.** The program began F-35C carrier landings, catapult take-offs, and jet blast deflector testing at the Lakehurst, New Jersey, test facility in July.

Live Fire Testing

- FUSL testing conducted on the first flight test aircraft (CTOL aircraft AA-1) provided aircraft flight control, electrical, propulsion, and fuel system vulnerability data. Due to commonality of the three variants, these results are extendable to the STOVL and CV variants as well.
- Contractor Fuel System Simulator tests showed the On-Board Inert Gas Generation System (OBIGGS) performance to be inadequate to support the vulnerability reduction requirements of the aircraft. A two-phase redesign effort is underway to provide protection against threat-induced fuel tank explosion across the entire flight envelope. Engine test articles have been delivered and structural test articles have been identified.

Assessment

F-35A Flight Sciences

- The test team was able to complete the F-35A flight sciences testing needed to provide flight envelope for the initial training mission capability and make progress toward other flight sciences goals needed to complete the SDD phase.
- An error in the test point planning metrics was discovered in November and the planned number of flight science test points were adjusted accordingly (590 test points removed from the planned metric). After this correction, test point completion lagged the planned level for the year by 11 percent. This lag was a result of accomplishing fewer test points per flight than planned. Contributing factors included deficiencies in the air vehicle's air data system as well as in-flight data indicating different structural loads than that predicted by computer modeling. These departures from model prediction of loads led to the addition of more build-up points, which are incremental, "stepping stone" expansions of the flight envelope. Additionally, planned air refueling testing did not take place because the instrumented tanker was not available at the expected time.
- The test team worked to overcome two obstacles to progress: test point constraints and aircraft reliability. Aircraft

operating limitations and inadequate instrumentation often constrained the available test points to a small subset of those planned. Aircraft reliability and parts shortages also negatively affected flight generation.
- While the lag is not a significant shortfall at this point in flight sciences testing, the program needs to continue to address the obstacles to flight and test point productivity to avoid a compounding effect. Weapons integration, high angle of attack testing up to 50 degrees, and completion of elevated g-loads testing are significant challenges of traditionally difficult test regimes that lie ahead.
- Discoveries included:
  - An Integrated Power Package failure during ground start on aircraft AF-4 in early August resulted in grounding all aircraft, all variants, for two weeks. A malfunctioning valve in the power and thermal management system created the conditions for the failure. Flights resumed after putting new procedures in place to monitor the valve with instrumentation on SDD flight test aircraft. The program also created a procedural change for production aircraft to manage the risk of failure on aircraft that engineering personnel cannot monitor. The program completed testing of a software change that has since been installed on the F-35A lot 2 aircraft at Eglin in November 2011.
  - The F-35A flight sciences tested evaluated handling characteristics and performance in a larger, more stressful flight envelope than the other two variants (e.g. up to 20 degrees angle-of-attack, with 50 degrees being the required maximum, and 9 g-load factor, which is the planned maximum load factor). The program worked to improve handling characteristics in transonic flight regimes through changes to flight control software, resulting in acceptable handling characteristics at high and medium altitudes (software version R25.0.7). However, the structural loads on the vertical tail fins of the F-35A aircraft, which stem from sideslip occurring in this regime, are higher than predicted and may require modifications to the tails or further changes to flight control software to reduce these effects. Additionally, flight tests of the magnitude and effects of buffet during elevated g-load and angle-of-attack revealed characteristics that need to be further examined. Testing in the regime where buffet is expected to be most pronounced had not occurred by the time of this report, due to load-factor flight envelope limitations. Fixes for handling characteristics must be balanced with other aircraft performance factors to find an acceptable, optimized solution. The program plans to continue this testing into 2012; more discoveries of performance trade-offs or adverse effects to structures are possible.
  - The program previously discovered deficient aircraft braking performance during landing on wet runway surfaces. The program tested new brake control unit hardware and software intended to improve performance. The program accelerated testing of the capability to stop the aircraft after landing on wet runway surfaces to 2011 to support the military flight release for aircraft ferried to the training center. Changes to the wheel brake controller improved this capability, but the program has not determined if the deficiency is resolved. Effective use of the latest design depends on the adequacy of simulations used to train pilots in maintaining directional control while activating differential braking. This requires precise control of brake pedal deflection, which will be difficult if not impossible during non-instrumented flight.
  - Fuel dump tests found that fuel migrated back into the aircraft, similar to results discovered on F-35B test aircraft. This has the potential to create an unsafe condition.
  - Engine airstarts require sufficient revolutions-per-minute of the engine for a successful re-start. The Integrated Power Package and the engine starter generator combine to provide additional torque to achieve the needed revolutions-per-minute in a flamed-out engine during an assisted airstart procedure. Ground tests recently indicated that the power output from the Integrated Power Package and the torque supplied by the starter-generator are lower than expected and may result in a failed start at speeds below 320 knots. Pilot procedures have been written requiring the airspeed to be maintained between 320 and 350 knots for an assisted airstart, which produces a high descent rate. Airstart flight tests have not begun. Software changes are under consideration to reduce the likelihood of failed start. This will affect all variants.
  - The horizontal tail of aircraft AF-1 was discovered to have sustained heat damage at the inboard trailing edge area after long duration afterburner operations on a flight test mission. The damage consisted of blistering of the surface and missing pieces of the trailing edge. Restrictions are in place and the test team is adding instrumentation to gain more accurate data on the conditions and cause of the problem.

F-35B Flight Sciences
- The test team was able to improve the tempo of STOVL-mode flight test early in the year in order to open sufficient flight envelope and accomplish other shore-based build-up for the ship trials in October 2011. Test and engineering teams accomplished a significant amount of modifications to the test aircraft to bring about this needed increase in the pace of STOVL-mode flight test. To accomplish 2011 goals, the test team also worked to overcome the challenges of low aircraft reliability and parts shortages.
- The test team was able to conduct safe flight tests of the STOVL-mode and successfully completed initial ship trials using flight monitoring systems in SDD test aircraft. The program has not completed the final re-designs and plans to correct deficiencies through modifications of F-35B production aircraft intended for the fleet, which cannot be monitored in-flight because these aircraft are not instrumented. Production aircraft will be restricted from STOVL-mode flight operations until Service airworthiness authorities grant a flight clearance. A significant amount

of flight test and development of system maturity of the final STOVL-mode door and propulsion system designs remains to be accomplished. A system mature enough for unmonitored STOVL-mode flight may be needed as early as late 2012 to coincide with the delivery of lot 4 F-35B aircraft to the Marine Corps at Yuma, Arizona. If testing of the changes is not complete and needed modifications are not installed by late 2012, aircraft at Yuma will fly in CTOL-mode only.

- The following table describes the door and propulsion problems by component, and identifies the production cut-in, if known.

F-35B Door and Propulsion Problems				
Category	Component	Problem	Design Fix and Test Status	Production Cut-In
Subsystems	Upper Lift Fan Inlet Door Actuators	Actuator redesigns due to high actuator failure rates.	New actuator under development. Interim design will be tested during SDD, planned for late CY12.	BF-38 LRIP 6
Structure	Auxiliary Air Inlet Door	Problems included inadequate life on door locks, excessive wear and fatigue due to the buffet environment, inadequate seal design.	Redesign currently being installed on BF-1, including associated structural longeron repair. Flight testing to begin in mid-December 2011.	BF-38 LRIP 6
Structure	Lift Fan Door Actuator Support Beam	Cracks occurring earlier than predicted. Root cause analysis showed fastener location incorrectly inserted in design.	BF-1 and BF-2 modifications are complete. BF-3 will not to be modified (will not be used for STOVL Mode 4 operations). BF-4 has resumed Mode 4 operations. Potential design fix is on BF-5; however, limited STOVL mode testing has been done on BF-5 to date (less than 30 total hours as of November 2011).	BF-5 LRIP 2
Structure	Roll Post Nozzle Doors	Doors separated from aircraft BF-2 and BF-3 during flight; door loads not well understood, aero pressures higher than expected. Impact not limited to STOVL mode operations – flight not to exceed 400 KCAS below 18K ft and 0.5 minimum g-load.	BF-3 is being instrumented. All SDD F-35B aircraft have an interim fix with door stiffeners/clips and strengthened torque tube fasteners. Final design is still to be determined (TBD).	Not known
Structure	3 Bearing Swivel Nozzle Door	Door attachment wear/damage found on BF-1 (6/11) requiring new inspection interval every 25 mode-4 flights. During Slow Landing flight testing, measured door loads exceeded limits.	Interim mod on BF-1 (01/12), instrumentation added. Final design and retrofit plan is TBD. Slow Landings now prohibited below 100 knots pending the results of flight testing.	Not known
Structure	Main Landing Gear Doors	Door cracking observed on BF-1, 2, 4 aft door adjacent to aft lock.	Final design is TBD. Instrumentation added to BF-2.	Not known
Propulsion	Drive Shaft	Lift fan drive shaft undergoing a second redesign. Original design inadequate due to shaft stretch requirements to accommodate thermal growth, tolerances, and maneuver deflections.	Analysis of failure of 2nd design and corrective action is ongoing. Additional spacers needed – uniquely fitted for each aircraft – to ensure proper lift fan performance.	BF-44 LRIP 7
Propulsion	Clutch	Lift fan clutch has experienced higher than expected drag heating during conventional (up and away) flight.	Temperature data from the clutch housing is being collected on the test aircraft to determine risk and a path forward.	BF-44 LRIP 7
Propulsion	Roll Post Nozzle Actuator	Roll post nozzle bay temperatures exceed current actuator capability. Actuator failure during Mode 4 operations.	Insulation between the roll post nozzle bay and the actuator is being installed and tested to provide interim solution for LRIP 2 – 4 STOVL aircraft. Increased temperature actuator is scheduled to be available for test in early 2012.	TBD

- The status of F-35B door and propulsion deficiencies follows.
  - Redesign of the auxiliary air inlet doors continued, this being needed to reduce deflection under actual flight loads that have proven to exceed design and modeling predictions. The program plans flight testing of the new design in early 2012. These doors conflicted/jammed during operation on newer F-35B test aircraft, necessitating special attention to door rigging.
  - Analysis continued on the three-bearing swivel nozzle doors and the lower lift fan door as a result of flight tests indicating higher than predicted loads. The program plans to modify the design of the three-bearing swivel nozzle doors and test concurrently with the modified auxiliary inlet door in early 2012. This testing is expected to generate the dynamic loads data required to assess whether any further design changes to the three-bearing swivel nozzle doors will be required to achieve full-life capability.
  - Temperatures in the roll control nozzle actuator area exceeded the heat tolerance of the current actuator design during flight test, necessitating a redesign. The program is

  - changing the insulation in the nozzle actuator area as an interim fix and redesigning the nozzle actuator to improve heat tolerance. The program plans new hardware by the end of 2011 for testing.
  - Roll control nozzle doors separated in-flight from a test aircraft twice, drawing attention to door rigging and the potential for redesign. The program plans to conduct flight test on a new door in early 2012 to support the redesign effort.
  - The interim solution to unacceptably high clutch temperatures is to add a temperature sensor and display page so that the pilot can be aware of increasing temperature inside the clutch housing. Fuel and operational conditions permitting, changing flight regimes (e.g. configuration, altitude, and airspeed) may cool the clutch so that the pilot can engage STOVL modes. Such a cooling procedure may be untenable in combat conditions.
  - The program added spacers to the lift fan driveshaft to address unanticipated expansion/stretching that takes place during flight. This is an interim solution while the program redesigns the driveshaft for better performance and durability.
- The vertical lift bring-back requirement is a primary STOVL-mode attribute and is a Key Performance Parameter (KPP). It is the weight of a minimum fuel quantity and other necessary payload needed to safely recover the aircraft on the ship after an operational mission, plus a representative weapons payload. Managing aircraft empty weight growth is essential to being able to meet the vertical lift bring-back requirement. The F-35B aircraft weight management challenge is complicated by balancing available lift, thrust required, and vertical descent rates in the vertical landing mode. Current and projected F-35B aircraft weight growth threatens the ability to meet this vertical lift bring-back requirement. The November 2011 weight data show only 230 pounds of margin between the current weight and the intended not-to-exceed weight of 32,577 pounds, which is the program's technical performance measurement threshold for empty aircraft weight currently programmed for January 2015. This weight margin represents 0.71 percent of the current weight and allows for only 0.22 percent weight growth per year until the technical performance measurement assessment deadline, which is prior to the end of SDD. The program recently determined that allowing a greater descent rate to touchdown (7 feet per second) plus possible positive thrust margins available from the lift fan may add an additional 142 pounds of weight tolerance to the technical performance measure not-to-exceed weight. This additional weight increases the margin to 1.2 percent of current weight and allows for 0.36 percent weight growth per year. Managing weight growth with such tight margins for the balance of SDD will be a significant challenge, especially with over 70 percent of the scheduled F-35B flight sciences test flights remaining to be accomplished in the next 60 months. For comparison, weight growth on the F/A-18 E/F was approximately 0.69 percent per year for first the 42 months following first flight.
- Other discoveries included:
  - The program found that later models of upper lift fan door actuators caused the door to stop moving as commanded. The program intends to redesign the actuator in time to begin flight test in late 2012, and introduce the new actuator into production aircraft in lot 6.
  - The fuel dump system causes fuel to migrate back into the aircraft structure, where it is retained until after landing. While some improvement was noted with modifications to the vent area on test aircraft, the program plans more work to correct this deficiency.
  - Flight test teams discovered cracks in landing gear doors on STOVL aircraft. Analysts determined that gear door stresses were within tolerance. Root cause analysis of the cracks continued through the time of this report.
  - Using the version of flight control software available at the beginning of 2011, undesirable wing roll-off, airframe buffet, and sideslip occurred in transonic flight regimes. Through changes to flight control software, the program improved these handling qualities. By the end of November 2011, testing of the latest flight control software change (version R25.0.7) indicated the handling qualities did not meet the current criteria. No further software modifications specific to transonic roll-off are planned. The program is examining the handling characteristics criteria for operational relevance. Two options remain: a) consideration of structural modifications to improve handling characteristics, or, b) relaxation of the handling characteristics criteria. Testing also began to survey the magnitude and effect of buffet during elevated g-load and increasing angle-of-attack; e.g. up to 16 degrees angle-of-attack, of the 50 degrees required maximum, and 7.5g load factor, which is the required maximum. Testing in the regime where buffet is expected to be most pronounced had not occurred by the time of this report. As with the CTOL aircraft, the test and engineering teams must balance improvements to handling qualities with other performance factors to find an acceptable, optimized solution. This testing will continue into 2012.
  - Aircraft BF-2 experienced damage to coatings on the horizontal tail following afterburner use similar to that found on F-35A aircraft AF-1. Restrictions are in place and the test team is adding instrumentation to gain more accurate data on the conditions and cause of the problem.

F-35C Flight Sciences

- As F-35C flight sciences focused on preparation for and execution of carrier launch and landing testing at Lakehurst, a limited amount of other envelope expansion occurred in 2011. The F-35C flight sciences test points accomplished thus far are approximately 15 percent of the total expected in SDD.
- The lack of available flight envelope in the transonic regime currently constrains testing of F-35C aircraft handling

qualities. In limited testing using flight control software that benefitted from F-35A and F-35B testing, the F-35C aircraft performance in the transonic flight regime demonstrated the predicted intensity of uncommanded rolls but higher buffet levels. The F-35C aircraft was expected to have the greatest challenge of the three variants in the transonic flight regime, which led to the decision to incorporate structural provisions for the installation of external spoilers in one test aircraft.

- The carrier launch and landing testing at Lakehurst provided valuable lessons regarding the impacts of these dynamic environments on the aircraft early in the testing. Corrections and regression testing are needed as a result of the discoveries listed below. The program is also working to correct other performance problems such as excessive nose gear oscillations during taxi, excessive landing gear retraction times, and overheating of the electro-hydrostatic actuator systems that power the flight controls. The program will subsequently evaluate the need for modifications of production aircraft for these items.
- Discoveries included:
  - Flight test aircraft could not engage the arrestment cable during tests at the Lakehurst, New Jersey, test facility. The tail-hook point is undergoing a redesign and the hold-down damper mechanism requires modifications to enable successful arrestments on the carrier. Resolution of these deficiencies is needed for testing to support F-35C ship trials in late 2013.
  - Hold-back bar and torque arm components, which keep the F-35C aircraft from moving forward when tensioned on the catapult at full power, require a redesign due to the use of incorrect design load factors. Actual loads are greater than predicted. The impact of these greater-than-predicted loads on strength and fatigue characteristics is under analysis by the program.
  - Loss of inertial navigation and GPS inputs to pilot displays occurred during a catapult launch. Root cause analysis was in progress at the time of this report.
  - The test team conducted initial testing in the transonic flight regimes with one version of air vehicle software on aircraft CF-2. Problems similar to the other variants were observed, such as excessive buffeting and roll-off, at times making the helmet-mounted displays unreadable.
  - Higher than predicted temperatures exist in the electro-hydrostatic actuator system during flight testing of the aircraft in a landing configuration. This component provides the force to move control surfaces.

Mission Systems

- Assessing mission systems progress requires a review of the allocation of flight test activity so far, and an understanding that the total mission systems verification to date is only approximately 4 percent of that planned to complete SDD mission systems software testing.
  - Operating only one test aircraft for the first six months, and three total aircraft for the remainder of the year, the Edwards test team was able to exceed the planned mission systems flight rate and limited test point productivity for mission systems capability. However, the majority of this year's mission systems test point accomplishment was for F-35A maturity (37 percent) and other non-software verification tasks (34 percent). This occurred partially because of the constraints on test operations caused by delays in obtaining clearances to test the Electro-Optical Targeting System laser and operate the Identification Friend-or-Friend Interrogator. F-35A maturity flights more than offset these test constraints in consuming mission systems aircraft flight test productivity. The need to add maturity flights is a manifestation of highly concurrent production of aircraft and development of the air vehicle. To accomplish these flights, the program had to use the mission systems test aircraft from production lot 1as they represented the low-rate initial production (LRIP) aircraft that would be flying unmonitored at the training center. Even though these aircraft were mission systems test assets, these flights evaluated the overall maturity of the air vehicle, not just the effectiveness of the limited mission systems capability for initial training.
  - Overall, the program has demonstrated very little mission systems capability thus far in flight test on F-35 aircraft. In fact, the program has not delivered some of the intended initial training capability, such as effective and consistent radar performance. Only very limited F-35 flight testing of sensor fusion took place this year. In accordance with the test plans to build up to operationally relevant flight test scenarios, flight tests to date largely focused on verifying correct sensor contributions to sensor fusion, with limited stressors on the system. The program plans more stressing flight test scenarios in upcoming flight testing. It is too early to determine the effectiveness of the fusion design. Knowledge of mission systems performance is extremely limited until the measure of fusion performance is oriented to operationally relevant weapons employment, electronic warfare, threat location, and threat identification.
- The limited progress in demonstrating mission systems capability so far causes increasing concurrency among the first three increments of mission systems software capability.
  - If the program introduces Block 2 into flight test in early 2012 as it plans to do, there will be a significant amount of overlap of the remaining Block 0.5 and Block 1.0 test execution with Block 2 development, integration, and flight testing. Per the status of execution of the test plans at the end of 2011, 40 percent of the Block 0.5 and over 85 percent of Block 1 test points will remain unaccomplished; these are demonstrations of functions and capability that are largely foundational to Block 2 capability. This situation creates uncertainty as to what capability will be provided to production lots 3 and 4 and how this capability will be verified before release to the field.
  - The inherent and growing concurrency in the mission systems flight test plan is a source of risk in the program.

The difficulty of managing multiple configurations on test and operational flight lines to assure use of appropriate software, increasing rework of software, and the potential for greater than expected regression flight tests are significant challenges to the program.

- This creates an uncertain starting point for the next two years, during which the program plans to evaluate Block 2 capability. Significant challenges come with correcting the current known deficiencies and evaluating weapons delivery capability, interoperability with other platforms, and electronic warfare capability. A significant risk area for the program during this time is the absence of mission systems testing with an operationally representative mission data file, which is the compilation of threat and other system data needed for track identification and appropriate threat countermeasures.

- Discoveries included:
  - The helmet-mounted display system is deficient. It is meant to display key aircraft handling/performance information as well as tactical situational awareness and weapons employment information on the pilot's helmet visor, replacing conventional heads-up display systems.
    - Deficiencies include integration of the night vision capability, integration of Distributed Aperture System video for night vision, symbology jitter or swimming, and latency. These stem in turn from poor acuity with night vision camera hardware, limited computer processing power, inaccurate head position tracking, and poor helmet fit, complicated by vibration-inducing airframe buffet experienced at high angles-of-attack in some dynamic maneuvering regimes.
    - The program began pursuing a dual path to resolve the technical shortfalls and provide a system that will enable flight test to proceed and meet operational mission needs. One path is to complete development of the original helmet-mounted display system by the end of SDD Block 3. The alternate path is to integrate a technically mature, existing helmet-mounted display system that addresses the symbology stability problems that have been discovered, but requires an additional night vision system (such as existing night vision goggles) to provide night combat capability, and does not display Distributed Aperture System imagery on the pilot's visor. The impacts of these two paths on mission systems schedule cannot be measured until plans are integrated into the master schedule.
    - The program made several modifications to the helmet to be useful in daytime flight test and the benign initial training environment. Shimming and visor alignment changes have corrected some of the virtual heads-up display deficiencies for flight test and initial training; however, more work is needed for the existing helmet to support certain flight test missions in the near future (e.g. high angle-of-attack, elevated g-loading, weapons employment) and combat operations.
  - Panoramic cockpit displays in the mission systems aircraft overheat during flight test. The program is pursuing modifications to test aircraft to increase cooling and decrease heat load so that testing can continue.
  - While mission systems software has been stable during flight tests so far, startup time and startup stability is poor, usually taking more than 30 minutes to complete. The most recent Block 1B software improved startup times, but more improvement is needed for suitable operations.
  - Radar anomalies in flight included loss of air target tracks without indicating radar faults or failure to the pilot. Root cause analysis was in progress at the time of this report.

Operational Assessment

- The JSF Operational Test Team completed an operational assessment of the F-35 program and determined that it is not on track to meet operational effectiveness or operational suitability requirements. The JSF Operational Test Team assessed the program based on measured and predicted performance against requirements from the JSF Operational Requirements Document, which was re-validated in 2009.
- The primary operational effectiveness deficiencies include poor performance in the human systems integration (e.g. helmet-mounted display, night vision capability) and aircraft handling characteristics, as well as shortfalls in maneuvering performance (e.g. F-35A combat radius, which is a KPP, and F-35C acceleration).
- The driving operational suitability deficiencies include an inadequate Autonomic Logistics Information System (ALIS) for deployed operations, excessive time for low observable maintenance repair and restoration capability, low reliability and poor maintainability performance, and deficient crypto key management and interface compatibility.
- The assessment was completed prior to release of an updated program integrated master schedule. While additional time and resources in development may aid the program in resolving some deficiencies, several requirements are not going to be met given current, known program plans. After the new master schedule is available, along with documentation of the application of the additional resources applied to SDD plans, an updated operational assessment may be provided.

Air System-Ship Integration and Ship Suitability Testing

- The F-35B initial ship trials on USS *Wasp* supported initial short take-off and vertical landing envelope expansion efforts for shipboard operations with data collected as planned across a portion of the wind-over-deck conditions. As expected, high starboard crosswinds produced the most challenging environment. One approach to hover prior to a vertical landing was waved off by the pilot due to turbulence in the ship's airwake. A minimal nozzle clearance of 2 inches was observed at rotation during a short take-off with high starboard crosswinds when the pilot made an aggressive correction to maintain centerline. The test team demonstrated deck and hangar operations.

Although maintenance was completed while aboard the ship, limited support equipment was positioned on USS *Wasp* and no ALIS equipment supported the deployment aboard the ship. The test team created a virtual private network connection between the ship and the prime contractor in Fort Worth such that they were able to process maintenance actions as if operating at Patuxent River. Aircraft BF-2 diverted to Patuxent River twice during the deployment for maintenance – once for a fuel leak that could not be addressed at sea and once when the team elected to have upper lift fan door actuators replaced ashore. The upper lift fan door actuators on BF-4 had to be replaced twice during the trial period, once at Patuxent Rive and once at sea with an embarked maintenance team.

Ground Structural Testing and Analysis

- The fatigue cracks that occurred in November 2010 in a F-35B wing carry-through bulkhead early in durability testing were the result of unpredicted high stress concentrations. The finite element modeling previously conducted by the program to analyze the airframe was not adequate and did not predict these stress concentrations.
- As a result of the bulkhead crack, the program completed a detailed analysis of the full structural design for all variants, which identified more life-limited parts. A total of 58 parts were identified across all three variants. The most significant of these in terms of complexity, aircraft downtime, and difficulty of the modification for existing aircraft is the forward wing root rib on the F-35A and F-35B aircraft. All production aircraft in the first four lots will need the forward root rib modification before these aircraft reach 1,000 hours.
- The risks of concurrent development, testing, and production are highlighted by the experience with structural testing. Since most flight testing remains to be completed, the potential for more discoveries exist. The program predicts another 22 major discoveries and 43 moderate discoveries within SDD. The program plans to continue durability testing through two airframe lives (16,000 hours). Current schedules indicate the completion of the second airframe life will occur in early 2015 for F-35A and late 2014 for F-35B and F-35C. This means a total of nine aircraft production lots will be procured before completion of durability testing.

Issues Affecting Operational Suitability

- Flight test and lot 1 aircraft demonstrated low reliability compared to the operational requirement (i.e., the reliability required at 50,000 total flight hours for each variant) and compared to where program plans expect reliability to be at this point in system maturity. Based on data at the end of September 2011, the mean flight hours between critical failures were measured to be 2.65 hours for the F-35A, 2.05 hours for the F-35B, and 2.06 hours for the F-35C. These values range between 21 to 31 percent of the planned mean flight hours between critical failure for each variant given the flight hours accumulated so far. However, the rolling three-month trend of this measure is not stable for any of the variants, indicating continued discovery in reliability. Due to the initial low reliability experienced so far in all variants, the program has a significant challenge to provide sufficient reliability growth to meet the operational requirement. The program is working to update the reliability growth plan, last produced in 2006. Significant contributors to low reliability include the following:
  - F-35A wheel and tire assemblies, thermal management system, flight control actuators, fuel systems, and electrical power systems/connectors
  - F-35B lift fan system, thermal management, fire protection system, electrical power system/converters, wheel and tire assemblies, access doors/covers, lower inlet lip, wing and fuselage repairs, panoramic cockpit displays, doors, and actuators
  - F-35C landing gear wiring, wheel and tire assemblies, thermal management system, wing and fuselage repairs, engine nozzle segment, electrical power system, and fuel system.
- Maintenance of flight test and production lot 1 aircraft is taking longer than required for the mature system. For example, mean corrective maintenance time for critical failures for F-35A and F-35B aircraft is approximately twice that required of the mature system. The F-35C air vehicle is currently maintained at the required threshold for this requirement. Mean time to repair data show that all three variants currently are experiencing approximately twice the required time for the mature system. Current maintenance repair times are driven largely by immature health management and autonomic logistics information systems; however, the potential exists for discoveries in flight test and early operational fielding to further reduce maintainability. Timely maturation of these systems, completing and verifying technical order data are critical to improving maintainability for operational units. It is too early to predict whether the required maintainability thresholds can be met.
- The program failed to design the unit-level ALIS hardware for deployability. The squadron operating unit weighs 2,466 pounds and measures 79 inches high by 40 inches deep and 24 inches wide. It also requires climate-controlled environments. The program worked through late 2010 and 2011 to redesign the system and provide improved deployability by late 2014. However, there is no plan for end-to-end testing of the system, and funding of retrofits or changes to the units that will be purchased in the meantime. The problem needs correction in order to take advantage of F-35 capability in forward operating locations expected in combat.
- Data Quality and Integration Management (DQIM) is a vital part of the autonomic logistics global sustainment plan for the F-35. The ALIS version 1.0.3 is supposed to incorporate DQIM; however, missing data elements (e.g. part number, logistics control number, serial number) of vendor supply databases have prevented timely testing and fielding of ALIS version 1.0.3. This results in the development of manual

data tracking processes for early LRIP aircraft. The program expects to have DQIM data products available to support ALIS 1.0.3 fielding in May 2012.

Modification of Low-Rate Initial Production (LRIP) Aircraft

- The aircraft produced in the first five production lots will require significant numbers of structural modifications and configuration upgrades to attain the planned service life and the intended Block 3 capability. The program office worked with the Services this year to organize a funding and scheduling strategy. These are known as concurrency modifications because ground and flight tests concurrent with production identified the need to change the design after production began in order to achieve acceptable performance. These modifications include corrections to airframe parts discovered to have limited life during structural durability testing conducted so far. Additionally, the program has always planned a significant hardware and software upgrade from Block 2 to Block 3 mission systems capability; this will affect the first five lots of aircraft.
- Service plans, particularly in regards to throughput at the training center equipped with the initial production aircraft, must account for the planned downtime, which will be 45-60 days. For example, the program plans the F-35A and F-35B forward wing root rib modification to take a depot repair team 45 days to complete. All of the aircraft intended for operational testing require many of these modifications and the Block 3 upgrade in order for the JSF Operational Test Team to conduct an adequate IOT&E.

Training

- The JSF Operational Test Team developed an OUE test plan to provide the PEO the assessment he requested of the initial F-35A training mission capability, initially planned to begin in August 2011. The readiness-to-test and readiness-to-begin training processes highlighted several issues that have led to delays to the start of pilot flight training.
- Based on the flight schedule planned in April 2010, the program expected to have completed over 1,100 sorties and over 1,980 flight hours on the F-35A SDD aircraft (including the two lot 1 aircraft) by the end of November 2011. Actual numbers were 622 flights and 1,175 hours. The lower than expected flight rate and hours created schedule pressure to start training activities with a less mature aircraft system than planned.
- The primary problem for the program and the Air Force has been determining the acceptable level of risk involved with starting training in immature aircraft. The key event anticipated by the program office and the training center is obtaining a suitable military flight release from the Air Force airworthiness authorities, which is needed before pilots can fly the aircraft at the training center. The results of the maturity flights on the production lot 1 mission systems test aircraft were that approximately half required intervention by flight test control room personnel, an indication of low system maturity and likely mission abort in a non-flight test environment. The abort rate was measured at three times the measure of success set by the program and the airworthiness authority.
- As of the end of November 2011, the program had made progress on some of the safety-related items identified by DOT&E in October. Although the program and the training center leadership had officially committed to an event-driven start of flight training, they had provided no explicit plan for building maturity in the F-35A aircraft in order to safely conduct the OUE and begin F-35A pilot training. As of the end of November 2011, there were less than 80 total flight hours on the training mission software configuration and less than 1,200 hours on the F-35A variant. Historically, more than 2,500 fleet hours have been needed to reduce risk of beginning training in a new aircraft to an acceptable level.

Live Fire Test and Evaluation

- Live Fire FUSL testing of the first flight test aircraft consisted of 25 ballistic tests. Testing confirmed the ability of the airplane to isolate the damage to targeted components. Testing validated the robustness of both the Flight Control and Electrical Power Systems. Further analysis of the data will take place to compare with the pilot-in-the-loop simulations completed in FY09, which provided the basis for FUSL pre-test predictions, and to ensure that test limitations did not obscure potentially significant vulnerabilities.
- Analyses of OBIGGS fuel system simulator tests showed that the system is incapable of providing protection from threat-induced fuel tank explosions during some critical segments of combat missions when the aircraft is most vulnerable. Program focus is currently on the immediate need to meet requirements to protect the aircraft from lightning-generated fuel tank explosions and on redesigning OBIGGS to provide protection throughout all combat mission segments.

Recommendations

- Status of Previous Recommendations. The program and Services are satisfactorily addressing four of seven previous recommendations. The remaining three recommendations concerning use of objective criteria for evaluating flight test progress, integrating flight test of an operational mission data load, restoring shut-off valves, and redesigning the OBIGGS are outstanding.
- FY11 Recommendations. The program should:
  1. Conduct an integrated test review of the final flight test schedule to ensure the new integrated master schedule matches flight test schedule sequencing and content, and that both comply with the TBR-recommended planning factors.
  2. Use a criteria-based event-driven strategy to reduce risk before beginning flight operations with early, immature production aircraft at the training center or elsewhere.

3. Determine the impact of the alternate path for the helmet-mounted display on the integrated master schedule, including potential for cockpit and pilot systems redesigns.
4. Ensure operationally relevant criteria are used to evaluate handling characteristics in transonic flight regimes and in buffet testing.
5. Produce and implement a realistic reliability growth plan.
6. Evaluate and reduce the risk of later than intended completion of structural durability testing given concurrent production.
7. Improve spares efficiency/resupply and test aircraft reliability at the flight test centers.
8. Survey the test plans for certifications required by government agencies outside program and Service control and plan appropriate lead-time for these certifications.