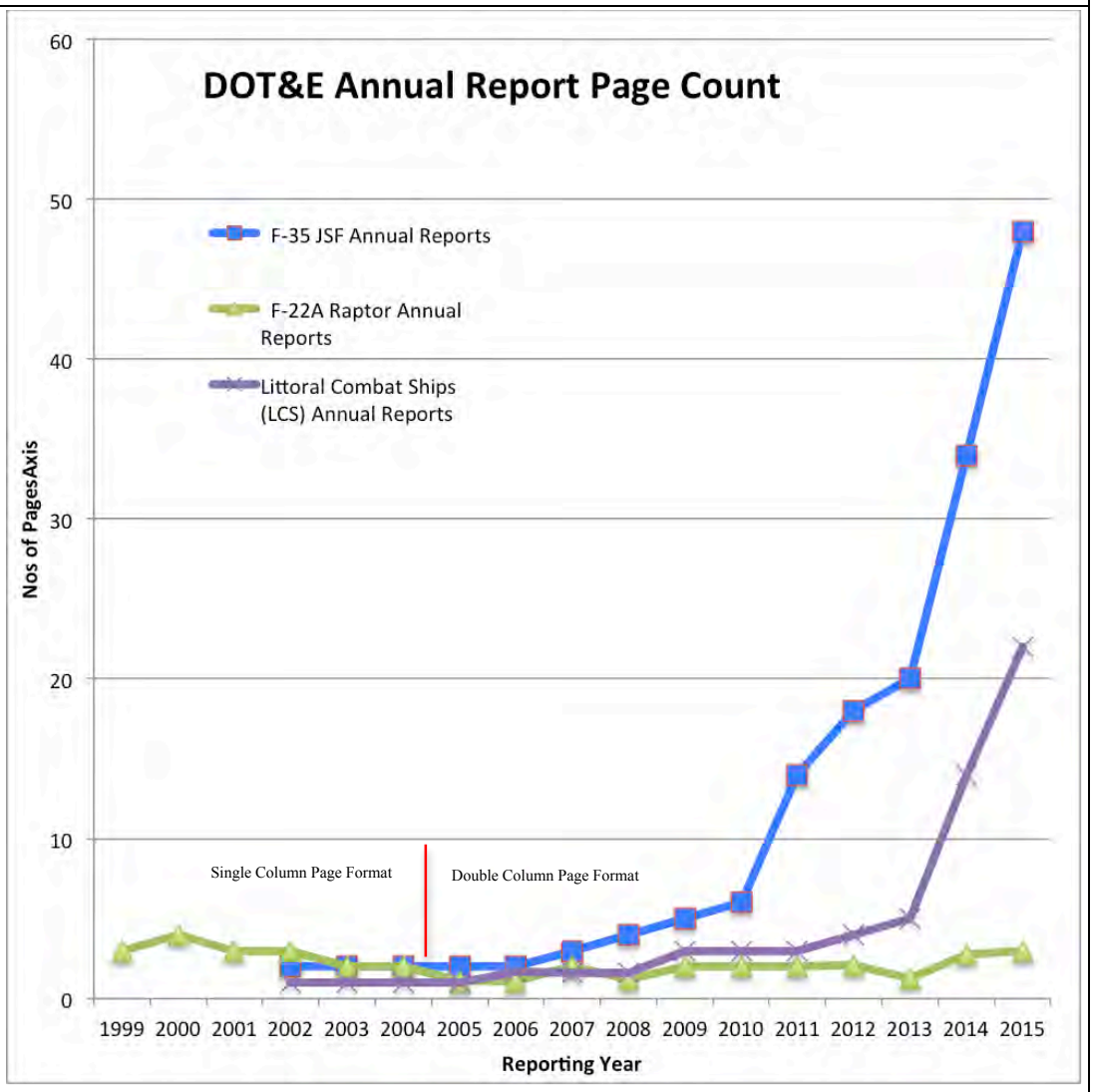
COMPENDIUM OF DOT&E ANNUAL REPORTS: F-22A RAPTOR AIR DOMINANCE FIGHTER PROGRAM

Report Year	*Page Count*
1999	3
2000	4
2001	3
2002 **	3
2003 **	2
2004 **	2
2005	1
2006	1
2007	2
2008	1
2009	2
2010	2
2011	2
2012	2
2013	1
2014	3
2015	3
Total:	38

Page Count Chart

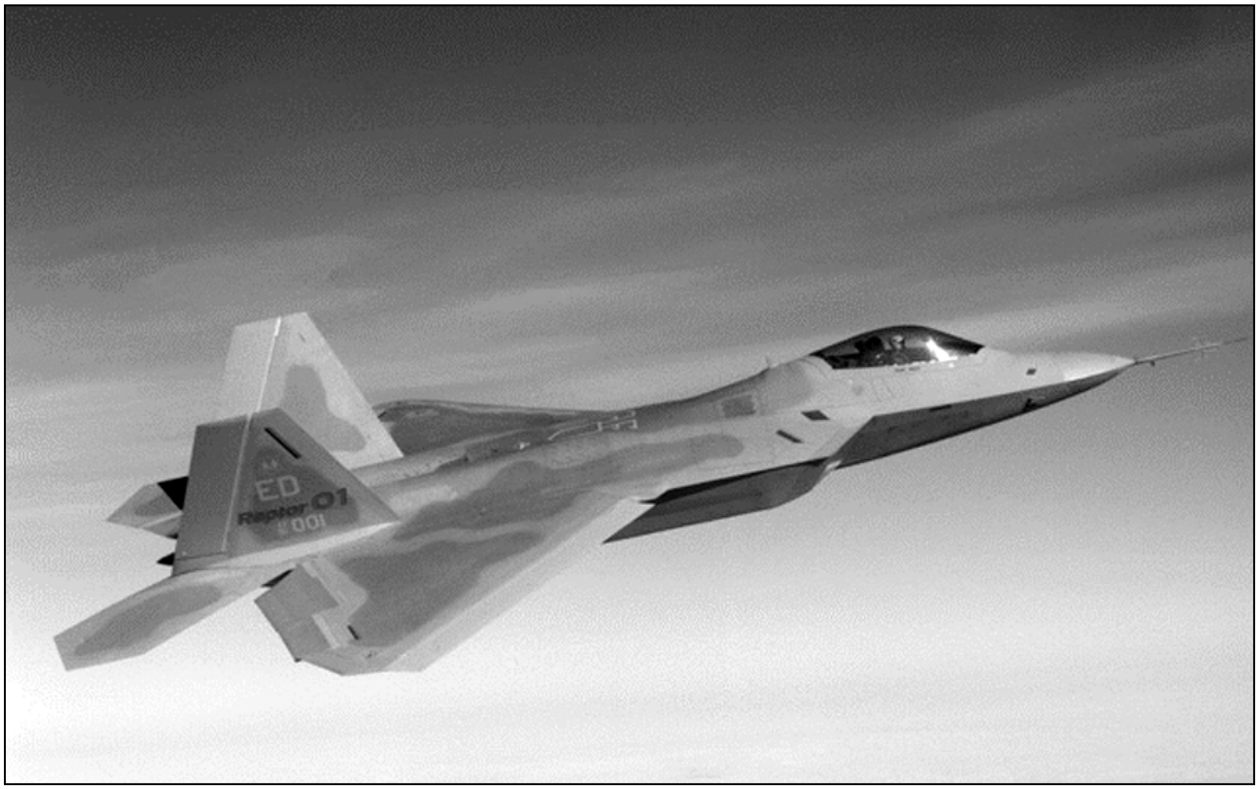


** *Go to 'Attachments' to this Compendium to view these reports*

Notes:

1. DOT&E reports annually on all Major Defence Acquisition Programs (MDAP). The reports focus on major issues/problems discovered during the year, identifying areas of risk arising from these that are assessed as warranting further action.
2. A standard way for assessing the health of any MDAP is to read its latest DOT&E Annual Report in conjunction with preceding reports, then comparing the findings with the results and management plans from the MDAP Technical and Programmatic Risk Assessments over the period since program approval and, importantly, those assessments and plans done prior to DOT&E reporting of any issues/problems.
3. Plots of the page counts for two other MDAPs are provided for comparison.

F-22 RAPTOR (ATF)



Air Force ACAT ID Program

Total Number of Systems:	339
Total Program Cost (TY$):	$62.5B
Average Flyaway Cost (TY$):	$97.9M
Full-rate production:	3QFY03

Prime Contractor

Lockheed Martin, Boeing, Pratt &Whitney

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

The F-22 is an air superiority fighter designed to dominate the air environment in the 21st Century. Key features include low radar observability (with internal weapons carriage) and supersonic cruise combined with the classic fighter characteristics of superior maneuverability, wide field-of-regard offensive and defensive sensors, multi-spectral countermeasures, and high reliability.

Basic armament of the F-22 will consist of six AIM-120C missiles, two AIM-9 missiles, and a 20mm cannon. F-22 will be a major contributor to the ***Joint Vision 2010*** future strategy. It is to be a predominant Air Force weapon system to provide ***full-dimensional protection*** to all forces, and its stealth, integrated offensive and defensive sensors, and air-to-air and air-to-ground weapons mix are to effectively support ***precision engagement*** and ***dominant maneuver***.

BACKGROUND INFORMATION

F-22 completed Milestone II DAB and entered the EMD phase in July 1991. Since then, the program has undergone several major changes due to budget reductions and cost growth. An independent Joint Estimating Team identified significant cost growth in the EMD phase and recommended restructuring EMD. This program restructure was approved by a February 5, 1997 DAB. A primary element of this restructure was elimination of the four Pre-Production Vehicles. The essential OT&E impact of this change was the assignment of four aircraft (4008-4011) and one spare aircraft (4007) during four ship operations. Aircraft 4010 and 4011 are Production Representative Test Vehicles (PRTV 1) and are the performance baseline for OT test aircraft. This program restructure also increased the length of the EMD phase by nine months, allowing more time for integrated avionics testing. Dedicated IOT&E is currently scheduled to begin in August 2002, with Milestone III scheduled for September 2003.

The F-22 was placed under OSD oversight for LFT&E in October 1989 as the Advanced Tactical Fighter. An Alternative Plan for meeting LFT&E objectives was approved, and a waiver from full-up, system level testing was granted with notification to Congress in August 1997. The alternate live fire test (LFT) plan includes hydrodynamic ram, dry bay fire, and critical component separation tests as well as demonstration of active fire suppression systems. LFT in prior years has included hydrodynamic ram vulnerability testing of wing box and aft fuel tanks, fire vulnerability testing of wing attach, aft side of fuselage, main landing gear (MLG), and airframe mounted accessory drive (AMAD) dry bays, and penetration vulnerability testing of avionics bays. In addition, high explosive threat effect tests were performed to evaluate component separation adequacy.

TEST & EVALUATION ACTIVITY

The first flight of the EMD flight test program occurred on September 7, 1997 at Lockheed Martin, Marietta, GA. After being transported from Marietta, the first test aircraft resumed test flights at Edwards AFB on May 17, 1998. The second flight test aircraft's first flight was on June 29, 1998; and its ferry to Edwards AFB occurred on August 26,1998. Both aircraft are continuing to expand the allowable flight envelope and have accumulated 392.4 hours as of the end of FY99. The third flight test aircraft's first flight is planned for March 2000, and the fourth flight test aircraft (the first capable of avionics testing) is scheduled to fly in May 2000.

DOT&E's activities this year continued to support test planning outlined in the August 1997 F-22 TEMP. Toward this end, DOT&E participated in integrated product team (IPT) meetings of the Test Planning Working Group, Air Combat Simulator (ACS) management reviews, and Working Level IPT meetings. Additional program insight was provided by an OSD Action Officers visit to Edwards AFB. Review of the TEMP update for final approval has provided insight into the test plans for the remainder of EMD.

Development of ACS, consisting of two domes and ten manned interactive cockpit stations at Marietta, GA, continued in the system development stage. A $5.7 million budget reduction in March 1998 forced substitution of a Commercial-off-the-Shelf computer to host F-22 mission software instead of the original plan to host the mission software portion of the aircraft's operational flight program on the Central Integrated Processor flight hardware in ACS. Restructuring ACS to accommodate this change has occurred with IOC to support IOT&E scheduled for October 2001. DOT&E reviewed ACS development plans periodically during this fiscal year to ensure that test adequacy is not being compromised by strong cost reduction pressures.

LFT&E activities in 1999 have focused on analysis of test results for MLG and AMAD dry bays. Test planning and pre-test evaluation was also performed for upcoming tests of a replica of the fuselage fuel tank, scheduled for FY00, and the air vehicle 4001 wing, scheduled for FY02. The Air Force conducted hydrodynamic ram analyses of the fuselage fuel tank to identify appropriate shotlines. A shotline was selected which will provide data to evaluate fuselage fuel tank hydrodynamic ram damage and its affect on safe operation of the crew escape system. Analyses were also conducted in support of LFT&E to assist shotline selection for the upcoming wing hydrodynamic ram test. A shotline was selected for which detailed wing hydrodynamic ram damage analyses will be conducted to predict results of the test to be performed on air vehicle 4001.

A Flying Test Bed (FTB), consisting of a APG-77 radar in an F-22 forebody, spliced onto the nose of a Boeing 757 test aircraft, completed the radar phase of testing this year. APG-77 performance in FTB confirmed the adequacy of the basic radar design. The Director and staff observed this performance in a demonstration flight on April 27, 1999. FTB was modified to install a sensor wing (containing some of the F-22 sensors and wing antennas) on top of the fuselage for resumption of expanded testing emphasizing integration of radar and some Communication, Navigation, and Identification sensors. Testing of this next step in the integrated avionics evolution should resume in November 1999.

Software development testing is proceeding in the Avionics Integration Laboratory in Boeing's Seattle facility. Software Block 1.1 development has been completed and delivered to FTB. This will be the software for the first avionics test aircraft. Block 2.0 software was delivered to FTB on October 21, 1999.

The static test aircraft has completed the first increment critical loads tests to 100 percent of the design load limit without any problems and will progress to 150 percent of design limit load limit in FY00. The fatigue test article has been calibrated and testing of the first lifetime is scheduled to start in June 2000.

In addition to flight testing at Edwards AFB, logistics testing tasks including initial low observability maintainability tasks are ongoing using low observable test articles and exercising aircraft access doors. The basic F-22 design has some good improvements in terms of minimizing the number of access doors in their design. High reliability is also essential to minimizing access requirements and the attendant low observable restoration procedures. The brush and roll repair process has been developed and should reduce repair risk. The concept for low observable sustainment and how to test it is an issue yet to be addressed. Although new materials and techniques have been developed, the plan does not include demonstrating the ability to sustain operations in adverse conditions. In addition, operational field measurement capability has not been fully addressed; plans are to rely solely on maintainer adherence to technical data.

TEST & EVALUATION ASSESSMENT

The F-22 flight test program is progressing about as expected, and flight and engine performance is matching simulation projections. While flight testing is progressing satisfactorily, the major risks and challenges to F-22 performance remain in the avionics area. No operational tests have been conducted, but IOT&E planning reflects the TEMP's integrated test approach of evaluating F-22's operational effectiveness and suitability through a combination of open air testing, ACS, Hardware-in-the-Loop (HITL), and constructive models. This balanced approach will support the F-22/F-15 Comparison Test against then-current and future threats and scenarios for which the F-22 was developed. Credible

simulation tools are mandatory to supplement evaluation data from 240 test sorties allocated for Dedicated IOT&E and some Combined DT/OT sorties. Critical HITL simulation facilities, in addition to ACS, include the Avionics Integration Laboratory in Seattle, WA; the Electronic Combat Integrated Test and the Integrated HITL Avionics Test facilities at Edwards AFB; and the Flying Test Bed. Sustaining funding for these facilities is essential to the overall F-22 test program. Planning for selection and verification, validation, and accreditation of constructive models to assist in test planning and providing evaluation data beyond that which can be supplied by ACS or open air tests is in process. This planning follows Simulation Test and Evaluation Process guidelines.

An IOT&E test planning concern is that about 20 avionics test months have been lost due to late deliveries of flight test aircraft 4004–4007, without any plans to delay the start of Dedicated IOT&E. Although continuing re-planning of the flight test program has shown that this revised test program may be executable, no risk margin remains to accommodate any significant development problems that may surface during the remaining test period.

AFOTEC has initiated a five-year OA with periodic reports based on a structured strategy-to-task assessment of all F-22 mission tasks. The first interim briefing supports the December 1999 DAE review with a plan to issue a report to support the December 2000 LRIP DAB and Readiness to Test Certification in August 2002. To date, good accessibility to AFOTEC regarding program information allowed extensive integration with developmental test and early involvement with aircraft design. AFOTEC identified both positive highlights and potential issues during the interim briefing of operational assessment results. The current results were based on bench, lab, and flying test bed data, which supplemented flight test data and extensive participation on the integrated product teams. Performance concerns included: risk to avionics integration progress, development of low observable maintenance concept of operations, flight envelope expansion considerations related to structural adequacy analysis, ground handling, cockpit design, security issues, possible operational training constraints, and future performance of the environmental control system. Test and evaluation concerns included: data processing timeline and data display capability for the primary test organization, degree and consistency of production representation among the operational test aircraft (4007-4011), ACS development risk due to threat model delivery by outside agencies and validation, verification and accreditation data prioritization during developmental test, and adequacy of instrumentation of PRTV II aircraft (4012-4017) for FOT&E and FDE events. Due to the success of the combined test force concept, the program is aware of the potential problems and actively working all of these issues within the constraints of the resources available to them.

Low observable maintainability is a risk area based on B-2 and F-117 experience; this risk category also includes reliability and logistics support. The contractor appears to have learned many support lessons from previous stealth systems; however, maintainability and logistics support typically lag airframe development and, in a cost cap environment, may have difficulty in retaining budget to complete their tasks.

Based on observation of LFT&E dry bay tests, DOT&E's preliminary assessment is that both MLG and AMAD bays contain significant vulnerabilities. Preliminary data also showed that fire suppression systems could be developed using either pentafluoroethane (HFC-125) or solid propellant gas generating technologies. However, a program decision was made by the Air Force to eliminate development of fire extinguishing systems for MLG bay. Fire extinguishing was not in the original AMAD bay design. DOT&E recommends the Air Force reconsider elimination of the fire suppression system for MLG bay and consider adding AMAD bay fire protection.

Early LFT&E of wing hydrodynamic ram effects resulted in redesign that will be tested using flight test air vehicle 4001. Changes to the wing design included addition of titanium wing spars, an extra wing rib, and extra wing skin fasteners. If successfully demonstrated, the wing redesign will have significantly decreased F-22 vulnerability.

CONCLUSIONS, RECOMMENDATIONS, LESSONS LEARNED

LFT&E results thus far have shown that dry bay fires do occur but are not predicted well by current modeling and simulation. Additional modeling and simulation effort is required to develop an adequate methodology for predicting dry bay fires, taking into account all independent variables.

The original LFT&E strategy called for manufacturing a production representative wing for the hydrodynamic ram test. The Air Force has decided to use flight test air vehicle 4001 for this test as a more economical alternative. Using the flight test vehicle, in addition to economic savings, will provide a more realistic test article. This use of early flight test vehicles for some LFT&E issues should be an option considered in future programs.

F-22 RAPTOR (ATF)

Air Force ACAT ID Program

Total Number of Systems:	339
Total Program Cost (TY$):	$63.4B
Average Flyaway Cost (TY$):	$83.6M
Full-rate production:	4QFY03

Prime Contractor

Lockheed Martin, Boeing, Pratt &Whitney

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2020

The F-22 is an air superiority fighter designed to dominate the air environment in the 21st century. Key features include low radar observability (with internal weapons carriage) and supersonic cruise combined with the classic fighter characteristics of superior maneuverability, wide field-of-regard offensive and defensive sensors, multi-spectral countermeasures, and high reliability.

Basic armament of the F-22 consists of six AIM-120C missiles, two AIM-9 missiles, and a 20mm cannon. F-22 will be a major contributor to the ***Joint Vision 2020*** future strategy. It is to be a predominant Air Force weapon system to provide ***full-dimensional protection*** to all forces, and its stealth, integrated offensive and defensive sensors, and air-to-air and air-to-ground weapons mix are to effectively support ***precision engagement*** and ***dominant maneuver***.

BACKGROUND INFORMATION

F-22 completed the Milestone II DAB and entered the EMD phase in July 1991. Since then, the program has undergone several major changes due to schedule delays, budget reductions, and cost growth. An independent Joint Estimating Team identified significant cost growth in the EMD phase and recommended restructuring EMD. This program restructure was approved by a February 5, 1997, DAB. A primary element of this restructure was elimination of the four Pre-Production Vehicles. The essential IOT&E impact of this change was the assignment of four aircraft (4008-4011) and one spare aircraft (4007) during four ship operations. Aircraft 4010 and Aircraft 4011 are Production Representative Test Vehicles (PRTV 1) and are the performance baseline for OT test aircraft. This program restructure also increased the length of the EMD phase by nine months, allowing more time for integrated avionics testing. Dedicated IOT&E is currently scheduled to begin in August 2002, with Milestone III scheduled for September 2003.

In December 1999, the DAB delayed the planned LRIP decision and designated the next block of six aircraft as Production Representative Test Vehicles II (PRTV II). It also provided long lead-time funding for the LRIP Lot 1 of 10 aircraft and established exit criteria for the LRIP decision planned for December 2000. The test-related exit criteria are listed below:

- Complete avionics Block 3.0 first flight, initiating testing of Block 3.0 unique functionality.
- Complete first flight on EMD Aircraft 4003, 4004, 4005, and 4006.
- Complete static structural testing.
- Initiate fatigue life testing with the goal of completing 40 percent of first fatigue life.
- Conduct flight testing to include initiating Radar Cross Section (RCS) flight testing, initiating high angle-of-attack testing with weapons bay doors open, and initiating separation testing of AIM-9 and AIM-120 missiles.
- Complete first portion of engine Initial Service Release (ISR) qualification test.

The F-22 was placed under OSD oversight for LFT&E in October 1989 as the Advanced Tactical Fighter. An Alternative Plan for meeting LFT&E objectives was approved, and a waiver from full-up, system-level testing was granted with notification to Congress in August 1997. The alternate Live Fire Test (LFT) plan includes testing to determine hydrodynamic ram structural damage, dry bay fire, and critical component separation as well as demonstration of active fire suppression systems. LFT in prior years has included hydrodynamic ram vulnerability testing of wing box and aft fuel tanks, fire vulnerability testing of wing attach, aft side of fuselage, main landing gear (MLG), airframe mounted accessory drive (AMAD) dry bays, and penetration vulnerability testing of avionics bays. In addition, high explosive threat effect tests were performed to evaluate component separation adequacy. Fuselage fuel tank hydrodynamic ram damage ballistic testing is scheduled for FY01. A realistic forward fuselage test article has been manufactured for this test. Aircraft 4001 is scheduled to be used for wing fuel tank hydrodynamic ram damage and leading edge dry bay fire ballistic tests in FY01 and FY02.

TEST & EVALUATION ACTIVITY

The first flight of the EMD flight test program, Aircraft 4001, occurred on September 7, 1997, at Lockheed Martin, Marietta, GA. After being transported from Marietta, the first test aircraft resumed test flights at Edwards AFB on May 17, 1998. Aircraft 4002 first flight was on June 29, 1998, and its

ferry to Edwards AFB occurred on August 26, 1998. Both aircraft expanded the allowable flight envelope and have accumulated 797.4 hours at of the end of calendar year 2000. Aircraft 4003 first flight occurred on March 6, 2000, and ferried to Edwards AFB on March 15, 2000. Following an extended modification and calibration period at Edwards AFB, this aircraft started productive flight testing on September 19, 2000, and accumulated 31.9 hours by the end of calendar year 2000.

DOT&E's activities this year continued to support test planning outlined in the August 1997 F-22 TEMP. Toward this end, DOT&E participated in Integrated Product Team (IPT) meetings of the Test Planning Working Group (TPWG), Air Combat Simulator (ACS) management reviews, IOT&E Red Force Working Group, and Working IPT (WIPT) meetings. Additional program insight was provided by visits to contractor facilities in Marietta, GA, and Seattle, WA. The Seattle visits included two Flying Test Bed (FTB) test flights. A TEMP revision is required to support the LRIP DAB. Four TEMP working group sessions were held to address 11 issues submitted by DOT&E during the West Palm Beach TPWG in January 2000. All issues have been resolved and the TEMP has been approved.

Development of the ACS, consisting of two domes and ten manned interactive cockpit stations at Marietta, GA, continued in the system development stage. A $5.7 million budget reduction in March 1998 forced substitution of a Commercial-Off-The-Shelf computer to host F-22 mission software instead of the original plan to host the mission software portion of the aircraft's operational flight program on the Common Integrated Processor flight hardware in ACS. Restructuring ACS to accommodate this change has occurred with IOC to support IOT&E scheduled for November 2001. The ACS team moved into the new F-22 Air Vehicle Integration Facility this year and have received delivery of their first simulator dome. DOT&E reviewed ACS development plans periodically during this year to ensure that test adequacy is not being compromised by strong cost reduction pressures.

An FTB, consisting of an APG-77 radar in an F-22 forebody spliced onto the nose of a Boeing 757 test aircraft, completed the radar phase of testing early this year. After it was modified to install a sensor wing (containing some of the F-22 sensors and wing antennas) on top of the fuselage, FTB testing resumed emphasizing multi-sensor fusion of radar; Communication, Navigation, and Identification (CNI); and EW sub-systems. Block 3S software was tested against a variety of air and ground targets as a precursor to the initiation of Block 3.0 software testing on September 1, 2000—almost a month ahead of schedule. This FTB development testing of Block 3.0 software was a key part of the process leading to flying this software in Aircraft 4005. The Director, OT&E and his staff participated in a FTB Block 3.0 development mission this year, and his staff also participated in a Block 3S development mission earlier this year.

An equally important part of the avionics development process is played by the Avionics Integration Lab (AIL) at Boeing's Seattle plant. Development and troubleshooting of all software blocks have been conducted in this test facility since 1998. Block 3.1 software fusion of radar, CNI, and EW is in development testing in the AIL and will soon be installed in the FTB. The Block 3.1 software will provide the core functions of Block 3.1.1 software to be demonstrated in IOT&E. Block 3.1.1 is now starting elemental testing and will transition the AIL testing in mid-2001 and to FTB testing by late 2001.

Static structural testing has been conducted during the past two years, starting in April 1999. Testing was successfully completed to 100 percent of Design Limit Load (DLL) in 1999, and plans were to complete the ultimate load testing (150 percent of design loading) in 2000. The start of static structural testing was significantly delayed due to flaperon repairs. Also, the failure of the static test fixture, housing the test vehicle, at 141 percent of design limit load will further delay static testing to 150 percent of design ultimate load. However, static testing to 141 percent design limit load will support Aircraft 4003 clean envelope expansion, thereby meeting the LRIP DAB exit criterion. Approximately

one and one-half months are required to redesign and change the material of the failed fixture component.

Delays in static testing also impacted the initiation of fatigue testing from the original scheduled start in early 2000 to actual start on December 21, 2000. The applicable LRIP DAB exit criterion, established in December 1999, is initiation of fatigue testing with a goal of 40 percent of first life complete by the end of 2000. While the LRIP DAB exit criterion was met, the goal was not since only about one percent of the first life has been accomplished. Although this fatigue testing does not impact expansion of the allowable flight envelope, completion of the first fatigue life does affect the point at which structural changes, necessitated by the results of fatigue testing, can be installed into the production line.

LFT&E activities in 2000 have focused on pre-test analysis and test planning for fuel tank hydrodynamic ram damage tests. Test planning and pre-test evaluation were performed for upcoming tests on a replica of the fuselage fuel tank and Aircraft 4001 wing scheduled for FY01. The Air Force conducted hydrodynamic ram analyses of the fuselage fuel tank to identify appropriate shotlines. A shotline was selected which will provide data to evaluate fuselage fuel tank hydrodynamic ram damage and its affect on safe operation of the crew escape system. A change in threat projectile for this test has required a re-evaluation of the pre-test predictions. Analyses were also conducted in support of LFT&E to assist shotline selection for the upcoming wing hydrodynamic ram test. A shotline was selected and detailed wing hydrodynamic ram damage analyses are being conducted to predict results of the test, which will be performed on Aircraft 4001.

Engine testing remains on schedule to support the flight test program through the end of EMD. The LRIP DAB exit criterion "Complete first portion of engine Initial Service Release (ISR) qualification test (2150 TACs - full hot section life)" was completed on Flight Test Engine (FTE) #18 on November 3, 2000. The complete ISR qualification test of 4325 Tactical Accelerated Cycles (TACs) is expected to be completed before the end of 2001. Based on this nearly-on-schedule test performance, engine deliveries to support the two PRTV I aircraft (Aircraft 4010 and Aircraft 4011) for IOT&E support should not be a problem. The F119 engine performance and reliability in the three F-22 flight test aircraft have been the highlight of the F-22 flight test program. There has not been an engine-caused failure to complete a scheduled test condition. In addition, there has not been an engine-related shutdown to this point in the test program, although there have been two precautionary shutdowns due to indications of Airframe Mounted Accessory Drive (AMAD) and generator problems.

In addition to flight testing at Edwards AFB, logistics testing tasks including initial low observability maintainability tasks are ongoing using low observable test articles and exercising aircraft access doors. The basic F-22 design has some good improvements in terms of minimizing the number of access doors in their design. High reliability is also essential to minimizing access requirements and the attendant low observable restoration procedures. The brush and roll repair process has been developed and should reduce repair risk. The concept for low observable sustainment and how to test it are issues yet to be addressed. Although new materials and techniques have been developed, the plan does not include demonstrating the ability to sustain operations in adverse conditions. In addition, operational field measurement capability has not been fully addressed; plans are to rely solely on maintainer adherence to technical data. Completion of logistics test tasks proceeded throughout this year but were severely constrained by the lack of flight test vehicles with avionics sub-systems.

TEST & EVALUATION ASSESSMENT

The F-22 flight test program has fallen considerably behind schedule during the last year. Although some of the necessary test support activities, such as the Flying Test Bed (FTB) and Avionics Integration Lab (AIL), have been making progress in supporting the test program, the flight testing at Edwards AFB has not met the beginning of the year 2000 projections. As of January 3, 2001, flight test aircraft have only accumulated 324 hours of the 590 hours planned just one year ago. Although Aircraft 4003 was delivered to Edwards AFB on March 15, 2000, it did not begin productive flight testing until September 19, 2000, due to a extended lay-up for structural modifications and instrumentation calibrations. Aircraft 4003 is the first flight test aircraft to incorporate the extensive structural modifications identified as Block II structure, which is the production-representative structural configuration required to expand the permissible flight envelope. This aircraft must, however, complete selective regression testing of the envelope explored by Aircraft 4001 and Aircraft 4002 before it can start to expand beyond these limited flight envelope boundaries. As of January 10, 2001, Aircraft 4003 has only flown for 31.9 hours.

Since January 2000, various problems have caused program delays and occasional flight test stoppages. Test flying was constrained primarily by late delivery of aircraft, canopy transparency cracks, aileron hinge pin problems, flaperon repairs, environmental control system problems, and inlet delamination inspections. As a result of these delays, only about 40 percent of the projected test points have been completed.

Analysis shows that late deliveries of avionics flight test Aircraft 4004 through 4009 requires 8.6 additional months to complete the currently planned 1,970, from the original 2,270, avionics flight test hours. Without any adjustments to the program schedule, the F-22 System Program Office (SPO) estimates that approximately 150 flight hours of planned airframe development testing and about 17 aircraft months of required avionics testing would not be completed by the start of IOT&E. Although some limited airframe and avionics development testing could be accomplished in parallel with IOT&E, there are other required test events that must be completed before start of IOT&E. Also, the scheduling and availability of test assets and resources would limit the scope of any parallel test operations.

The current status of the test program and the SPO schedule estimates show that the planned test program cannot be completed as originally scheduled and that IOT&E cannot be started in August 2002 without clearly unacceptable risks. On December 20, 2000, the Air Force briefed DOT&E with a plan that would defer the start of IOT&E by four to six months allowing additional time to complete the required developmental testing. Although as much as nine months to a year delay may be needed to complete required testing, DOT&E strongly supports the plan.

Weapons internal carriage provides the F-22 with lethal capabilities while maintaining low observability. The integration of avionics and weapons systems to launch precision weapons is a major step in the flight test program for validation of the software block algorithms. These software block algorithms are also necessary for the mission-level simulation in the air combat simulator (ACS) during pilot training and mission-level IOT&E sorties. The completion of three exit criterion, “Initiate high angle-of-attack testing with weapons bay doors open,” “Initiate separation testing of AIM-9 missile,” and “Initiate separation testing of AIM-120 missile” demonstrated the initial test tasks in weapons employment. To date, the flight test program has demonstrated unguided launch of an AIM-9M Sidewinder from the side weapons bay on July 25, 2000, and an unguided launch of an AIM-120 from the main weapon bay on October 14, 2000, from Aircraft 4002. High angle-of-attack testing with the main and side weapons bay doors open began on August 22, 2000. This testing was accomplished relatively easily, further demonstrating the F-22’s outstanding high angle of attack flying qualities.

Flight test validation of the software block necessary for the start of IOT&E pilot upgrade training is critical. The SPO proposed parallel developmental test (DT) sorties during IOT&E should be a DAE review topic to better understand the impact on the EMD schedule. In addition, we are concerned about the deferral of the external weapons/stores flight testing to the Seek Eagle Program, currently planned for FOT&E in 2003 at the earliest. It would be better to do this external carriage testing earlier to identify the aerodynamic impact of external stores, so that any issues could be resolved much sooner.

Completion of static structural testing without any major failures is an important prerequisite for expanding the allowable flight envelope by Aircraft 4003, justifying its selection as an LRIP DAB exit criterion. This has been achieved with only one of 19 major tests left to complete. The initiation of the first fatigue life with a goal of 40 percent of first life is another LRIP DAB exit criterion. Fatigue testing started on December 21, 2000, but only about one percent of the first life has been accomplished. Although this fatigue testing does not directly impact flight envelope expansion, completion of the first fatigue life does affect the point at which structural changes necessitated by fatigue test failures can be inserted in the production line and possible retrofit requirements.

Low observable measurement and maintainability continues to be a risk area, based on previous low observable platforms. This risk category includes reliability and logistics support. The concept for low observable sustainment and how to test it is an issue, not only to validate the new materials and repair techniques, but also to validate the low observable specifications as measured during full-scale pole and chamber testing. All available measurement tools, including ground, air, and range, should be utilized in this validation process. RCS flight testing has not yet begun. The baseline plan showed that this would be conducted in mid-2000 on an outdoor test range after RCS mapping in the Lockheed Martin RCS Measurement Facility in Marietta, GA. However, late aircraft delivery plus RCS impacts from an inflight main landing gear door gap problem and weather delayed open-air range testing. The aircraft went through extensive surface preparations and painting in preparation for this inflight RCS measurement testing. RCS measurement with an alternate inflight air-to-air imaging system was used to spot certain low observability features, but this did not meet the requirement to measure full aircraft RCS at a calibrated range. After Aircraft 4004 is ferried to Edwards AFB, it will complete the final portion of the exit criteria with a flight across a calibrated range.

Early LFT&E of wing hydrodynamic ram effects resulted in a redesign that will be tested using flight test Aircraft 4001. Changes to the wing design included addition of titanium wing spars, an additional wing rib, and additional wing skin fasteners. If successfully demonstrated, the wing redesign will significantly decrease F-22 vulnerability.

The results of the dry bay Live Fire Tests indicate that both MLG and AMAD bays, which lack an onboard fire protection system, pose significant vulnerabilities that could be significantly reduced or even eliminated. Preliminary data show that an effective fire suppression system could be developed using either pentafluoroethane (HFC-125), solid propellant gas generating technologies or other approaches. However, a programmatic decision was made by the Air Force to forgo development of fire extinguishing systems for MLG bay. An onboard fire protection system for the AMAD was not included in the aircraft design. Live Fire Testing has shown that the overall vulnerability had been underestimated. Once the vulnerability models used to estimate the overall vulnerability were updated using the test results, there was a significant increase in F-22 vulnerability. The Air Force relaxed the estimates of F-22 vulnerability requirement by about 30 percent to accommodate increases in the estimated vulnerability since January 1995. The current design meets the new relaxed design specification for vulnerability. Since no significant design changes are expected, additional changes to the vulnerability specification are not anticipated. The overall vulnerability of the current design may change depending on the outcome of the remaining Live Fire Tests.

AFOTEC has initiated a five-year Operational Assessment with periodic briefings and a report, based on a structured strategy-to-task assessment of all F-22 mission tasks, to support the Readiness to Test Certification of IOT&E. AFOTEC identified both positive highlights and potential issues during the interim briefing of operational results this year. The current results were based on bench, lab, and flying test bed data, which supplemented flight test data and extensive participation on the integrated product teams. Performance concerns included risk to avionics integration progress, development of low observable maintenance concept of operations, flight envelope expansion considerations related to structural adequacy analysis, ground handling, cockpit design, security issues, possible operational training constraints, and future performance of the environmental control system. Test and evaluation concerns included consistency of production representation among the operational test aircraft, flight envelope expansion for operational test pilot training, and air-to-air range infrastructure data processing timeline and data display capability for the primary test organization. Since an AFOTEC test pilot and several maintenance personnel are members of the F-22 combined test force, AFOTEC has first-hand knowledge of potential operational problems, thus able to contribute to timely solutions.

LESSONS LEARNED

A lesson can be learned from the deletion of the ECS simulator as a cost-saving measure. This decision contributed to the delay of the Aircraft 4004 first flight by at least two months and may indirectly result in further delays to the remaining avionics-equipped test aircraft.

The original LFT&E strategy called for manufacturing a production-representative wing for the hydrodynamic ram test. The Air Force has decided to use flight test Aircraft 4001 for this test as a more economical alternative. Using the flight test vehicle, in addition to economic savings, will provide a more realistic test article. This use of early flight test vehicles to address LFT&E issues should be an option considered in future programs. LFT&E results thus far have shown that dry bay fires do occur but are not predicted well by current modeling and simulation (M&S). Additional M&S effort is required to develop an adequate methodology for predicting dry bay fires, taking into account all independent variables. DOT&E recommends that the Air Force reconsider its decision to eliminate the fire suppression system for the MLG bay as well as consider adding AMAD bay fire protection.

CONCLUSIONS AND RECOMMENDATIONS

As I have stated the last two years in testimony before the Senate Armed Services Committee, AirLand Forces Subcommittee, programmatic efforts to reduce costs to stay within the cost cap almost always result in less testing and increased development risks. These development risks become greater with elapsed time as the cost reduction options become harder to implement. At this point, since the test budget is essentially the only remaining uncommitted EMD budget, cost reductions become test reductions. Any reduction of testing tasks increases the risk of not being ready to start or successfully complete IOT&E.

F-22 RAPTOR (ATF)

The F-22 is an air superiority fighter designed to dominate the most severe battle environments projected during the first quarter of the 21st Century. Key features of the F-22 include low radar observability (with internal weapons carriage) and supersonic cruise capability in non-afterburning power, combined with superior maneuverability and excellent handling qualities. Other features critical to the F-22 concept of operations are wide field-of-regard offensive and defensive sensors, multi-spectral countermeasures, and high reliability, maintainability and supportability combined with enhanced deployability for worldwide operations. Basic armament consists of six AIM-120C radar-guided air-to-air missiles, two AIM-9 infrared guided missiles, and a 20mm cannon.

BACKGROUND INFORMATION

The F-22 started as the Advanced Tactical Fighter (ATF) with Milestone 0 in 1983, Milestone I in 1986, and Milestone II in July 1991. Since then, the program has undergone several major changes due to schedule delays, budget reductions, and cost growth. An independent Joint Estimating Team identified significant cost growth in EMD and recommended program restructuring that was approved by a February 1997 DAB. A primary element of the restructure was elimination of the four Pre-Production Vehicles. As a result, two EMD test aircraft and two Production Representative Test Vehicles (PRTV 1) were assigned as OT test aircraft. EMD was also increased by nine months to allow more time for avionics testing. The EMD flight test program began on September 7, 1997, with first flight of aircraft 4001 at Marietta, GA.

In December 1999, a DAB delayed the LRIP decision and designated the next block of six aircraft Production Representative Test Vehicles II (PRTV II). It also provided long lead funding for LRIP Lot 1 (10 aircraft), and established the following exit criteria for the LRIP decision, then planned for December 2000:

- Complete avionics Block 3.0 first flight, initiating testing of Block 3.0 unique functionality.
- Complete first flight on EMD Aircraft 4003, 4004, 4005, and 4006.
- Complete static structural testing.
- Initiate fatigue life testing with the goal of completing 40 percent of first fatigue life.

- Conduct flight testing to include initiating RCS flight testing, initiating high angle-of attack testing with weapons bay doors open, and initiating separation testing of AIM-9 and AIM-120 missiles.
- Complete first portion of engine Initial Service Release (ISR) qualification test.

F-22 testing progressed slowly during CY 2000, mainly due to late aircraft deliveries. Only one test aircraft, of the five scheduled, was delivered to Edwards that year. In addition, aircraft deficiencies, including structural issues requiring onsite modifications and canopy problems, further delayed test progress. The December 2000 LRIP DAB was deferred to allow additional time to complete Exit Criteria. The F-22 TEMP was approved in January. In June 2001, to improve executability of the program, the Air Force again restructured the test program. The outcome was a reduction in testing across the avionics, flight sciences, and weapons integration areas and the deferral of some testing to beyond the start of IOT&E. In addition, the planned IOT&E start date was delayed from August 2002 to April 2003. All LRIP Exit Criteria were completed in February 2001 and the DAB was held in August 2001. Initiation of LRIP was recommended along with removal or adjustment of the previous F-22 production cost cap to reflect the $5.4B increase in production. To compensate for the cost increase, production quantity was reduced from 331 (plus 8 production representative test vehicle aircraft) to 295 aircraft with the caveat that the Air Force could increase this quantity if production cost reduction programs yielded sufficient savings. Removal of the EMD cost cap was also recommended.

The F-22 live fire test (LFT) plan includes evaluation of hydrodynamic ram structural damage, dry bay fire, and critical component separation. Critical component separation reduces the possibility that a single hit will result in the loss of the aircraft. LFT in prior years included hydrodynamic ram vulnerability testing of the wing and aft fuel tanks, fire vulnerability testing of the wing attachment, aft side of fuselage, main landing gear (MLG), and airframe mounted accessory drive (AMAD) dry bays, and penetration vulnerability testing of avionics bays. High explosive threat effect tests were performed to evaluate component separation adequacy.

TEST & EVALUATION ACTIVITY

Initial Service Release (ISR) accelerated ground testing of the F119 engine was completed in May 2001. F119 performance has generally been excellent throughout those portions of the flight envelope tested. However, the ferry range requirement is now projected as not achievable by a marginal amount due to actual specific fuel consumption. Additionally, some required mission/maneuver performance points may not be achievable with this engine. Full-scale airframe static testing has been completed but fatigue testing has been hampered by test fixture and attachment pad failures and only about one third of first fatigue life testing has been completed. Expansion of flight testing into the high-speed, high g-load regions of the performance envelope has begun. However, only one test aircraft incorporates the structural modifications and test instrumentation necessary to conduct this testing, which is crucial to expanding the allowable flight envelope for IOT&E and current aircraft operating limitations further increase schedule risk. Loads testing has been conducted in approximately 40 percent of the envelope. The ability to handle the load stress while performing at required maneuverability, especially asymmetric/rolling maneuvers, and fin buffet phenomena are areas of current known limitations. Structural limitations have been identified through static testing in regimes where flight testing at high load factors has not yet taken place. The program is also exploring candidate solutions to potential limitations found through flight testing in other regimes. Flight envelope expansion paces weapons integration and avionics testing since the flight envelope must be opened to complete necessary testing and prepare for IOT&E in those areas.

F-22 aircraft avionics flight test began in January 2001 with initial focus on validating installed radar performance. The APG-77 radar met detection range performance parameters, and radar testing continues in conjunction with the Communications, Navigation, and Identification (CNI) and Electronic Warfare (EW) subsystems that provide the other components of the integrated closed loop tracking. As a result of reductions in planned avionics test runs, the Flying Test Bed (FTB) is playing an even more essential role. The FTB consists of the radar in an F-22 forebody, spliced onto the nose of a Boeing 757 test aircraft, CNI components, EW components, and common integrated processors. It evaluates integration of avionics software and hardware components prior to their being installed and tested on the F-22. Used in concert with the Avionics Integration Laboratory, the FTB constitutes a key part of the process that culminates in F-22 avionics flight test.

Safe separation unguided missile launches were conducted with AIM-9 and AIM-120 unguided missiles. Testing revealed a "q bias" problem in the AIM-120 software. The q bias provides a command to the AIM-120 flight control system to ensure that the missile safely separates from the aerodynamic flow field surrounding the launch aircraft. A modified q bias command was developed and tested and has resolved this issue. Initiation of guided missile testing revealed a boresight problem in the current software that will be corrected in the next planned major software update. The first guided AIM-120C launch from the F-22, a CY 2001 exit criterion, occurred in September 2001 with the missile guiding to within lethal radius of the target. Though it was not conducted at TEMP required operational shot parameters, the event was a successful developmental test and highlights the need for continued guided, end-to-end missile testing.

Testing of F-22 stealth characteristics has included measurements of both radar and infrared signatures and initiation of stability over time and logistics testing. Stealth sustainability testing is in progress and the first of several planned 50-hour LO maintenance test blocks have been completed. Environmental risks in the LO area have been reduced and maintenance processes for restoration of RCS have been developed.

DOT&E provided inputs to the Defense Acquisition Executive on CY 2002 exit criteria for the F-22 program. The inputs emphasized performance based criteria with relevance to readiness to enter the IOT&E early in the following year. Some exit criteria have been selected and final resolution of all criteria will take place at a quarterly program review in early 2002.

TEST & EVALUATION ASSESSMENT

The 1991 Milestone II DAB directed an Operational Assessment (OA) to support the F-22 LRIP decision. The Air Force conducted OA began in January 1998 and the report documenting results was published in April 2001. Numerous issues including main landing gear strut settling, environmental control system problems, intra-flight data link shortfalls, and missile launch detector performance were identified. Aircraft brake and arresting tail hook design difficulties were highlighted as creating a potential for the F-22 to be forced to operate from longer airfields. While none is planned, if specialized LO related support equipment is required, it could adversely affect mobility support requirements. The greatest risks to certification of the F-22 for IOT&E were identified as avionics test progress, software development, flight envelope expansion, and test aircraft configuration. DOT&E concurs in this assessment.

The revised F-22 test program has many ramifications. In the avionics area, the number of planned flight test runs was reduced by about half by combining various objectives into single test runs.

In the flight sciences area, some aspects of flight envelope expansion were deferred to after the start of IOT&E and previously planned test program content was reduced. The Air Force also reduced and restructured the planned F-22 weapons integration test program by deferring AIM-9 testing under rolling launch conditions. Additionally, they proposed to reduce the number of TEMP-required guided missile test scenarios. The Air Force intends to demonstrate that the captive-carry instrumented test vehicle (ITV) version of the AMRAAM missile is a valid OT evaluation tool — which may result in fewer guided missile launches being accomplished. The TEMP was revised to reflect the option to use ITV data in lieu of actual live launches in certain scenarios if approved by DOT&E. The initial missile test launch was conducted at non-operationally realistic (slower) airspeeds as an engineering build-up to TEMP scenarios. This was due to the slower than expected pace of flight testing in flight sciences envelope expansion. Some fully integrated guided missile test launches required by the TEMP will be done concurrently with IOT&E or as part of a post-EMD effort. DOT&E believes that the largest F-22 development risk, from both a technical and a schedule perspective, lies in the integration and validation of the advanced avionics suite with realistic air-to-air weapons employment.

Only one F-22 flight test aircraft incorporates the structural modifications and special instrumentation to enable the flight envelope to be fully cleared to its airspeed, altitude, and g-load design limits. This situation poses a high schedule risk in clearing the required flight envelope prior to IOT&E. Completion of the highly concurrent, integrated avionics system test plan also presents a significant challenge. Problems exist with CNI, EW, and integrated avionics. All have been hampered by lack of stability and difficulties getting software upgrades loaded onto test aircraft. Elimination of previously planned build-up test runs increase the probability that the avionics suite may enter IOT&E with unresolved and unrecognized anomalies. If redesign to meet performance thresholds is required, the current schedule may not allow sufficient time to incorporate and validate modifications prior to IOT&E.

Based on testing conducted to date, F-22 stealth parameters are meeting required capabilities. However, flight test with production representative finishes has yet to begin and a significant amount of RCS stability over time, environmental and sustainment testing remains to be completed. Remaining logistics tasks involve maintenance of F-22 stealth capabilities under sortie generation rate conditions. Availability of the Integrated Maintenance Information System (IMIS) is essential for IOT&E as are production representative aircraft and support equipment.

The F-22 Air Combat Simulator (ACS), an integral part of the planned IOT&E, will model the dense surface-to-air and air-to-air threat and electronic signal environment that is impractical or too costly to generate in open-air tests. Development of the ACS, consisting of two domes and ten manned interactive cockpit stations, continues but recent reductions in planned avionics flight test affects Verification, Validation and Accreditation (VV&A) activities, necessary prior to initiation of IOT&E. The planned flight test program will not provide all data required for accurate ACS system characterization. FTB and ground hardware-in-the-loop laboratory data will be used to supplement flight test data in the ACS VV&A effort.

Wing fuel tank hydrodynamic ram tests were conducted in FY01 using aircraft 4001 and leading edge dry bay fire ballistic tests will occur in FY02. Fuel tank inerting tests will use a fuel system simulator to evaluate the on-board inert gas generating system. Fuselage fuel tank hydrodynamic ram damage ballistic testing is also planned for FY02 and a realistic forward fuselage test article has been manufactured for this test. The Air Force relaxed the vulnerability requirement to accommodate increases in vulnerability determined as a result of LFT. Based on completed testing, the current F-22 design meets the new specification for vulnerability.

DOT&E supported relief from EMD cost caps for the F-22 program. Continuing the cap would limit required testing and potentially prevent the Service from implementing corrections for known deficiencies. To prepare for and execute an adequate IOT&E, the Service needs to be able to channel sufficient resources to find mission affecting problems and correct them. An EMD cost cap would hinder that effort.

F/A-22 – Advanced Tactical Fighter

Executive Summary

- The F/A-22 successfully demonstrated mission capability in air-to-air mission roles during IOT&E. Air-to-ground mission capability is to be determined through the follow-on testing now in progress.
- Operational testing identified several areas for improvement, including: avionics, weapons integration, diagnostics accuracy, low observable repair, and technical order data.
- Continued improvement is needed in operational suitability to ensure the weapons system is available and sustainable in combat operations.
- Follow-on testing is needed to ensure the improvements to the F/A-22 have the desired effect on battlefield performance, to confirm fixes, and to perform previously deferred testing.

System

- The F/A-22 is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F/A-22 low observability reduces threat capability to engage it with current weapons.
- It maintains supersonic speeds without use of afterburner.
- Avionics designed to fuse AESA radar, other sensor, and data-linked information for the pilot—enables employment of medium- and short-range air-to-air missiles, and gun.
- It is intended to be more reliable and easier to maintain than current fighter aircraft.
- Its air-to-air weapons are the AIM-120C radar-directed missile and the AIM-9M infrared-guided missile.
- It is developing air-to-ground precision strike capability with two 1,000 pound Joint Direct Attack Munitions.

- The F/A-22 program is designed to deliver capability in increments.

Mission

- A unit equipped with the F/A-22 is designed to:
  - Provide air superiority over friendly or enemy held territory
  - Defend friendly forces against fighter, bomber, or cruise missile attack
  - Escort friendly air forces into enemy territory
- Its intended air-to-ground capability includes counter-air, strategic attack, counter-land, and, eventually, enemy air defense suppression missions.

Activity

- Air Force Operational Test and Evaluation Center (AFOTEC) completed IOT&E in December 2004; DOT&E delivered the beyond low-rate initial production report on March 10, 2005. The test was conducted in accordance with the test plan approved by DOT&E.
- Air Combat Command began a series of user tests in February 2005 to test fixes and aid in tactics development. This series of tests, known as Force Development Evaluations, will conclude in early 2006.
- AFOTEC conducted the first Follow-on Operational Test and Evaluation (FOT&E) between August and November 2005. This FOT&E included air-to-ground strike capability using the 1,000-pound variant of the Joint Direct Attack Munition. DOT&E continues to review the data and will report on results at the Defense Acquisition Board planned for early 2006.
- The Air Force plans to incorporate better equipped adversary aircraft for the upcoming FOT&E of Increment 2 capability, planned to begin in 2006.

Assessment

- At the end of IOT&E, DOT&E determined that the F/A-22, in the air-to-air mission role, was operationally effective and survivable, but not operationally suitable. The F/A-22 was successful in 90 percent of its mission trials, but demonstrated a need for more maintenance resources and spare parts than planned.
- The Air Force identified 351 individual deficiencies for correction. Areas needing improvement included avionics capabilities, weapons integration, diagnostics accuracy, low observable repair, and technical order data.

Recommendation

1. The Air Force should address IOT&E test limitations and test the F/A-22 against adversary aircraft and other threat systems that are representative of the intended operational environment.

F-22A – Advanced Tactical Fighter

Executive Summary

- The F-22A successfully demonstrated air-to-ground mission roles capability during Follow-on Test and Evaluation (FOT&E) using 1,000-pound Joint Direct Attack Munitions.
- Many of the deficiencies highlighted in IOT&E were resolved, but additional deficiencies in air-to-ground weapons integration and defensive avionics suite capabilities were identified in follow-on testing.
- Defensive avionics deficiencies highlighted in user tests suggest the need for a comprehensive approach to address defensive suite shortfalls and assess improvements in follow-on test venues commensurate with follow-on F-22A operational flight program software releases.
- Modest improvements in some suitability measures were observed, but sortie generation capability remains hampered by low diagnostics accuracy, long repair times, and subsystem reliability that does not meet user requirements.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- It maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data-linked information for the pilot enable employment of medium- and short-range air-to-air missiles and guns.
- It is intended to be more reliable and easier to maintain than current fighter aircraft.

- Its air-to-air weapons are the AIM-120C radar-directed missile and the AIM-9M infrared-guided missile.
- Its air-to-ground precision strike capability consists of two 1,000-pound JDAMs.
- The F-22A program is designed to deliver capability in increments.

Mission

- A unit equipped with the F-22A should be able to:
  - Provide air superiority over friendly or enemy territory
  - Defend friendly forces against fighter, bomber, or cruise missile attack
  - Escort friendly air forces into enemy territory
- Its air-to-ground capability includes counter-air, strategic attack, counter-land, and eventually, enemy air defense suppression missions.

Activity

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed the first F-22A FOT&E in December 2005. Testing assessed F-22A air-to-ground mission capability using the 1,000-pound variant of the JDAM.
- Air Combat Command completed a series of user Force Development Evaluation (FDE) tests in January 2006 aiding in tactics development and assessment of F-22A defensive avionics suite capabilities.

Assessment

- At the conclusion of IOT&E in December 2004, DOT&E determined that the F-22A was operationally effective in the air-to-air mission role but not operationally suitable. AFOTEC FOT&E and Air Combat Command FDE testing conducted in FY05-06 led to the DOT&E determination that the F-22A was operationally effective in the air-to-ground mission role against fixed targets using JDAMs. However, the F-22A is still not operationally suitable.
- AFOTEC FOT&E and Air Combat Command FDEs revealed that:
  - The F-22A is operationally effective at air-to-ground missions against fixed targets and has resolved many of the deficiencies found in IOT&E.
  - Additional deficiencies were found in air-to-ground weapons integration that need to be addressed in future development efforts. Improvements require evaluation in follow-on operational testing.

- Air Combat Command FDE results highlighted shortfalls in defensive avionics suite capabilities to include threat identification, system response time, symbology resolution, and reliability. These shortfalls affect fundamental aspects of effectiveness in the operational environment in which the F-22A performs.

• While there were modest improvements in a few suitability measures, sortie generation capability is still hampered by low diagnostics accuracy, long repair times, and subsystem reliability that does not meet user requirements.

Recommendations

• Status of Previous Recommendations. FY05 recommendations to address IOT&E test limitations, as well as test the F-22A against adversary aircraft and other threat systems representative of the intended operational environment, are being incorporated in the AFOTEC FOT&E testing scheduled for FY07.

• FY06 Recommendation.

1. The Air Force should pursue a comprehensive approach to address the defensive avionics suite shortfalls and assess improvements in FOT&E and FDE venues commensurate with follow-on F 22A operational flight program software releases.

F-22A – Advanced Tactical Fighter

Executive Summary

- The F-22A completed an aggressive array of follow-on testing to include enhanced mission capabilities, and the evaluation of new hardware and software capabilities. F-22A system maturity demonstrated positive trends and modest improvement in subsystem reliability and fault diagnostics accuracy. However, inspection and repair of low observables continues to impact F-22A maintainability. The Air Force is investing in reliability and maintainability programs which may enable the F-22A to continue progress toward meeting its long term requirements specified in the F-22A Operational Requirements Document.
- Air Force Operational Test and Evaluation Center (AFOTEC) Follow-on Test and Evaluation (FOT&E) of F-22A Increment 2 Operational Flight Program (OFP) capabilities demonstrated operational effectiveness in expanded air-to-ground missions against fixed targets. The FOT&E also demonstrated improvements in certain suitability metrics including modest gains in subsystem reliability and fault diagnostics accuracy.
- New hardware subsystems incorporated into Lot 5 aircraft were found to be interoperable with Increment 1 aircraft and found to be as effective and suitable as legacy Increment 1 subsystems.
- Air Combat Command electronic warfare Mission Data Optimization (MDO) testing was sufficiently integrated with AFOTEC FOT&E testing to evaluate defensive avionics suite performance with the Increment 2 OFP.
- Data collection and analysis to date has not identified significant trends in the stability of the F-22A Low Observables signature or effectiveness of the Signature Assessment System. It is likely that any trends will not be realized until further data becomes available during FY08 testing

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.

- It maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data-linked information for the pilot enable employment of medium- and short-range air-to-air missiles and guns.
- The F-22A is designed to be more reliable and easier to maintain than current fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-directed missile and the AIM-9M infrared-guided missile.
- F-22A air-to-ground precision strike capability consists of two 1,000-pound Joint Direct Attack Munitions (JDAMs).
- The F-22A program is designed to deliver capability in increments.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Activity

- The Air Force implemented elements of its F-22A reliability and maintainability enhancement program resulting in improvements in some suitability metrics in FY07 testing.
- AFOTEC completed the second F-22A FOT&E in August 2007. The FOT&E 2 assessed the F-22A Increment 2 OFP aircraft software configuration, including expanded air-to-ground mission capability and improvements in system suitability.
- Air Combat Command conducted an Operational Utility Evaluation (OUE) of new hardware subsystems that will be in production F-22As starting with Lot 5 aircraft deliveries. The OUE assessed the effectiveness, suitability, and

interoperability of Lot 5 hardware with the currently fielded F-22 fleet. The Lot 5 hardware, which includes the F-22A fourth generation radar, digital electronic warfare suite, intra-flight data link, communications/navigation/identification system, and several diminishing manufacturing source replacement components, provides the foundation for future F-22A increments, beginning with Increment 3 in 2010.

- Air Combat Command continued electronic warfare MDO software development and testing throughout FY07. Upgrades to F-22A electronic warfare mission data software sets were released to the field in support of specific F-22A global mission tasking. Testing under the currently DOT&E-approved MDO Test Plan will be ongoing throughout FY08.
- Air Combat Command completed the second year of the F-22A Low Observables Stability Over Time test. This five-year test is designed to assess the durability and stability of the F-22A radar cross section, and to validate the F-22A Signature Assessment System, which is used at the flight line to ensure that aircraft have a sufficiently low signature for operational missions.

Assessment

- FOT&E results demonstrated that F-22As configured with the Increment 2 OFP are operationally effective in the suppression and destruction of fixed enemy air defenses. Some of the outstanding system deficiencies and weapons integration problems that were significant detractors in previous testing were resolved, enabling Increment 2 OFP-configured F-22As to achieve success in this high threat mission area. F-22As executed increasingly complex missions in high threat environments. FOT&E testing increased the understanding of the capabilities needed for sustained operational use in air-to-air and air-to-ground roles.
- Air Combat Command testing determined Lot 5 hardware was interoperable with Increment 1 aircraft, and the new hardware subsystems exhibited the same level of effectiveness and suitability as the legacy Increment 1 aircraft configuration.
- Air Combat Command electronic warfare MDO testing was sufficiently integrated with AFOTEC FOT&E testing to evaluate defensive avionics suite performance with the Increment 2 OFP.
- Data collection and analysis to date has not identified significant trends in the stability of the F-22A Low Observables signature or effectiveness of the Signature Assessment System. It is likely that any trends will not be realized until further data becomes available from FY08 testing.
- Overall F-22A system maturity exhibited some positive trends and modest improvement in subsystem reliability and fault diagnostics accuracy. However, inspection and repair of low observables continues to impact F-22A maintainability. Test results demonstrated that maintaining the low-observable signature continues to require a significant effort and accounted for half of the overall maintenance man-hours expended in FOT&E 2. Additionally, restoration of the low-observable signature requires long durations to cure materials often resulting in extended periods of time during which aircraft are not available for operational missions.
- Though maintainability challenges continue to exist, reliability gains suggest incremental improvements in overall system suitability. FY07 test results suggest the Air Force's reliability enhancement program has had a positive effect. Evaluation of F-22A reliability and maintainability improvements in follow-on testing will be necessary to assess and confirm suitability as the F-22A progresses towards system maturity.

Recommendations

- Status of Previous Recommendations. There are no outstanding recommendations from previous annual reports.
- FY07 Recommendation.

1. The Air Force should continue to invest resources in reliability and maintainability improvement programs to provide the opportunity for the F-22A to meet the user's suitability requirements at system maturity.

F-22A – Advanced Tactical Fighter

Executive Summary
- F-22A test efforts included developmental testing and support systems modification necessary to support Increment 3.1 enhanced global strike FOT&E scheduled to begin in June 2010.
- F-22A Low Observables Stability Over Time testing completed the third of a five-year series of testing to assess the validity of the F-22A low observable Signature Assessment System tool and the metrics used to determine durability and priorities for low observables maintenance actions in operational environments and employment. Accurate assessment of trends will not be realized until the entire body of test data has been collected and analyzed over the five-year test period.

System
- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- It maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data linked information for the pilot enable employment of medium- and short-range air-to-air missiles and guns.
- The F-22A is designed to be more reliable and easier to maintain than current fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-directed missile and the AIM-9M infrared-guided missile.

- F-22A air-to-ground precision strike capability consists of two 1,000-pound Joint Direct Attack Munitions (JDAMs).
- The F-22A program is designed to deliver capability in increments.

Mission

A unit equipped with the F-22A:
- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Prime Contractor
- Lockheed Martin

Activity
- F-22A testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan.
- The Air Force began modifications to the Air Combat Simulator necessary to support F-22A Increment 3.1 FOT&E. Increment 3.1 incorporates enhanced air-to-ground weapons capabilities and avionics enhancements to expand F-22 global strike capabilities. Simulator systems modifications include threat system upgrades, weapons models, mission scenarios, and the establishment of a verification, validation, and accreditation plan. Increment 3.1 FOT&E is scheduled to begin in June 2010.
- Developmental flight testing of the aircraft instrumentation system needed to support Increment 3.1 FOT&E completed in FY08. Six instrumentation units will be delivered to the operational test unit at Nellis AFB, Nevada, in December 2008 for operational testing in preparation for Increment 3.1 FOT&E.
- Initial planning for the scheduled June 2010 Increment 3.1 FOT&E began in FY08.
- The Air Force Air Combat Command concluded the third year of the five-year Low Observable Stability Over Time Test. This evaluation is an on-going Force Development Evaluation assessing the validity of the F-22A low observable Signature Assessment System tool and the metrics used to determine durability and priorities for low observables maintenance actions in operational environments and employment. The Air Force Air Combat Command conducted testing under the provisions of the DOT&E-approved test plan.

- Air Combat Command continued electronic warfare software development and testing throughout FY08 under the DOT&E-approved Mission Data Optimization Test Plan.

Assessment

- F-22A FY08 test efforts largely supported future Increment 3.1 FOT&E scheduled for June 2010. Developmental testing and operational test planning efforts suggest the program is progressing to meet the Increment 3.1 FOT&E target date.
- F-22A Low Observables Stability Over Time test data collection and analysis to date has not revealed significant trends in the stability of the F-22A low observables signature or effectiveness of the Signature Assessment System. Continued collection and analysis of data, in accordance with the DOT&E-approved test plan is ongoing and accurate assessment of trends will not be realized until the entire body of test data has been collected and analyzed over the five-year test period.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY08 Recommendations. None.

F-22A – Advanced Tactical Fighter

Executive Summary
- F-22A test efforts included developmental flight testing and operational test planning necessary to support Increment 3.1 Enhanced Global Strike FOT&E scheduled to begin in November 2010.
- F-22A Low Observables Stability Over Time testing completed the fourth year of a five-year operational test to assess the validity of the F-22A low observable Signature Assessment System tool, the durability and stability of the F-22A low observable system over time, and the low observables maintainability concept of operations.
- Results reported by the Air Force for the third year of F-22A Low Observable Stability Over Time (LOSOT) test indicate continued challenges in F-22A maintainability associated with the aircraft low observables capabilities.
- Low observables maintainability trends suggest the Air Force may experience significant challenges in meeting a number of operational suitability at maturity threshold requirements specified in the current F-22 operational requirements and capabilities production documents.

System
- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- It maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data linked information for the pilot enable employment of medium- and short-range air-to-air missiles and guns.
- The F-22A is designed to be more reliable and easier to maintain than current fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-directed missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.

- F-22A air-to-ground precision strike capability consists of two 1,000-pound Joint Direct Attack Munitions.
- The F-22A program delivers capability in increments. The Air Force F-22A Increment 3.1 will deliver enhanced air-to-ground mission capability to include incorporation of Small Diameter Bomb Increment One in 2011.

Mission

A unit equipped with the F-22A:
- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Prime Contractor
- Lockheed Martin Aeronautics Company, Fort Worth, Texas

Activity
- F-22A testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan.
- F-22A test efforts in FY09 included developmental flight testing and operational test planning necessary to support Increment 3.1 Enhanced Global Strike FOT&E scheduled to begin in November 2010.
- The Air Force Air Combat Command (ACC) concluded the fourth year of the five-year test and reported on findings from the third year of testing. This evaluation is an ongoing five-year Force Development Evaluation assessing the validity of the F-22A low observable Signature Assessment System (SAS), durability and stability of the F-22A low observable system over time, and the low observables maintainability concept of operations. ACC conducted testing under the provisions of the DOT&E-approved test plan.

Assessment

- The program is progressing to meet planned Increment 3.1 FOT&E scheduled for November 2010 through May 2011.
- In FY07 DOT&E assessed that inspection and repair of low observables had a considerable impact on F-22A maintainability. FY07 test results demonstrated that maintaining the low observable signature required a significant level of F-22A maintenance effort. These FY07 test results further indicated that restoration of the low observable signature required long durations to cure materials often resulting in extended periods of time during which aircraft are not available for operational missions.
- Though a complete assessment of trends will not be realized until the entire body of LOSOT test data is collected and analyzed, ACC reporting of third year interim findings indicate ongoing challenges in F-22A low observables maintainability. ACC interim findings noted:
  - The F-22A SAS appears to be adequate for low observables maintenance documentation. However, SAS accuracy is dependent upon the expertise and accuracy of individual maintenance personnel in documenting signature discrepancies and inputting data into the automated system.
  - The current SAS software and hardware should be upgraded to speed data entry procedures and decrease system processing time to increase productivity.
  - Maintaining SAS data integrity requires regular audits and database checks performed by experienced low observables maintenance personnel.
  - Continuation training for low observables maintenance personnel is required for the proper documentation of aircraft damage discrepancies, recognition of differences between similar types of low observables damages, and identification of correct logistical control numbers when using SAS.
  - LOSOT testing should be continued after completion of the current five year test in FOT&E to include F-22A Block 30 aircraft.
- DOT&E agrees with the ACC FY09 F-22A LOSOT interim findings. The findings are consistent with F-22 operational fleet trends and DOT&E FY07 observations. Low observables maintainability is an ongoing challenge and continues to account for a significant proportion of the man hours per flight hour required to maintain the F-22. This impacts both aircraft operational availability and mission capable rates.
- The F-22A will reach 100,000 fleet flight hour system maturity in the 2010 to 2011 time period. Given the maintainability metrics achieved in operational testing to date, the Air Force may experience significant challenges in meeting a number of at maturity operational suitability thresholds specified in the current F-22 operational requirements and capabilities production documents.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY09 Recommendation.
  1. The Air Force should plan to conduct further follow-on test and evaluation of F-22A low observables capabilities after the completion of the current five-year LOSOT test to continue to assess the validity of the F-22A low observable SAS, durability and stability of the F-22A low observable system over time, and to assess the low observables maintainability concept of operations.

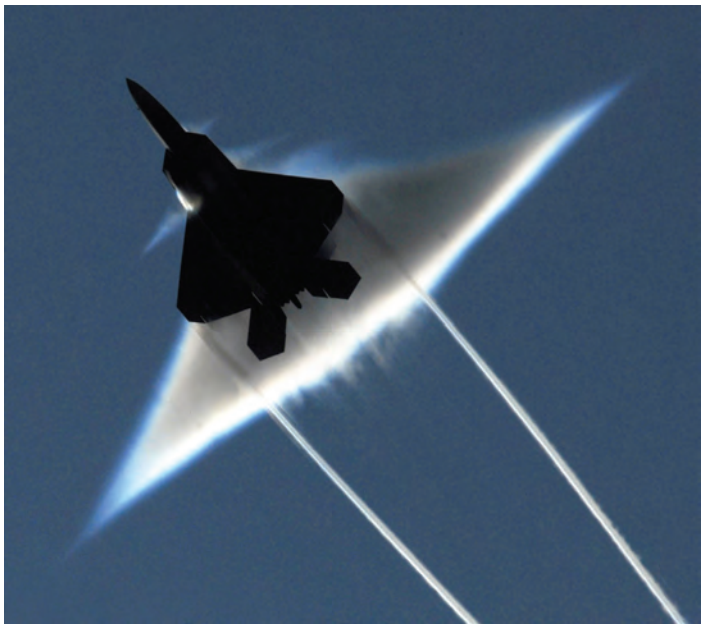
F-22A – Advanced Tactical Fighter

Executive Summary

- The Air Force F-22A developmental flight testing and operational test planning necessary to support Increment 3.1 Enhanced Global Strike FOT&E continued throughout FY10. FOT&E is scheduled to begin in January 2011.
- The Air Force completed the 2009 F-22A Mission Data Load (MDL), Mission Data Optimization (MDO) testing to assess the operational effectiveness of reprogrammable threat files supporting F-22A electronic warfare capabilities.
- The Air Force completed the first phase of a three-phase Force Development Evaluation (FDE) for the F-22A Update Three Operational Flight Program, assessing system software enhancements and electronic protection upgrades to the F-22A. Preliminary results indicate the software provides enhanced mission effectiveness and electronic protection capability.
- The Air Force F-22A Low Observables Stability Over Time (LOSOT) testing completed the fifth year of operational flight test to assess the validity of the F-22A low observable Signature Assessment System (SAS) tool, the durability and stability of the F-22A low observable system over time, and the low observables maintainability concept of operations.
- Low observables maintainability trends continue to suggest the Air Force may experience significant challenges in meeting a number of operational suitability threshold requirements specified in the current F-22A operational requirements and capabilities production documents when the system reaches maturity in early calendar year 2011.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data linked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions..
- The F-22A is designed to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.



- F-22A air-to-ground precision strike capability consists of two 1,000-pound Joint Direct Attack Munitions.
- The F-22A program delivers capability in increments. The Air Force F-22A Increment 3.1 will deliver enhanced air-to-ground mission capability in 2011, to include incorporation of Small Diameter Bomb Increment One.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E approved Test and Evaluation Master Plan and FOT&E and FDE test plans.
- The Air Force continued F-22A Increment 3.1 Enhanced Global Strike developmental testing throughout FY10. The Air Force Operational Test and Evaluation Center (AFOTEC) finalized test planning efforts for Increment 3.1 FOT&E, scheduled to begin in January 2011.
- AFOTEC conducted a series of simulator test events supporting F-22A Increment 3.1 FOT&E development in the F-22 Air Combat Simulator (ACS). The ACS facility consists of four F-22 cockpits installed in visual scene domes and ten other manned interactive cockpit stations and is designed to model the dense surface-to-air and air-to-air threat and electronic signals environment that is impractical or too costly to generate in open-air flight test. Ongoing validation, verification, and accreditation of the ACS for use in AFOTEC Increment 3.1 mission effectiveness evaluation occurred throughout FY10.
- Air Force Air Combat Command (ACC) completed F-22A electronic warfare testing conducted under the May 2009 F-22 MDL, MDO FDE Test Plan.
- Air Force ACC concluded the first phase of a three-phase FDE in July 2010 for the F-22A Update Three Operational Flight Program assessing system software enhancements and electronic protection upgrades to the F-22A system.
- Air Force ACC concluded the final year's flight testing for the five-year LOSOT test and reported on findings from the fourth year of testing. This evaluation assesses the validity of the F-22A low observable SAS, durability and stability of the F-22A low observable system over time, and the low observables maintainability concept of operations.
- The Air Force instituted the F-22A Signature Management Program, a flight test program to verify the long term signature stability of the operational F-22A fleet and to continue to verify and refine SAS. In addition, the Signature Management Program assesses the completeness, correctness, and process clarity in management of the F-22A low observables system across the operational fleet.

Assessment

- The Increment 3.1 Enhanced Global Strike program experienced developmental challenges requiring additional software releases and flight test in FY10. The originally planned November 2010 through May 2011 FOT&E period is now scheduled from January through August 2011. Increment 3.1 FOT&E will include both open-air flight testing and complex missions conducted in the F-22 ACS. Evaluating F-22A Increment 3.1 capabilities in the context of the F-22's anticipated operational threat and electronic signals environment requires that the ACS provide the realistic threat density and fidelity to complement open-air flight testing.
- ACC 2009 MDL MDO testing verified and validated upgrades in F-22A reprogrammable mission data loads resulting in the fielding of updated electronic warfare capabilities to operational units enabling enhanced global mission operations.
- Preliminary results from ACC Update Three FDE Phase One testing indicate the software provides enhanced mission effectiveness and electronic protection capability.
- ACC LOSOT fourth year interim findings indicate the following:
  - The F-22A SAS appears to be adequate for low observables maintenance documentation. Continual emphasis must be placed on training personnel to assure that low observable damages are properly identified and input into SAS so that accurate results are reported and proper maintenance can occur.
  - SAS is improving through periodic updates to increase the speed and usability of the program.
  - SAS data integrity should be maintained with regular audits and database checks performed by experienced low observables maintenance personnel.
  - As noted in the third year interim findings, continuation training for low observables maintenance personnel should be emphasized for the proper damage documentation and identification of correct logistics control numbers when using SAS.
- LOSOT findings are consistent with F-22 operational fleet trends and DOT&E FY07 follow-on operational testing observations. Low observables maintainability continues to account for a significant proportion of the man hours per flight hour required to maintain the F-22. This affects aircraft operational availability, mission capable rates, and sortie generation rates. LOSOT testing should be continued under the Signature Management Program or similar test venue after final reporting of the current ACC five year test and should include an assessment of the F-22A operational test fleet in addition to operational unit aircraft.
- The F-22A will reach 100,000 fleet flight hour system maturity in early 2011. Given the maintainability metrics achieved in operational testing to date, the Air Force is likely to experience significant challenges in meeting a number of "at maturity" operational suitability thresholds specified in the current F-22 operational requirements and capabilities production documents. DOT&E will assess the operational effectiveness and suitability of the mature F-22A system in conjunction with oversight of Increment 3.1 Enhanced Global Strike FOT&E.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY10 Recommendation.
  1. The F-22A LOSOT testing should be continued under the Signature Management Program or similar test venue after final reporting of the current ACC test and should continue to include an assessment of the F 22 operational test fleet as well as operational unit aircraft.

F-22A Advanced Tactical Fighter

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) began FOT&E of F-22A Increment 3.1 Enhanced Global Strike capabilities in January 2011. Flight testing did not complete in FY11; however, nominal performance during FY11 resulted in an Air Force decision to begin interim fielding of the hardware and software to support fleet-wide aircraft retrofit and non-combat familiarization flight training.
- Air Force Air Combat Command (ACC) concluded the final phase of a three-phase Force Development Evaluation (FDE) for the F-22A Update Three Operational Flight Program (OFP) software suite assessing system software enhancements and electronic protection upgrades to the F-22A system. Analysis of Update Three OFP electronic protection performance results was ongoing at the end of FY11, and preliminary results indicate the OFP provides enhanced mission effectiveness and electronic protection capability for F-22A aircraft.
- Air Force ACC issued its final report on the five-year Low Observables Stability Over Time (LOSOT) test. DOT&E assesses the results of this test demonstrate: the F-22A low observables (LO) system is durable and stable over time; the F-22A LO maintenance concept of operations is executable with adequate support procedures and documentation to facilitate LO maintenance activities; and the F-22A Signature Assessment System (SAS) is an adequate maintenance tool for determining when aircraft LO maintenance actions are required. However, LO maintenance continues to account for a significant proportion of the man hours per flight hour required to maintain the F-22A.
- Suitability data from Increment 3.1 FOT&E flight testing to date suggests improvement over F-22A system reliability, maintainability, and supportability metrics observed in previous formal OT&E periods.
- The Air Force grounded the F-22A fleet due to suspected contamination problems associated with the aircraft environmental control system and associated onboard oxygen generation system from late April through late September 2011. The fleet grounding precluded planned FY11 completion of Increment 3.1 FOT&E flight testing. The Air Force intends to complete this FOT&E in early FY12. Ongoing FY11 OT&E flight activities were suspended through mid-September.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.

- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and datalinked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The F-22A is designed to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of two 1,000-pound Joint Direct Attack Munitions.
- The F-22A program delivers capability in increments. The Air Force F-22A Increment 3.1 delivers enhanced air to ground mission capability, to include incorporation of Small Diameter Bomb (SDB) Increment One.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and FOT&E and FDE test plans.
- The Air Force began F-22A Increment 3.1 Enhanced Global Strike FOT&E in January 2011. AFOTEC completed associated air-to-air and air-to-ground weapons testing and Advanced Combat Simulator mission testing in FY11. Open-air Increment 3.1 FOT&E flight test missions on the Nevada Test and Training Range (NTTR) did not complete as planned in FY11 due the grounding of the F-22A fleet from April through September 2011. Increment 3.1 FOT&E is expected to complete flight test missions in early FY12. In July 2011, the Air Force authorized an early fielding of the capability prior to conclusion of remaining NTTR mission testing to support aircraft retrofit and non-combat flight training across the F-22A fleet based on preliminary results of FOT&E testing.
- Air Force ACC concluded the final phase of a three-phase FDE for the F-22A Update Three OFP assessing system software enhancements and electronic protection upgrades to the F-22A system. Analysis of Update Three OFP electronic protection performance results was ongoing at the end of FY11.
- Air Force ACC issued its final report on the five-year LOSOT test. This evaluation assessed the validity of the F 22A low observable SAS, durability and stability of the F-22A LO system over time, and the LO maintainability concept of operations.

Assessment

- Preliminary results of Increment 3.1 FOT&E testing in FY11 suggest that the enhanced air-to-ground capabilities will permit the F-22A to perform its intended offensive counter-air suppression of enemy air defenses mission in Global Strike scenarios.
  - FOT&E 3.1 weapons testing results demonstrated the F-22A remains capable of effectively employing legacy JDAM, AIM-9M, and AIM-120C weapons as well as the newly incorporated SDB.
  - Aircrews are capable of using the F-22A radar and onboard sensors to locate and designate surface targets with sufficient accuracy to effectively employ air-to ground weapons to suppress enemy air defenses.
  - Suitability data from 225 sorties and 445 flight test hours suggest improvement over previous F-22A reliability, maintainability, and supportability metrics observed in previous formal OT&E periods.
  - Preliminary trends suggest Increment 3.1 mission capable rates are comparable to those observed in previous OT&E periods. Similarly, testing trends suggest a significant increase in Mean Time Between Critical Failure (MTBCF) compared to previous OT&E periods. Increment 3.1 observed MTBCF in FY11 FOT&E testing to date was 4.01 hours (80 percent lower confidence bound) compared to the reported MTBCF in FY07 FOT&E of 1.73 hours, suggesting Increment 3.1 configured F-22As should be better able to satisfy Air Force operational mission availability and sortie generation rate requirements than previous configurations. Final determination of progress in satisfying the F-22A "at maturity" operational suitability thresholds will be made in conjunction with the conclusion of Increment 3.1 FOT&E in early FY12.
- At the completion of the five-year LOSOT FDE, DOT&E assesses the following:
  - The F-22A LO system is durable and stable over time.
  - The F-22A LO maintenance concept of operations is executable, and support procedures and documentation are adequate to support LO maintenance activities.
  - The F-22A SAS is an adequate tool for determining when aircraft LO maintenance actions are required.
  - LO maintenance accounts for a significant proportion of the man hours per flight hour required to maintain the F-22A affecting aircraft operational availability, mission capable rates, and sortie generation rates. The original LO maintenance manpower estimate was 1.67 spaces per aircraft. The Air Force has increased LO personnel authorizations to 3.1 spaces per aircraft at F-22A operational units to meet the increased manpower demands associated with maintaining the LO system.
  - The Air Force has begun implementation of measures aimed at assisting in the long term maintenance of the F-22A LO system. In FY10, the Air Force instituted F-22A Signature Management Program, a flight test program to verify the long-term signature stability of the operational F-22A fleet and to continue to verify and refine SAS. Since then the Air Force has acted to procure and field an LO Repair Verification Radar tool to aid in evaluating and verifying LO repairs and assist in performing periodic maintenance audits of the LO system. Additionally, the Air Force has made funds available for periodic aircraft LO reduction efforts wherein contract field teams restore the F-22 LO system to production signature levels. These measures, in conjunction with increased LO manpower should enable the Air Force to continue to maintain the F-22 LO system within tolerances necessary to meet operational mission requirements.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY11 Recommendations. The Air Force should:
  1. Continue to fund and implement measures begun to assist in the long-term maintenance of the F-22A LO system to include: the Signature Management Program; the Repair Verification Radar tool; and periodic field team aircraft LO reduction for operational unit F-22As.
  2. Complete the ongoing FOT&E to fully characterize F-22A Increment 3.1 effectiveness, suitability, and mission capability.

F-22A Advanced Tactical Fighter

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed FOT&E of F-22A Increment 3.1 Enhanced Global Strike capabilities in November 2011. FOT&E results demonstrated that the enhanced air-to-ground hardware and software enable the F-22A to perform its intended offensive counter-air suppression of selected, but not all relevant enemy air defenses in Global Strike scenarios.
- Overall Increment 3.1 operational suitability was substantially improved compared with the performance in previous evaluation periods.
- The Air Force completed a formal investigation of the aircraft life support system and associated onboard oxygen generation system, and ruled out contamination as the root cause of hypoxia-like incidents that resulted in the fleet-wide F-22A grounding in FY11. The Air Force concluded that impedance/restriction caused by life support system elements were significant contributors to the physiological incidents and is pursuing actions to resolve the problem including: removal of the aircrew C21A filter pack, and testing of a modified aircrew upper pressure garment. Additionally, the Air Force is installing a back-up emergency oxygen system to provide emergency oxygen in the event of an environmental control system shut down, rapid decompression, or failure of the onboard oxygen generator.
- In conjunction with the completion of Increment 3.1 FOT&E and the F-22A fleet achieving its "at maturity" 100,000 fleet flight hours milestone, DOT&E conducted an analysis of F-22A progress in satisfying the original weapon system operational suitability requirements. Based on performance from IOT&E through Increment 3.1 FOT&E, DOT&E assesses the mature F-22A weapon system is operationally effective and suitable.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- F-22A low observability reduces threat capability to engage with current weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and datalinked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.

- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition (JDAM) and the 250-pound Small Diameter Bomb (SDB) Increment One.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and projected increments:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geo-location of selected emitters, electronic attack, air-to-ground synthetic aperture radar mapping and designation of surface targets, and SDB integration. Increment 3.1 is currently fielded in operational F-22A units.
  - Increment 3.2A is a software-only upgrade intended to provide improved Electronic Protection, Link 16, and Combat Identification capabilities in FY14. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record.
  - Increment 3.2B is a hardware and software upgrade intended to integrate AIM-120D and AIM-9X missile systems, and provide additional Electronic Protection enhancements and improved emitter geo-location capability in FY17. Increment 3.2B will be a separate Major Defense Acquisition Program with Milestone B projected for December 2012.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly or enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack

- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor
Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and FOT&E plans.
- The Air Force completed F-22A Increment 3.1 FOT&E in November 2011. Fleet-wide Increment 3.1 retrofits of Block 30 F-22As were ongoing throughout FY12.
- The Air Force completed a formal investigation of the aircraft life support system and associated onboard oxygen generation system due to several unexplained hypoxia-like incidents that occurred throughout FY11. Fleet-wide F-22A grounding from April through September 2011 delayed the planned completion of Increment 3.1 FOT&E until November 2011. The Air Force investigation ruled out contamination as the root cause of the incidents. As of August 2012, the Air Force concluded that impedance/restriction caused by life support system elements were significant contributors to the physiological incidents. Accordingly, the Air Force is pursuing the following actions in the interest of resolving the problem: removing the aircrew C21A filter pack, and testing a modified aircrew upper pressure garment. Additionally, the Air Force is installing a back-up emergency oxygen system to provide emergency oxygen in the event of an environmental control system shut down, rapid decompression, or failure of the onboard oxygen generator.
- The Air Force conducted planning activities in support of Increment 3.2A and 3.2B modernization efforts. Increment 3.2A developmental testing will begin in FY13. In conjunction with the completion of Increment 3.1 FOT&E and the F-22A fleet achieving its "at maturity" 100,000 fleet flight hours milestone, DOT&E conducted an analysis of F-22A progress in satisfying the original weapon system operational suitability requirements.

Assessment

Increment 3.1 FOT&E

- Results of Increment 3.1 FOT&E testing completed in November 2011 demonstrated that the enhanced air-to-ground capabilities enable the F-22A to perform its intended offensive counter-air suppression of enemy air defenses mission in Global Strike scenarios.
  - The F-22A remains capable of effectively employing legacy JDAM, AIM-9M, and AIM-120C weapons as well as the newly incorporated SDB.
  - Aircrews are capable of using the F-22A radar and onboard sensors to reliably locate and designate surface targets with sufficient accuracy to effectively employ both legacy JDAM and newly incorporated SDB munitions to suppress selected, but not all relevant enemy air defenses.
  - Overall Increment 3.1 operational suitability was substantially improved compared with the performance in previous evaluation periods. FOT&E demonstrated a significant improvement in Mean Time Between Critical Failure (MTBCF) compared to previous OT&E periods. Increment 3.1 FOT&E MTBCF was 4.68 hours (4.01 hours 80 percent lower confidence bound; 5.26 hours 80 percent upper confidence bound) compared to the reported MTBCF in the FY07 FOT&E of 1.73 hours.
  - The Increment 3.1 F-22A weapons system exceeded the operational deployability threshold requirement of seven C-17 airlift equivalents by one additional C-17.
  - The Increment 3.1 F-22A weapons system met both combat sortie generation requirements and material availability threshold requirements.

F-22A System At Maturity Assessment

- In conjunction with the completion of Increment 3.1 FOT&E, DOT&E assessed F-22A progress since the completion of IOT&E in satisfying the original weapon system's operational effectiveness and suitability requirements. Findings include the following:
  - Based on performance from IOT&E through Increment 3.1 FOT&E, DOT&E assesses the mature F-22A weapon system as operationally effective in both air-to-air and air-to-ground mission roles.
  - DOT&E compared Increment 3.1 FOT&E suitability results with operational F-22A unit performance through an independent model that simulated the combat sortie generation operations of an operational F-22A squadron. Based on suitability results achieved during Increment 3.1 FOT&E and results of the DOT&E model, DOT&E assesses that the mature F-22A weapons system is operationally suitable.
  - The Air Force has matured maintenance practices, improved subsystem suitability, adjusted manpower requirements, and modified the F-22A deployment concept of operations in order to meet F-22A combat air power needs. The F-22A weapons system is capable of achieving material availability and combat sortie generation Key Performance Parameter thresholds. However, based on increased maintenance manpower, equipment, and supplies necessary to sustain combat operations, the Air Force is likely to continue to require eight C-17 airlift equivalents to deploy an F-22A squadron in support of global operations.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY12 Recommendation.
  1. Commensurate with the maturation of the F-22A weapons system and ongoing F-22A modernization efforts, the Air Force should apply past lessons learned for forthcoming F-22A upgrades, and the development and fielding of future manned fighter aircraft programs. Particular attention should be given to the challenges of maintaining low observable systems.

F-22A Advanced Tactical Fighter

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed FOT&E of F-22A Increment 3.1 Enhanced Global Strike capabilities in November 2011, and fleet-wide Increment 3.1 retrofits of Block 30 F-22As continued throughout FY13.
- F-22A Increment 3.2A developmental testing proceeded throughout FY13 and will continue in FY14. Increment 3.2A is a software-only modernization effort integrating Link 16 Receive, enhanced Combat Identification, and enhanced Electronic Protection (EP) capabilities.
- The F-22A Modernization integrated test construct enabled operational test pilots to fly familiarization, training, regression, and developmental test support missions with F-22As configured with early developmental Increment 32.A Operational Flight Program (OFP) software releases throughout FY13. This enabled the F-22A Increment 3.2A program to identify problems early in system development and preserve the overall Increment 3.2A developmental test schedule throughout FY13.
- F-22A Modernization Increment 3.2B, a separate Major Defense Acquisition Program, achieved Milestone B in June 2013.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- Low observability reduces threat capability to engage F-22As with current adversary weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and datalinked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition and the 250-pound Small Diameter Bomb (SDB) Increment One.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and projected increments:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geo-location of selected emitters, electronic attack, air-to-ground synthetic aperture radar mapping and designation of surface targets, and SDB integration. Increment 3.1 is currently fielding in operational F-22A units.
  - Increment 3.2A is a software-only upgrade intended to provide improved EP, Link 16 Receive, and Combat Identification capabilities in early FY15. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record.
  - Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM-120D and AIM-9X missile systems and provide additional EP enhancements and improved emitter geo-location capability. Increment 3.2B IOT&E is currently planned for FY17.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly and non-permissive, contested enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
- The Air Force completed F-22A Increment 3.1 FOT&E in November 2011. Fleet-wide Increment 3.1 retrofits of Block 30 F-22As continued throughout FY13.
- F-22A Increment 3.2A developmental testing proceeded throughout FY13 and will continue in FY14. Increment 3.2A FOT&E is scheduled to begin in June 2014.
- F-22 Increment 3.2B achieved Milestone B in June 2013.

Assessment

The F-22A Increment 3.2A integrated testing construct enabled the program to progress in accordance with the planned FY13 development schedule. Air Combat Command's 53d Wing operational test pilots flew familiarization, training, regression, and developmental test support missions with F-22As configured with early developmental OFP releases throughout FY13. This effort provided operational testers early insight into capabilities and helped shape development efforts and the scope of testing that will be required to vet system capabilities in the FY14 AFOTEC FOT&E.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY13 Recommendation.
  1. The Air Force should continue to utilize the integrated testing construct for F-22A Increment development, and should provide increased opportunities, where feasible, for operational test unit pilots to conduct familiarization, training, regression, and developmental flight test support with early OFP releases.

F-22A Advanced Tactical Fighter

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed FOT&E of F-22A Increment 3.1 Enhanced Global Strike capabilities in November 2011, and fleet-wide Increment 3.1 retrofits of Block 30 F-22As continued throughout FY13.
- F-22A Increment 3.2A developmental testing proceeded throughout FY13 and will continue in FY14. Increment 3.2A is a software-only modernization effort integrating Link 16 Receive, enhanced Combat Identification, and enhanced Electronic Protection (EP) capabilities.
- The F-22A Modernization integrated test construct enabled operational test pilots to fly familiarization, training, regression, and developmental test support missions with F-22As configured with early developmental Increment 32.A Operational Flight Program (OFP) software releases throughout FY13. This enabled the F-22A Increment 3.2A program to identify problems early in system development and preserve the overall Increment 3.2A developmental test schedule throughout FY13.
- F-22A Modernization Increment 3.2B, a separate Major Defense Acquisition Program, achieved Milestone B in June 2013.

System

- The F-22A is an air superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- Low observability reduces threat capability to engage F-22As with current adversary weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and datalinked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition and the 250-pound Small Diameter Bomb (SDB) Increment One.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and projected increments:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geo-location of selected emitters, electronic attack, air-to-ground synthetic aperture radar mapping and designation of surface targets, and SDB integration. Increment 3.1 is currently fielding in operational F-22A units.
  - Increment 3.2A is a software-only upgrade intended to provide improved EP, Link 16 Receive, and Combat Identification capabilities in early FY15. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record.
  - Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM-120D and AIM-9X missile systems and provide additional EP enhancements and improved emitter geo-location capability. Increment 3.2B IOT&E is currently planned for FY17.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly and non-permissive, contested enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
- The Air Force completed F-22A Increment 3.1 FOT&E in November 2011. Fleet-wide Increment 3.1 retrofits of Block 30 F-22As continued throughout FY13.
- F-22A Increment 3.2A developmental testing proceeded throughout FY13 and will continue in FY14. Increment 3.2A FOT&E is scheduled to begin in June 2014.
- F-22 Increment 3.2B achieved Milestone B in June 2013.

Assessment

The F-22A Increment 3.2A integrated testing construct enabled the program to progress in accordance with the planned FY13 development schedule. Air Combat Command's 53d Wing operational test pilots flew familiarization, training, regression, and developmental test support missions with F-22As configured with early developmental OFP releases throughout FY13. This effort provided operational testers early insight into capabilities and helped shape development efforts and the scope of testing that will be required to vet system capabilities in the FY14 AFOTEC FOT&E.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY13 Recommendation.
  1. The Air Force should continue to utilize the integrated testing construct for F-22A Increment development, and should provide increased opportunities, where feasible, for operational test unit pilots to conduct familiarization, training, regression, and developmental flight test support with early OFP releases.

F-22A Advanced Tactical Fighter

Executive Summary

- F-22A Increment 3.2A is a software-only modernization effort integrating Link 16 Receive, enhanced Combat Identification, and enhanced Electronic Protection capabilities. Increment 3.2A developmental testing proceeded throughout FY14. Software stability and radar performance shortfalls discovered late in developmental testing precluded the start of FOT&E planned by the Air Force Operational Test and Evaluation Center (AFOTEC) for FY14. This FOT&E is currently projected to begin in FY15.
- F-22A Modernization Increment 3.2B, a separate Major Defense Acquisition Program, achieved Milestone B in June 2013. Laboratory and flying test bed developmental testing continued throughout FY14. IOT&E is planned for FY17.
- AIM-120D weapons models required for Increment 3.2B IOT&E were not on contract to support planned FY17 IOT&E. Should these models not be available to meet planned IOT&E, operational testing will be delayed, or additional live-fire missile events beyond those already projected may be required during IOT&E.

System

- The F-22A is an air-superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- Low observability reduces threat capability to engage F-22As with current adversary weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and datalinked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition and the 250-pound Small Diameter Bomb (SDB) Increment One.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and projected increments:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geolocation of selected emitters, electronic attack, air-to-ground synthetic aperture radar mapping and designation of surface targets, and SDB integration. Increment 3.1 is currently fielding in operational F-22A units.
  - Increment 3.2A is a software-only upgrade intended to provide improved electronic protection, Link 16 Receive, and Combat Identification capabilities in FY15. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record.
  - Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM-120D and AIM-9X missile systems and provide additional electronic protection enhancements and improved emitter geolocation capability. The Increment 3.2B IOT&E is currently planned for FY17.

Mission

A unit equipped with the F-22A:

- Provides air superiority over friendly and non-permissive, contested enemy territory
- Defends friendly forces against fighter, bomber, or cruise missile attack
- Escorts friendly air forces into enemy territory
- Provides air-to-ground capability for counter-air, strategic-attack, counter-land, and enemy-air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity

- The Air Force conducted F-22A testing in accordance with the DOT&E-approved Test and Evaluation Master Plan.
- F-22A Increment 3.2A developmental testing proceeded throughout FY14. Software stability and radar performance shortfalls discovered late in developmental testing precluded the start of AFOTEC's planned FY14 FOT&E. Additional unanticipated software releases required further developmental testing, and FOT&E is scheduled to begin in 1QFY15.
- F-22A Modernization Increment 3.2B achieved Milestone B in June 2013. Post Milestone B, F-22 Increment 3.2B developmental testing continued throughout FY14. IOT&E is planned for FY17.
- At the conclusion of the FY12 F-22A FOT&E, the Air Force reduced the level of support needed to sustain the Air-to-Air Range Infrastructure (AARI) capability and ensure system readiness for subsequent F-22A OT&E. In FY14, the Air Force undertook efforts to restore the system to support the planned FY14 Increment 3.2A FOT&E.

Assessment

- F-22 Increment 3.2A realized software stability and radar performance shortfalls late in the developmental flight test schedule. These shortfalls necessitated additional unplanned software releases in order to demonstrate readiness for FOT&E. Accordingly, the FOT&E planned for 3QFY14 was postponed pending resolution of the shortfalls and completion of developmental test and evaluation. FOT&E is now projected to begin in 1QFY15.
- F-22 Increment 3.2B requires upgraded threat and weapons models for IOT&E effectiveness evaluation trials that will be performed in both open-air flight test at the Nevada Test and Training Range and in the Lockheed Martin F-22 Advanced Combat Simulator (ACS) in Marietta, Georgia. At the end of FY14, AIM-120D modeling was not yet on contract to support FY17 IOT&E. Should the models not be available for FY17 ACS trials, IOT&E will be delayed.
- F-22A OT&E requires the use of the AARI instrumentation system for flight test missions at the Nevada Test and Training Range.
  - AARI is designed to enable testers to credibly shape air battles and resolve complex operational mission outcomes through real-time instrumented air and surface threat engagements.
  - The system aids real-time, open-air threat and friendly force removal assessments, and is required for F-22A OT&E flight test adequacy. AARI mission outcomes further serve as a foundation for ACS accreditation for F-22A OT&E effectiveness evaluations performed at the ACS.
  - The Air Force struggled to ensure AARI readiness to support planned FY14 F-22A Increment 3.2A testing. At the conclusion of FY12 F-22A testing, the Air Force began an extensive AARI network upgrade and the implementation of new weapons models to support future F-22A and F-35 operational testing. However, the level of effort the Air Force placed on maintaining AARI functionality was insufficient to ensure readiness for Increment 3.2A FOT&E, and AARI system test readiness experienced unplanned delays. To ensure readiness for FY15 and beyond F-22A operational testing, the Air Force will need to fully support development, modernization, and sustainment of the AARI system.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address all previous recommendations.
- FY14 Recommendations. The Air Force should:
  1. Continue to resolve F-22 Increment 3.2A software anomalies and radar performance shortfalls in developmental testing before proceeding to formal AFOTEC FOT&E in FY15.
  2. Resolve AARI sustainment, test readiness, and modernization shortfalls in order to support both near-term F-22 Increment 3.2A and future Increment 3.2B IOT&E test adequacy.
  3. Commit sufficient resources necessary to ensure that AIM-120D models are available for F-22 Increment 3.2B FY17 IOT&E.

F-22A Advanced Tactical Fighter

Executive Summary

- F-22A Increment 3.2A is a software-only modernization effort integrating Link 16 Receive, enhanced combat identification, and enhanced electronic protection capabilities. Increment 3.2A developmental testing completed in early FY15; however, several software stability, radar, and Link 16 datalink performance shortfalls remained unresolved during developmental testing and were carried forward into FY15 FOT&E.
- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted FOT&E of Increment 3.2A from November 2014, through May 2015. FOT&E results demonstrated that the Operational Flight Program (OFP) software suite is operationally effective; however, shortfalls carried forward from developmental testing and re-discovered during FOT&E detract from overall operational capability.
- Increment 3.2A FOT&E results further indicated the OFP software suite is not operationally suitable as it did not meet the Air Force threshold Mean Time Between Avionics Anomaly requirement, and there is a high probability that pilots may not be able to complete combat missions without having to reset or restart avionics subsystems during flight.
- F-22A Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM 120D and AIM-9X missile systems and provide additional electronic protection enhancements and improved emitter geolocation capability. Ongoing developmental testing experienced several delays due to additional unplanned regression testing for Increment 3.2A and Update 5 OFP efforts, and associated competition for limited developmental test resources. Given the delays observed in FY15, it is unlikely the program will achieve the currently scheduled Milestone C date of April 30, 2016.
- Update 5 combines an OFP upgrade providing software-driven radar enhancements, Ground Collision Avoidance System software, and the incorporation of limited AIM-9X capabilities The Air Force Air Combat Command began a Force Development Evaluation (FDE) of Update 5 OFP software suite and limited AIM-9X integration. FDE testing completed in 1QFY16.
- Due to the Joint Strike Fighter (JSF) Program Office's recent decision to terminate funding for the F-35 version of the Air Combat Simulator (ACS), there is a high likelihood that a significant cost transfer to the F-22 program may occur in order to enable the overall development of the ACS and complete the integration of certain advanced threats into the ACS battlespace environment necessary to support Increment 3.2B IOT&E.

System

- The F-22A is an air-superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- Low observability reduces threat capability to engage F-22As with current adversary weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data linked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition and the 250-pound Small Diameter Bomb Increment 1.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and near-term modernization efforts:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geolocation of selected emitters, electronic attack, air-to-ground synthetic aperture radar

mapping and designation of surface targets, and Small Diameter Bomb integration. Increment 3.1 is currently fielded in operational F-22A units.
- Increment 3.2A is a software-only upgrade intended to provide improved electronic protection, Link 16 Receive, and combat identification capabilities in FY15. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record. Increment 3.2A is currently fielding in operational F-22A units.
- Update 5 combines an OFP upgrade providing software-driven radar enhancements, Ground Collision Avoidance System software, and the incorporation of limited AIM-9X capabilities. Update 5 OFP FDE testing began in late FY15 and completed in 1QFY16.
- Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM 120D and AIM-9X missile systems and provide additional electronic protection enhancements and improved emitter geolocation capability. The Increment 3.2B IOT&E is currently planned for FY17.

Mission

Commanders will use units equipped with the F-22A to:
- Provide air superiority over friendly and non-permissive, contested enemy territory
- Defend friendly forces against fighter, bomber, or cruise missile attack
- Escort friendly air forces into enemy territory
- Provide air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity
- The Air Force conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan, FOT&E, and FDE test plans.
- Increment 3.2A developmental testing completed in early FY15; however, several software stability, radar, and Link 16 datalink performance shortfalls remained unresolved during developmental testing and were carried forward into FY15 FOT&E.
- AFOTEC conducted FOT&E of Increment 3.2A from November 2014, through May 2015. During the FOT&E, a software anomaly affecting legacy system performance deficiency was discovered resulting in a test pause and necessitating additional, unplanned developmental testing efforts to resolve the associated radar operation shortfall. Following completion of the FOT&E, the Air Force Air Combat Command released the Increment 3.2A software OFP for installation in operational F-22A units beginning in July 2015.
- Increment 3.2B developmental testing continued throughout FY15, but experienced delays due to the additional regression testing for Increment 3.2A and Update 5 OFP software suite. The Air Force is projecting a March 2016 Milestone C, and IOT&E is projected to begin in spring 2017.
- The JSF Program Office has recently announced that it plans to cancel the development of the Lockheed-Martin F-35 simulation and transfer the project to a government team. Both F-22 and F-35 JSF simulations currently share a common facility and software environment, including the battlespace environment and threat models. Each program leverages new threats and other capabilities added by the other. The ACS is a Lockheed-Martin facility that provides the F-22 operational test community the ability to simulate dense threat environments that cannot be replicated in open air. It has been used successfully for IOT&E and FOT&E since 2004. The ACS includes man-in-the-loop and OFP in the-loop F-22 systems, and capable man-in-the-loop adversary systems.
  - The F-22 Program Office plans to use the ACS for Increment 3.2B for operational effectiveness trials during FY17 IOT&E.
  - Several ACS upgrades are required to implement new 3.2B capabilities and to develop and integrate new weapons and threats into the ACS battlespace environment to support operational testing.
  - Increment 3.2B also requires the integration of new weapons on the F-22 simulation. The AIM-120D model has not yet been delivered to ACS by the weapon vendor.
- Air Force Air Combat Command began an FDE of the Update 5 OFP software suite. The FDE completed in 1QFY16.

Assessment
- Results of Increment 3.2A FOT&E testing demonstrated that the OFP suite is operationally effective; however, several unresolved radar and Link 16 datalink performance shortfalls carried forward from developmental testing and discovered during FOT&E detract from overall operational capability. The Increment 3.2A OFP is not operationally suitable as it did not meet the Air Force threshold Mean Time Between Avionics Anomaly requirement. Furthermore, based upon the demonstrated software stability performance during the FOT&E, there is a high probability that pilots may not be able to complete combat missions without having to reset or restart avionics subsystems during flight.

- Increment 3.2A cybersecurity testing consisted of compliance checks on security controls. Increment 3.2A did not meet standards for multiple compliance checks.
- Increment 3.2B developmental testing experienced several delays due to additional unplanned regression testing for Increment 3.2A and Update 5 OFP efforts, and associated competition for limited test resources. All F-22A modernization efforts and increments are tightly coupled, and recent years' reduction in developmental test force aircraft and personnel leaves little margin for unanticipated regression testing and correction of critical deficiencies when discovered in operational testing. Given these factors and delays observed to date, it is likely that the Air Force Milestone C decision will slip to late FY16.
- Update 5 OFP FDE testing to date included five AIM-9X missile live fire trials; a first for the F-22A operational test community. Four of the five performed nominally, yet the fifth failed to guide to the intended target. The root cause of the miss is under investigation.
- The primary schedule risk for completing ACS weapons model is the integration of a validated AIM-120D model. Delivery of the Raytheon AIM-120D model to Lockheed Martin for incorporation into the ACS is behind schedule. Other weapons and threats appear to be on track for planned delivery to support Increment 3.2B IOT&E.
- Due to the JSF Program Office's recent decision to terminate funding for the F-35 version of the ACS, there is a high likelihood that a significant cost transfer to the F-22 program may occur in order to enable the overall development of the ACS and complete the integration of certain advanced threats into the ACS battlespace environment necessary to support Increment 3.2B IOT&E. Fully-funded ACS capabilities are required to support F-22 Increment 3.2B IOT&E adequacy, regardless of whether or not F-35 funding is available.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address previous recommendations, but did not resolve Increment 3.2A software anomalies and performance shortfalls before proceeding to formal AFOTEC FY15 FOT&E.
- FY15 Recommendations. The Air Force should:
  1. Place increased emphasis and devote necessary resources to ensure system performance shortfalls identified in developmental testing are effectively resolved before proceeding with operational testing.
  2. Improve F-22A avionics software stability to support operational mission execution and meet Air Force software stability requirements.
  3. Ensure the adequacy of the force structure and schedule margins necessary to support forthcoming F-22A developmental testing efforts
  4. Ensure adequate funding of ACS capabilities for F-22 operational test and evaluation regardless of F-35 funding decisions.
  5. Ensure AIM-120D models are delivered and incorporated into the ACS to meet Increment 3.2B scheduled FY17 IOT&E.