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.

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