Statement by
The Honorable Philip E. Coyle
Director, Operational Test and Evaluation

Before The
Senate Armed Services Committee
AirLand Forces Subcommittee

Tactical Aviation

March 22, 2000

INTRODUCTION

Mr. Chairman, members of the Subcommittee, I appreciate the opportunity to appear before you to discuss the testing and evaluation programs for the F/A-18E/F, the F-22, and the Joint Strike Fighter. This is my third appearance before this Subcommittee, and I very much appreciate the Subcommittee's commitment to demonstrated performance through realistic test and evaluation. This commitment has been expressed in your past statements and comments in these hearings, by the time you have devoted to these issues, and by the bipartisan approach this Subcommittee has taken with respect to achieving the best military capability for our warfighters. Thus I look forward to our exchange today, and being able to bring you up to date on our views of the current status of these programs.

F/A-18E/F SUPER HORNET

With your permission I will begin with the F/A-18E/F. Last year, in my testimony before this subcommittee, I said that in the F/A-18E/F the Navy was getting the aircraft it wanted. Six months of intense operational testing this year has confirmed that judgement. In addition, the Navy is getting an aircraft that in most respects is substantially better than the F/A-18C/D. A side-by-side comparison of the two aircraft is shown on the charts at the back of this section. In particular, the F/A-18E/F is superior in overall operational performance, flexibility, and survivability as a fighter/attack aircraft. In addition, I would like to call your attention to the missions that the F/A-18E/F can perform that are not available in the F/A-18C/D. Here I am referring to the ability to perform as a refueling tanker and the ability to replace the EA-6B electronic warfare aircraft. The need for an aircraft to take the place of the EA-6B has been well documented by this Committee.

The F/A-18 E/F program has just completed a six month formal Operational Evaluation (OPEVAL) by the Navy. The Navy report was released last month and judged the aircraft operationally effective and operationally suitable. Our independent assessment and Live Fire Testing report will be forwarded to Congress before the end of the month. Testing often reveals new problems, but we did not experience anything that was unexpected during OPEVAL. Results were consistent with the previous Operational Test periods, which we reported last year. This consistency is indicative of the extensive testing prior to IOT&E. The comprehensive test effort to date has resulted in the F/A-18E/F being a mature program. The F/A-18E/F has accumulated nearly 8,000 hours of developmental and operational flight test to date, over 3,500 more than last year. This testing identified strengths that will be utilized by the fleet and deficiencies that will be corrected or mitigated by the program manager. The Navy continues to take an open and balanced approach in this regard.

BACKGROUND

The F/A-18E/F Super Hornet, like the F/A-18C/D before it, is a multi-mission strike fighter combining the capabilities of a fighter with those of an attack aircraft. Recognized deficiencies with the F/A-18C/D gave rise in 1991 to Navy Operational Requirements (OR) for an F/A-18E/F Upgrade. This document served as the basis for multiple acquisition reviews, which resulted in approval to enter EMD for the F/A-18E/F. The OR stated that the number one priority was increased internal fuel. In addition, it identified three principal improvements over the existing F/A-18C/D needed in the F/A-18E/F Upgrade:

- Increased mission radius/payload flexibility.
- Increased carrier recovery payload.
- Improved survivability/reduced vulnerability.

The OR also identified required improvements in several other areas. These included combat performance (turn rate, climb rate, and acceleration—as compared to the Lot XII F/A-18C/D); and growth capability (for general avionics, electrical, environmental control system, flight control, and hydromechanical systems) to support future roadmap improvements.

While the 1991 OR required both a single-seat (F/A-18E) and a two-seat version (F/A-18F), originally the two-seat version was envisioned to serve as a trainer. Subsequently, the Navy directed that the F/A-18F would become the inventory replacement for the F-14. A revised Operational Requirements Document (ORD) was promulgated in 1997. This ORD specifically directed that the F/A-18E/F enter service in two increments. Specifically, the F/A-18F would be initially fielded as a baseline two-seat aircraft (comparable to a Lot XII F/A-18D), and then further upgraded to incorporate decoupled or independent cockpits. This would allow the aircrew to conduct near simultaneous air-to-air and air-to-ground missions.

TEST AND EVALUATION ACTIVITY

OPEVAL of the F/A-18E/F was conducted from May through November 1999. Air Test and Evaluation Squadron Nine (VX-9), a component of the Navy's Operational Test and Evaluation Force (OPTEVFOR), conducted the testing.

OPEVAL was conducted in accordance with the Chief of Naval Operations (CNO) Project Test and Evaluation Master Plan (TEMP) 201-04 for the F/A-18E/F. The TEMP was reviewed and approved by DOT&E. The test plan provided for approximately 700 F/A-18E/F sorties and 445 support sorties from other aircraft (F/A-18C/D and simulated adversary aircraft such as F-16, etc). The test team included 14 primary pilots and nine Weapon System Operators. The test team had a variety of experience levels, both in type aircraft and total flight hours. This expertise spanned almost all of the tactical combat aircraft the Navy has operated over the last 20 years. These included S3, A6, A7, F14, and all variants of the F/A-18.

OPEVAL was conducted using a total of seven aircraft delivered under the low rate initial production (LRIP) Lot 1 contract. These OPEVAL aircraft consisted of three F/A-18E (single-seat) aircraft and four F/A-18F (two-seat) aircraft. Not all weapons planned for eventual employment from the F/A-18E/F were cleared for use during OPEVAL. A large number of payload configurations comprising 29 distinct load-outs were employed for the test. Configuration changes and improvements in future F/A-18E/F production lots are expected. The Lot 1 aircraft and the payloads tested in OPEVAL were representative of the operational configurations to be fielded.

The principal testing location during OPEVAL was the Naval Air Weapons Center-Weapons Division at China Lake, CA. In addition to the testing at China Lake, three extended periods of detached operations were conducted.

1. **IOT&E Air-to-Ground Phase** - The evaluation began on May 27, 1999, at China Lake, CA. Flights in support of Air-to-Ground Weapons, Air-to-Air Sensors, Air Combat Maneuvering, Defense Suppression, and Survivability were conducted. During this phase, several items of significance were accomplished. There were multiple ordnance flights dropping a variety of weapons such as Mk 82 (500 lb.), Mk 83 (1000 lb.), and CBUs (cluster bombs). Also, for the first time since the A-6 aircraft, a new organic "by design" tanking capability was demonstrated by the F/A-18E/F during day and night operations. Maintenance personnel became acquainted with a new computerized portable maintenance system associated with this aircraft. In support of the subsequent simulated air combat phase, each aircrew received instruction and flights focusing on high angle of attack maneuvering and general confidence building events. These included air-to-air weapons performance verification and several range profiles to verify the flight performance data base.

2. **Air Combat Phase** - This phase took place at NAS Key West, FL, from June 14-25, 1999. During this detachment, portions of Fighter Escort, Combat Air Patrol, Air Combat Maneuvering, Tactics, and Survivability were assessed. Scenarios generally included up to four Super Hornets versus an equal or larger number of opponents. Mixed formations of F/A-18C's and Super Hornets were also flown to compare the two aircraft in similar scenarios. The 185th Fighter Squadron Air National Guard from Sioux City, IA, provided adversary support flying F-16Cs. These F-16Cs emulated the latest generation MiG-29 threat aircraft and flew realistic threat tactics.

3. **Carrier Operations** - The Super Hornet operated from the deck of the USS JOHN C. STENNIS, CVN 74, near the southern California coast, from July 12-28, 1999. The aircraft was integrated into Carrier Air Wing NINE and conducted simulated alert launches, long-range strikes and tanking among many other tasks. Initially, aircraft were deployed from NAS China Lake to USS JOHN C. STENNIS. This allowed the OPEVAL pilots numerous opportunities to conduct carrier landings and catapult launches in the F/A-18E/F in both daylight and night conditions. The aircraft then remained aboard for integration into the normal ship air plan.

4. **Combined/Joint Operations** - The Super Hornet operated from Nellis AFB, NV, participating in a Combined/Joint Exercise Red Flag from August 16-27, 1999. Red Flag is an intense training exercise involving Air Force, Navy, Marine Corps and multinational assets. A realistic air campaign is conducted to attack representative threat targets with inert

and live munitions. Adversary aircraft and multiple surface-to-air threat systems oppose these assets. The exercise was conducted on an instrumented range. All parameters were recorded and played back for after action review.

5. **Survivability, Air-to-Air Missile and Smart Weapon Usage** - During September through November 1999, operational testing at China Lake focused upon survivability flights. These also included the delivery of air-to-air missiles and smart weapons. Survivability flights involved the conduct of operationally representative strike missions. The targets and/or en route flight paths were defended by a variety of actual and surrogate threat Surface-to-Air Missile systems. Air-to-air gunnery and air-to-ground sensor flights rounded out the China Lake operational testing activity.

EFFECTIVENESS TESTING

Effectiveness testing during OPEVAL exercised the F/A-18E/F in representative operating environments. The conduct of realistic mission scenarios encompassed all of the primary missions of the F/A-18E/F, namely: Interdiction; War-At-Sea; Fighter Escort; Combat Air Patrol; Deck Launched Interceptor; Air Combat Maneuvering; Defense Suppression; Close Air Support; Forward Air Controller (Airborne); and Tanker. The reconnaissance mission was not tested during OPEVAL. In accordance with the approved TEMP, this mission is planned to be tested during Follow-On Operational Test and Evaluation.

The following addresses specific areas of F/A-18E/F tested performance which, in the opinion of DOT&E, have a significant impact, positive or negative, upon its operational mission effectiveness.

AREAS OF SIGNIFICANT ENHANCEMENT

Tactical Flexibility - The attributes of the F/A-18E/F, as confirmed by testing, contribute significant tactical flexibility for the planning and execution of a wide variety of missions. Tactical flexibility extends not only to the planning and execution of combat missions but also to the integration of these combat missions into the support capability of the carrier. Most notable in this regard are the fuel and fuel transfer capabilities of the F/A-18E/F force. In some circumstances, the increased fuel load of the F/A-18E/F will allow the air wing commander flexibility in recovering aircraft within the carrier operating cycle.

Payload flexibility - Payload flexibility is a major element of tactical flexibility. Increasing the options available to the F/A-18E/F to plan and execute missions increases mission effectiveness and aircraft survivability. Along with the increased payload of the F/A-18E/F, this aircraft also has two more weapon stations than the F/A-18C/D. This combination of increased weapon stations and payload-carrying capability may be used in a variety of ways to increase mission effectiveness. Payload advantages allow the F/A-18E/F to achieve the desired probability of destruction with fewer sorties in the threat area, or carry additional self-protect weapons. As an example, a Super Hornet could carry several precision guided munitions, a targeting pod to self-designate targets, and air-to-air and air-to-ground self-protect missiles.

Carrier Performance - Aircraft performance operating on and off the aircraft carrier was remarkable. The approach speeds are slower than the F/A-18C/D in similar configurations. Quick throttle response, combined with aircraft stability and low approach speeds, resulted in excellent glide slope control, an important safety characteristic for carrier operations. The aircraft also demonstrated a high tolerance for hard CV landings. The immediate power response and power available also gives the aircraft exceptional wave-off characteristics.

The aircraft has increased bring-back over its predecessor. This is the ability to land on the carrier with unexpended ordnance. Typically, the bring-back of an aircraft is limited by the maximum loads; i.e., kinetic energy that the aircraft can sustain on a repeated basis. During operational missions, it is common that self-protect weapons are not expended. Similarly, weapons loaded for contingency operations are often not expended, and with the preponderance of operations other than war, the likelihood of this happening has increased. With the increased use of expensive self-protect and "smart" weapons, routine jettisoning of unexpended ordnance in order to reduce the landing weight below bring-back constraints is not affordable. Over the lifetime of the aircraft this could amount to millions of dollars. In the past, to avoid this problem, the fleet has flown contingency operations with fewer weapons than the aircraft could carry. This exposes pilots to added risk. F/A-18E/F aircrew will not face this problem.

Due to the slower landing speed and more robust structure of the F/A-18E/F, the F/A-18E increases the allowable bring-back payload by about 3,400 lbs., as compared to the Lot XIX F/A-18C. The increased payload allowed by this bring-back can be used as increased fuel, increased self-protection loads, increased offensive weapon load, or any combination thereof. For example, the self-protect capability of the F/A-18E could be increased by carrying two to three additional AMRAAM and/or one to two more HARM over what the F/A-18C/D could carry. The F/A-18F has an increased bring-back of approximately 2,400 lbs., as compared to a Lot XIX F/A-18C.

Tanker Capability - The capability of the F/A-18E/F to conduct a tanker mission offers great flexibility for carrier operations, both by providing a tanker to refuel aircraft en route or returning from their assigned missions and by adding flexibility to recovery operations. Since the F/A-18E/F tanker can match the altitude and speed performance of the carrier's other strike and attack aircraft, it can keep up with the mission package. This provides great flexibility in planning and executing long-range missions, including the support of inevitable changes to the planning. By serving as a recovery tanker, the F/A-18E/F tanker, positioned near the carrier, can refuel aircraft that return to the carrier in a low fuel state, thereby extending their flight time to allow an orderly recovery of aircraft within the established carrier cycle time for flight operations.

Earlier versions of the F/A-18 are not capable of performing this tanker mission. Accordingly, carrier operations at long-range are currently limited by the scarce availability of existing S-3 tankers. The introduction of the F/A-18E/F, with its inherent ability to function as a tanker, will add major flexibility to the carrier air wing, enhancing both its effectiveness and its safety. Following carrier operations aboard the USS JOHN C. STENNIS, all flight operations personnel interviewed by DOT&E personnel reported very favorable opinions as to the affect that F/A-18E/F will have on overall carrier operations.

Survivability Enhancements - Survivability improvements for F/A-18E/F include reduced vulnerability design through structural improvements and incorporation of an active fire suppression system, and reduced susceptibility due to the incorporation of the ALE-50 towed decoy, the ALR-67 V(3), a reduced radar cross-section, and increased numbers of expendable countermeasures. Changes in cockpit display options also contribute to survivability improvements by creating a cockpit environment conducive to increased situational awareness. In addition, the F/A-18E/F gains considerable benefit from the additional fuel it carries. This can be translated into routing alternatives or use of lower altitudes to avoid threat areas, or into use of afterburner to maintain energy while maneuvering during a threat engagement.

Air Combat Maneuvering Handling Qualities - The F/A-18E/F resists departure even under aggressive maneuvering at high angles of attack. Testing of intentionally induced departures has shown quick and predictable recovery once the controls were released, with the nose below the horizon, and airspeed increased. Pilot confidence engendered by these flight characteristics is likely to provide significant benefits to the effectiveness of this aircraft in missions demanding aggressive maneuvering; e.g., close-in air-to-air combat or maneuvering versus missile shots.

OPEVAL also confirmed another associated enhancing characteristic—positive nose pointing. The F/A-18E/F has unusual agility and control of the pitch axis, allowing the pilot to point the nose and take the first shot on most engagements. This nose pointing capability impressed the pilots of adversary aircraft during operational tests of Air Combat Maneuvering.

Weapon Delivery Accuracy - During OT-IIB and OPEVAL, many sorties were conducted to evaluate the bombing accuracy of the F/A-18E/F. These sorties executed weapons deliveries using operationally realistic delivery profiles in the conduct of Interdiction, Close Air Support, and Forward Air Controller (Airborne) Missions. The deliveries included large numbers of general-purpose bombs from a large number of delivery profiles involving varying altitudes and dive angles. In addition, a number of deliveries of laser guided bombs were conducted.

The delivery accuracy of these weapons was excellent, exceeding the ORD accuracy requirements. The tested results are equal to or better than those experienced from the F/A-18C using the current operational flight programs (OFP 11C and OFP 13C).

AREAS OF CONCERN

External Stores - Although an unusually large number of store configurations were cleared for carriage, OPEVAL was constrained to 29 specific configurations. This compares to two store configurations for the FA-18A at the time of its development. In addition, the Stores Limitation Manual governing OPEVAL imposed several carriage, release, and aircraft restrictions associated with the 29 cleared configurations. Air-to-air missiles could not be employed if they were carried on a store station adjacent to air-to-ground ordnance. Numerous munitions could be carried and/or employed only from selected store stations, although the plan is to clear these munitions from other stations as well. Consequently, many of the load advantages planned for the F/A-18E/F were not demonstrated during OPEVAL. Nonetheless, the 29 configurations cleared for OPEVAL did include some loads beyond the capability of the F/A-18C.

Aero-acoustic Under-Wing Environment - Operational testing included the carriage of and the actual release or firing of several key weapons (AIM-120, AIM-7, AIM-9, Maverick, HARM, SLAM, Laser Guided Bombs, Mines, Mk 80 series general-purpose bombs, etc). However, testing has revealed that the noise and vibration environment under the wing of the F/A-18E/F is more severe than that of the F/A-18C/D. Accordingly, several stores have experienced some form of damage such as fins or support structure cracking. Some of the stores cleared for carriage during OPEVAL required additional inspections or maintenance. The F/A-18E/F program office and the developing contractor have conducted extensive activities to identify the root causes of the increased noise and vibration environment and to develop "fixes" to ameliorate the effect of this environment.

Aerodynamic Performance and Energy Maneuverability - The only Key Performance Parameter (KPP) related to energy maneuverability of the F/A-18E/F is a single value of specific excess power, Ps, specified at .9 Mach number and 10,000 ft MSL altitude. The specified value is Ps=600ft/sec. This value is low by current fighter state of the art and reflects the modest energy performance demanded by the Navy for the Super Hornet. The OPEVAL measured value is 619 ft/sec. The consequences of low specific excess power in comparison to the threat are poor climb rates, poor sustained turn capability, and a low maximum speed. Of greatest tactical significance is the lower maximum speed of the F/A-18E/F since this precludes the ability to avoid or disengage from aerial combat. In this regard, the F/A-18E/F is only marginally inferior to the F/A-18C/D, whose specific excess power is also considerably inferior to that of the primary threat, the MiG-29.

At subsonic speeds the climb and turn rates and the acceleration performance of the F/A-18E/F are comparable to those of both the F/A-18C/D and the primary threat. At transonic and supersonic speeds, the F/A-18E/F will experience large decelerations (airspeed bleed-off) during a maneuvering fight. Maneuvering air combat in the transonic/supersonic portion of the flight envelope are not of high tactical relevancy since any maneuvering engagement rapidly migrates to the so-called "corner" of the flight envelopes (typically 0.6 Mach at 15,000 feet MSL). In this regard, the F/A-18E/F has little or no disadvantage. In fact, given that the unloaded subsonic acceleration performance of the F/A-18E/F is excellent, the higher bleed rates experienced by the F/A-18E/F may be considered an advantage since this facilitates reaching the corner speed faster and translates to positive nose pointing in a dogfight. The principal consequence of this limitation as it bears on survivability is the inability of F/A-18E/F to avoid or disengage ("bugout") from a close-in fight. In this regard, the F/A-18E/F is marginally inferior to the Lot XIX C/D and significantly inferior to the MiG-29. Many fighter aircrews and air warfare analysts believe that, with modern aircraft and missiles, the probability of a close-in fight requiring a disengagement is small. Within this context, the reduced energy maneuverability of the F/A-18E/F is not viewed as a major detriment to its overall operational effectiveness. As the F/A-18E/F incorporates planned improvements, specifically, the Joint Helmet Mounted Cueing System and the AIM-9X missile, these differences in energy-maneuverability will pose even less concern to operational effectiveness in the air-to-air role.

Counterbalancing the poor energy-maneuverability performance of the F/A-18E/F in the air-to-air arena is its extraordinary departure resistance. The F/A-18E/F's flight control software and complex flight control surfaces have resulted in an aircraft that is almost immune to unintentional departures from controlled flight. The impact of this to the tactical arena is likely to be significant. During a close-in air-to-air engagement, maintaining aircraft control typically consumes a large fraction of a pilot's concentration. By removing this burden from the average pilot, the pilot of an F/A-18E/F can concentrate fully on winning the fight rather than "flying" the airplane. Since most tactical pilots are by definition "average," this property alone may improve the overall effectiveness of the F/A-18E/F fleet significantly over that of its predecessor, or for that matter, over most tactical aircraft in use today. Future tactics development for the F/A-18E/F are likely to capitalize on this property to arrive at a highly capable close-in fighter.

Buffet - During OT-IIB and the OPEVAL, pilots reported two forms of buffet. The first is only experienced in 1G transonic flight and is described by pilots as "driving on a gravel road." The other occurs at a variety of altitudes and configurations and is associated with high angles of attack. While such buffet does not interfere with the mission, some pilots may find that the frequent occurrence of light to moderate buffet causes pilot fatigue. OPEVAL pilots found that they were able to avoid the buffet by holding at lower altitudes or at a slightly higher airspeed.

Wing Drop/ Lateral Activity - Early during the developmental testing of the EMD design, pilots reported experiencing abrupt, uncommanded rolls. The phenomenon was nicknamed “wing drop,” and gained considerable attention in the press. Wing drop occurred as flow separated unevenly from one wing to the other, creating large rolling moments. The program office and the developing contractor designed and tested numerous configuration changes intended to prevent the uneven flow separation. The final design added a porous fairing over the wing fold area of the wing. Operational testing (OT-IIB) conducted with a prototype version of the porous fairing verified that this design change was successful in eliminating the wing drop.

The LRIP aircraft used in OPEVAL incorporated the production version of the porous fairing over the wing fold area. During the OPEVAL, some minor "residual lateral activity" has been observed, but its magnitude has been assessed as insignificant by the aircrews. This residual lateral activity is characterized by changes in bank angle that are small (<10 degrees) and very low roll rates (< 10 degrees/sec). It is unclear if this "residual lateral activity" results from the same causes that produced “wing drop.” These effects are of such different scope and severity that all of the OPEVAL pilots have commented that it is virtually unnoticeable during tactical operations.

Lack of Decoupled Cockpits in the Two-Seat F/A-18F. The revised ORD for the F/A-18E/F specifically states that the initial version of the two-seat F/A-18E/F is to have "coupled" cockpits. Decoupled cockpits; e.g., allowing the pilot to concentrate on the air-to-air picture while the back-seater addresses an air-to-ground mission, is purposefully delayed until a future improvement to the F/A-18F. While the production configuration of the F/A-18F, tested during OPEVAL, meets the expectation of the ORD, it is apparent that the full potential of the F/A-18F will not be realized until the two cockpits are decoupled.

AREAS OF COMMON CONCERN TO F/A-18C/D

Many key subsystems incorporated into the F/A-18E/F, as tested in OPEVAL, were retained from the earlier F/A-18C/D. Some of these subsystems introduce constraints that limit the effectiveness of both the F/A-18C/D and F/A-18E/F. These subsystems with known deficiencies include: the Targeting Forward-Looking Infrared (TGTFLIR) sensor; the AN/APG-73 radar; and the Cockpit Video Recording System (CVRS).

Targeting Forward Looking Infrared Sensor - Known deficiencies of the TGTFLIR include limited resolution, inadequate magnification, insufficient stability, and poor reliability. Due to the limited resolution, F/A-18 aircrew are frequently unable to classify or identify targets at ranges that support the full capabilities of inventory weapons. The limited target magnification capabilities of the TGTFLIR prevent the employment of maximum range capabilities of inventory laser guided bombs against a full range of viable targets. Frequent target "break locks" occur as the F/A-18 pulls g's while pulling off of the target, resulting in loss of guidance to laser guided bombs and the inability to assess bomb hits/damage. All of these problems were seen during OPEVAL.

AN/APG-73 Radar - Previous testing of this radar conducted under the AN/APG-73 Radar Upgrade Program determined that this radar is largely ineffective in the presence of electronic attack.

Positive Identification (PID) Capability - During OPEVAL, the F/A-18E/F lacked a PID capability.

AREAS OF PRIOR CONCERN RESOLVED IN OPEVAL

ALE-50 Burnoff - The severing of the ALE-50 tow cable due to the use of afterburner and/or maneuvering observed during OT-IIA has been somewhat ameliorated with the use of a new towline material. Nonetheless, the ALE-50 maneuvering envelope remains restricted. Exceeding established limits at specific power settings resulted in degradation and possible separation of the ALE-50. During OPEVAL, about ten percent of the deployed ALE-50 towed decoys degraded and/or separated from the F/A-18E/F after pilots inadvertently exceeded the envelope during tactical maneuvering. However, the pilots did find it a valuable survivability tool.

Inability to Add Energy by Rapidly Converting from Nose High to Nose Low - The significant problem of very poor linear acceleration from minimal airspeeds, seen in OT-IIB, has been corrected by modification of the flight control software. All pilots during OPEVAL have reported excellent acceleration from minimal airspeeds.

VALIDITY OF KEY PERFORMANCE PARAMETERS (KPPs)

Range Requirements - The F/A-18E/F has met or exceeded all required thresholds. Throughout its history, the F/A-18A/B/C/D has received praise for its versatility and general performance. However, it has been criticized for its limited range and payload, restricting the ability of the carrier force to project power at extended ranges. Shorter cycle times and near exclusive use of scarce tanker assets is an undesirable workaround frequently used.

The ORD establishes three KPPs that address the required range capability of the F/A-18E/F.

Mission	**Objective Range F/A-18E/F**	**Threshold Range F/A-18E/F**	**Criteria Met**
Fighter Escort Mission Radius	425 nm	410 nm	Yes
Interdiction Mission Radius • w/2 – 480 gallon external tanks: • w/3 – 480 gallon external tanks:	400 nm 450 nm	390 nm 430 nm	Yes

Associated with these KPP range requirements, as established by the ORD, are specific flight profiles. These are the Fighter Escort Mission and Interdiction Mission flight profiles established by the F/A-18E/F Specification. These profiles are well defined in the system specification and are documented in the F/A-18E/F TEMP.

While the *System Specification* defines specific profiles to be used as contractual range requirements and KPPs, these Specification mission profiles are not representative of the actual aircraft configurations or flight profiles that would be used in combat operations. Accordingly, the CNO defined a set of operationally representative flight profiles to be assessed in the OPEVAL. Those flight profiles and the associated range requirements were provided by the CNO and incorporated into the approved TEMP and are well-defined.

OT&E of Range Performance - In order to increase the efficiency of flight testing, the Navy and Boeing developed a methodology to assess range performance using a Flight Performance Data Base. This data base was constructed based on theoretical considerations, wind tunnel and engine-run data, and developmental flight test data. The data base represents a table that provides a value for specific range under any combination of aircraft weight and drag indexes in the flight regime. Successful use of the Flight Performance Data Base is dependent on the accuracy of the calibration data points and the number of the calibration points within the flight envelope. During the operational evaluation, the operational testers of VX-9 independently checked the data base through operational flight test results. The process was closely observed and carefully reviewed by DOT&E.

Calibration of the *Performance Data Base* was conducted by VX-9 pilots using a flight "segment" approach by which fuel consumption data was collected in small, dedicated portions of many flights under various aircraft configurations, gross weights, and flight loads experienced during the conduct of the operational evaluation. Deviations between actual and predicted fuel use were insignificant, being normally distributed with an average deviation of a few percent. Also, for the dominant segments (i.e., cruise/climb) the deviations were less than one percent.

Based upon the results of the Flight Performance Data Base calibration by the operational evaluation aircrews, the accuracy of the data base is considered valid by DOT&E within the limits of precision available. The Flight Performance Data Base has been used to analytically compute the range performance of the F/A-18E/F in the mission profiles defined by the ORD and those defined by CNO.

Of the twelve mission profiles, nine were CNO-defined operational missions and were computed using a 4000 lb. fuel reserve. The remaining three are the ORD-defined specification missions using a 2000-lb. reserve fuel. This point has created concern and some confusion among oversight organizations and requires an explanation. The reason for the difference in the definition of required reserve fuels appears to be largely historical, although no official reason could be found. The specification/ORD missions were defined as "combat missions" and as such the fuel reserve for these missions was determined according to the mandate of the aircraft specification document, MILSPEC SD565-3. This specification requires a fuel reserve in terms of loiter time after a 100 nautical mile divert while retaining the external tanks. For the F/A-18E/F, the loiter time requirement equates to about 2000 lb. All computations of ORD profile ranges were conducted to include the 100 nautical mile divert leg to arrive overhead at the divert location with 2000 lbs. of fuel. In contrast, the CNO/operational missions did not have a reserve fuel specified, and as such the threshold values were interpreted relative to current F/A-18C/D practices. For these missions, the peacetime training reserve fuel of 4000 lbs. was used. If a lower reserve were to be used for these missions, both thresholds and calculated values would increase proportionally.

LIVE FIRE TEST & EVALUATION (LFT&E)

One of the objectives of the F/A-18E/F LFT&E Program was to reduce some of the aircraft vulnerabilities identified through past Joint Live Fire (JLF) Testing of earlier models of the F/A-18. The F/A-18E/F design changes include the addition of an active onboard fire suppression system in selected dry bays—areas which contain various wires, cables, fuel and hydraulic lines and located in close proximity to fuel tanks. The aircraft also has incorporated improved ballistic protection for the fuel cells to prevent fuel from being ingested by the engines causing fires or engine failure and a more survivable stabilator bearing attachment. LFT&E also yielded survivability improvements in the flight control system, including increased separation of the redundant hydraulic lines to reduce vulnerability to ballistic threats. While the F/A-18E and

F versions of the aircraft are about 20 percent larger than the C & D models, their vulnerable areas have not grown proportionately due to these survivability improvements.

The Live Fire Test Program was adequate to assess the survivability of the F/A-18E/F aircraft. Hundreds of controlled damage tests and ballistic tests were performed on F/A-18E/F components and surrogates to jointly fill the need to identify and correct potential design flaws and assure their success. The Live Fire Testing culminated with approximately 30 tests into a nearly full-up F/A-18E/F test aircraft, complete with running engine. This test article had been previously used for drop and barrier tests to assure that its design was sufficiently robust to hold up under demanding aircraft carrier operations. It was then reconditioned and reconfigured for the Live Fire Tests.

DoD Instructions recommend that the Services investigate battle damage repair during the LFT&E Program whenever practical to demonstrate that damage can be repaired, and ensure that required procedures, equipment, and materials are available. Due to time constraints, the Navy's F/A-18E/F LFT&E Program did not include an aircraft battle damage repair program, and thereby missed an early opportunity to investigate this important issue. Many of the test articles damaged during Live Fire Testing, including the nearly full-up aircraft, are still available to support a battle damage repair program, and we recommend that the Navy conduct an F/A-18E/F battle damage repair program while the opportunity still exists.

DEFICIENCIES

As is to be expected with any aircraft at this stage, operational testing has identified a number of deficiencies, perhaps about 100 items—of which I believe about 25-30 are appropriately considered major deficiencies. By a major deficiency, I mean a deficiency that will, or could, degrade the operational effectiveness or suitability of the aircraft. The other deficiencies are more of the nature of annoyances, which should be fixed if practical, but can be successfully "lived with" if needed.

There are several aircraft performance areas in which the aviator prefers more. While the F/A-18E/F brings other enhancing characteristics to the aerial combat arena, in selected areas—such as maximum speed, transonic acceleration, and sustained turn rate—its performance is constrained by the basic aerodynamics of the aircraft and the thrust of its engines. Barring major aerodynamic redesign or reengineering, these are performance limitations that must be lived with. Approximately five of the identified deficiencies fall in this category. These deficiencies are very close to the early predictions of aircraft performance, and are not a surprise to the manufacturers or the Navy.

RECOMMENDATIONS

Stores Carriage and Release - The under-wing noise and vibration environment is now clearly recognized as being more severe than that of the F/A-18C/D. This does raise special concerns about the ability to obtain full weapon life. This is not a new issue and other aircraft such as the F-15 have had similar issues with external stores. Clearing all planned weapons and stores configurations, while maintaining the effectiveness and reliability of the weapons without increasing their associated logistics burdens, is a concern. The carriage and release limitations and required maintenance procedures during OPEVAL, if not substantially removed, would significantly jeopardize the overall effectiveness and suitability of this aircraft for fleet operations. Accordingly, DOT&E recommends close attention to the progress of efforts to ameliorate these noise and vibration issues.

With the continuing clearance and release to the fleet of additional stores configurations, the F/A-18E/F should be able to carry numerous payload configurations that are beyond the ability of the current F/A-18C. In general, given comparable air-to-ground loadouts on both the F/A-18E/F and the F/A-18C/D, the F/A-18E/F will be able to carry additional air-to-air missiles and/or self-protect missiles. This extensive combination of planned loads is expected to provide significant payload flexibility to the fleet. Currently, there are prohibitions on release of mixed loads (i.e., air-to-air missiles next to air-to-ground weapons) because of time constraints for required flight testing to clear adjacent weapon release/launch positions. Removal of these constraints deserves high priority.

Joint Helmet Mounted Cueing System and AIM-9X - Two of the key roadmap systems, the JHMCS and the AIM-9X, are essential to the operational effectiveness of the F/A-18E/F in the within-visual-range aerial combat arena. The JHMCS and the AIM-9X will provide to the F/A-18E/F the ability to rapidly designate and attack threat aircraft at large off-boresight angles. When equipped with these systems, the relative aircraft performance capabilities in close-in combat will decrease in importance. Currently, key threat systems currently possess the AA-11 Archer missile with its off-boresight capability. Until the JHMCS and the AIM-9X are incorporated, the F/A-18E/F will have significant disadvantage versus such threats.

The JHMCS also has the potential also to provide significant benefits by enabling the rapid designation of off-boresight ground targets.

Active Electronically Scanned Array (AESA) - The Navy is developing the AESA to replace the AN/APG-73 radar. The AESA is made up of large numbers of independent transmitter/receiver (T/R) modules. These active elements, under high-speed computer control, enable the radar to rapidly change its waveform and the pointing direction of its radar beam. This promises a multitude of improved and new capabilities, including much needed electronic protection and reduced probability of intercept modes. This capability is essential to provide not only effective combat capability in the Electronic Attack arena, but also enhances survivability through signature reduction.

Advanced Targeting FLIR (ATFLIR) - The Navy is developing an ATFLIR to correct the performance and reliability deficiencies of the current TGTFLIR. In order to make full use of standoff weapon capabilities, the ATFLIR is a needed capability.

Positive Identification (PID) Capability - The Navy roadmap calls for equipping the F/A-18E/F with a Combined Interrogator Transmitter (CIT). While the CIT will not provide positive ID of "hostiles," it will enable interrogation and positive ID of "friendlies" using the NATO standard Mark XII encrypted Identification Friend/Foe system.

Decoupled Cockpits - The dual cockpit configuration tested in OPEVAL meets the ORD requirements for initial fielding. However, it is apparent that the full capability inherent in a two-person aircrew can not be reached until the cockpits are decoupled—along with numerous related cockpit configuration fixes.

Multi-Function Information Distribution System (MIDS) - When incorporated into the F/A-18E/F, MIDS should provide the aircrew with enhanced situational awareness by providing tactical information from other friendly platforms via Link 16. In view of the F/A-18E/F's lack of effective self-contained positive ID of "hostiles," the MIDS capability offers significant potential to provide identification from other cooperating platforms, thereby enabling application of the F/A-18E/F's BVR capabilities within likely rules-of-engagement. In addition, in some situations MIDS may enable the F/A-18E/F to penetrate enemy airspace without use of its air-to-air radar, thereby denying to an enemy early indication of the Super Hornet's presence.

Integrated Defensive Electronic Countermeasures (IDECM) - The Navy is developing the IDECM to reduce the susceptibility of the F/A-18E/F. OPEVAL has demonstrated that the F/A-18E/F, equipped with the ALE-50 meets the ORD survivability requirements. However, more capable threats continue to proliferate. Consequently, IDECM is needed to provide the necessary survivability in potential future threat environments.

There are remaining deficiencies that largely fall into the "should fix" category. These include several troublesome subsystems; for example, the Cockpit Video Recording System, which has limited capability while it is working and breaks too often. None of these deficiencies is, by itself, a "showstopper." But, cumulatively, they are more than just annoyances and their aggregate resolution is more than a "nice-to-have." I believe this is an area in which the Navy should make appropriate tradeoffs. I have discussed many of these items with the F/A-18E/F program manager, and I am assured that a large number of these remaining deficiencies will be addressed and corrected.

One of the principal reasons underlying the upgrade to the F/A-18E/F is the need for growth capacity to accept further improvements and correct problems inherent in some existing key subsystems common to the F/A-18C/D. The F/A-18E/F has been designed with this growth capacity in mind, and it is essential that these Navy roadmap improvements be rapidly developed, tested, and incorporated.

Until these improved capabilities are provided, the F/A-18E/F cannot fully realize its potential and the operational capabilities for which it was envisioned.

F-22 RAPTOR

The F-22 Raptor is now in Engineering and Manufacturing Development (EMD) to replace the F-15 as this country's air dominance fighter. The F-22 has been in the EMD phase since 1991 and has completed almost 15 percent (about 600 hours) of the planned flight testing, approximately 400 hours more than when I testified before this committee last year. The F-22 design emphasizes stealth, supercruise, and integrated avionics to provide major improvements in effectiveness and survivability.

Initially, the F-22 program had planned a Low Rate Initial Production (LRIP) commitment in December 1999. However, Congress delayed the LRIP decision until December 2000 when more test data will be available. The Congress also wisely required some flight testing of Block 3.0 software, which includes integration of the radar; Communication, Navigation, and Interrogation (CNI); and Electronic Warfare (EW) modes in a fused architecture, as a December 2000 Defense Acquisition Board (DAB) exit criterion.

F-22 test results thus far are quite positive. Several problems have been identified in testing to date, but they are being addressed and corrected. The principal issue that I have with the test program is that it is proceeding much more slowly than in previous aircraft development programs, and even these lagging testing schedules continue to slip over time. Continuing slips in flight test aircraft deliveries reduce the aircraft months available for testing as shown in Table 1 below. The issue is shrinking flight test operating months in the development program prior to the start of dedicated Initial Operational Test and Evaluation (IOT&E). This shrinkage is shown from the Joint Cost Estimating Team (JET) reschedule to the current operating schedule, identified as proposed. The intermediate schedules are the Master Schedule 24 and the ASIT 1.1 schedule. Over the past three years we have lost 49 flight test months which could have been available for testing.

Scheduled / Planned Flight Test Months

JET (5/97)	MS-24 (12/98)	ASIT-1.1 (11/99)	Proposed (3/00)
243 months	214 months	203 months	194 months

Table 1

This is a reduction of 20 percent in the available flight test months in the past three years from the JET baseline. To accommodate the loss of test time and reduce test costs, flight test changes have reduced the total flight test hours from 4,337 hours to 3,757 hours. This is a 13 percent reduction due mostly to deferral of the requirement for external combat configuration testing and hoped-for avionics test efficiencies. To squeeze these 3,757 test hours into the available flight test time will require an increased test flying rate.

Basically, not enough of the test program has been completed to know whether or not significant development problems remain to be corrected.

OPERATIONAL ASSESSMENT

In support of the December 1999 Defense Acquisition Executive (DAE) review, the Air Force Operational Test and Evaluation Center (AFOTEC) conducted an early Operational Assessment (OA). This OA focused on aircraft performance, programmatic voids, testability, and readiness to test. Although only limited flight test data were available for this assessment, aircraft component design problems, potential maintainability concerns, and programmatic issues were identified. Cockpit design problems highlighted included internal canopy reflections, glare shield blockage, and switch design. Aircraft design issues highlighted included erratic braking, hot brakes, and unpredictable landing gear strut settling. Another significant aircraft operating issue is environmental control system (ECS) problems with moisture, cockpit heating/cooling, canopy fogging and icing, and fuel temperature overheating. Avionics design concerns included potential sensor track fusion throughput limitations, radar warning latencies, Missile Launch Detector (MLD) false alarms, and faulty load sharing of some antennas. Also replacement of the Common Integrated Processor (CIP) computer immediately after IOT&E poses additional risk. Low Observable (LO) maintainability concerns concentrated on hazardous materials used for brush-roll LO repairs and lack of an independent method for verifying LO repairs during operations. Programmatic security issues included complex crypto keys encryption, security clearance delays, and LO signature protection during testing. These problems, along with recommend corrective actions, were discussed with Air Combat Command (ACC) and the F-22 System Program Office (SPO) and actions are ongoing to resolve these problems. This OA process is continuing and AFOTEC will provide another assessment to support the December 2000 DAB LRIP decision.

FLIGHT TEST PROGRAM PROGRESS

The flight test program employs both of the existing test aircraft flying at Edwards AFB. These aircraft have accumulated about 600 hours expanding the allowable flight envelope with emphasis on flying qualities and airplane/engine performance data. Flight test program progress should improve significantly this year with additional test aircraft. The third flight test aircraft arrived at Edwards AFB on March 15, 2000, and is scheduled to start structural flight testing activities in mid May. The fourth flight test aircraft, and the first with mission avionics installed, is scheduled to start the avionics flight test program in June. Initially, the fifth flight test aircraft also will emphasize avionics tests starting in September. The sixth flight test aircraft is scheduled to reach Edwards AFB to start integrated avionics and LO testing in late October. The seventh flight test aircraft is scheduled to fly shortly after the beginning of next year. Flight testing this year has not revealed any major problems within the allowable flight envelope. Within limitations, this envelope extends above 50,000 feet, in excess of Mach 1.5, and from minus 40 degrees to greater than plus 60 degrees angle of attack. The allowable test envelope has been expanded as planned without any major impediments, except for fin buffeting in the vertical tails. Two Key Performance Parameters—supercruise and internal missiles payload—have been demonstrated this year. Performance of the F119 engine has been outstanding throughout the allowable flight envelope. There have not been any inflight shutdowns because of engine problems in the first 600 hours of the test program. In addition, engine performance in the test cells has met requirements, and minor hardware problems with low-pressure turbine blades and combustor oxidation/erosion are being corrected.

Airframe/engine performance has also been very good throughout the large angle of attack excursions. Despite test pilot attempts to induce spins at high angles of attack, the aircraft has been very stable and shows no tendency to depart controlled flight.

STATIC AND FATIGUE TESTING

Static testing on the static test article was initiated in April 1999, and the 100 percent limit load testing of critical structure was completed in October 1999 as a December 1999 DAE exit criterion. Ultimate load testing to 150 percent of design load was resumed in February with the first aileron loads test. Although the aileron itself did not fail during this test, a problem with the adjacent flaperon was identified and the flight test aircraft were grounded until an interim fix could be installed. An exit criterion for the December 2000 DAB is completion of the 150 percent ultimate loading of the aircraft structure. Previous aircraft program experience with structural failures at these high load conditions indicates some risk in meeting this criterion. Ultimate load static test completion was scheduled for October 1999 under the 1997 JET proposed plan, and then rescheduled to be completed in February 2000. This testing, now scheduled to be completed prior to the December 2000 DAB, is more than a year behind the JET schedule. Any redesigns to correct static test failures will need to be incorporated into the production vehicles; therefore, it is important to successfully complete the static test program prior to an LRIP commitment.

Fatigue testing has slipped even more than static testing. The fatigue test article was delivered to the test laboratory in November 1999; however, fatigue testing is not scheduled to start until at least August of this year. The JET schedule planned for first-life fatigue test completion in December 1999, but slipped to February 2001 in the November 1999 plan. Even this later completion date is now in jeopardy because of additional delays in starting the testing, related primarily to limited test and engineering personnel shared with the static test program. Any major failures during fatigue testing will also require production aircraft redesigns. Incorporating redesigns into production will depend on where in the first life spectrum any failures occur. An exit criterion for the December 2000 DAB is initiation of fatigue testing with the goal of completing 40 percent of the first life testing. This goal doesn’t appear to be achievable based on the planned fatigue testing start date of August or later this year.

AVIONICS FLIGHT TEST PROGRAM

The primary challenge remaining in the F-22 EMD phase is flight testing of the integrated avionics suite. As previously mentioned, a December 2000 DAB exit criterion established by Congress is flight testing of Block 3.0 software in a flight test aircraft. A 3S software block will be a precursor developmental operational flight program (OFP) to be tested in all of the development laboratories, including the Flying Test Bed (FTB), and then in the fourth flight test aircraft starting in August. Testing of the Block 3.0 OFP is planned to be initiated in November on the fifth test aircraft. Much of the avionics test emphasis this year will be in support of this challenging requirement.

AVIONICS LABORATORY TESTING

A Boeing 757 aircraft is the FTB for the F-22 integrated avionics suite. This flying test laboratory started test support of the F-22 program in November 1997 and flew 80 sorties (404 hours) with the F-22 APG-77 radar installed in an integrated forebody (IFB) resembling the F-22 production IFB (replacing a conventional radome). This test set-up included one Common Integrated Processor (CIP) plus simulated cockpit controls to evaluate radar modes and functions, in addition to an early APG-77 radar. This initial radar testing was finished in the summer of 1999, and the FTB has been modified in the interim to install a replica of the F-22 wings, containing simulated sensor antennas, on top of the 757 fuselage. This allows an expansion of the avionics testing that will include the Communication, Navigation, and Interrogation (CNI), and Electronic Warfare (EW) functions, as well as integration with the radar functions. A second CIP was also installed during this FTB modification to allow continued development of the software to support this integrated avionics suite. The FTB will continue testing leading to delivery of Block 3.0 software to flight test aircraft in October. Although this software development task is critical to successful development of the F-22 integrated avionics suite, it does not substitute for testing in a flight test aircraft.

The Avionics Integration Laboratory (AIL) at Boeing, Seattle is another important avionics development facility for integrated avionics hardware and software integration. This AIL is now completing testing of the Block 2.0 software OFP that will be delivered to the FTB in April. Next, the AIL will test the Block 3S software on the way to checking out the Block 3.0 OFP for delivery to the FTB and then to the fifth flight test aircraft to satisfy the December 2000 DAB exit criterion requiring flight test of the Block 3.0 OFP.

Another major avionics development asset is the System Integration Laboratory/Integrated Hardware-in-the-Loop Avionics Test (SIL/IHAT) test facility at Edwards AFB. This facility will become operational this year to support the avionics flight test program. This should be very valuable for development and troubleshooting of problems as the avionics flight test program starts at Edwards AFB this summer.

The Air Combat Simulator (ACS) is under development in Marietta, GA, and is the first occupant of the newly constructed Air Vehicle Integration Facility (AVIF). This simulator will allow the evaluation of large numbers of simulated sorties in complex engagement scenarios not practicable in open-air testing. This simulator also is critical to provide data for an adequate operational test and evaluation, to augment the 240 sorties dedicated to the Initial Operational Test and Evaluation (IOT&E). Development progress is generally on schedule, except for lagging deliveries of threat models. However, there is very little schedule margin to deliver an operational capability to support the start of IOT&E pilot training in February 2002.

WEAPONS TESTING

Flight testing of the AIM-120 (AMRAAM) and AIM-9M (Sidewinder) air-to-air missiles has consisted of carriage in the internal weapons bays on most test missions, and extension of an AIM-9 missile from its weapons bay at several subsonic flight conditions. Separation of each of these two missile types will be demonstrated this year, to satisfy one of the exit criteria established for the December 2000 DAB. This requirement will be satisfied by executing a separation and launch of each missile on a preprogrammed trajectory. Ground tests of missile ejections into pits or other containment barriers will precede this flight testing.

LOW OBSERVABLE (LO) MAINTAINABILITY

LO maintainability is recognized as a high-risk area. The contractor has learned valuable maintainability and support lessons from the B-2 and F-117. The preferred LO repair process is currently the brush and roll technique, but this process may require more support equipment and hazardous waste handling facilities than planned. Hazardous materials operations restrict the ability to perform concurrent maintenance, potentially affecting overall sortie generation. Maintaining low observable characteristics during sustained operations is a major program challenge. In addition, practical operational LO measurement equipment has not been planned for F-22 operational use; maintenance plans are to rely solely on maintainer adherence to technical data under a “process control” strategy. The viability of this process has not been demonstrated and will not be until early operational experience is accumulated. Of special IOT&E concern is the potential for LO maintainability problems to adversely impact the suitability evaluation, as it did in the B-2 program.

The current test program does not include any operational testing under adverse environmental conditions, especially in rain and cold weather. Of particular concern in this area is that the flight test aircraft cannot be flown near thunderstorms to identify potential rain-induced problems or to gather data on static discharge impact on the aircraft, a continuing B-2 problem. Adverse environments will be simulated in the climatic test chamber at Eglin AFB, but this is basically a static test (although engines, flight controls and landing gear will be operated). Test aircraft will not be operationally flown or maintained in these adverse environments. All planned EMD flight testing, including IOT&E, is to be based at Edwards AFB, CA, and Nellis AFB, NV, where rain and high humidity are infrequent.

TEST SCHEDULE DELAYS

Delayed flight test aircraft, scheduled for delivery this year, are significantly increasing the risk to completion of adequate flight testing prior to the start of dedicated IOT&E scheduled for August 2002. Increasingly optimistic proposed development test schedules, schedules that have not been met to date, accentuate this risk. Forty-nine flight test months to complete the EMD flight test program have been lost due to major slips in the flight test aircraft delivery schedules from the 1997 JET schedule. The F-22 SPO proposed a new flight test schedule in November 1999 for the remainder of EMD to allow completion of all the remaining critical developmental tasks. This schedule established a goal of 26.4 flight hours per month for all of the flight test aircraft, and a minimum requirement of 25 hours per month in order to fulfill all of the remaining test objectives. Because of various problems, the two flight test aircraft have not reached this goal. Actual flight hour performance was 22.8 hours in November, 23.7 hours in December, 19.0 hours in January, and 19.4 hours in February. In addition, the flight test aircraft sortie generation performance in March will be significantly worse than these data primarily because of the flaperon repair requirement described previously in this testimony. These data do not engender confidence that the proposed flight test schedule can be achieved, even if no additional major test-related problems occur. Even with the recent decrease of planned flight test hours during EMD to 3,757 hours, it is increasingly unlikely that the necessary development flight testing will be completed in time to begin Dedicated IOT&E in August of 2002. The strike of Boeing engineers and technicians has aggravated this problem at a critical phase of the avionics development and laboratory and test process.

LIVE FIRE TEST AND EVALUATION (LFT&E)

The F-22 Live Fire Test and Evaluation Program is progressing in accordance with the strategy and alternative plan that I approved in 1997. Fifteen of the twenty-one scheduled ballistic tests have been completed. Test results show that some of the unprotected dry bays are more vulnerable to ballistically initiated fires than desirable. Live Fire Testing also has led to a F-22 wing redesign that replaced selected composite spars with titanium spars. The avionics coolant system has been redesigned to provide automatic shutoff of pressurized lines containing flammable fluids in the event of damage.

Two of the six Live Fire test series that have not been completed are intended to assess the potential for sustained fires. One test series will investigate fire in the wing leading edge using both a simulator and a full-up wing. The other fire tests will evaluate the effectiveness of the engine nacelle fire suppression system given combat damage. In addition, a full-scale engine simulator has been used to conduct hundreds of peacetime fire events. However, the engine nacelle Live Fire tests will specifically address threat-induced fires. Two other test series will investigate hydrodynamic ram damage to fuel tanks located in the wings and fuselage. The first flight test aircraft is scheduled to be flown to the test range at Wright Patterson Air Force Base, OH, in June of this year to prepare for Live Fire testing. This aircraft will be used to conduct the wing hydrodynamic ram and wing leading edge fire test series. The test article for the fuselage hydrodynamic ram tests is the second forward fuselage produced during EMD. The remaining two tests were intended to assess the capability of the onboard fire protection system in the main landing gear bays and the aft wing attach bays. The Air Force has decided to remove the fire protection system from these dry bays. The assessed probability of kill given a hit is very high in these unprotected bays based on our evaluation of existing test data for other dry bays.

It is important that the upcoming Live Fire Test with high explosive incendiary threats against the F-22 wing be done with flight representative airflows and loads with the wing properly fixed to the aircraft. Prior tests with the wing mounted in a test fixture have shown the potential to introduce unrealistic results. These tests must be conducted realistically because they will evaluate the new wing design that was changed as a result of poor performance during previous Live Fire Tests. The Air Force has recently stated that they intend to conduct these tests with the wing attached to the fuselage.

Fire and explosion are the leading causes of aircraft loss, and the fuel tanks onboard the F-22 represent the largest presented area of any F-22 aircraft subsystem. Hence, effective fire suppression is mandatory to achieve a survivable aircraft design. The decision by the Air Force to remove some of these fire suppression systems and other factors have further increased the aircraft's probability of being killed given a hit and estimates are now that the vulnerable area is some 30% higher than the F-22 specification had called for. The F-22's vulnerable area estimates could increase further as a result of the remaining test series.

The original onboard inert gas-generating system (OBIGGS) design could not withstand the F-22's vibration environment. A new OBIGGS design and vender has been selected. Functional testing of the new OBIGGS design using the Fuel System Simulator needs to be redone. These tests are expected to demonstrate the new design achieves the inherent concentration needed to protect the fuel tanks against explosion. The F-22 should demonstrate its fire and explosion survivability prior to the decision to enter full-rate production.

COST CAP CONCERNS

While a cost cap may have been useful earlier in the F-22 program, it now appears that the EMD cost cap is harming the test program. The cost cap is causing many programmatic changes to reduce costs, which almost always result in less testing and increased development risks. Further, these development risks become greater with elapsed time as the cost reduction options become harder to implement. At this point in the EMD phase, cost reductions are largely test related since the test budget is essentially the only remaining uncommitted EMD budget. Not only are testing tasks often eliminated, but there is concomitant inefficient rescheduling of the remaining tasks. Any further reduction of testing tasks increases the risk of not being ready to start or successfully complete IOT&E. A specific current example is the inability to add engineers to maintain the static and fatigue testing schedules.

The AIM-9X and Joint Helmet Mounted Cueing System (JHMCS) will not be tested in IOT&E. This important capability will be tested in Follow-On Test and Evaluation (FOT&E) prior to Initial Operational Capability (IOC). Another testing deferral, proposed as a cost-saving measure, is the external combat capability demonstration. This combat capability is the carriage of AIM-120 missiles and external fuel tanks. Current plans are to defer this testing outside of the F-22 EMD program budget to the SEEK EAGLE program at a later undefined period. This is also a deferral of an ORD-required capability outside of the F-22 development program.

RECOMMENDATIONS

A most helpful congressional action would be to remove the EMD cost cap and institute an alternative method for controlling the F-22 program cost. One suggested alternative is to retain the total program cost cap, adjusted for inflation, while removing the EMD cost cap. This would achieve the overall program cost control objective, but allow the ORD-defined combat capabilities to be effectively and efficiently demonstrated during EMD and allow more testing prior to dedicated IOT&E. This would certainly require an extension of EMD, probably a delay of up to one year of IOT&E (from 2002 to 2003) and Milestone III. I would support the continued LRIP proposed ramp-up rates (long lead of 16 aircraft in FY01 and long lead of 24 aircraft in FY02) to preserve the industrial base and negotiated target price commitment curves.

JOINT STRIKE FIGHTER (JSF)

The Joint Strike Fighter Program is intended to develop and deploy an affordable family of strike aircraft meeting the requirements of the Air Force, Navy, Marine Corps, UK Royal Navy and Air Force, and possibly other allies. This family of strike aircraft will consist of three variants: Conventional Takeoff and Landing (CTOL), Aircraft Carrier Suitable (CV), and Short Takeoff and Vertical Landing (STOVL). The focus of the program is affordability: reducing the development, production, and ownership costs of the JSF family of aircraft. The JSF will be a single-seat, single-engine aircraft capable of performing and surviving lethal strike warfare missions using an affordable blend of key technologies developed by other aircraft programs and integrated into the JSF in a block upgrade approach. The STOVL variant will retain the option for a two-seat version. A multi-year $2.2 billion JSF Concept Demonstration And Risk Reduction effort commenced in November 1996, with competitive contract awards to Boeing and Lockheed Martin for the Concept Demonstration and Risk Reduction Program. These competing contractors are building and will fly two concept demonstrator aircraft, conduct concept unique ground demonstrations, and continue refinement of their ultimate delivered weapon system concepts.

The Joint Strike Fighter program was placed under oversight for OT&E and LFT&E in June 1995 as the Joint Advanced Strike Technology (JAST) program. Representatives from DOT&E and the Navy and Air Force Operational Test Agencies (OTAs) participate in several of the Integrated Program Teams (IPT) established by the JSF program.

In support of an affordable, highly-common family of next-generation multi-role strike fighter aircraft, the JSF program employed an iterative approach to achieve fully validated, affordable operational requirements which were recently codified in an approved Operational Requirements Document. This approach emphasized the early and extensive use of cost-performance trades. To assess military utility in support of these trades, the JSF program is continuing development of its Virtual Strike Warfare Environment (VSWE), a Modeling and Simulation (M&S) environment, to ensure consistent models and data bases. The Service Operational Test Agencies (OTAs), AFOTEC and COMPOTEVFOR, as part of the first Early Operational Assessment, are actively participating in several simulations that the program has established to provide insights to determining the final operational requirements. This active participation by the OTAs at the early requirements-formulation stage is both unusual and commendable. As a result, we expect the operational testers to have a full understanding of the trades and reasoning underlying the final requirements. Such understanding provides a sound foundation for successful operational testing in future years. This open process for requirements development and the availability of the VSWE provides needed avenues to improve the linkage between the test and requirements processes. In addition, the models used in conjunction with the VSWE may prove useful also in the test and evaluation process, although experience has shown that the best available models are not sufficiently credible for all T&E needs.

During the JSF Concept Demonstration and Risk Reduction phase begun in 1996, competing contractor teams led by Boeing and Lockheed Martin are each building, qualifying, and will fly two concept demonstrator aircraft, designated the X-32 and X-35, respectively.

Rather than being prototypes with full-up systems, these demonstrators incorporate the engine and key features of the outer mold lines of the contractor's preferred JSF design, but they will largely use off-the-shelf systems and avionics. These demonstrators are intended to demonstrate the viability of each contractor's design concept for a common, modular family of strike aircraft, including the ability to accomplish short takeoff, hover and transition to flight, up-and-away performance, and low-speed handling consistent with landing aboard a carrier. During this phase, each contractor is responsible for planning and executing the ground and flight tests and demonstrations. Flight-testing of these demonstrator aircraft is planned later this year. Government personnel are actively participating in test planning and execution with the competing contractors. The principal purpose of this demonstration program is to assist the contractors in determining designs and reduce associated risks for the Preferred Weapon System Concepts that they will propose for Engineering and Manufacturing Development (EMD).

The ongoing Concept Demonstration and Risk Reduction phase will allow early test insights into the viability of the basic aircraft designs. More challenging to assess in this phase will be the contractors' progress in developing the integrated avionics suite that will be essential to the final JSF design, as well as validating the needed improvements in operational supportability and the cost of ownership. Improved insights into the risks of integrated avionics had been hoped for prior to the planned JSF Milestone II decision next year from the ongoing F-22 program, which is leading the way in facing such challenges. Since both of the competing JSF contractors are key members of the F-22 team, the lessons learned from that program have the potential to reduce the risks in similar areas of the JSF.

It is essential that the Live Fire Test Program be done realistically and thoroughly. To accomplish its combat mission, the JSF will be expected to go into harm's way. The JSF will replace several existing aircraft, some of which have proven to be very survivable in combat due to prior Live Fire and Joint Live Fire Testing and resultant design modifications. Vulnerability modeling and simulation tools alone are inadequate to effectively predict damage at the component level. Reliable vulnerability predictions at the subsystem and full system levels are even more uncertain.

Given the JSF's anticipated challenging threat environment, its new and as yet undemonstrated technologies, materials, fly-by-wire controls, avionics integration, and single engine design (coupled with the demonstrated inadequacy of our current vulnerability modeling and simulation capability even at the component level), full-up, system-level live fire testing of at least one variant is the practical, affordable and correct approach. Unique design features of other JSF variants can be tested at the component and subsystem levels, drawing applicable insights for common areas shared from the full-up, system-level testing of the aircraft variant selected. While the JSF Program Office may propose a waiver request from full-up, system-level Live Fire Testing for all JSF aircraft variants, I disagree with this approach. At least one of the variants must undergo full-up, system-level LFT&E. The other variants could draw from this testing coupled with component and subsystem level live fire testing of variant-unique areas. We are working with the Program Office to assure availability of full-up, full-scale test articles for an acceptable LFT&E strategy.

As we discussed with this committee last year, none of the major components of the F-119 engine were Live Fire tested under the F-22 program. I am happy to report that some limited tests of engine components are being planned and funded by JSF using unserviceable F-119 components from the F-22 program and these tests are scheduled to begin this year.

The Service OTAs are currently conducting an Early Operational Assessment (EOA), but the Program Office does not plan to include the EOA findings in the source selection criteria. Structuring the participation of the OTAs poses unique challenges since the OTAs must carry out thorough assessments while preserving the legitimate proprietary information of each contractor in this competitive environment. The EOAs will, however, be useful in assessing the maturity of key JSF technologies at the end of Concept Demonstration and Risk Reduction, and assessing the likelihood that the proposed capability will meet user requirements.

My staff has been heavily involved in cooperation with JSF staff and the OTAs in shaping the plans for OT&E activities during EMD. These plans will be definitive in the TEMP update just before Milestone II, which will be further updated with even greater detail following down-select and contract award for EMD.

As I look down the road, the planning for EMD provides ample opportunities for the conduct of Operational Assessments leading up to Dedicated IOT&E/OPEVAL. As the program matures, it will be essential to define specific accomplishments or characteristics that each of these Operational Test periods must confirm, consistent with the event-driven acquisition strategy required by DoD Regulations and adopted by JSF. Current planning for Dedicated IOT&E includes six production-representative test articles for block I, 12 for Block II, and 18 for block III. While this quantity of aircraft appears adequate for the conduct of a thorough operational test, it is none too many since three different aircraft configurations must be tested in the accomplishment of a variety of missions. With deliveries of three variants in multiple blocks, staggered over multiple years, it will be difficult to structure a test program that capitalizes on the similarities of the three variants and supports a full-rate production decision for all three variants in 2009 on the basis of Block I OT&E. I believe that we will have a better idea after Block II testing, and a complete evaluation of all mission capabilities after Block III OT&E.

At this relatively early stage of the JSF program, the integration of program planning and test and evaluation planning appears to be on a sound foundation. A program as complex as the JSF (multiple aircraft configurations for multiple users) especially needs to employ fully the Integrated Program and Process Development concept to develop operational requirements and formulate integrated T&E strategies. Operational Test Agencies must participate fully and continuously in relevant program activities. Despite the near-term concerns of the competitive environment, I am confident that we will establish a thorough program of operational assessments during Concept Demonstration and risk Reduction to support progress of the JSF program, and, later during EMD, thorough operational testing of the JSF.