NOT FOR PUBLIC RELEASE
UNTIL APPROVED BY THE
COMMITTEE ON ARMED SERVICES
U.S. SENATE

STATEMENT

BY

J. MICHAEL GILMORE

DIRECTOR, OPERATIONAL TEST AND EVALUATION

OFFICE OF THE SECRETARY OF DEFENSE

BEFORE THE

SENATE ARMED SERVICES COMMITTEE

NOT FOR PUBLIC RELEASE
UNTIL APPROVED BY THE
COMMITTEE ON ARMED SERVICES
U.S. SENATE

SASC – APRIL 26, 2016

J. Michael Gilmore
Director, Operational Test and Evaluation (DOT&E)
Office of the Secretary of Defense

Good afternoon, Mr. Chairman, Ranking Member Reed, my testimony today discusses the status of the F-35 program using my Fiscal Year (FY) 2015 Annual Report as the basis. There are a few updates since the report was released in January 2016, which I will highlight today.

Overall, the program is at a critical time. Although the Marine Corps has declared Initial Operational Capability (IOC) and the Air Force plans to do so later this calendar year (CY), the F-35 system remains immature and provides limited combat capability, with the officially planned start of Initial Operational Test and Evaluation (IOT&E) just over one year away. Over the past year, flight test teams continued to accomplish test flights at the planned rate, and a new version of software capability, Block 3i, was fielded. However, there are still many unresolved significant deficiencies, the program continues to fall behind the planned software block development and testing goals, and sustainment of the fielded aircraft is very burdensome. (The latter is not a surprise, since, as the Program Executive Officer has noted, F-35 remains under development notwithstanding the Services' declarations of IOC.) The program is working to resolve the many issues it confronts, and has recently made some progress addressing problems with the stability of Block 3i mission systems, but my assessment is that the F-35 program will not be ready for IOT&E until CY18 at the soonest. Because aircraft continue to be produced in substantial quantities (all of which will require some level of modifications and retrofits before being used in combat), IOT&E must be conducted as soon as possible to evaluate F-35 combat effectiveness under the most realistic combat conditions that can be obtained. Over 300 aircraft are planned to be built by the end of FY17 when IOT&E is currently scheduled to begin.

Test Flights and Software Development. Before operational testing, developmental test teams fly sorties under very specific conditions to examine the system's performance. This year, those teams executed very closely to the planned sortie production rate throughout the year, as has been the case in previous years. It will be important to ensure the government flight test centers and the associated ranges and facilities at Edwards Air Force Base (AFB) and Patuxent River Naval Air Station (NAS) remain sufficiently resourced to overcome the remaining test challenges, which are significant. However, sortie production does not necessarily mean that planned test points were completed successfully, the system under test functioned as designed, the data collected were usable to sign off contract specification compliance, or that the system will actually be effective and suitable in combat.

In fact, the program did not accomplish the amount of test points planned in several flight test venues, and the program continued to add testing via "growth points" while deleting many mission systems test points as no-longer-required. This continues to be the case, as the program recently deleted Block 3F test points and added test points to address Block 3i deficiencies in mission systems performance and stability. Because of a change by the program in defining growth in test points, the amount of this re-defined growth was less during the last year than in previous years.

Regarding mission systems test progress over the past year, the program focused on culminating Block 2B development and testing in order to provide a fleet release enabling the Marine Corps F-35B Joint Strike Fighter (JSF) declaration of IOC, while transitioning development and flight test resources to Block 3i and Block 3F.

The program terminated Block 2B development in May 2015, and the Marine Corps declared IOC in July 2015, despite many known deficiencies and, as expected, with limited combat capability. Block 3i developmental flight testing restarted for the third time in March 2015, after two earlier attempts in May and September 2014. As mentioned in my annual report, Block 3i began with re-hosting the immature Block 2B software and capabilities into new avionics processors. Although the program originally intended that Block 3i would not introduce new capabilities and would not inherit technical problems from earlier blocks, both of these things occurred. The combination of re-hosted immature software and new processors resulted in avionics stability problems that were significantly worse than Block 2B. Despite the problems with avionics stability, sensor fusion, and other inherited issues from Block 2B, the program terminated Block 3i developmental flight testing in October 2015, and released Block 3i software to the fielded units. This decision was made, despite the unresolved Block 3i deficiencies, in an attempt to meet the program's unrealistic schedule for completing development and flight testing of Block 3F mission systems.

The Air Force insisted on fixes for five of the most severe deficiencies inherited from Block 2B as a prerequisite to use the final Block 3i capability in the Air Force IOC aircraft; Air Force IOC is currently planned for August 2016 (objective) through December 2016 (threshold). However, as the program attempted to concurrently develop and test Block 3i and Block 3F software, the latter of which began flight testing in March 2015, the immaturity and instability of the Block 3i mission systems software continued to manifest problems in flight testing. In February 2016, when the latest version of Block 3F software – version 3FR5 – was delivered to flight test, it was so unstable that productive flight testing could not be accomplished. Consequently, the program elected to reload a previous version of Block 3F software – version 3FR4 – on the mission systems flight test aircraft, to allow limited testing to proceed. The program then converted its developmental labs back to the Block 3i configuration in another attempt to address key unresolved software deficiencies, including the avionics instabilities troubling both Block 3i and Block 3F. This decision by the program to return to the Block 3i configuration and address the poor mission systems performance should be commended. It has caused some near-term delays, but it is a necessary step to ensure the Air Force has adequate Block 3i software for IOC and that the additional full set of combat capabilities planned in Block 3F can be effectively tested with a stable baseline of software and eventually fielded to operational units. The program recently loaded all the mission systems test aircraft with a new build of Block 3i software – version 3iR6.21 — which started flight testing on March 25. The program is in the process of completing Block 3iR6.21 flight testing, which includes 4-ship test missions, to evaluate performance prior to providing this software to the fielded units. The avionics stability of Block 3iR6.21 during these recent test missions appears to have improved compared to previous versions, however incidences of start-up and in-flight instability were still observed. Although analyses of the test data are still on-going, test reports indicate that inflight stability has potentially improved to be comparable with the fielded version of Block 2B while the significant initial startup problems continue to be a challenge. During the first 30 flights with Block 3iR6.21, which accumulated 75.6 hours of flight time, no less than 27 power cycles were required to get all systems functioning between initial startup and takeoff. These power cycles varied in degree – from "cold iron" resets, where the aircraft had to be shut down and then restarted, to component or battery power recycling. The extent to which the initial startup sequence has improved – or not – compared to earlier versions of Block 3i software is not known, as the program does not track startup events in the same manner as flight instability events. The status of the other "must fix" deficiencies is unknown at the time of this testimony.

Delivering and testing the numerous new and advanced capabilities planned to be in Block 3F mission systems, which are specified in the program's Operational Requirements Document (ORD), presents significant challenges for remaining development and flight test. Before the program's decision to pause Block 3F developmental flight testing and rework Block 3i software, test progress was limited as flight testing had only accomplished approximately 20 percent of the Block 3F baseline test points by the end of March 2016. This is because many of the test points, including the more complex weapons delivery accuracy events, could not be flown until stable, functioning Block 3F software was available. While the new Block 3iR6.21 software was in flight testing, the program finished developing and testing an updated version of Block 3FR5 in the lab, released it to the test centers, and started loading it on the mission systems aircraft to resume Block 3F flight testing in mid-April. Because of the reworking of Block 3i software and the added capability being incorporated in the remaining Block 3F software, it is incorrect to assume that the difficult testing is behind the program. In fact, the most stressing missions systems testing remains to be completed, since the final Block 3F capabilities are both complex and important to the F-35's viability. A relatively recent example of the problems with an earlier version of Block 3F software was an attempted four-ship Electronic Warfare "Super Scenario" mission that resulted in only two aircraft arriving at the range because the other two aircraft ground aborted due to avionics stability problems during startup. Also, when the aircraft operated in a dense and realistic electromagnetic environment, the current avionics problems caused poor detection and fusion performance, which is exacerbated in multi-ship F-35 formations. Due to the large amount of difficult flight testing remaining, it is likely there will be discoveries of additional significant deficiencies that will need to be rectified before IOT&E.

United States Reprogramming Laboratory (USRL). Significant, correctable deficiencies exist in the U.S. Reprogramming Laboratory (USRL) that will preclude development and adequate testing of effective mission data loads for Block 3F. Despite a $45 Million budget provided to the Program Office in FY13, the required equipment was not ordered in time and the USRL is still not configured properly to build and optimize Block 3F Mission Data Files (MDFs). The program still has not designed, contracted for, and ordered all of the required equipment – a process that will take at least two years for some of the complex equipment – after which significant time for installation and check-out will be required. The estimate of earliest completion, with the required signal generators and other upgrades to properly test Block 3F mission data loads, is late 2019, which is after the planned IOT&E of Block 3F. As I explain in my annual report, the corrections to the USRL are needed to provide the F-35 with the ability to succeed against the modern threats that are the key rationale for pursuing this $400-Billion program. If the situation with the USRL is not rectified, U.S. F-35 forces will be at substantial risk of failure if used in combat against these threats. Further, I note that the laboratory being built to provide MDFs to the partner nations will be more capable than the USRL is when we are preparing for IOT&E. Therefore, the full set of required upgrades for the USRL should be pursued immediately, without further delay.

Cybersecurity testing. The limited and incomplete F-35 cybersecurity testing accomplished to date has nonetheless revealed deficiencies that cannot be ignored. Multiple tests are scheduled for spring 2016 and some are on-going at this time; however, the JSF Program Office (JPO) and contractor are still reluctant to allow testing of the actual, operational Autonomic Logistics Operating Unit (ALOU) including its many connections, fearing the testing might disrupt its operations. Even though the program is providing alternate systems for ALOU testing in the near term, which is better than foregoing all testing, it must allow full, end-to-end, cooperative and adversarial cyber tests on every level and component of the operational Autonomic Logistics Information System (ALIS). The program must also designate an aircraft and provide the authority to test it, as soon as possible, a process the Program Office has been hesitant to do to date. Cybersecurity testing on the next increment of ALIS – version 2.0.2 – is planned for this fall, but may need to be delayed because the program has not been able to resolve some key deficiencies and complete content development and fielding as scheduled.

IOT&E readiness and adequacy. IOT&E will be the first rigorous and operationally representative evaluation of the combat capability of the F-35. Unlike previous developmental testing, IOT&E will examine the completed, fully operational aircraft to ensure it is capable of prevailing in combat against realistic threats. However, the slow rate of maturation of required combat capabilities renders the current schedule to complete development and enter IOT&E by August 2017 unrealistic. Essential systems are not becoming stable and viable enough quickly enough to successfully begin testing at that time. Based on the historical performance of the program and the large amount of testing that remains, my estimate for completion of developmental flight test is no earlier than January 2018. For these reasons, the test organizations' capacity should be maintained at current levels, and not reduced in a counter-productive effort to meet unrealistic budget targets. Several other significant obstacles remain to be overcome before IOT&E can begin, including the following:

- **Weapons integration.** A significant amount of weapons integration developmental testing remains in order to integrate and qualify for operational use of the full suite of Block 3F weapons, including the gun. Since my annual report, nothing has changed my estimate that the program must complete weapons employment test events at a pace three times faster than it has previously been able to do. In fact, most mission systems Weapons Delivery Accuracy (WDA) testing has been on hold for months while awaiting a version of Block 3F with the required capabilities and maturity to complete these important and difficult tests. Eliminating or failing to execute some of the remaining planned developmental WDA test events will only result in deferring them to be done later by the operational test squadrons, which will likely delay identification and correction of significant new discoveries and, therefore, increase the risk of delays to IOT&E. The developmental WDA test events are critical in preparing for IOT&E and the Block 3F weapons events are much more complex than previous testing for Block 2B and Block 3i. For example, critical air-to-air and air-to-ground gun accuracy testing still has not occurred because test aircraft have not received the required gun modifications, which are expected in late summer 2016. Whether the F-35, the first modern fighter without a heads-up display, can accurately employ the gun in realistic air-to-air and air-to-ground situations, with the Generation III Helmet Mounted Display System, remains to be seen until this testing can be conducted.

- **Modification of aircraft.** One of numerous penalties associated with highly-concurrent F-35 development and production is that all the early operational aircraft now need many significant, time-consuming, and costly modifications. The 18 U.S. aircraft (6 each of F-35A/B/C) required for IOT&E need to be representative of the configuration of the weapons system that will be bought at full production rates, which is Lot 9 or Lot 10 and later; recall that the operational test aircraft were purchased in early production lots (Lot 3 through 5), when the program planned

IOT&E to occur in 2013. The program and the Services need to decide whether to pursue all of the modifications needed to those early-lot aircraft prior to IOT&E, or to equip later production aircraft, requiring few or no modifications, with the necessary instrumentation for IOT&E. Other than continued new discoveries of structural deficiencies which may cause further modifications and delays, nothing substantive has occurred since my annual report to change my estimate that if the former course is pursued, the aircraft designated for IOT&E will not be ready before April 2019. This is despite ongoing efforts by the program to accelerate the modification schedule. An example of a recent discovery of a structural deficiency is overloads that are occurring while carrying external AIM-9X missiles that may require a structural modification to the wings of some F-35 variants. The program is also pursuing other options for mitigating some of the other modification delays, including taking some of the new Block 3i processor sets from the production line to modify some of the IOT&E aircraft. However, the program apparently does not have enough new processor sets to provide even two sets without significantly affecting the production line and delaying aircraft deliveries. This situation is indicative of poor management of the production and modification plans since the requirement for modifying the operational test aircraft has been known for many years. The program and Services are also considering swapping new Block 3i processors from other delivered aircraft with the operational test aircraft that are currently configured with Block 2B hardware. The primary problem with staying on the course of completing modifications of the older aircraft is that the production line and the depots – where earlier lot aircraft are being modified – compete for the same materiel. Of course, this issue affects not only the IOT&E aircraft, but all of the aircraft produced before at least Lot 9 as well. Also, since the program and Services still have not agreed on a plan for modifications, it is still not clear if a schedule with the required modifications, including the gun and follow-up radar signature testing, is even executable prior to IOT&E due to the demand on available parts and depot capacity. A decision is needed now on the approach to be taken, so I have asked the program to brief me on their plan to either complete the required modifications or provide instrumented production-representative operational test aircraft prior to IOT&E by June 2016.

- **Mission data.** I already addressed earlier in my statement the problems with the USRL with respect to the need for upgrades in order to be able to produce mission data loads for Block 3F IOT&E. Again, this is a significant problem for the program, and the processes involved in completing the Block 3F laboratory upgrades need to be accelerated, or IOT&E could be delayed well into 2019, with the combat capability of the F-35 remaining deficient. Besides programming the mission data loads, the laboratory is also used as a test venue for optimizing the performance of scan schedules within the data loads. These schedules control the time-sharing of the radar and the electronic support systems to ensure threat signals are detected, geo-located, and correctly identified for battlespace awareness. Such testing takes time in the laboratory and should be completed prior to, and refined after, testing on the open-air ranges. Failure to properly develop, test and optimize these data loads could adversely impact F-35 mission capability during IOT&E or, worse yet, in combat.

- **Sustainment.** In my annual report I provided details on operational suitability. I highlight here, with respect to IOT&E readiness, that if the program is only able to achieve and sustain its goal of 60 percent aircraft availability, the length of IOT&E will increase significantly because a combat-ready availability of 80 percent is planned and needed to efficiently accomplish the open-air mission trials with the number of aircraft planned for IOT&E. Improvements in reliability and maintainability, along with significant improvements to the ALIS, are all needed. The program has worked and achieved better performance in these areas over the past two years, but progress is still too slow if the program is to be ready for IOT&E in less than two years. Of course, this is not only an issue for IOT&E execution, but also for the fielded operational units.
- **Operator preparedness.** In addition to having production representative aircraft, effective mission data, and improved sustainment, the units that will execute the operational test trials need viable tactics and enough time to become proficient by training to them. For example, the pilots will need time to adapt to and train with the new lightweight Generation III Helmet Mounted Display System that will begin testing later this year. The operational test team has always planned for this training to occur; however, the program continues to believe that this can be done concurrently with development. Concurrent development and training for test has been tried in other programs, and is fraught with difficulty and failure.
- **Test range improvements.** I have been working within the Office of the Secretary of Defense and with the Service staffs for the past five years to improve the test venues for operational testing of F-35 and other platforms, in particular the open-air

test resources. These efforts have resulted in putting improvements on track for F-35 IOT&E to be able to include already fielded advanced threats that previously were not going to be available for testing and training. However, resistance and bureaucratic delays to adequately integrating these assets have made progress difficult, despite the decision having been made by the Secretary of Defense to ensure a full and complete test capability that is no less than that available with older threat systems. I will continue to work to bring the needed level of integration to fruition, and appreciate the support provided so far.

- **IOT&E plans.** IOT&E will include trials in various mission areas, specifically Close Air Support (CAS), Surface Attack, Suppression/Destruction of Enemy Air Defenses (SEAD/DEAD), Air Warfare (both offensive and defensive), and Aerial Reconnaissance. The IOT&E will also include tests that compare the ability of the F-35 to accomplish CAS, Combat Search and Rescue and related missions – such as Forward Air Controller (Airborne) – with the A-10, plus Suppression of Enemy Air Defenses (SEAD)/Destruction of Enemy Air Defenses (DEAD) missions with that of the F-16, and Surface Attack missions with that of the F/A-18. These comparison test trials are essential to understanding the new capabilities expected from the F-35 program, relative to the legacy systems it is designed to replace. The trials will be designed to answer the question, "Is the new system as good as or better at accomplishing the mission than the legacy system under the same conditions and in the same environment?" Comparison testing is not new with the JSF. Of note, the F-22 completed comparison testing with the F-15 during its IOT&E. Typically, many variables are present during operational testing that cannot be controlled, especially in force-on-force exercises. Areas where commonality in the variables can be sought among trials to enable valid comparisons include: the type of mission; the size, organization, and capability of the enemy force; the terrain (or environment) where the test is conducted; the size, organization, and capability of the supporting blue forces; and time available to accomplish the mission. These comparison test trials will be designed as "matched pairs" where the F-35 aircraft will fly the mission trial and then the comparison aircraft will fly the same mission trial, under the same operational conditions, with pilots making best use of the differing capabilities and tactics for employing each aircraft.

Block 2B Capabilities Fielded. As mentioned in my annual report, if used in combat, the Block 2B F-35 will need support from command and control elements to avoid threats, assist in target acquisition, and control weapon employment for the limited weapons carriage available (i.e., two bombs and two air-to-air missiles). Block 2B deficiencies in fusion, electronic warfare, and weapons employment result in ambiguous threat displays, limited ability to respond to threats, and a requirement for off-board sources to provide accurate coordinates for precision attack. Since Block 2B F-35 aircraft are limited to two air-to-air missiles, they will require other support if operations are contested by enemy fighter aircraft. The program deferred deficiencies and weapons delivery accuracy test events from Block 2B to Block 3i and Block 3F, a necessary move in order to transition the testing enterprise to support Block 3i flight testing and Block 3F development, both of which began later than planned in the program's integrated master schedule. The program fielded new software for the ALIS during 2015. These versions included new functions, improved interfaces, and fixes for some of the deficiencies in the earlier ALIS versions. The program also fielded a new version of the Standard Operating Unit (SOU) which is more modular and easier to deploy. However, many critical deficiencies remain which require maintenance personnel to use workarounds to address the unresolved problems. For example, transferring aircraft data between SOUs, which is needed to support deployments, does not function seamlessly within ALIS – as it was designed – but often requires manual updating or corrections to data files after a transfer has occurred. The program's failure to integrate propulsion data into ALIS, a feature which was originally planned to be included in version 1.0.3 but is now scheduled for a two-phased release in ALIS 2.0.2 and ALIS 3.0, causes field units to rely heavily on contractor support and maintenance applications entirely separate from ALIS to complete post flight maintenance actions. This process adds time to the maintenance timeline for preparing aircraft for subsequent flights. Other ALIS functions, such as customer support, have failed to improve as planned. Supply functions that should be autonomic, such as identifying where to send failed parts for repair and routing replacement parts to operating units, are manual and labor intensive, contributing to supply delays. Training programs for ALIS are immature and require maintenance personnel to learn ALIS processes in the fielded locations. In addition, the process for creating and receiving action requests, needed for resolving maintenance issues when technical data are insufficient or not clear, is lengthy and burdensome. Lack of standardization of supply procedures across the F-35 enterprise also impacts aircraft availability. For example, prioritization of requisitions that are not designated as "most critical" has led to lower priority customers receiving needed spare parts first and has resulted in the low levels of F-35B engine and module sparing currently available. The Marine Corps has found that the Level of Repair Analysis (LORA) study conducted by the Program Office has not led to a path forward to achieve repair capabilities at the unit or intermediate levels that would support expeditionary warfare. They have also found that program guidance is overly restrictive in designating when to make repairs to the outer mold line and air vehicle structure based on damage limits and tolerances. In general, these repairs are done at the depot level, but small repairs can be done at the unit level, although the guidance on how to do so is lacking. Instead, unit maintenance personnel must generate action requests for assistance or clarification, a process which slows down the necessary repair actions.

Marine Corps units have noted that their aircraft have a range of configurations as they are from different production lots and each has undergone some level of required modification. This increases the variability in which spare parts are acceptable on each aircraft. Accurately tracking aircraft configurations is manually intensive and is a potential safety issue since ALIS parts management functions may allow de-modification of aircraft by permitting installation of parts that are no longer acceptable after an aircraft has completed modifications.

The Marine Corps conducted a deployment demonstration to the USS *WASP* in May 2015, which provided lessons learned and highlighted limitations for conducting ship-borne operations. The Marines also conducted a deployment demonstration to the Strategic Expeditionary Landing Field near Marine Corps Air Station (MCAS) Twentynine Palms, California, in December 2015. Both deployments required extensive time to transfer data to the deployed ALIS and ensure files were formatted correctly to support operations. In addition, low aircraft availability rates resulted in less than planned sortie generation rates.

The Air Force also conducted deployment demonstrations – one as a “cross-ramp” deployment of three F-35A aircraft across the ramp at Edwards AFB, California, in April and May 2015 and another with six F-35A aircraft to Mountain Home AFB, Idaho, in February 2016. Like the Marine Corps demonstrations, the cross-ramp deployment required extensive time to get ALIS set up and data files transferred from the operational unit. ALIS set up and data transfer during the Mountain Home deployment was more efficient than in other demonstration, being completed within four hours for each of the six aircraft. The Air Force attempted two alert launch procedures during the Mountain Home deployment, where multiple F-35A aircraft were preflighted and prepared for a rapid launch, but only one of the six aircraft was able to complete the alert launch sequence and successfully takeoff. Problems during start-up that required system or aircraft shut-downs and restarts –a symptom of immature systems and software – prevented the other alert launches from being completed.

There are several issues affecting the F-35's CAS capabilities, as mentioned in my annual report. Both the Air Force, with the F-35A, and the Marine Corps, with the F-35B, have flown simulated CAS missions during training or in support of training exercises, with the aircraft in the Block 2B configuration. These training missions have shown that the Block 2B aircraft will need to make substantial use of voice communications to receive target information and clearance to conduct an attack. This is because of the combined effects of digital communications deficiencies, lack of infrared pointer capability, limited ability to detect infrared pointer indications by a controller (which may be improved in the Generation III Helmet Mounted Display System), and inability to confirm coordinates loaded to GPS-aided weapons. Many pilots consider the Electro-Optical Targeting System (EOTS) on the F-35 to be inferior to those currently on legacy systems, in terms of providing the pilot with an ability to discern target features and identify targets at tactical ranges, along with maintaining target identification and laser designation throughout the attack. Environmental effects, such as high humidity, often forced pilots to fly closer to the target than desired in order to discern target features and then engage for weapon employment, much closer than needed with legacy systems, potentially exposing them to threats around the target area or requiring delays to regain adequate spacing to set up an attack. When F-35 aircraft are employed at night in combat, pilots with the currently-fielded Generation II helmet will have no night vision capability from the helmet, due to the restriction on using the current limited night vision camera, which is planned to be subsequently upgraded after aircraft are retrofitted with Block 3i and pilots are equipped with the Generation III helmet, which is still in development and testing. In general, using Block 2B F-35 aircraft, pilots would operate much like early fourth generation aircraft using cockpit panel displays, with the Distributed Aperture System providing limited situational awareness of the horizon, and heads-up display symbology produced on the helmet.

Fuel and weapons limitations also affect F-35 CAS performance. For example, a combat-loaded F-35B, assuming a 250-nautical mile ingress to a CAS area contact point, would have only approximately 25 – 40 minutes to coordinate with the controller, assess the tactical situation and execute an attack using its two air-to-surface weapons before needing to depart for fuel. By comparison, an Air Force A-10 would have approximately one hour (without external tanks) and one and one half hours (with external tanks) of time in the CAS area under the same conditions, but would be able to autonomously acquire and identify targets, while using datalink to receive and/or pass target and situational awareness information. Also, an A-10 would be able to employ at least four air-to-surface weapons, including a mixed load of ordnance and its internal gun, which provides flexibility in the CAS role. Although F-35 loiter time can be extended by air refueling, operational planners would have to provide sufficient tankers to make this happen, similar to current contingency operations. Recent exercises involving the use of F-35A and F-35B aircraft in limited CAS mission environments have shown that the fuel burn rate with internal weapons (two bombs and two air-to-air missiles) is 10 to 20 percent higher than the F-16, depending on variant, and about 50 to 70 percent higher than the A-10. This creates a burden on the air refueling resources if used to increase F-35 time on station. With additional external weapons, the fuel burn rate would be even higher due to the additional weight and drag. Also, the recent exercises were flown from medium altitudes, where fuel burn rates are less than at lower altitudes or during climbs back to altitude. Gun employment, which will be available with Block 3F aircraft and needed for the CAS mission environments, will likely increase fuel burn rates as the F-35 would accomplish gun strafing maneuvers at lower altitudes and then climb back to higher altitudes for subsequent CAS attacks. Of course, the F-35 is designed to do more missions than CAS, which is the primary mission for which the A-10 was designed. Also, the F-35 is designed to do these missions in a high-threat area.

F-35 development is still not complete, but if the capabilities stated in the ORD are realized, Block 3F aircraft will have the ability to carry additional weapons externally, for an increased payload, as well as a gun. For example, a Block 3F F-35A aircraft could carry six Guided Bomb Unit (GBU)-12 laser-guided bombs (vice two in Block 2B) along with four air-to-air missiles (two Air Intercept Missile (AIM)-120C and two AIM-9X). The gun capabilities of the F-35 and A-10 are significantly different. The F-35 has a lightweight, 25-millimeter cannon, internally mounted on the F-35A with 182 rounds, and in an external pod with 220 rounds for the F-35B and F-35C, while the A-10 has a 30-millimeter cannon with 1,150 rounds. Even though the A-10 gun has a higher rate of fire, the A-10 gun can fire for over 17 seconds versus approximately 4 seconds for the F-35, providing the capability for many more gun attacks. Also, while both guns have a similar muzzle velocity, the rounds fired by the A-10 are twice as heavy, providing twice the impact energy on the target. The F-35's fusion of information from onboard sensors and data from off-board sources (i.e., F-35 aircraft in formation via the Multi-function Advanced Data Link (MADL) and other aircraft via Link 16), along with all-weather ground-moving target and synthetic aperture radar capability, are planned to be more capable in Block 3F and should provide better battlespace awareness than that being fielded with Block 2B and better capability in these aspects than an A-10. The extent that these capabilities improve combat capability over legacy systems will be evaluated during IOT&E.

Mission planning time and the debriefing times for the F-35 with the current version of ALIS – which must account for the long download process for cockpit video – are much longer than those of legacy platforms and will affect operations when the F-35 unit is a member of composite air and surface forces, since planning timelines will have to be adjusted. The program plans to field an improved Ground Data Receptacle – which downloads maintenance and flight data files, including the cockpit video for mission debrief – later this year. Early end-to-end testing shows that transfer times have been cut in half, although the Program Office is working with the contractor to correct software deficiencies that are expected to improve transfer times by a factor of five – from the current times – once completed.

Software -- Block 3. As I explained above, Block 3i was intended to be a simple re-hosting of Block 2B mission systems software on new hardware and processors. However, Block 3i content also includes attempted fixes for five significant functional deficiencies related to mission systems identified by the Air Force as necessary for its IOC declaration. Four additional discoveries in Block 3i have since been identified as deficiencies in need of fixes. The final version of Block 2B, version 2BS5.2, had 32.5 hours between stability events during flight testing, versus only 4.3 hours for Block 3iR6. Because Block 3i is the basis for the final new and challenging Block 3F capabilities, the program has rightly determined to focus on Block 3i problems in lieu of further Block 3F development. The program is currently flight testing another version of Block 3i software – version 3iR6.21 – on its mission systems test aircraft at the Edwards test center. The initial test sorties with Block 3iR6.21 show improved stability in flight, with indications that the mean time between stability events is again comparable to the fielded version of Block 2B; but, as mentioned earlier, initial start-up continues to be challenging. Moreover, the estimates of mean time between stability events provided above are contractor-reported from developmental testing and almost certainly do not count all the events operational pilots would consider significant in combat. The status of the other "must fix" deficiencies is unknown at the time of this testimony. The Block 3i software instabilities, unresolved deficiencies, lab delays, and the potential for additional discoveries are adversely affecting Block 3i tactics development and the IOC Readiness Assessment, currently underway at Nellis AFB, and are likely to affect Air Force IOC. However, some of the Nellis aircraft have now loaded 3iR6.21 and they are also seeing improved avionics stability in flight. Nevertheless, the program continues to deliver Block 3i aircraft configured with the available software to fielded units and will continue to do so into next year.

Success of Block 3F mission systems depends on the program resolving the problems with Block 3i. The stability and functionality problems in the initial versions of Block 3F, including those inherited from Block 3i and problems caused by new Block 3F capabilities, were so significant that the program could not continue flight test. As a result, the program recently announced a shift to capability-based software releases, rather than schedule-driven and overlapping releases. While this may cause further short-term delays to the program, I agree with the program's decision to shift to a serial process of testing and fixing software in the lab before releasing the next software version, and the recent improvements observed in Block 3i stability validate this serial approach. The program recently released an updated version of Block 3FR5 software to flight test in April and then Block 3FR6 later this summer. If the fixes to stability programmed into the latest Block 3i software continue to suppress the need for avionics resets in flight, mission systems testing and weapons releases can potentially resume in earnest and the test point completion rate will increase, which is essential given the significant amount of testing that remains.

The program continues to carry a heavy load of technical debt in open and unresolved deficiencies. As of the end of March 2016, the program had 1,165 open, documented deficiencies, 151 of which were Category 1, defined as deficiencies which may cause death, severe injury, or severe illness; may cause loss of or major damage to a weapon system; critically restricts the combat readiness capabilities of the using organization; or result in a production line stoppage. Of the 151 Category 1 deficiencies, 128 were associated with the air vehicle and the remaining 23 were associated with the ALIS or support equipment. Furthermore, 95 of the 151 open Category 1 deficiencies were categorized as "high severity" by the program or Services. The Program Office, in cooperation with representatives from the Services, developmental test and operational test organizations, recently led a detailed review of the open deficiencies. This effort, which I applaud, assessed the effect of each deficiency with respect to both combat capability and IOT&E. The resulting list of critical deficiencies should be the top priority fixes for the program prior to finalizing Block 3F and conducting IOT&E.

Mission Data. The problems in the USRL described earlier will not only adversely affect Block 3F combat capability; they are crippling the ability to produce effective mission data loads for today's fielded aircraft. The current tools and software in the lab are very difficult to work with, resulting in a lengthy, inefficient process to produce and test the mission data. Along with the decision to delay moving the lab equipment from the contractor facilities in Fort Worth, Texas, these inefficiencies created sufficient schedule pressure that the program and the Marine

Corps directed the lab to truncate the planned testing of the Block 2B mission data so that an immature version could be fielded in mid-2015 to "support" Marine Corps IOC. The lab provided a Block 2B mission data load, but the risks of operating with these mission data are not understood, and will not be characterized until the full set of planned testing, including operational test flights with the mission data, are conducted later this year. Because the hardware in aircraft equipped with Block 3i cannot operate with the Block 2B mission data, Block 3i mission data must be developed and tested independently of, but concurrently with, the mission data for Block 2B. This creates an additional significant strain on the lab, which is already burdened with inefficient reprogramming tools. Block 3i mission data will likely incur the same fate as Block 2B mission data, as inevitable schedule pressure to field immature mission data will drive product delivery despite incomplete optimization and testing. In any case, the risks in combat associated with operating with these early mission data versions will remain unknown until the planned lab and flight testing are complete.

Escape System. The F-35's pilot escape system is immature; it requires modifications and additional testing if the Services are to be reasonably confident the system is safe for their intended pilot populations. The failures during sled tests last summer simulating controlled, low-speed ejections caused the program and Services to restrict pilots below 136 pounds bodyweight from flying the aircraft. Also, the risk to pilots weighing up to 165 pounds, while lower than the risk to lightweight pilots, is still considered "serious" by the program. Last year the program assessed the risk for this 136 to 165 pound weight class, which accounts for approximately 27 percent of the pilot population. The program assessed the probability of death during an ejection in these conditions to be 23 percent and the probability of some level of injury resulting from neck extension to be 100 percent. However, the program and the Services decided to accept that risk and not restrict pilots in this weight category from flying. Subsequently, the program conducted "proof of concept" tests last fall for modifications to the escape system including a "lightweight pilot" switch on the seat and a fabric head support panel between the parachute risers behind the pilot's head, intended to restrict the severe backward neck extension. The tests apparently showed that the lightweight pilot switch and head support panel prevented a neck load exceedance after parachute deployment and opening shock. However, these changes do not prevent the high loads on the pilot's neck earlier in the ejection sequence due to the rocket firing and wind blast. Full testing of these fixes using the new Generation III Light helmet and full range of mannequin weights across different airspeeds is expected to extend through this summer with flight clearance this fall and modification kits in 2017. The first of these tests with all the proposed fixes was recently completed on March 31st using a 103-pound manikin ejected from a rocket sled at 150 knots while wearing a Gen III Light helmet. The JPO assessed this test to be a success and therefore plans to continue the testing through this summer. Even if these fixes are successful, additional testing and analyses are also needed to determine the risk of pilots being harmed by pieces of the transparency from the canopy removal system during ejections (the canopy must be explosively shattered during ejection) in other than stable conditions (such as after battle damage or if out-of-control), referred to as "off nominal" conditions.

Structural testing. Major findings are continuing in the durability test articles, particularly in the titanium bulkhead in the F-35C test article. Significant limitations to the life of the fielded F-35C aircraft can only be addressed with intrusive structural modifications prior to the expected full service life, and show again the high cost of concurrent production and development. In the past year, discoveries of unpredicted cracks continued to occur, and in some cases required pauses in testing to determine root causes and fixes. This occurred in all three variants. Currently, only the F-35A structural test article is being tested; it recently started the third lifetime test phase, or the third series of 8,000 equivalent flight hours of testing on March 11, 2016. The F-35B test article is undergoing inspections at the mid-point of its second lifetime of testing. The F-35C test article restarted testing in mid-February but stopped three days later when strain gauges indicated cracking in a titanium bulkhead; it is expected to restart in May.

ALIS. The program has developed a new version of the ALIS hardware, termed Standard Operating Unit version 2 (SOU v2), which possesses all of the functional capabilities included in the original version – SOU v1 – but in a modularized, more deployable form. As I described earlier in my statement, in recent months, both the F-35A and F-35B have conducted deployment demonstrations in an effort to learn how to forward deploy with, and conduct flying operations using, the SOU v2. The Marine Corps and Air Force needed several days to successfully establish a new network in an austere expeditionary environment or to integrate ALIS into an existing network at a non-F-35 military installation before ALIS was able to support flying operations. Although the hardware for the SOU v2 was much more manageable to move and set up, the processes for connecting to the main Autonomic Logistics Operating Unit (ALOU) at Lockheed Martin facilities in Fort Worth took time, as did ensuring the data from home station units was transferred correctly to the deployed unit.

These two Service-led deployment demonstrations showed that ALIS operations will require significant additional time to initiate beyond setting up hardware modules, since the details of a network configuration and data file structure vary among base operating locations. ALIS requires a secure facility to house hardware, including SOU modules, mission planning workstations, and receptacles for transferring data to and from aircraft storage devices, which must be connected to power and external communications and integrated into a network with data exchanges occurring at multiple levels of security. It is difficult to establish and configure a network in the precise manner that ALIS requires, so network personnel and ALIS administrators have needed several days to troubleshoot and implement workarounds to prepare ALIS for operations. Although Lockheed Martin has provided several techniques for transferring aircraft data from a main operating location SOU to a deployed SOU, data transfers have proven time consuming and have required high levels of support from Lockheed Martin. Also, relatively minor deviations in file structures relative to ALIS' specifications can cause the process to fail.

The program plans to release another increment of ALIS software this year – version 2.0.2, with added capabilities to support Air Force IOC declaration. However, it is struggling to meet the current schedule to deliver the planned content. A recent Program Office schedule assessment shows delays from 60-90 days that will slip the ALIS 2.0.2 installation at Hill AFB to at least October 2016, which does not align with the Air Force need date of 1 May for their planned IOC objective date of August 2016, but may support their planned IOC threshold date of December 2016. Cybersecurity testing of ALIS 2.0.2 is planned for this fall, but may need to slip or be accomplished using the earlier version of ALIS if the program cannot deliver version 2.0.2 it on time, adding associated risk to fielding systems and declaring IOC because adequate cybersecurity testing will not have been completed.

Delays in completing development and fielding of ALIS 2.0.2 will likely compound the delay already realized for ALIS 3.0, the last planned increment of ALIS, which is needed for IOT&E but is currently not scheduled to be released until March 2018. Although the program is considering deferring content and capabilities to make up schedule, the full set of capabilities for ALIS 3.0 will be needed to comply with the program's requirements and therefore are required for IOT&E.

Aircraft Reliability, Maintainability, and Availability. Although measurements of aircraft reliability, maintainability, and availability have shown some improvement over the last two years, sustainment relies heavily on contractor support, intense supply support to arrange the flow of spare parts, and workarounds by maintenance and operational personnel that will not be acceptable in combat. Measures of reliability and maintainability that have ORD requirement thresholds have improved since last year, but six of nine measures are still below program target values for the current stage of development; two are within 5 percent of their interim goal, and one – F-35B mean flight hours between maintenance events (unscheduled) – is above its target value. Aircraft availability improved slightly in CY15, reaching a fleet-wide average of 51 percent by the end of the year, but the trend was flat in the last few months and was well short of the program's goal of 60 percent availability that it had established for the end of CY14. The Marine Corps has recently described difficulties in completing pilot training requirements due to low aircraft availability with full functionality. For pilots to complete training tasks, aircraft must be nearly Fully Mission Capable (FMC), but low mission systems component reliability, software stability problems, and Prognostics & Health Management (PHM) limitations have contributed to limited aircraft ability to complete pilot training tasks. The FMC rate for the F-35 fleet has declined steadily since December 2014. Data from February 2016, the latest month available, show a fleet-wide FMC rate of 30 percent and an F-35B FMC rate of less than 14 percent. It is also important to understand that the program's metric goals are modest, particularly in aircraft availability, and do not represent the demands on the weapons system that will occur in combat. Making spare parts available more quickly than in the past to replace failed parts has been a significant factor in the improvement from 30 to 40 percent availability experienced two years ago. However, F-35 aircraft spent 21 percent more time than intended down for maintenance in the last year, and waited for parts from supply 51 percent longer than the program targeted. At any given time, 10 to 20 percent of the aircraft were in a depot facility or depot status for major re-work or planned upgrades, and of the fleet that remained in the field, on average, only half were able to fly all missions of the limited capabilities provided by Block 2B and Block 3i configuration.

The program showed improvement in 11 of 12 reliability metrics by May 2015; however, as I depicted in my annual report, 8 of the metrics are still below the program interim goals for this point in development, and it is not clear that the program can achieve the necessary growth to reach the reliability requirements for the mature system, at 200,000 total fleet flight hours. Many components have demonstrated reliability much lower than predicted by the contractor, such as fiber channel switches, main and nose-wheel landing gear tires, the display management computer for the helmet, and signal processors. These low-reliability components drive down the overall system reliability and lead to long wait times for re-supply, which negatively affects aircraft availability.

Maintainability metrics indicate flight line maintenance personnel are working extremely hard to keep up with the demands of unscheduled maintenance (e.g. trouble-shooting and fixing failures) and scheduled maintenance (e.g. inspections). Small improvements in maintainability metrics occurred in the past year, but the measures for all variants are far from the operational requirements. There are a few individual causes for long down times that may be addressed by the program, such as long cure times for low observable repairs, but many must be accepted as facts of life for the time being. Maintenance manuals and technical information must continue to be produced, verified, and validated for use by the military maintenance personnel so that they can learn how to generate combat missions in the most efficient manner. The current process requiring "action requests" to fill gaps in technical information, while improved, will not be acceptable for combat. F-35 maintainers must also dedicate a significant amount of time to scheduled maintenance, in addition to repairs. This accounts for over half of all maintenance time in the last year (from June 2014 through July 2015), a result of fielding an aircraft with an immature structural design that must be inspected for evidence of wear and cracking, such as that which has been found in the structural static test articles.

Fielded units, and the overall program, have a new challenge with managing multiple software and hardware configurations as aircraft emerge from depot and local modification processes. Modified aircraft include new parts and this should improve reliability metrics. However, managing multiple configurations requires continual, intense focus to ensure correct procedures and parts are used based on aircraft configuration and data elements tracked within ALIS.

Deployment sustainment results. As I outlined earlier in my statement, Service-led deployments over the past year have revealed challenges to adequate suitability performance, and provided useful lessons for future operations. More detail is provided below.

During the Cross Ramp Deployment Demonstration flying period at Edwards AFB during May 4 – 8, 2015, the operational test squadron flew 20 of 22 planned missions. The squadron originally intended to deploy four F-35A aircraft and planned most fly-days with two aircraft flying two sorties apiece, but could only make three aircraft available to participate in the exercise. The ALIS data transfer problems forced the detachment to operate in an ALIS-offline mode until the morning of May 7, which restricted aircraft maintenance to minimal, simple activities. The detachment was able to achieve a relatively high completion rate of planned sorties in spite of this largely because no mission systems were required for the flights, so failures in these components were left un-repaired. By the end of the deployment, one of three aircraft had to be towed back to the test squadron hangar because it was down for a flight system discrepancy that the detachment could not fix in time. The detachment also exposed problems with retaining spare part requisitions against aircraft when they are transferred between SOUs, and issues with keeping maintenance records intact when returning from ALIS-offline operations.

The shipboard flying period of the USS *WASP* deployment demonstration from May 18 – 28, 2015, excluding the return flights from the ship to home base on May 29, was not intended to maximize aircraft utilization rates, but showed difficulties in achieving adequate availability to support planned flight schedules. The six deployed F-35B aircraft were mission capable for flight operations approximately 55 percent of the time, which led to the detachment flying 61 of 78 planned missions. The Marine Corps reports a higher number of sorties than missions, since each vertical landing constituted a sortie, while each post-flight engine shut down constituted a mission. Several missions were canceled for weather, or other operational reasons, but 13 missions were canceled, apparently due to a lack of available aircraft. In order to consistently generate tactically relevant four-aircraft mission packages day after day, out of the normal complement of six F-35B aircraft onboard an L-class amphibious ship, the F-35B would likely have to achieve availability rates closer to 80 percent; although during the deployment demonstration, the detachment did generate a four-aircraft mission on one day. Fuel system reliability was particularly poor. This is more burdensome in the shipboard environment than at land bases, as fuel system maintenance in the hangar bay can restrict the ability to perform maintenance on other aircraft in the bay. Due to a fuel system problem that would have required an engine to be pulled, one aircraft was transferred on a one-time flight back to shore and swapped with an alternate aircraft, an option that would not exist in forward-deployed combat conditions. Aircraft availability and utilization varied widely among the seven different aircraft used in total on the deployment, with the top performing aircraft flying 20 missions, and the least performing aircraft flying only 2 missions, not including a one-time ferry flight to shore to be swapped. The ALIS data transfers also relied on combat-unacceptable workarounds, including using commercial Wi-Fi access to download aircraft files. Several factors limited the ability to draw more conclusions about shipboard integration of the F-35B from this deployment demonstration. These included the lack of the rest of the Air Combat Element (ACE) aircraft onboard ship except for the required Search and Rescue (SAR) helicopters; the use of developmental Support Equipment (SE), vice the production-representative SE the Marine operational squadron is now equipped with; and no employment of ordnance.

The Marine Corps conducted an assessment of F-35B austere site deployed operations at Twentynine Palms, California, from December 8 – 16, 2015, with eight F-35B aircraft assigned. The Marines intended to fly four aircraft a day from an expeditionary landing field made of aluminum matting and with minimal permanent infrastructure, representing the type of temporary airfield that can be quickly built near the forward line of troops. The demonstration included the use of inert ordnance and production representative support equipment. Aircraft availability for this detachment was again in the 55 to 60 percent range, which led to a significant number of missed flights on the planned flight schedule. The detachment flew 41 out of 79 planned missions; however, 22 of the 38 missions not flown were due to high crosswinds which made landing and taking off from the aluminum matting too risky. Overall, 16 missions were lost due to either lack of aircraft availability, difficulties in transferring and accepting aircraft data into the deployed ALIS, or ground aborts. Propulsion system maintenance was particularly burdensome. Two F-35B aircraft received foreign object damage to their engine fan stages, a result from operating in rugged conditions with jet wash likely blowing small rocks into aircraft intakes. This prevented those aircraft from further participation in flying activities until repairs were completed just prior to the ferry flights home. A contractor technician was called in from the East Coast and was able to repair the engine damage on site, as opposed to having to perform a full engine swap. A further engine system discrepancy required an aircraft swap around mid-way through the detachment. Routine flight operations, such as aircraft start-up and basic troubleshooting, also relied heavily on contractor maintenance.

The Air Force sent a detachment of six F-35A operational test aircraft from Edwards AFB to Mountain Home AFB from February 8 to March 2, 2016, to simulate a combat deployment of this variant in preparation for Air Force IOC later this year. This demonstration employed both inert and live ordnance in the CAS and Aerial Interdiction roles, in conjunction with legacy platforms. Results from this demonstration are still too preliminary to report on in full, although some early observations were made. The detachment discovered a major discrepancy in the technical data for loading free fall ordnance after a released bomb hit the weapons bay door and then impacted and gouged the horizontal stabilizer. The aircraft returned to base safely and was eventually repaired on station, and the detachment coordinated with Lockheed Martin to correct the appropriate ordnance loading instructions. The deployment also successfully transferred aircraft data files within the autonomic logistics infrastructure (i.e., using ALIS, the Central Point of Entry, and the ALOU); however, there were some difficulties in establishing ALIS on the host Air Force network on Mountain Home AFB. Finally, the relatively frequent requirement to shut-down and restart an aircraft on start-up before flying due to software instabilities in vehicle and mission systems hampered the detachment's ability to conduct alert launches.

Key test range capability improvements are required for IOT&E, on which we have been working with the Office of the Secretary of Defense and Service staff for several years. In particular, these include the Air-to-Air Range Infrastructure-2 (AARI2) system, the instrumentation that allows the many engagements during complex test trials to be accurately assessed and shaped in real time; and the integration of the Electronic Warfare Infrastructure Improvement Program (EWIIP) emitters, that will simulate current, advanced threats on the range. For an adequate IOT&E, the integration of AARI2 with the F-35 should allow the F-35 Embedded Training modes to realistically emulate and display weapons employment data and threat indications to the pilot, and include the shot validation method that is being developed for this purpose. The planned schedule for AARI2 integration, however, does not align with the current plans for IOT&E and does not include these features. Therefore, the product may either be inadequate or late to need. The new EWIIP emitters, that will simulate current, advanced threats on the range, start arriving in fall of this year. However, until recently, Air Force integration plans fell short of what is needed for an adequate IOT&E, both in how the emitters are integrated with the range infrastructure and the degree of incorporation with the AARI2 battle-shaping instrumentation. We continue to work with the Air Force to correct these problems, and ensure we get the most of the investment made in these emitters. There is no alternative to correcting these problems if IOT&E is to provide a representative threat environment – an environment that has been in existence, and robustly so, in the real world for several years. Not properly incorporating these assets, in a realistic way, will result in a test of the F-35 only against decades-old threats, which do not represent the intended operational environment for this fifth-generation system. I assess the technical challenges to the integration requirements I mention here as relatively minor; this test concept is not new. Unfortunately, the issues seemed to stem primarily from cultural resistance to change and to the adoption of modern technology.

Of all the issues mentioned earlier that threaten IOT&E spin-up and start, the most significant are the modifications needed for operational test aircraft, Block 3F completion (including flight test, weapons deliveries, and envelope release), and completion of ALIS 3.0. The program has an executable plan to pull completion of the modifications back from 2019 to 2018; however, the Services must commit to executing that plan, which has not yet occurred. The Block 3F schedule, even with significant improvements in software stability, deficiency resolution, and flight test rates, still appears to extend into 2018 before the capabilities will be ready and certified for IOT&E. Inadequately tested mission data and failure to provide the simulation environment will likely not delay the start of IOT&E, but will affect the results and adequacy of the test, respectively, and the former will likely limit significantly the ability of the F-35 to be used in combat against existing, modern, stressing threats. Therefore, despite recent progress with Block 3iR6.21 software stability, a mid-2018 start for IOT&E appears to be the earliest viable date based on when the modifications, full Block 3F capabilities (including envelope and weapons), and ALIS 3.0 will be ready. Based on the issues above that will not likely be resolved or ready until 2018 or later, I am concerned that the program may not have adequate resources to complete the required System Development and Demonstration activities prior to IOT&E.

Block Buy. In my annual report, I raised several questions regarding the program's proposed "block buy" to combine three production lots comprising as many as 270 U.S. aircraft purchases to gain near-term savings. My understanding is that the program and the Services have decided to delay the consideration of the block buy for at least another year, possibly starting in FY18. Nonetheless, in that case, all of the questions I pose in my annual report remain valid, since IOT&E will not start until FY18, at the earliest, and will not be complete until later that year.

Follow-on Modernization (FoM). The program's proposed "F-35 Modernization Planning Schedule" is overly optimistic and does not properly align with the program’s current software development schedule, which is also unrealistic. The program recently announced that the FoM development effort will require new processors – referred to as Technical Refresh 3, or TR3 – with more capacity to permit the new capabilities to be hosted on the aircraft, at a cost of $700M. This additional cost was not part of the planned Block 4 FoM program, so it is currently unfunded and the Services must program this into their FY18 budget submissions. Also, there is a four-year gap between the final planned Block 3F software release in 2016 and fielding of the first proposed modernization increment, labeled Block 4.1, in late 2020. The proposed schedule also does not depict any incremental software releases to correct open Block 3F deficiencies and new discoveries, likely to be found during the remaining developmental testing and IOT&E, prior to adding the proposed new Block 4.1 modernization capabilities. Such a schedule greatly increases risk to development and testing of Block 4 due to the inevitably substantial number of deficiencies and untested fixes upon which the new Block 4 capabilities will be added. Despite the significant ongoing challenges with F-35 development, including the certainty of additional discovery, the proposed modernization schedule is very aggressive; it finalizes the content of Blocks 4.1 and 4.2 in early 2016. Then, before or during IOT&E, the program would award contracts to start simultaneous development of Blocks 4.1 and 4.2 in 2018, well prior to completion of IOT&E and having a full understanding of the inevitable problems it will reveal. Also, the proposed Block 4 FoM plan and schedule do not clearly depict acquisition milestones, despite the complexity and substantial number of capabilities to be implemented and funding required.

Even though the baseline F-35 System Development and Demonstration (SDD) program, including delivery of Block 3F capabilities and ALIS 3.0 (and therefore IOT&E start), is clearly going to slip into 2018, the program still claims that SDD will end in 2017. In fact, the program has apparently asked the Services to provide additional bridge funding for test infrastructure in FY18-19, even though the DT activities extending into 2018 (and IOT&E into 2019) are clearly part of SDD and therefore should already be funded. Also, the program plans to significantly cut the test force in the 2018-2019 timeframe, precisely when the program should be developing and testing an incremental software update of Block 3F to correct critical deficiencies and new discoveries from IOT&E prior to adding the new Block 4.1 capabilities. Furthermore, the Block 4 FoM plan and schedule still do not allocate adequate schedule and resources (i.e., enough test aircraft and time) for developmental test (DT) and operational test and evaluation (OT&E) of each increment, consistent with the approach being used for F-22 follow-on development. The proposed Block 4 FoM plan reduces test infrastructure from 18 DT aircraft and 1,768 personnel to just 9 aircraft and approximately 600 personnel. The proposed Block 4 FoM plan also does not allocate enough time for test of the significant new capabilities including in each increment. For example, the F-22 Block 3.2B program planned approximately two years for DT flight test and one year of OT&E spin-up and flight test, versus approximately one year for DT flight test and six months for OT&E of F-35 Block 4.2, which has more new capabilities and weapons than F-22 Block 3.2B. Also, the F-35 program claims the new F-35 Block 4 software, which is designed to run on TR3 processors, will be backward-compatible to run in the hundreds of aircraft with TR2 processors. However, the program's current proposed Block 4 plan apparently does not include resources (funding, schedule or TR2-equipped test aircraft) to conduct the necessary developmental laboratory and flight testing followed by OT&E of the new Block 4 capabilities in aircraft equipped with the old TR2 avionics hardware. For these reasons, any proposed reductions in test infrastructure for Block 4 FoM should be reexamined due to the substantial number and complexity of new capabilities to be developed and fielded, multiple aircraft hardware configurations, need for regression testing, and inadequate time allocated for DT and OT&E for each increment.

In summary, it is increasingly clear that the current plans being described by the program office for F-35 Block 4 Follow-on Modernization are not executable. The program, warfighters, partners and taxpayers would be better served by a realistic plan that is informed by, and properly addresses, the many lessons learned from the ongoing F-35 program, as well as from the ongoing F-22 upgrade program. The corrective actions I recommend include the following:

- Updating the Block 4 cost estimate and schedule to include the inevitably required additional costs and time to actually execute FoM (i.e., $700M for TR3, test infrastructure bridge funding for FY18-19, the additional test resources for regression testing for Block 4.1 on TR2 processors, etc.);
- Rigorously justifying the need for the new open-architecture TR3 processors including the specifics of the shortfalls of the TR2 processors and the extent to which these shortfalls will affect Block 3F performance;

- Adding a software maintenance release in 2019 and slipping Block 4.1 development by a year to provide the time needed to correct the significant deficiencies that will inevitably emerge from IOT&E and remain from SDD;
- Re-structuring the content of the Block 4 increments to incorporate a realistic and lesser amount of content so development and testing will fit within the compressed two-year cycles driven by the planned aircraft production and delivery schedules;
- Adding the time and sustaining the test force needed to conduct adequate developmental and operational testing consistent with the complexity and number of new capabilities to be incorporated in each increment of Block 4.

These changes to the program's current plans for Follow-on Modernization are essential for it to succeed rather than be set for failure from the outset.