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AC-130J Ghostrider

Executive Summary

- U.S. Special Operations Command (USSOCOM) is developing AC-130J through the integration of a modular Precision Strike Package (PSP) onto existing MC-130J aircraft. An earlier version of the PSP was previously developed and tested on several AC-130W aircraft since 2009 and fielded in 2010.
- The 18th Flight Test Squadron conducted an Operational Utility Evaluation (OUE) of the Block 10 AC-130J from December 2015 to March 2016 to support Milestone C and an early fielding decision, but USSOCOM will not pursue early fielding of Block 10.
- The Block 10 PSP demonstrated system immaturity during the OUE that diminished the usability of the system. The AC-130J entered operational testing with numerous open deficiency reports (DRs), which required aircrews to use burdensome workarounds in order to conduct their missions. Almost none of the surveyed aircrew rated the system "usable" during the OUE.
- In single-weapon live-fire engagements during the OUE, the AC-130J successfully achieved nominal direct hits and effective kills against two static and two moving targets with Griffin missiles and four static targets with Small Diameter Bombs (SDBs) using two different target coordinate systems.
- The OUE discovered problems with the 30 mm gun control system that affected its accuracy. Preliminary results from an upgraded gun tuning software resident in Block 20 indicate both the 105 mm and 30 mm guns are performing within accuracy specifications.
  - Preliminary results from lethality analysis of the PGU-46/B 30 mm round against mannequin targets indicate that this round has limited effectiveness against personnel in the open on soft ground but is more effective against personnel on hard surfaces.
  - Data also indicate that lethality to personnel above a "soft" plywood roof is lower than predicted by existing models because the round detonated below the roof's surface; mannequins above a concrete roof incurred more fragmentation damage than above a plywood roof.
- Cybersecurity testing of the Block 10 PSP found vulnerabilities that are described in the classified Cooperative Vulnerability and Penetration Assessment (CVPA) report. These vulnerabilities are addressed in Block 20 software modifications.
- Lockheed Martin delivered the first Block 20 AC-130J to USSOCOM in July 2016 to begin developmental testing of new capabilities, such as the 105 mm gun. As of the end of FY16, the program received eight donor MC-130J for modification and produced four AC-130J. The first AC-130J, which experienced a Class A mishap in FY15 rendering it non-flyable, will become an Air Education and Training Command training asset.
- The 18th Flight Test Squadron will conduct IOT&E on a Block 20 aircraft from March through June 2017 to support a Full-Rate Production decision in 1QFY18.

System

- The AC-130J is a medium-sized, multi-engine, tactical aircraft with a variety of sensors and weapons for air-to-ground attack.
- USSOCOM is developing the AC-130J by integrating a modular PSP onto existing MC-130J aircraft, and replacing the MC-130J refueling pods with weapon racks. USSOCOM continues to develop new PSP capabilities on legacy AC-130W aircraft in parallel before they are introduced on the AC-130J in an evolutionary acquisition approach:
  - The Block 10 AC-130J PSP provides a weapons suite that includes an internal, pallet-mounted 30 mm side firing chain gun; wing-mounted, GPS-guided SDBs; and Griffin laser-guided missiles mounted internally and launched through the rear cargo door.
  - The PSP also provides two electro-optical/infrared sensor/laser designator pods and multiple video, data, and communication links.
  - A dual-console Mission Operator Pallet (MOP) in the cargo bay controls all PSP subsystems with remote displays and control panels (including master arm and consent switches and a gun trigger) on the flight deck. An interim, limited-functionality, carry-on flight deck workstation for a Combat Systems Officer has been added to the Block 10 AC-130J.
  - Block 20 AC-130J adds a 105 mm gun, laser-guided SDB, a side-mounted pilot tactical display, and Large Aircraft Infrared Countermeasures. The aircrew will increase

from seven to nine. The first Block 20 configuration was delivered on aircraft number 4 in July 2016.
  - Future updates are expected to include a permanent Combat Systems Officer station, wing-mounted HELLFIRE missiles, radio-frequency countermeasures (RFCM), all-weather engagement capability, and on a limited number of aircraft, a high-energy laser.
- The AC-130J retains all survivability enhancement features found on the MC-130J aircraft.
  - Susceptibility reduction features include the AN/ALR-56M radar warning receiver, the AN/AAR-47(V)2 missile warning system, and the AN/ALE 47 countermeasure dispensing system.
  - Vulnerability reduction features include fuel system protection (fuel tank foam to protect from ullage explosion), redundant flight-critical components, and armor to protect the crew and the oxygen supply.
- The AC-130J will replace legacy AC-130H/U aircraft.

Mission

The Joint Task Force or Combatant Commander will employ units equipped with the AC-130J to provide close air support and air interdiction using battlespace wide area surveillance, target geolocation, and precision munition application.

Major Contractor

Lockheed Martin – Bethesda, Maryland

Activity

- The 18th Flight Test Squadron conducted an OUE in accordance with the DOT&E-approved test plan of the Block 10 AC-130J from December 2015 to March 2016 to support an early fielding decision. USSOCOM has subsequently decided not to pursue early fielding of Block 10. Testing consisted of 18 sorties and 74 flight hours during the dedicated OUE period and accomplished approximately half of the operational test designs for the Griffin missile and the SDB. The remainder of the Griffin and SDB tests will occur in IOT&E.
- The OUE included cooperative cybersecurity testing of most of the PSP, but precision-guided munition subsystems and aircraft avionics and support systems were not part of the test, and DOT&E did not approve the cybersecurity test plan. The Block 20 AC-130J will undergo a full-aircraft CVPA and an Adversarial Assessment during IOT&E.
- Live fire tests during the OUE and follow-on developmental testing comprised the first phase of AC-130J weapons effectiveness testing. The 780th Test Squadron collected live fire data against operationally representative mannequin and vehicle targets to support lethality evaluation of the 30 mm gun and the Griffin missile. Block 20 testing will include additional Griffin engagements and characterization of the 105 mm gun.
- Lockheed Martin delivered the first Block 20 AC-130J to USSOCOM in July 2016 to begin developmental testing of new capabilities, such as the 105 mm gun. As of the end of FY16, the program received eight donor MC-130J for modification and produced four AC 130J. The first Block 10 AC 130J, which experienced a Class A mishap in FY15 rendering it non-flyable, will become an Air Education and Training Command training asset.
- Block 20 developmental testing began in July and includes additional flying and handling qualities tests to verify flight characteristics of the modified aircraft are consistent with technical data. The program expects to complete developmental testing in December 2016.
- Through a Memorandum of Agreement, USSOCOM Program Executive Office-Fixed Wing, Air Force Special Operations Air Warfare Center, 96th Test Wing, and 1st Special Operations Wing formed a Special Operations Combined Test Force to conduct AC-130J developmental testing in lieu of the traditional Air Force Materiel Command framework. Test team members and aircrew will come from 1st Special Operations Wing (1st Special Operations Group Detachment 2), 96th Test Wing (413th Flight Test Squadron), and Air Force Special Operations Air Warfare Center (18th Flight Test Squadron), depending on the nature of the test sortie.
- The Program Office submitted, and DOT&E approved, an updated Test and Evaluation Master Plan (TEMP) in July to support a Milestone C decision in September. The program updated the TEMP to include full-aircraft cybersecurity testing and phase two lethality testing of the Griffin missile and 105 mm gun as part of developmental and operational testing of the Block 20 AC-130J.
- The 18th Flight Test Squadron will conduct IOT&E on a Block 20 aircraft from March through June 2017 to support a Full-Rate Production decision in 1QFY18. IOT&E will complete the Griffin and SDB tests, add 105 mm gun and Laser Small Diameter Bomb (LSDB) testing, and repeat much of the 30 mm gun testing due to problems discovered in the OUE.
- The 780th Test Squadron, in coordination with DOT&E, has submitted the phase two weapons lethality test plan for the Griffin missile and 105 mm gun to the Combined Test Force for approval and execution. The plan includes four more Griffin missile engagements against static ground and maneuvering boat targets and 105 mm gun engagements against structures, personnel, technical vehicles, and lightly armored air defense vehicles.
- USSOCOM is developing an RFCM system for MC-130J and AC-130J under a separate Acquisition Category II program. A recent change in program strategy will implement and test

the system first on the AC-130J instead of the MC-130J, with RFCM IOT&E on an AC-130J scheduled for 4QFY18. The RFCM program plans a Milestone B decision and source selection in 1QFY17.
- The U.S. Air Force Combat Effectiveness and Vulnerability Analysis Branch expect to have completed the Ballistic Vulnerability Analysis, Anti-Aircraft Artillery Susceptibility Analysis, Proximity Burst Analysis, and Occupant Casualty Analysis by 2QFY17. These analyses are being conducted in accordance with the LFT&E Alternate Test Plan.

Assessment
- The Block 10 PSP demonstrated system immaturity during the OUE that diminished the usability of the system. The system entered operational testing with numerous open DRs, which required aircrews to use burdensome workarounds in order to conduct their missions. Almost none of the surveyed aircrew rated the system "usable" during the OUE.
  - The Block 10 AC-130J entered the OUE with 19 Category 1-Urgent and 60 Category 2-Urgent open DRs. Testing generated 10 additional Category 1-Urgent or Category 2-Urgent DRs. The program has since closed out 18 DRs, but only downgraded the severity of 6 Category 1-Urgent and 1 Category 2-Urgent DRs.
  - Nine Category 1-Urgent DRs remained open as of the OUE report covering the following problems:
    - MOP computers become overloaded and perform poorly or must be reset (two DRs).
    - Software does not update target coordinates frequently enough in some modes.
    - MOP hand controllers do not provide adequate control of the sensor or may allow accidental movement of the targeting sensor (two DRs).
    - Laser designator frequently does not fire, and settings may spontaneously change during editing (two DRs).
    - One of the aircraft radios interferes with the PSP GPS receiver.
    - Oxygen hoses are too short.
  - The Block 20 update is designed to address eight of the Category 1-Urgent DRs, which are currently under evaluation. The DR on GPS receiver interference remains open.
- The overall operating environment aboard the AC-130J also diminished PSP usability. Crews reported problems with night-vision goggle compatibility caused by MOP display screens, gun noise preventing hands-free communication on the intercom system, the temporary flight deck workstation laptop physically interfering with aircraft controls and displays, and a physically challenging aft-cabin environment due to the "roll-on" nature of the PSP creating multiple trip hazards and narrow passageways.
  - The test team submitted a Category 1-Urgent and a Category 2-Urgent DR regarding trip hazards in the cargo compartment where special mission aviators routinely carry high-explosive ammunition, but the material improvement project review board downgraded the Category 1-Urgent DR to Category 2-Urgent.
- Previously reported problems with the Block 10 PSP sensors appear to have been corrected as of the OUE and will be validated during IOT&E of Block 20. No un-commanded sensor movements occurred that were not attributable to allowing the sensor to pass through nadir.
- Block 10 flying and handling qualities testing showed no significant differences from basic C-130J performance as a result of the AC-130J modifications. An Air Force Materiel Command investigation into the Class A mishap on the first aircraft attributed the departure from controlled flight primarily to improper control inputs and test procedures.
- Although the OUE missions did not experience the same kind of complete shutdowns of MOP computers that crews observed during the operational assessment, operators still frequently reported software instability and poor computer performance during more complex tasks. Hardware and software upgrades on Block 20 MOP are intended to resolve these issues and will be evaluated during IOT&E.
- In single-weapon live-fire engagements during the OUE, the AC-130J successfully achieved nominal direct hits against two static and two moving targets with Griffin missiles and four static targets with SDBs using two different target coordinate systems.
  - Preliminary results from lethality analysis of the Griffin vehicle targets indicate mobility kills against a stationary truck and two moving trucks in both height-of-burst and point-detonate modes, which appear to correlate well with pre-test modeling and simulation; however, the level of incapacitation and effective distance of fragmentation against personnel appear to be lower than predicted by existing models.
- The OUE discovered problems with the 30 mm gun control system that affected its accuracy and are still under investigation. Preliminary results during Block 20 developmental testing indicate an upgraded gun tuning software has resolved the DR and both the 105 mm and 30 mm guns are performing within accuracy specifications.
  - Preliminary results from lethality analysis of the PGU-46/B 30 mm round against mannequin targets indicate that this round has limited effectiveness against personnel in the open on soft ground but is more effective against personnel on hard surfaces.
  - Data also indicate that lethality to personnel above a "soft" plywood roof is lower than predicted by existing models because the round detonated below the roof's surface; mannequins above a concrete roof incur more fragmentation damage than above a plywood roof.
  - USSOCOM has indicated that it may change the standard operational round for the 30 mm gun from PGU-46/B to PGU-13D/B for production reasons. If the operational round changes, the program will need to repeat the phase one lethality testing with the new round to characterize

its effectiveness in the LFT&E report required for the Full-Rate Production decision.

- The OUE did not adequately support DOT&E evaluation of the suitability of crew compartment armor because the crews did not install it during test flights for weight and balance reasons that will be remedied by the addition of the 105 mm gun in the rear of the aircraft. However, a ground demonstration indicates that crew compartment armor hinders crew egress in an emergency.
- Cybersecurity testing of the Block 10 PSP found vulnerabilities that are described in the classified CVPA report. The program expects to test and verify remediation of these deficiencies in April 2017 as part of the Block 20 CVPA.
- The mission success-based measure of Weapon System Reliability exceeded the Capabilities Production Document requirement of 82 percent during the OUE, but the AC-130J experienced hardware and software failures that diminished system effectiveness and limit the system's inherent availability.
- The AC-130J still does not satisfy two Key System Attributes from the Capabilities Production Document:
  - The program has not implemented a solution to provide flight deck crew a geo-rectified tactical display superimposed on the field of view. A side-mounted heads-up display next to the pilot station is planned for Block 20 and is expected in early FY17, but it is not yet available for developmental testing to ensure its readiness for IOT&E.
  - The AC-130J does not have a sensor system that enables adverse weather engagements by detecting and tracking targets obscured by weather, smoke and haze, or obscurants. Earlier efforts to integrate an AN/ASQ-236 radar pod were unsuccessful.
- The current test schedule leaves only 29 days between delivery of the developmental test and evaluation report and the start of IOT&E, with an operational test readiness review 22 days before IOT&E instead of the recommended 45 days. This raises the risk that any problem discoveries in developmental testing may delay the start of IOT&E or adversely affect the evaluation of the AC-130J.

Recommendations

- Status of Previous Recommendations.
  1. The program included the recommended lethality testing in the TEMP update for Milestone C, has conducted phase one lethality testing of the Griffin and 30 mm gun, and plans to conduct phase two lethality testing prior to IOT&E. However, a change in ammunition for the 30 mm gun will require a repeat of that portion of testing.
  2. The program briefed an updated baseline for block capability development and fielding at the June 2016 program management review, but it is not reflected in the Milestone C TEMP, and the test strategy for the new capability increments is unclear.
- FY16 Recommendations. The Program Office should:
  1. Correct, close, and verify all Category 1-Urgent DRs and as many Category 2-Urgent DRs as possible prior to IOT&E.
  2. Conduct additional 30 mm lethality testing using PGU-13D/B in time to support the Full-Rate Production decision if that round is likely to be employed in combat.
  3. Include a clear test strategy for future testing of the new capability increment baseline in the TEMP update for the Full-Rate Production decision.

AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM)

Executive Summary

- The Air Force and Navy completed FOT&E of the AIM-120D Advanced Medium-Range Air-to-Air Missile (AMRAAM) in July 2014 and fielded the system in January 2015.
- The Services completed operational test activities for the AIM-120D System Improvement Program (SIP)-1 in FY16. The results are pending. SIP-1 is one of several follow-on programs designed to enhance AIM-120D performance.
- The Services completed operational test activities for the AIM-120 AMRAAM Basic Electronic Protection Improvement Program (EPIP), a software upgrade to AIM-120C3-C7 variants, in FY16. Basic EPIP met its requirements.
- The Services began operational test activities for the AIM-120 AMRAAM Advanced EPIP, a software upgrade to the AMRAAM C-7 variant, in FY16.
- The Air Force and Navy are in the final stages of test planning to conduct cybersecurity testing for all variants of the AMRAAM missile.

System

- AMRAAM is a radar-guided, air-to-air missile with capability in both the beyond visual-range and within visual-range arenas. A single-launch aircraft can engage multiple targets with multiple missiles simultaneously when using AMRAAM.
- F-15C/D/E, F-16C/D, F/A-18C/D/E/F, EA-18G, and F-22A aircraft are capable of employing the AMRAAM, and the missile is currently being tested/fielded for employment on the F-35A/B/C.
- The AMRAAM program periodically develops and incorporates phased upgrades. The AMRAAM Basic EPIP is a software upgrade to AIM-120C3-C7. An Advanced EPIP software upgrade began operational testing in FY16.

Mission

- The Air Force and Navy, as well as several foreign military forces, employ various versions of the AIM-120 AMRAAM to conduct air-to-air combat missions.
- All U.S. fighter aircraft use the AMRAAM as the primary, beyond visual-range air-to-air weapon.

Major Contractors

- Raytheon Missile Systems – Tucson, Arizona
- Rocket Motor Subcontractor: Nammo (Nordic Ammunition Group) – Raufoss, Norway

Activity

- The Air Force and Navy conducted all testing in accordance with DOT&E-approved test plans.

AIM-120D

- The Services completed SIP-1 testing in FY16. Assessment of effectiveness and suitability is pending.
- SIP-2 operational test planning is in progress. Testing is scheduled to begin in FY17 and finish in FY18.

AMRAAM EPIP

- The Services completed operational testing for the Basic EPIP software upgrade to C-3 through C-7 missiles in FY16.
- Operational testing for the Advanced EPIP software upgrade to C-7 missiles began in FY16 and is expected to complete in FY17.

Cybersecurity

- The Air Force and Navy are in the final stages of test planning to conduct cybersecurity testing for all variants of the AMRAAM missile.

Assessment

- AMRAAM continues to be operationally effective and suitable.
- Based on FY15 testing, the AIM-120D SIP-1 missile appears to be meeting performance and reliability requirements, although a final assessment is pending.
- Missiles equipped with Basic EPIP software are meeting performance requirements.

Recommendations

- Status of Previous Recommendations. Although test planning and execution are ongoing, the Air Force has not yet satisfactorily addressed the previous FY15 recommendations to:
  - Complete SIP-2 and Advanced EPIP operational testing to achieve the Services' desired mission effectiveness improvements for AMRAAM.
  - Complete cybersecurity testing for all variants of the AMRAAM missile in accordance with the August 1, 2014, DOT&E policy memorandum.
- FY16 Recommendations. None.

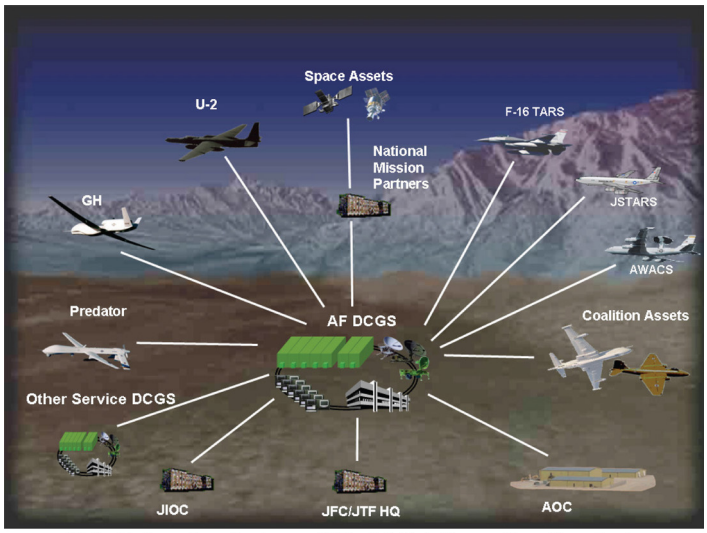
Air Force Distributed Common Ground System (AF DCGS)

Executive Summary

- The Air Force Distributed Common Ground System (AF DCGS) consists of eight Acquisition Category (ACAT) III programs. The Air Force plans to phase out the current architecture and move toward an open architecture. The Air Force is updating test and evaluation, systems engineering, and requirements documentation based on the open architecture.
- The Air Force Operational Test and Evaluation Center completed an Operational Utility Evaluation (OUE) of System Release (SR) 3.0 in September 2015. The test showed that the overall signal intelligence (SIGINT) performance is poor, and SR 3.0 did not significantly improve SIGINT performance. SR 3.0 is neither operationally suitable nor survivable against cyber threats.
- The Air Force 605th Test and Evaluation Squadron (TES) completed the second and third phases of the three-phased Force Development Evaluation (FDE) on the Geospatial Intelligence (GEOINT) Baseline (GB) 4.1 in November 2015 and April 2016, respectively. GB 4.1 added the ability to ingest new synthetic aperture radar data from Global Hawk Block 40. However, GB 4.1 did not significantly improve the Air Force GEOINT capabilities.

System

- The AF DCGS, also referred to as the AN/GSQ-272 SENTINEL weapon system, is an intelligence enterprise system that is composed of 27 geographically separated, networked sites, including 5 core sites across the globe.
- AF DCGS provides hardware and software tools for planning and direction, collection, processing and exploitation, analysis and dissemination (PCPAD) of intelligence, surveillance, and reconnaissance (ISR) information. The DCGS Integration Backbone provides the framework that allows sharing of ISR information with other military Services and intelligence agencies.
- The Air Force declared AF DCGS to be at Full Operational Capability in 2009 despite Air Force plans to continue system development.
- Currently, AF DCGS consists of eight ACAT III programs: Sensor Integration, GEOINT Transformation, GB 4.1, SIGINT Transformation, SR 3.0, Infrastructure Transformation, Multi-Intelligence, and DCGS Reference Imagery Transition (DRT).
- To date, only two of the eight programs have undergone operational testing: GB 4.1 and SR 3.0.
  - GB 4.1 is a GEOINT upgrade that includes deficiency corrections and the capability to process and exploit feeds from updated sensors such as the Airborne Cueing and Exploitation System – Hyperspectral. The GB 4.1 update also allows continued interoperability with the sensors on the Global Hawk Block 40.
  - SR 3.0 is a SIGINT upgrade, which makes SIGINT data and services available to internal and external users, improves operations with the Airborne Signals Intelligence Payload low-band sensor, and improves processing, exploitation, and dissemination for high-band sensors.
- The Air Force is in the process of transitioning AF DCGS to an open architecture system via an agile acquisition strategy. This transition is expected to take several years. The open architecture is designed to enable the Air Force to field modular upgrades and updates on a standardized infrastructure.



AOC - Air Operations Center
AWACS - Airborne Warning and Control System
GH - Global Hawk
HQ - Headquarters
JFC - Joint Forces Command
JIOC - Joint Intelligence Operations Center
JSTARS - Joint Surveillance Target Attack Radar System
JTF - Joint Task Force
TARS - Tactical/Theater Airborne Reconnaissance System

Mission

- The Air Force uses AF DCGS to plan sensor information requests and to produce intelligence information from data collected by a variety of sensors on the U-2, RQ-4 Global Hawk, MQ-1 Predator, MQ-9 Reaper, MC-12, and other ISR platforms.
- The Air Force uses AF DCGS to connect to the multi-Service DCGS Integration Backbone, manage requests for sensors, process sensor data, exploit sensor data from multiple sources, and disseminate intelligence products.

Major Contractors
- Raytheon – Garland, Texas
- Lockheed Martin – Denver, Colorado
- L-3 Communications – Greenville, Texas

Activity
- The Air Force Operational Test and Evaluation Center conducted the SR 3.0 OUE from September 10 to November 6, 2015. Testing was conducted in accordance with a DOT&E-approved test plan. DOT&E published a report on the test results on July 20, 2016.
- The 605th TES conducted Phase 2 of the three-phased GB 4.1 FDE from November 11 – 20, 2015, at Distributed Ground System (DGS)-2 and Phase 3 at DGS-1 from April 19 – 28, 2016. DOT&E reported on the results of the first phase of the FDE on November 23, 2015. The FDE was conducted in accordance with a DOT&E-approved test plan.
- The 605th TES conducted a high altitude mission workflow comparison test between the GEOINT Workflow Enhancement (GWE) and the GB 4.1 baseline (legacy) at DGS-X from March 28 – 30, 2016, to assess differences in the workflow of geospatial analysts.
- The 605th TES conducted GWE OUE from August 7 – 16, 2016, at DGS-1.

Assessment
- The Air Force does not have a test plan that integrates the eight ACAT III programs that comprise AF DCGS. This approach makes it difficult to determine if AF DCGS, as a whole, supports mission success. DOT&E is working with the Air Force to integrate test events. The integrated evaluation plan will be documented in the TEMP.
- The program lacks rigorous and comprehensive software problem tracking and reporting procedures. The Air Force is working to develop and implement the software tracking and reporting process.
- AF DCGS continues to have challenges executing PCPAD of GEOINT.
  - GB 4.1 did not deliver significant new capabilities other than the ability to work with Global Hawk Block 40 sensors.
  - Full motion video continues to have problems with freezing and degraded images. Full motion video analysts continue to rely on software that is not a part of AF DCGS.
  - The 605th TES observed problems creating secondary image products (images with analyst's annotations) in the GB 3.0 system and these problems continue in GB 4.1. A GEOINT exploitation tool called Softcopy Exploitation Tool – Geospatial Exploitation Products (SOCET GXP) occasionally creates secondary image products with corrupted metadata and metadata fields. When this happens, operators have to completely rebuild the secondary image product.
  - GB 4.1 continues to have problems with mission planning. In Phase 3 of the GB 4.1 FDE, some mission sets were not compatible with the external tasking service, forcing operators to manually complete mission planning.
  - Training and documentation continues to be problematic. In Phase 2 of the GB 4.1 FDE, for instance, 50 percent of general system administrators reported that documentation did not support maintenance duties. The test team reported that operators were using old checklists and had not been trained on the GB 4.1 system upgrades.
  - DOT&E will evaluate the GEOINT capability using the data from the GB 4.1 FDE and GWE OUE.
- The SR 3.0 OUE showed that the overall SIGINT performance was poor. Only a small percentage of collectable SIGINT was accurately reported.
  - SR 3.0 processing and exploitation software did not add significant operational value to the onboard processing and exploitation provided by the Airborne Signals Intelligence Payload on Global Hawk.
  - SR 3.0 reliability, availability, and maintainability were poor and negatively affected performance; SR 3.0 availability was 33 percent versus the required 98 percent.
  - SR 3.0 is not survivable against cyber-attacks.
- The 46th Test Squadron conducted a cybersecurity assessment of AF DCGS GEOINT 4.1 at DGS-X March through June 2015 and reported vulnerabilities. The Air Force is working on completing the Plan of Actions and Milestones (POA&M) to mitigate the vulnerabilities. DOT&E will work with the Air Force to maintain an accurate and timely cybersecurity POA&M.

Recommendations
- Status of Previous Recommendations. The Air Force satisfactorily addressed, or made satisfactory process towards implementing, six of the nine previous recommendations. The three recommendations still pending are:
  1. Submit a Test and Evaluation Master Plan (TEMP) for DOT&E approval, which includes an accurate description of AF DCGS requirements, architecture, and interfaces sufficient to justify the test approach. The Program Office is making good progress, but the TEMP is not yet approved.
  2. Develop and implement a software change request process including tracking of software metrics for problems open and closed by severity and time.
  3. Document all known cyber vulnerabilities and plan for mitigation in a POA&M and track the progress.
- FY16 Recommendations. None.

Air Operations Center – Weapon System (AOC-WS)

Executive Summary

- The Air Operations Center – Weapon System (AOC-WS) 10.1 is a system of systems that incorporates third-party software applications, to enable its mission execution.
- In October and November 2015, the Air Force conducted an assessment of Out-of-Cycle (OOC) 13.1 at Combined Air Operations Center – Experimental (CAOC-X).
  - OOC 13.1 was found to be not operationally effective due to three Category I deficiencies.
  - Resolution of the Category I deficiencies was scheduled to be accomplished in OOC 13.3 in November and December 2016; however, the Defense Information Systems Agency (DISA) failed to provide the Program Management Office with viable updates.
  - OOC 13.1 was found to be operationally suitable, and there were no significant cybersecurity findings.
  - The AOC Configuration Review Board (CRB) has recommended fielding OOC 13.1 despite the Category I deficiencies in order to meet other warfighter capability requirements.
- In February 2016, the Air Force conducted an assessment of OOC 13.2 at CAOC-X.
  - OOC 13.2 was found to be operationally effective and suitable, but one portion of software content introduced four Category II cybersecurity deficiencies. The Air Force removed the non-secure content from the delivery, deferring fielding until the four deficiencies are resolved.
  - The CRB approved fielding of OOC 13.2 in conjunction with the fielding of OOC 13.1, since its implementation requires a successful OOC 13.1 installation.
- AOC-WS 10.2 failed to complete a second round of developmental testing and the associated operational assessment activities.
  - The test was canceled at the half-way point due to the number and severity of deficiencies identified.
  - The program is now proceeding through a Critical Change Review.

System

- The AOC-WS 10.1 (AN/USQ-163 Falconer) is a system of systems that incorporates numerous software applications developed by third-party vendors and commercial off-the-shelf products. Each third party system integrated into the AOC-WS provides its own programmatic documentation.
- The AOC-WS consists of:
  - Commercial off-the-shelf hardware
  - Software—including Theater Battle Management Core Systems – Force Level and Master Air Attack Plan Toolkit—to enable planning, monitoring, and directing the execution of air, space, and cyber operations

  - Third-party software applications—including Global Command and Control System – Joint (GCCS-J) and Joint Automated Deep Operations Coordination System—to enable joint and interagency integration
  - Additional third-party systems that accept, process, correlate, and fuse command and control data from multiple sources and share them through multiple communications systems
  - Voice, digital, and data communications hardware
- AOC-WS 10.1 operates on several different local area networks (LANs), including the Secret Internet Protocol Router Network, Joint Worldwide Intelligence Communications System, and a coalition LAN, when required. The LANs connect the core operating system and primary applications to joint and coalition partners supporting the applicable areas of operation. Users can access web-based applications through the Defense Information Systems Network.
- The Air Force typically tests major functionality upgrades to AOC-WS 10.1 during a three-phased Recurring Event (RE) test cycle, which includes event-based test periods primarily focused on software upgrades. The three phases of the RE test cycle typically includes:
  - Phase 1: Developmental testing conducted at the CAOC-X located at Joint Base Langley-Eustis, Virginia.
  - Phase 2: Operational testing conducted at CAOC-X to assess effectiveness.
  - Phase 3: Operational testing conducted at a fielded site to assess suitability.
- Testing of lower level, minor functionality upgrades, with assessment of "operational processes," are integrated with the latter portions of developmental testing. For these minor functionality upgrades (as opposed to purely cybersecurity

updates or maintenance-type upgrades), the Air Force uses the term OOC for their testing; i.e. OOC 13.1.
- The future upgrade, AOC-WS 10.2, is designed to deliver a modernized, integrated, and automated approach to AOC operations.
- Command and Control Air Operations Suite-Command and Control Information Services (C2AOS-C2IS) is a software developmental program to upgrade critical AOC-WS mission software, enhancing the ability of operators to perform AOC core tasks more quickly and efficiently, as well as providing new planning and execution capabilities for integrated air and missile defense and net-enabled weapons.

Mission
- The Commander, Air Force Forces or the Joint/Combined Forces Air Component Commander uses the AOC-WS to exercise control of joint (or combined) air forces, including planning, directing, and assessing air, space, and cyberspace operations to meet operational objectives and guidance.
- The AOC is the senior command and control element of the Air Force's Theater Air Control System and provides operational-level command and control of joint and combined air, space, and cyberspace operations. The AOC's capabilities include command and control of joint theater air and missile defense; preplanned, dynamic, and time-sensitive multi-domain target engagement operations; and intelligence, surveillance, and reconnaissance operations management.

Major Contractors
- AOC-WS 10.1 Production Center: Jacobs Technology Inc., Engineering and Technology Acquisition Support Services – Hampton, Virginia
- AOC-WS 10.2 Modernization: Northrop Grumman – Newport News, Virginia

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Activity
- In October and November 2015, the Air Force conducted operational testing of AOC-WS 10.1 OOC 13.1 in accordance with the DOT&E-approved test concept briefing and test plans. The primary focus of OOC 13.1 was to upgrade GCCS-J from version 4.2.0.9U2 to version 4.3U1. This upgrade of GCCS-J also required compatibility updates to the Joint Automated Deep Operations Coordination System and Theater Battle Management Core Systems.
- In February 2016, the Air Force conducted operational testing of AOC-WS 10.1 OOC 13.2 in accordance with the DOT&E-approved test concept briefing and test plans. The objectives of OOC 13.2 were to improve the AOC-WS' cybersecurity posture by closing over 200 Category II open deficiencies, upgrading the Master Air Attack Plan Toolkit, adding a Microsoft® active directory users and computer console (ADUC), and upgrading the Airspace Management Application.
- In April 2016, the Air Force completed its reports on OOC 13.1 and OOC 13.2. Both reports included data from integrated testing at CAOC-X.
- In August 2016, the AOC CRB recommended fielding OOC 13.1 and OOC 13.2 because GCCS-J 4.3U1, despite its deficiencies, is a better product than the currently fielded GCCS-J 4.2.0.9U2. The CRB made this decision because DISA failed to deliver a viable update to GCCS-J 4.3U1 that can be integrated into the OOC 13.3 to address OOC 13.1's Category I deficiencies.
- In February and March 2016, AOC-WS 10.2 failed to complete the second of two scheduled phases of developmental testing at CAOC-X. These failures occurred after contractor remediation actions taken as a result of Cure Notices issued in September 2014 and September 2015. A Cure Notice is a letter from the government to the contractor regarding concerns about poor performance in accordance with contract requirements. The severity and quantity of the functional and cybersecurity deficiencies identified during the first half of developmental testing resulted in the cancelation of the remaining developmental test events and planned operational assessment activities. Currently, the program is conducting a Critical Change Review.
- In June and July 2016, the Air Force conducted early developmental testing on several C2AOS-C2IS capability packages. These and subsequent developmental test events are precursors to integrating all the capability packages into a single software release that will be integrated into the AOC-WS baseline and then undergo IOT&E.

Assessment
- The Air Force adequately tested AOC-WS 10.1 OOC 13.1 and OOC 13.2 with an assessment of operational processes during integrated developmental/operational test events.
- OOC 13.1 was found to be not operationally effective due to three open Category I deficiencies against third-party software that affect AOC operations in two critical ways:
  - No acceptable public key infrastructure-enabled user authentication capability, which is required for access to GCCS-J integrated imagery and intelligence applications.
  - Due to the excessive track clutter that results in an unusable common operational picture (COP) display, operators are unable to monitor and assess electronic warfare threats. In addition, there is insufficient source information to enable COP managers to resolve these track clutter problems.
- Initially, OOC 13.1 was found to be operationally suitable with limitations. The upgrade could not be conducted without extensive Tier 2 Help Desk direct onsite interaction with the build team. However, subsequent software supplements and

improved build documentation resolved the issues, improving the assessment to operationally suitable.
- A cybersecurity evaluation of OOC 13.1 resulted in no significant findings and concluded that the results from RE13 (completed in August 2015) remain valid. However, the OOC 13.3 test concept includes a full Cooperative Vulnerability and Penetration Assessment of the OOC 13.1 functional capabilities along with the OOC 13.3 upgrades and fixes, and should provide an updated assessment of the baseline cybersecurity posture.
- OOC 13.2 was found to be operationally effective and suitable. During testing, four Category II cybersecurity deficiencies associated with ADUC increased the risk to the AOC-WS baseline. Consequently, the Air Force removed ADUC from OOC 13.2 until the deficiencies can be resolved, targeting ADUC for incorporation into RE15. Additionally, since OOC 13.2 cannot be implemented without the successful installation of OOC 13.1, its fielding was delayed while the Air Force attempted to resolve the OOC 13.1 issues.
- Air Combat Command initially decided not to field OOC 13.1 until the Category I deficiencies are fixed. Resolution of the Category I deficiencies was scheduled to be accomplished in OOC 13.3 in November and December 2016; however, DISA failed to provide the Program Management Office with viable updates. Therefore, despite the Category I deficiencies, the AOC CRB recommended fielding OOC 13.1, along with OOC 13.2, beginning in September 2016. These would enable delivery of upgraded capabilities to meet other warfighter operational requirements. Resolution of OOC 13.1 deficiencies are planned to be delivered as part of RE15, scheduled to be tested in April and May 2018.
- The key to successful testing and fielding of AOC-WS 10.1 continues to be close collaboration between the AOC-WS Program Office and the providers of third-party applications to ensure those applications meet the operational and cybersecurity needs of the AOC. Early AOC-WS tester involvement in third-party testing continues to be necessary to identify critical problems for early corrective action.

Recommendations
- Status of Previous Recommendations. The Air Force has made progress on one FY15 recommendation by developing and testing software updates that close cybersecurity vulnerabilities. However, the more secure software has not yet been deployed because of operational deficiencies, and new deficiencies have been identified with third-party software. The Air Force still needs to address the FY15 recommendations to improve dynamic cyber defensive capabilities focused on detecting and responding to cyber-attacks against the AOC-WS, and to reassess the Help Desk-enabling concept to support the build process. Additionally, the Air Force still plans to address a long-standing requirement to collect and report reliability, availability, and maintainability (RAM) data to the Program Office and DOT&E by implementing a technical RAM collection solution in the modernization increment, AOC-WS 10.2.
- FY16 Recommendations. None.

B-2 Defensive Management System Modernization (DMS-M)

Executive Summary

- In FY16, the Air Force developed a revised acquisition and test strategy for the B-2 Defensive Management System Modernization (B-2 DMS-M) program in support of an acquisition Milestone B decision. DOT&E approved the B-2 DMS-M Milestone B Test and Evaluation Master Plan (TEMP) in October 2015. USD(AT&L) approved program entry into the engineering, manufacturing, and development (EMD) phase on March 24, 2016.
- Contractor design activities are in progress, leading to a system-level critical design review in early FY17. Planning is in progress to modify a single B-2 test aircraft with new system components in FY17 to support installed system testing in the Benefield Anechoic Facility (BAF) at Edwards AFB, California. Developmental flight tests will begin in FY18, leading to an Air Force Operational Test and Evaluation Center (AFOTEC) operational assessment in FY19 and IOT&E in FY20.
- Beginning in FY17, the DOD Electronic Warfare Infrastructure Improvement Program (EWIIP) will deliver improved test range capabilities that are highly relevant to B-2 DMS-M operational testing. It is essential that the B-2 DMS-M program incorporate these improved threat representations, as they become available, into planned developmental and operational flight test events.
- The development of AFOTEC modeling and simulation (M&S) validation plans for the B-2 Weapons Support and Sustainment Center (WSSC) facility and related M&S tools is a critical early test planning requirement. Clear definition and approval of operational test M&S validation data requirements – in advance of planned FY18 BAF risk-reduction testing – is required to ensure efficient use of this early test opportunity.

System

- The B-2 is a two-pilot, long-range, air-refuelable, all-weather bomber aircraft designed to employ both nuclear and non-nuclear precision-guided weapons. It incorporates stealth technologies to reduce radar cross section and minimize electronic, infrared, acoustic, and visual signatures.
- B-2 mission systems include a GPS-aided precision navigation system, strategic radar targeting system, electronic support measures, and worldwide communications and data transfer systems.
- The B-2 can carry up to 50,000 pounds of munitions in internal bomb bays. Current weapons capabilities include a wide range of both nuclear and non-nuclear precision-guided munitions.

- The B-2 DMS-M upgrades include a digital electronic support measures (ESM) subsystem, new ESM antennas, and modern display processing units to improve threat radar detection, identification, and avoidance capabilities. Associated software components integrate these upgraded systems with existing B-2 avionics systems to improve overall pilot threat awareness, threat reaction, and survivability.

Mission

- Theater Commanders primarily use B-2 bomber aircraft to accomplish worldwide nuclear and conventional missions intended to find, fix, target, engage, and assess heavily defended, high-value targets located in denied adversary airspace.
- B-2 theater mission tasks include strategic attack, time-sensitive targeting, air interdiction, suppression/destruction of enemy air defenses, and nuclear deterrence.

Major Contractor

Northrop Grumman Aerospace Systems – Redondo Beach, California

Activity

- In FY16, the Air Force developed a revised acquisition and test strategy for the B-2 DMS-M program in support of an acquisition Milestone B decision. DOT&E approved the B-2 DMS-M Milestone B TEMP in October 2015. USD(AT&L) approved program entry into the EMD phase on March 24, 2016. The approved program schedule includes a Milestone C Low-Rate Initial Production decision in FY19, followed by IOT&E and the Full-Rate Production decision in FY20.
- Contractor design activities are in progress, leading to a system-level critical design review in early FY17. Following design approval, the program plans to conduct extensive hardware-in-the-loop laboratory and digital simulation risk reduction testing. Planning is in progress to modify a single B-2 test aircraft with new system components in FY17 to support installed system testing in the BAF at Edwards AFB, California. Developmental flight tests will begin in FY18, leading to an AFOTEC operational assessment in FY19 and IOT&E in FY20.
- The approved Air Force operational test strategy includes evaluation of B-2 defensive system performance in the open-air test range environment, leveraging new adversary threat system emulation capabilities provided by the EWIIP. The AFOTEC strategy also includes an extensive digital M&S component to evaluate performance in more advanced threat environments. AFOTEC is currently developing validation and verification plans necessary to support accreditation of the B-2 WSSC laboratory and other tools for operational test purposes.

Assessment

- The approved B-2 DMS-M TEMP defines a highly integrated developmental and operational test strategy that includes open-air test range missions as the most critical component. Beginning in FY17, EWIIP will deliver improved test range capabilities that are highly relevant to B-2 DMS-M operational testing. It is essential that the B-2 DMS-M program incorporate these improved threat representations, as they become available, into planned developmental and operational flight test events to support an adequate evaluation of operational effectiveness and suitability.
- Development of AFOTEC M&S validation plans for the B-2 WSSC facility and related M&S tools is a critical early test planning requirement. Clear definition and approval of operational test M&S validation data requirements, in advance of planned FY18 BAF risk-reduction testing, is required to ensure efficient use of this early test opportunity.
- Due to operational priorities and the small B-2 fleet size, the B-2 DMS-M program must rely on a single test aircraft to support the entire 3-year developmental and operational ground and flight test program. Reliance on a single test asset significantly increases schedule execution risk. Limited test asset availability will also require close coordination between developmental and operational test organizations to meet program test requirements and schedule milestones.
- Previous B-2 operational test periods have incorporated only limited cybersecurity vulnerability and adversarial assessments. The B-2 DMS-M TEMP defines a more extensive cybersecurity test strategy comprised of progressive test events leading to a full IOT&E assessment of system-level cybersecurity status. Detailed planning and execution of this strategy is a critical IOT&E requirement.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY16 Recommendations. The B-2 Program Office and AFOTEC should:
  1. Coordinate B-2 DMS-M M&S validation and verification plans with DOT&E in advance of the planned installed system testing in BAF scheduled for FY17. These plans should also include validation data requirements to be collecting during integrated flight test events planned to begin in FY18.
  2. Coordinate with DOT&E to incorporate more advanced threat scenarios, based on new EWIIP threat emulation capabilities, into integrated test events and operational flight test plans.

Battle Control System – Fixed (BCS-F)

Executive Summary

- The Air Force completed a Force Development Evaluation (FDE) to evaluate operational effectiveness; interoperability; operational suitability; impact on tactics, techniques, and procedures; and cybersecurity postures on the Battle Control System – Fixed (BCS-F) Increment 3, Release 3.2.3 (R3.2.3) at all U.S. air defense sites in April 2016.
- BCS-F R3.2.3 is still not survivable against potential cyber-attacks despite the Air Force's efforts to resolve critical cybersecurity deficiencies.
- The BCS-F R3.2.3 has operational effectiveness deficiencies in system track management and datalink operations. The operators are able to use workarounds to mitigate these deficiencies to an acceptable level.
- The BCS-F R3.2.3 is operationally suitable with deficiencies in:
  - System maintenance documentation
  - Training program on system operations and maintenance
  - Lack of cybersecurity policies
  - Lack of program life cycle management policies and plan (i.e. Help Desk management, maintenance and repairs reporting, and spares management)
- All U.S. air defense sites were utilizing R3.2.3 in April 2016. Upon completion of the FDE, the Air Force formally fielded R3.2.3.

System

- BCS-F is the tactical air surveillance and battle management command and control system for the continental U.S. and Canadian air defense sectors (ADS)—Eastern ADS, Western ADS, Canadian ADS—of the North American Aerospace Defense Command (NORAD), the NORAD Alaska Regional Air Operations Center (RAOC), and U.S. Pacific Command's (PACOM) Hawaii RAOC.
- The system utilizes commercial off-the-shelf hardware within an open-architecture software configuration and operates within the NORAD and PACOM air defense architecture.
- The BCS-F R3.2.3 software upgrade includes the following system enhancements:
  - Increases maximum sensor and radar processing capacity, from 200 to 300 sensors
  - Fixes for 12 cybersecurity deficiencies previously identified
  - Updates to the air defense sector site radar parameters
  - Fixes for the operations display and the graphical user interface
  - Upgrades to the Internet Protocol converter/radar interface

- Also, the BCS-F R3.2.3 upgrade provided the following changes to system sustainment:
  - A software development/logistics support transition from contractor to government (520 Software Maintenance Squadron)
  - Updated Technical Order and System Manual documentation
  - Updated system training materials
- BCS-F R3.2.3 was designed to include the capability to interface with and process data from a sensor in the Wide Area Surveillance (WAS) program.
  - Due to WAS' lack of readiness, the Air Force did not conduct operational testing of WAS with BCS-F R3.2.3, but will evaluate sensor integration during operational testing of BCS-F R3.2.4.

Mission

- The Commander, NORAD and Commander, PACOM use BCS-F to execute command and control and air battle management to support air sovereignty and air defense missions for North American Homeland Defense and PACOM air defense.
- Air defense operators employ BCS-F to conduct surveillance, identification, and control of U.S. sovereign airspace and control air defense assets, including fighters, to intercept and identify potential air threats to U.S. airspace.

Major Contractor

Raytheon Systems – Fullerton, California

Activity

- From November 2015 through April 2016, the 605th Test and Evaluation Squadron conducted FDE on BCS-F R3.2.3 at all U.S. ADSs in accordance with a DOT&E-approved Test and Evaluation Master Plan and test plan.

- Upon completion of the FDE, the Air Force formally fielded R3.2.3. All U.S. ADSs were utilizing BCS-F R3.2.3 by April 2016.
- Canadian Air Defense Forces operationally accepted R3.2.3 in June 2016.

Assessment

- BCS-F R3.2.3 resolved 22 deficiencies in operational effectiveness and suitability associated with battle management and support operations.
  - These deficiencies were discovered during previous Increment 3.2 (R3.2, R3.2.0.1, R3.2.2) operational testing events.
  - Developmental testing and FDE of BCS-F R3.2.3 revealed 45 new deficiencies associated with battle management and support operations.
  - Operational testing of BCS-F R3.2.3 revealed two significant effectiveness deficiencies in system track management and two significant deficiencies in datalink operations.
  - Operator workarounds mitigated these deficiencies to an acceptable level.
- Although the Air Force did not collect sufficient operational test data to demonstrate the availability and reliability requirements with statistical confidence, BCS-F R3.2.3 is assessed as maintainable and reliable.
  - During 1,134.68 hours of testing, BCS-F R3.2.3 experienced 7 minutes of downtime in order to troubleshoot two system failures (a Category I and a Category II) at NORAD's Eastern ADS. This resulted in an operational availability of 99.99 percent (the 80 percent confidence interval is 99.79 to 99.99 percent).
  - Due to a lack of effective life-cycle management policies and plan, accurate data to assess overall system availability and reliability were not available.
  - BCS-F R3.2.3 was maintainable for routine maintenance actions, but the observed Mean Time Between Corrective Maintenance Action (MTBCMA) of 17 hours did not meet the requirement of 100 hours. This was not a critical shortfall since the maintenance actions had no negative effect on operations or operator workload.
  - After further analysis of maintenance activity, two types of maintenance actions were identified: Critical Field Repair and Non-Critical Field Repair.
  - A Critical Field Repair is assessed when a fault, failure, or malfunction results in the loss of any system's mission essential function as specified in the mission essential system list. Also, a critical failure includes greater than 10 percent of operator workstations becoming inoperative. A failure is not considered critical if mission operations are restored within 2 minutes.
  - MTBCMA for Critical Field Repair Actions (2 failures) was 211 hours and MTBCMA for Non-Critical Field Repair Actions (76 failures) was 17 hours.
  - In order to better understand system maintainability, future assessments may require separating Critical and Non-Critical MTBCMA measurements and identifying appropriate threshold requirements for each.
- While BCS-F R3.2.3 is operationally suitable, technical documentation and training for the system remains deficient. These deficiencies include:
  - System maintenance documentation
  - Training program on system operations and maintenance
  - Lack of cybersecurity policies
  - Lack of program life-cycle management policies and plan (i.e. Help Desk management, maintenance and repairs reporting, and spares management)
- Since only minor cybersecurity fixes were included in BCS-F R3.2.3, DOT&E assesses R3.2.3 remains deficient in all cybersecurity assessment areas. The system is poorly equipped to protect, detect, react, and restore/recover from attacks by current cyber threats, despite the fact that BCS-F R3.2.2 was designed to resolve many critical cybersecurity deficiencies. To address previously identified deficiencies, the Air Force implemented the Computer Network Defense Service Provider (CNDSP) agreement in 1QFY15. However, the Air Force has not conducted a cybersecurity assessment of BCS-F since the CNDSP was implemented.

Recommendations

- Status of Previous Recommendations. The Air Force satisfactorily addressed three of the previous recommendations. The Air Force still needs to:
  1. Correct and formalize all BCS-F Increment 3 system documentation and training deficiencies.
  2. Develop a plan for remote workstation management to include sustainment, training, documentation, and cybersecurity compliance.
  3. Upgrade the System Support Facility to support a more robust BCS-F developmental and operational testing capability in order to minimize the impact of overall testing at the operational air defense sector sites.
  4. Improve reliability to meet the threshold requirement for MTBCMA.
  5. Re-assess system cybersecurity vulnerabilities and correct identified cybersecurity deficiencies.
  6. Re-evaluate BCS-F survivability against cyber-attacks after the CNDSP has been implemented.
  7. Ensure appropriate policies, procedures, and tools exist for system administrators to effectively detect unauthorized intrusions.
- FY16 Recommendations. The Air Force should:
  1. Correct system operational effectiveness deficiencies.
  2. Correct and formalize all BCS-F R3.2.3 system operations and maintenance documentation, policy, and training deficiencies.
  3. Update the system threat assessment report for BCS-F.

CV-22 Osprey

Executive Summary

- Air Force Special Operations Command (AFSOC) conducted CV-22 testing to evaluate Tactical Software Suite (TSS) 20.2.02/20.2.03, which is a compilation of software and hardware packages.
- The Mission Computer Obsolescence Initiative (MCOI) upgrade portion of TSS allowed pilots to use MCOI-compatible planning tools to create and load mission plans into the aircraft systems.
- Both pilots and maintainers commented that the training provided for MCOI was not sufficient and more was required.
- The Color Helmet-Mounted Display (CHMD) system degraded pilot situational awareness during both day and night flights and was not reliable.
- The Generation 5 radios did not provide an improvement to CV-22 communications capabilities and did not resolve workload problems.

System

- The CV-22 is the AFSOC variant of the V-22. It replaced Special Operations Forces MH-53 helicopters in 2008. The tilt-rotor design provides the speed and range of a conventional fixed-wing aircraft and vertical take-off and landing capabilities of a helicopter.
- The CV-22 has terrain-following/terrain-avoidance radar, an advanced multi-frequency radio communication suite, an integrated electronic defense suite, and aerial refueling capability, allowing it to augment the AFSOC MC-130 fleet.
- The CV-22 electronic defensive suite includes the Suite of Integrated Radio Frequency Countermeasures (SIRFC) and the Directional Infrared Countermeasures (DIRCM) system with the AAR-54 Missile Warning Sensor, Small Laser Transmitter Assembly jammer, and the ALE-47 Countermeasure System capable of dispensing both flares and chaff. The Dedicated Electronic Warfare Display provides an integrated threat picture to the crews from SIRFC and DIRCM.

- The CV-22 can carry 18 combat-ready Special Operators 538 nautical miles and return. It can self-deploy up to 2,100 nautical miles with one aerial refueling.
- The Advanced Ballistic Stopping System (ABSS) is an optional protective armor kit that CV-22 squadrons can install for certain mission scenarios. The ABSS kit weighs 825 pounds.
- Bell-Boeing has delivered 51 of 52 purchased aircraft which includes one combat loss and one training loss. The final aircraft is expected to be delivered by the end of 2016.

Mission

Commanders employ AFSOC squadrons equipped with the CV-22 to provide high speed, long-range insertion and extraction of Special Operations Forces to and from high-threat objectives.

Major Contractors

- Bell-Boeing Joint Venture:
  - Bell Helicopter – Amarillo, Texas
  - The Boeing Company – Ridley Township, Pennsylvania
- The Protective Group, Inc. – Miami Lakes, Florida

Activity

- AFSOC's Operational Test Squadron, the 18th Flight Test Squadron (FLTS), conducted operational testing on the CV-22 TSS 20.2.02/20.2.03, which is a compilation of software and hardware upgrades, between October 1, 2015, and February 19, 2016. The 18th FLTS conducted the testing in accordance with the DOT&E-approved test plan.
- The 18th FLTS evaluated the updated TSS, which includes MCOI upgrades, JVX [Joint Services Advanced Vertical Lift Aircraft] Application System Software (JASS), a CHMD system, a Generation 5 AN/ARC 210 radio, and MCOI-compatible mission planning tools. The MCOI brings increased processor speed and capacity, will be included as the standard mission computer in all new-build V-22 aircraft, and will eventually be retrofitted into all V-22s. This testing updated the findings on the TSS 20.2.01 deficiencies reported in FY15.
- The Joint Live Fire test program completed supplemental testing of the ABSS armor in July 2016. The testing evaluated one additional threat type, additional obliquity angles, edge performance, and installed armor performance. This

additional testing was in response to gaps identified with the initial testing performed in 2014.
- AFSOC completed a portion of the upgraded SIRFC software version 8 tests in February through March 2015 at China Lake and the Nevada Test and Training Range to address CV-22 SIRFC active countermeasure deficiencies. AFSOC completed the remaining testing of the SIRFC software in October 2015.
- The Air Force's 46th Test Squadron in cooperation with the 18th FLTS conducted a Cooperative Vulnerability and Penetration Assessment of CV-22 cybersecurity protections and vulnerabilities in September 2016. This testing included the first investigations of Military Standard 1553 data bus cybersecurity on any V-22 aircraft. The data and results from this testing will be available in FY17.

Assessment
- The CHMD Color Display Day Module degraded CV-22 pilots' situational awareness and was not reliable during testing.
- The CHMD Color Display Night Module degraded CV-22 pilots' situational awareness while they were operating in brightly illuminated areas such as populated shorelines and urban areas.
- Pilots commented that they did not receive sufficient training on CHMD use and that they needed more training flights using the CHMD.
- CV-22 pilots were able to use the MCOI-compatible mission planning tools to create mission plans and load them onto the CV-22 aircraft systems. Pilots reported that the requirement to manually load hazard data was time-consuming, cumbersome, and increased mission-planning time by up to an hour.
- CV-22 maintenance personnel commented that they were not provided sufficient training to troubleshoot or repair the new MCOI mission computer.
- The Generation 5 radios did not provide an improvement to CV-22 communications capabilities and did not resolve workload problems identified in IOT&E.
- During TSS testing, operational test pilots reported frequent faults in the Icing Protection System (IPS).
  - AFSOC examined their fleet-wide data on the IPS, which revealed a mean time between failure of 37 hours for the period of March 2015 to February 2016. Availability of the fully-capable IPS systems across AFSOC was 43 percent with the highest availability among those units who have the highest potential for flight in icing conditions.
  - IPS failures affect other aircraft components. For example, 15 percent of failures charged to proprotor blades were caused by failure of IPS components on the blade. Poor IPS reliability increases sustainability costs and affects CV-22 employment in known or suspected icing. It can cause safety-of-flight issues if inadvertent icing is encountered.
  - Low availability/reliability of the IPS is a change from performance observed in 2013 IPS tests and could affect CV-22 suitability.
- Preliminary findings indicate the ABSS armor demonstrated better coupon performance than the 2014 testing. Aircraft shielding enhances the armor's performance and mitigates previously identified problems.
- Preliminary data analyses suggest that the active countermeasure component of the SIRFC 8.02 system did not address the subsystem deficiencies. Consistent with previous results, the subsystem does not meet most survivability requirements.
- AFSOC will publish the cybersecurity test results and analysis in FY17.

Recommendations
- Status of FY15 Recommendations. The Navy completed operational testing of SIRFC and conducted the recommended live fire testing.
- FY16 Recommendations. The Navy and AFSOC should:
  1. Investigate the causes of poor performance and reliability failures of the CHMD, reduce the time required to load mission data, improve maintenance training for MCOI maintainers, and continue efforts to improve air-to-ground communications.
  2. Investigate IPS reliability and determine if additional design changes are needed to increase IPS availability and reduce CV-22 supportability costs.

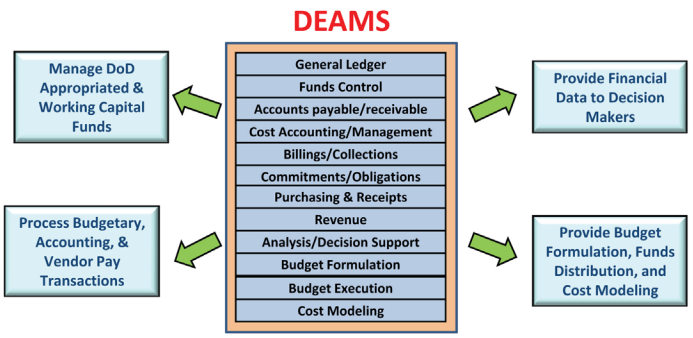
Defense Enterprise Accounting and Management System (DEAMS)

Executive Summary

- In accordance with a September 30, 2015, Acquisition Decision Memorandum, the Air Force Operational Test and Evaluation Center (AFOTEC) conducted a Verification of Fixes (VoF) test on the Defense Enterprise Accounting and Management System (DEAMS). AFOTEC planned to conduct the VoF test at four bases with the participation of three Air Force Major Commands, three U.S. Combatant Commands, and the Defense Finance and Accounting Service (DFAS), from January 4 – 29, 2016. However, the Program Executive Officer (PEO) stopped the VoF test after two bases (Scott AFB and Keesler AFB), when the data indicated that multiple Key Performance Parameters (KPPs) could not be met.
- The VoF test demonstrated that DEAMS remains not operationally effective and not operationally suitable. In the area of effectiveness, DEAMS Increment 1 did not effectively perform several critical accounting and management tasks, four of which were KPPs. DEAMS suitability issues included configuration management and usability as users continue to avoid using DEAMS to conduct financial analysis and reporting.
- DEAMS remains not survivable in the expected cybersecurity threat environment. Following IOT&E, the Program Management Office (PMO) conducted limited cybersecurity testing. From November 18 – 19, 2015, a cybersecurity test team conducted an event to assess three cybersecurity fixes. The team conducted this test on the live network in the pre-production environment, and verified that only one of the three fixes was successful. Subsequent cybersecurity testing demonstrated that another cybersecurity fix was successful on a single server in the DEAMS enclave. However, the cybersecurity deficiency still existed on two other servers in the enclave, indicating that the PMO's processes and procedures to prevent recurrence of cybersecurity problems are not yet adequate.

System

- DEAMS Increment 1 is a Major Automated Information System that uses commercial off-the-shelf Enterprise Resource Planning software to provide accounting and management services.
- The DEAMS Increment 1 PMO is following an evolutionary acquisition strategy that adds additional capabilities and users incrementally. There are six scheduled releases. The Air Force anticipates over 15,000 users worldwide will use DEAMS by the end of the increment.
- DEAMS Increment 1 is intended to improve financial accountability by providing a single, standard, automated financial management system that is compliant with the Chief Financial Officers Act of 1990 and other mandates. DEAMS Increment 1 performs the following core accounting functions:
  - Core Financial System Management
  - General Ledger Management
  - Funds Management
  - Payment Management
  - Receivable Management
  - Cost Management
  - Reporting



- DEAMS interfaces with approximately 40 other systems that provide travel, payroll, disbursing, transportation, logistics, acquisition, and accounting support.
- DEAMS supports financial management requirements in the Federal Financial Management Improvement Act of 1996 and DOD Business Enterprise Architecture. Therefore, DEAMS is a key tool for helping the DOD to have its financial statements validated as ready for audit by the end of FY17 as required by the National Defense Authorization Act for FY10.

Mission

Air Force financial managers and tenant organizations use DEAMS Increment 1 to do the following across the Air Force, U.S. Transportation Command, and other U.S. component commands:

- Compile and share accurate, up-to-the-minute financial management data and information
- Satisfy Congressional and DOD requirements for auditing of funds, standardizing of financial ledgers, timely reporting, and reduction of costly rework

Major Contractor

Accenture Federal Services – Dayton, Ohio

Activity

- In accordance with a September 30, 2015, Acquisition Decision Memorandum, AFOTEC conducted a VoF test on DEAMS. AFOTEC planned to conduct the VoF test at four bases with the participation of three Air Force Major Commands, three U.S. Combatant Commands, and DFAS, from January 4 – 29, 2016. However, the PEO stopped the VoF test after two bases (Scott AFB and Keesler AFB), when the data indicated that multiple KPPs could not be met. Therefore, AFOTEC completed testing at only two of the four test locations.
- In preparation for the VoF test, the Army Research Laboratory at White Sands Missile Range, New Mexico, supported the PMO in conducting a limited cybersecurity Cooperative Vulnerability and Penetration Assessment at Maxwell AFB – Gunter Annex, Alabama.
- The Joint Interoperability Test Command (JITC) completed a DEAMS Increment 1 interoperability evaluation in August 2016.
- AFOTEC conducted the VoF test in accordance with the DOT&E-approved Test and Evaluation Master Plan and the test plan.

Assessment

- DEAMS Increment 1 remains not operationally effective and not operationally suitable. DEAMS Increment 1 did not effectively perform several critical accounting and management tasks, four of which were KPPs. Some key effectiveness findings from the IOT&E and VoF test are as follows:
  - DEAMS does not provide an accurate balance of available funds to meet the KPP requirement. During the VoF test, only 62 percent (33 out of 53) of the balance queries were accurate, versus a 98 percent requirement.
  - DEAMS continues to have problems with interoperability with other systems, which contribute to the poor accuracy results discussed above. According to the August 2016 JITC interoperability report, four critical interfaces did not meet criteria due to timeliness problems which have a moderate to major impact on interoperability with two critical interfaces: the Centralized Disbursing System and Departmental Cash Management System.
  - Users continue to rely on the Commanders' Resource Integration System and other legacy systems for reporting instead of using the DEAMS Discoverer tool. Oracle Business Intelligence Enterprise Edition (OBIEE), the DEAMS replacement for Discoverer, has provided improved reporting capabilities on other programs (e.g., Defense Agencies Initiative), but challenges remain for implementation of OBIEE.
  - Transaction backlog continues to be a major problem with DEAMS. Transaction backlogs decreased during the summer of 2015, but increased in the fall and remained substantially above the low point seen during the previous months. At the start of the VoF test, the transaction backlog was near 20,000 transactions.
  - In both the IOT&E and VoF, the transaction backlog was a major contributor to the inadequate performance of DEAMS. The transaction backlog causes a transaction to take longer than normal to post on the General Ledger, which in turn causes inaccuracies in DEAMS reports, to include the Status of Funds.
  - Depending upon the type of backlogged transaction, an un-posted transaction can result in interest penalty payments on aged transactions, affecting timely decision-making and requiring additional manpower for DFAS staff to process backlog transactions.
- Numerous high-severity incident reports, deficiencies, and system change requests (SCRs) remain. The numbers of Severity 2 and 3 defects and SCRs are noted in Table 1 (Severity 2 problems adversely affect DEAMS and do not have a sustainable work around, while Severity 3 problems adversely affect DEAMS but have a sustainable work around). Of the 114 unresolved defects reported by the DEAMS Functional Management Office as of July 2016, 55 (48 percent) were over 8 months old. Of the 318 SCRs reported as of July 2016, 217 (68 percent) were over 8 months old.

Table 1: Defects and SCRs from prior to and after VoF

	November 2015	July 2016
Severity 2 Defects	52	34
Severity 3 Defects	174	68
Severity 2 System Change Requests (SCRs)	52	96
Severity 3 SCRs	204	186

- The DEAMS PMO is not following its own configuration management procedures, which prescribe rigorous developmental and regression testing prior to fielding new software releases. The PMO sharply reduced developmental and regression testing starting in August 2014 to meet a fixed deployment schedule. This led to the fielding of defective software; this software is likely a major contributor to the backlog problems that continue to affect DEAMS users. DEAMS regression testing has recently increased to cover close to 60 percent of the business processes. The PMO should implement regression scripts to test all critical interfaces in DEAMS.
- Where it is possible to do so, users continue to avoid using DEAMS to conduct financial analysis and reporting. For example, Keesler AFB users export DEAMS data to spreadsheets to perform analyses and reporting rather than use corresponding DEAMS functionality. Additionally, PMO data from the months of September and October 2015 indicate that users generated Status of Funds reports less than once per week on average per user. These reports are critical to end-of-month and fiscal year-end closeouts; therefore, these data indicate that most of the approximately 11,000 DEAMS

users are using legacy systems instead of DEAMS to evaluate fund status.

- DEAMS remains not survivable in the expected cybersecurity threat environment. Following IOT&E, the PMO conducted limited cybersecurity testing. From November 18 – 19, 2015, a cybersecurity test team conducted a limited event to assess three cybersecurity fixes. The team conducted this test on the live network in the pre-production environment, and verified that only one of the three fixes was successful. Subsequent cybersecurity testing demonstrated that another cybersecurity fix was successful on a single server in the DEAMS enclave. However, the cybersecurity deficiency still existed on two other servers in the enclave. This indicates that the PMO's processes and procedures to prevent recurrence of cybersecurity problems are not yet adequate. However, the PMO instituted improved cybersecurity processes by adding the cybersecurity problems to the deficiency management system for visibility and action, instituted dedicated cybersecurity patch releases, and reprioritized all cybersecurity findings for correction or risk acceptance.

Recommendations

- Status of Previous Recommendations. The Program Office did not satisfy the FY15 recommendations to:
  1. Correct balance accuracy defects in accordance with KPP requirements and demonstrate progress towards DEAMS Increment 1 achieving full auditability.
  2. Identify and implement processes, procedures, and software improvements to clear the transaction backlog to fix the lag time between transaction and posting of transaction, and to ensure accurate and timely reporting.
  3. Conduct regression testing to improve DEAMS Increment 1 performance and identify potential interface problems before fielding software updates and releases.
  4. Provide DEAMS Increment 1 training that prepares users to effectively employ DEAMS Increment 1 upon fielding.
  5. Work with AFOTEC to conduct follow-on operational testing to verify that the deficiencies have been corrected and that the new reporting tool is operationally effective, suitable, and survivable, once corrections have been made and a new reporting tool has been fielded.
- FY16 Recommendations. The DEAMS Program Manager should:
  1. Cease allowing DEAMS to be schedule-driven and delay DEAMS deployments, until the PMO fixes the backlog of high-severity deficiencies and shows that the system works properly during operationally realistic testing.
  2. Determine the root causes of the transaction backlogs and other anomalies that have appeared since the fielding of deficient software in August 2014 and make a concerted effort to clear remaining backlogs.
  3. Conduct FOT&E with a pilot set of users, prior to further deployments, to confirm DEAMS is operationally effective, operationally suitable, and survivable.
  4. Complete integration and testing of the OBIEE reporting tool and demonstrate effectiveness through operational testing to allow the retirement of Discoverer and fielding of OBIEE.
  5. Develop necessary regression testing scripts to ensure that all critical DEAMS interfaces are adequately tested.
  6. Complete mitigation of all cybersecurity vulnerabilities.

E-3 Airborne Warning and Control System (AWACS) Block 40/45

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed the IOT&E for the E-3 Airborne Warning and Control System (AWACS) Block 40/45 Modification during 2010. DOT&E and AFOTEC evaluated the system as operationally effective but not operationally suitable. Key deficiency areas included reliability and training. In addition, the Block 40/45 ground-based and deployable support systems were not available and operational testing of these elements was deferred to the FOT&E.
- The E-3 Block 40/45, designated E-3G, modifications include incremental updates to the business-grade commercial mission computing systems in the aircraft, ground support systems, and application software to address diminishing manufacturing resources, correction to deficiencies identified through testing and operational use, and to add enhancements. AFOTEC used E-3G hardware version l.0 for IOT&E and version 3.0 for some FOT&E events. The Air Force has fielded both versions.
- The Air Force conducted the following test events:
  - E-3G FOT&E began during 4QFY15, in accordance with the DOT&E-approved Test and Evaluation Master Plan, with the collection of suitability data on the version 3.0-configured E-3G aircraft.
  - Cold weather operational testing during 2QFY16.
  - A cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) and a comparative operational assessment of maritime surveillance and tracking in 3QFY16.
  - An operational deployment and observation of the deployed performance and suitability of the E-3 Block 40/45 and Deployable Ground System during a Red Flag Large Force Exercise in 4QFY16.
- Observations and emerging results from these events indicate that Block 40/45 version 3.0 with mission computing software version 11.1 has deficiencies related to multi-source track integration, maritime tracking, cybersecurity vulnerabilities, and software reliability.
- The Air Force halted completion of FOT&E during the Operational Test Readiness Review largely due to adverse pretest predictions provided by AFOTEC. Instead, AFOTEC was requested to observe employment during a Red Flag Exercise and provide feedback on required improvements to prepare for FOT&E.

System

- E-3 AWACS is built on a Boeing 707 airframe. The AWACS crew employ a surveillance radar and Identification Friend or Foe (IFF) system located in the rotodome above the airframe. Additionally, the E-3 AWACS' communications suite includes ultra high frequency, very high frequency, high frequency radios, satellite communications; and Link 16 and Link 11 tactical datalinks. The E-3 AWACS Block 30/35 upgrade included an Electronic Support Measures (ESM) system – passive detection of electronic signals – mounted on the cheeks of the airframe, under the nose, and in the tail.

- The Block 40/45 upgrade, designated the E-3G, replaces the mission computing system with open-architecture, commercial off-the-shelf hardware including servers and 15 mission crew interactive operator workstations. Also, the Block 30/35 Air Operations Computer Program has been replaced by the Block 40/45 mission computing software program; a set of local area networked, open architecture programs. The human-computer interface is built on the Windows operating system and licenses the Raytheon Solipsys Tactical Display Framework.
- The E-3G's mission computing system provides the capability to automatically fuse all on- and off-board sensor inputs to provide a single track for each air, sea, and land entity using a multi-sensor integration algorithm. The upgrade is also intended to provide:
  - An update to the E-3 AWACS Link 16 and satellite communications capabilities
  - Software to automatically refresh the onboard database
  - An updated mission system health monitoring tool
  - Improved interfaces and controls of the onboard ESM system
  - Improved mission planning and post-mission processing capabilities
- Also, the E-3G upgrade will include a deployable ground support system to enable deployed crews to conduct mission planning and post mission processing with a central data processing center for data storage and retrieval.

- The first six Block 40/45 E-3s are planned to have three different mission computing configurations. The Air Force plans to use the configuration of the seventh Block 40/45 E-3 to upgrade the next 11 jets.
- The AWACS Block 40/45 requires several new ground support systems, including the mission planning system, which the contractor delivered with the first upgraded aircraft. The contractor delivered a deployable mission planning system in support of Initial Operational Capability and trainers for maintenance personnel and mission crew.
- The Air Force is developing new communications and combat identification capability upgrades for the E-3 AWACS that will require integration with E-3G's mission computing system, the human-computer interface software, or both. These upgrades will improve and enhance data communications capabilities; tactical datalink management; and surveillance and identification operations.

Mission

Joint/Combined Forces Air Component Commanders use AWACS-equipped units to:

- Provide airborne early warning, airborne air surveillance and identification, air operations battle management, and beyond line-of-sight capabilities.
- Provide command and control of offensive and defensive counter-air and counter-sea operations, and strike missions including dynamic targeting, close-air support, suppression of enemy air defenses, and strategic attack.
- Manage air refueling operations, combat search and rescue missions, and special operations missions.

Major Contractor

Boeing Corporation – Seattle, Washington

Activity

- The Air Force did not conduct any developmental testing for Block 40/45 hardware configuration version 3.0. There are no dedicated test E-3 aircraft or government laboratories. DOT&E and AFOTEC leveraged operational and training flights from the 552nd Air Control Wing to collect data and were provided dedicated aircraft and aircrew by the 552nd Air Control Wing for the maritime tracking test.
- AFOTEC started suitability data collection with the first operational E-3G version 3.0 during 4QFY15 and will continue through 4QFY16 until the required mission computing operating hours are collected.
- During 2QFY16, AFOTEC conducted a cold weather suitability assessment with the deployment to Eielson AFB, Fairbanks, Alaska. The test was incomplete due to non-Block 40/45-related airframe and surveillance radar failures, which prevented take-off for the planned operational mission. Consequently, the elapsed time for bringing the Block 40/45 mission computing system on-line after a cold weather take-off, could not be measured.
- During 3QFY16, the Air Force conducted a CVPA of E-3G version 3.0 and supporting mission planning, software verification, and training ground systems to assess the system's performance in the presence of a realistic cyber threat.
- During 3QFY16, AFOTEC, with support of the 552nd Air Control Wing, conducted a test over the Gulf of Mexico to characterize E-3G maritime surveillance tracking performance. The comparative test employed a legacy E-3 Block 30/35 and an E-3G version 3.0 conducting surveillance of the same overwater track production area.
- AFOTEC observed and collected data during a 3-week hot weather (daytime temperatures in excess of 110 degrees Fahrenheit) deployment to a Red Flag Large Force Exercise conducted from Nellis AFB, Nevada. To assess operational employment, this test included two E-3G version 3.0 aircraft and Deployable Ground Support System version 3.0—downsized system with more computing capacity—to provide mission planning, rehearsal, and post-mission recording review.
- The Air Force Program Executive Officer (PEO) did not certify the system as "ready for Follow-On Operational Test and Evaluation (FOT&E)" after AFOTEC highlighted deficiencies observed during IOT&E and other events that had not been resolved. The PEO requested AFOTEC utilize the data collected during the Large Force Exercise Red Flag 16-3 to identify deficiencies to be corrected prior to any re-planned FOT&E of Block 40/45.

Assessment

- Observations and emerging results from the FY16 tests indicate that the E-3G version 3.0 has difficulty in combining various on- and off-board sensor data into a coherent single track on a consistent basis. Analysis of air and maritime and ESM sensors to assess and characterize current system performance for single track is ongoing.
- DOT&E could not collect data on E-3G mission computing start time and operating capability during cold weather operations due to aircraft mission cancellations. Additionally, the Deployable Ground System was not available to be deployed to the cold weather operating base. This metric remains unresolved.
- Based on the data collected during the 3-week cybersecurity vulnerability test, the E-3G version 3.0 and supporting Block 40/45 ground systems are highly vulnerable to cyber threats and not survivable.
- Block 40/45 tracking of sensed maritime objects, ships, and platforms, is less effective than the predecessor Block 30/35

aircraft, although both systems demonstrated deficiencies compared to truth data supplied by the Coast Guard.
- The E-3G version 3.0 hardware reliability trend indicates it may meet the post-IOT&E revised threshold requirement for hardware mean time between failure. System deficiency reports and software performance are being reviewed and compared with the revised threshold requirement for software reliability. The ESM sub-system, which experienced some hardware and software modification for Block 40/45, is not reliable due to a combination of legacy, built-in test false alarm, and Block 40/45 problems.
- Insufficient cooling resulting in Deployable Ground System version 1.0 overheating and failure was a critical deficiency identified during the operational deployment to the Caribbean Sea. In contrast, the Deployable Ground System version 3.0 performed well while deployed to Nellis AFB for the Red Flag Exercise and relying on room-modified, dedicated air conditioning ducts. It experienced only one required reboot during the 3-week deployment.
- The E-3G demonstrated several operational deficiencies during Red Flag Large Force Exercise, including inaccurate track quality data processing and inconsistent IFF response displays to the operator.
- Due to the program deficiencies and the PEO's decision to not certify AWACS Block 40/45 as "ready for FOT&E," AWACS Block 40/45 is delayed approximately 2 years while the program manager works to develop resolutions.

Recommendations
- Status of Previous Recommendations: The Air Force has satisfactorily addressed one of the previous recommendations. The Air Force still needs to:
  1. Complete and update aircrew and maintenance checklists and technical orders to address the new failure modes discovered during IOT&E.
  2. Modify the mission computing software and refine technician training to reduce the incidence of induced critical failures during Block 40/45 mission computing startup.
  3. Develop software modifications to improve aircrew ability to control the automated tracking capability.
  4. Review and update the planned training syllabus for both aircrew and maintenance personnel with information learned during the IOT&E.
  5. Conduct FOT&E of Block 40/45 using the first Block 40/45 configuration that will be installed on more than two aircraft. The FOT&E should include an operationally representative deployment in a stressful tracking and combat identification environment.
- FY16 Recommendations. The Air Force should:
  1. Identify the Block 40/45 mission computing hardware and software for E-3G aircraft and ground configurations for the new FOT&E and update the Test and Evaluation Master Plan accordingly to include a description of the planned verification of correction of deficiencies.
  2. Plan to conduct a second CVPA and a cybersecurity Adversarial Assessment as part of the new FOT&E.
  3. Plan to test the integration of new E-3 developmental communications and combat identification capabilities, including Next Generation IFF interrogation system, E-3 AWACS Radar Electronic Protection, Internet Protocol Enabled Communications, Combat Identification (also known as System R), and Communications Network Upgrade, with the Block 40/45 mission computing system and Primary AWACS Display (as appropriate) as part of the FOT&E.
  4. Plan to complete the test of mission computing during cold weather employment.

F-22A Advanced Tactical Fighter

Executive Summary

- F-22A Update 5 combines an aircraft Operational Flight Program (OFP) software suite upgrade providing radar enhancements and Ground Collision Avoidance System software with the integration of limited AIM-9X Block 1 air-to-air missile capabilities. The Air Force Air Combat Command completed a Force Development Evaluation (FDE) of these capabilities in 1QFY16, and the operationally effective system was fielded to F-22A units. Full AIM-9X Block 1 and Block 2 integration will be completed in F-22A Increment 3.2B.
- F-22A Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM-120D and AIM-9X missile systems; an Enhanced Stores Management System (ESMS) for weapons integration and employment improvements; Intra-Flight Data Link (IFDL) improvements and electronic protection enhancements; improved emitter geolocation capability; and a Common Weapon Employment Zone for air-to-air missile employment.
  - Increment 3.2B developmental testing experienced delays in FY15 due to additional unplanned regression testing for earlier Increment 3.2A and Update 5 OFP software development efforts and related competition for limited developmental test resources.
  - Increment 3.2B developmental testing continued throughout FY16 but experienced delays due to software stability and performance shortfalls.
    - In-flight cockpit display blanking and ESMS functionality deficiencies resulted in flight safety operating restrictions, and required additional unanticipated OFP software releases and regression testing. Consequently, the planned Air Force Milestone C decision slipped from March to August 2016.
    - At Milestone C, the Air Force authorized the procurement of 35 of 71 planned hardware kits through low-rate initial production (LRIP). The Air Force does not plan to procure the remaining LRIP kits until it confirms progress in resolving the deficiencies noted in FY16.
    - Flight testing through September 2016 showed improvement with cockpit display stability; however, ESMS deficiencies persisted in the software OFP. As of the end of FY16, investigative efforts had not fully ruled out the possible need for system hardware design changes.
  - Given the limited development progress in FY16, it is unlikely that Increment 3.2B developmental testing will complete as planned at the end of April 2017, or that IOT&E will begin as planned in August 2017.

System

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

Diameter Bomb integration. Increment 3.1 is currently fielded in operational F-22A units.
- Increment 3.2A is a software-only upgrade providing improved electronic protection, Link 16 Receive, and combat identification capabilities. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record and is currently fielded in operational F 22A units.
- Update 5 combines an OFP upgrade providing software driven radar enhancements, Ground Collision Avoidance System software, and the incorporation of limited AIM-9X capabilities. Update 5 OFP FDE testing completed in 1QFY16. The Update 5 OFP is currently fielded in operational F-22A units.
- Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM-120D and AIM-9X missile systems; an ESMS for weapons integration and employment improvements; IFDL and electronic protection enhancements; improved emitter geolocation capability; and integration of a Common Weapon Employment Zone for air-to-air missiles employed by the F-22A. The Increment 3.2B IOT&E is currently planned for 4QFY17.

Mission

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

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity
- The Air Force conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and Update 5 FDE plan.
- Air Force Air Combat Command completed an FDE of the Update 5 OFP software suite in 1QFY16. Operational flight testing was executed in three phases: assessments of new capabilities and tactics, techniques, and procedures (TTP) development; missionized scenarios to evaluate Update 5 capabilities and assess/refine derived TTPs in a tactical environment; and live fire weapons employment of the AIM-9X. Update 5 capabilities were fielded to operational F-22A units in FY16.
- Increment 3.2B developmental testing continued throughout FY16 but experienced delays due to software stability and performance shortfalls. The Air Force-planned Milestone C decision slipped from March to August 2016. At Milestone C, the Air Force authorized the procurement of 35 of 71 planned hardware kits through LRIP.

Assessment
- The F-22 Update 5 OFP software suite enhancements and limited AIM-9X Block 1 integration are operationally effective. Full AIM-9X Block 1 and 2 missile integration remains to be tested in Increment 3.2B IOT&E. Update 5 further corrected some of the software deficiencies noted in FY15 Increment 3.2A operational testing.
- F-22 Increment 3.2B developmental testing revealed flight safety and system performance shortfalls and experienced delays due to software stability in FY16.
  - The program experienced in-flight cockpit display blanking occurrences for which root cause fault analysis in still ongoing. Flight testing through September 2016 showed improvement with cockpit display stability.
  - The Increment 3.2B ESMS functionality as tested through the end of FY16 did not ensure proper weapons bay door and missile launcher positions, resulting in uncommanded and uncontrollable weapons bay door positions and cycling in f1ight. As with the display blanking problem, ESMS door shortfalls led to additional flight safety restrictions.
    - ESMS deficiencies persisted in the software OFP version flown through the end of September 2016. At the end of FY16, investigative efforts had not yet ruled out the possible need for system hardware design changes. Due to these problems, modification of the remaining three operational test aircraft was delayed until 1QFY17.
    - Delayed modification of the entire nine-aircraft test fleet hinders the program's ability to conduct four-ship test missions, which are needed to vet key Increment 3.2B capabilities and complete developmental testing within the scope of the Air Force's schedule.
  - Although the program has demonstrated some elements of each of the combat capability candidates in laboratory and flight testing, as of the end of September 2016 numerous performance shortfalls exist across the scope of the intended enhancements, and a substantial volume of developmental testing remains to be accomplished.
- The DOT&E November 2015 FOT&E report highlighted F-22A software reliability and performance problems realized in the F-22A Increment 3.2A software suite. In that report, DOT&E cautioned that F-22 modernization efforts risked potentially unacceptable software reliability and associated performance shortfalls unless the Air Force focused concerted efforts on software reliability improvements. Thus far, Increment 3.2B performance and reliability had not shown such improvements.

- F-22A modernization increments and development schedules remain tightly coupled, with little margin for unanticipated regression testing and correction of critical deficiencies when discovered in operational testing. To date, Increment 3.2B developmental testing has experienced several delays due to additional unplanned regression testing for Increment 3.2A and Update 5 OFP efforts in 2015, competition for limited test resources, and problems with Increment 3.2B display blanking and ESMS. These factors contributed to a delayed Increment 3.2B Milestone C decision. Given the limited development progress in FY16, it is unlikely that associated developmental testing will complete as planned at the end of April 2017, or that IOT&E will begin as planned in August 2017.
- In FY15, DOT&E highlighted that integration of the AIM-120D weapon model into the Advanced Combat Simulator (ACS) presented a risk to the Increment 3.2B program's ability to begin scheduled FY17 IOT&E on time. In FY16, delivery of the Raytheon AIM-120D model to Lockheed Martin for incorporation into the ACS remained a risk to the currently planned IOT&E schedule.
- In FY16, the Air Force initiated action to establish a comprehensive strategy for evaluating the cybersecurity vulnerabilities of the F-22 weapon system across the span of projected modernization efforts. Specific strategy details remain to be incorporated into forthcoming F-22 modernization efforts.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address previous recommendations; avionics stability shortfalls remain to be evaluated in the scope of Increment 3.2B IOT&E.
- FY16 Recommendations. The Air Force should:
  1. Correct performance deficiencies and software anomalies associated with Increment 3.2B before proceeding to IOT&E.
  2. Reassess the Increment 3.2B development schedule based on the risks of successful completion due to performance shortfalls realized to date, and ensure the program has adequate resources to complete and deliver the capabilities required by the Air Force with the avionics stability necessary for these capabilities to be operationally effective and suitable.
  3. Continue to improve F-22A avionics software stability to support operational mission execution needs.
  4. Ensure the adequacy of the force structure and schedule margins necessary to support F-22A modernization efforts.

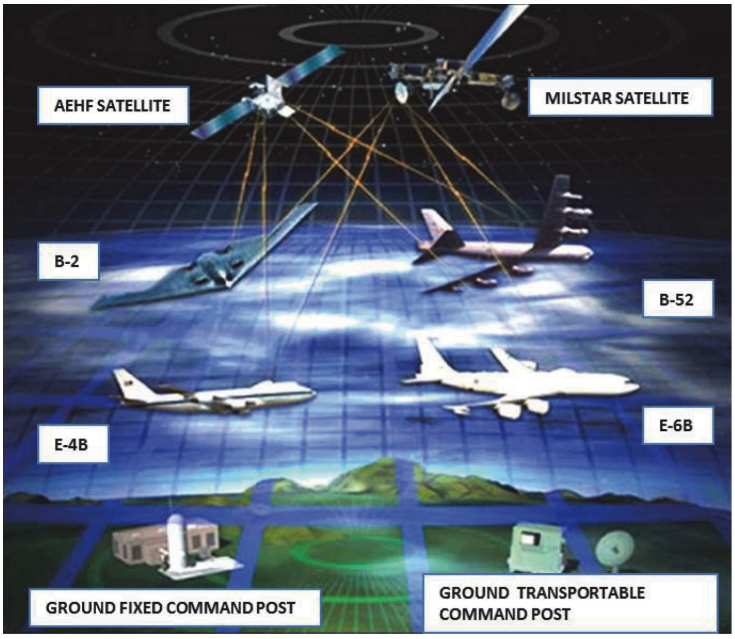
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)

Executive Summary

- On July 16, 2016, USD(AT&L) approved the procurement of 12 antenna modification kits for installation with the Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Command Post Terminals (CPTs). These modification kits are in addition to the 10 antenna modification kits USD(AT&L) authorized in September 2015 for low-rate initial production. The additional modification kits allow the program to keep in synchronization with airborne depot maintenance schedules and fielding of Initial Operational Capabilities.
- The Air Force's 46th Test Squadron (46 TS) conducted Nuclear Command, Control, and Communications (NC3) developmental testing from March 8 – 11, 2016, with 2 FAB-Ts and 13 cooperating Extremely High Frequency (EHF) terminals.
- The FAB-T Program Office conducted system-level functional qualification testing on the ground-transportable terminal antenna from February through March 2016. The program manager plans to conduct environmental qualification testing on the ground-transportable antenna from September through December 2016.
- The IOT&E has slipped from 4QFY17 to 1QFY18 due to delays in developmental testing and the lead time needed to integrate production-representative terminals required for the operational test at user ground-fixed sites and in ground-transportable platforms.
- The Airborne CPT (ACPT) demonstrated low reliability in the FY15 operational assessment (OA), and if not improved, increases risk to the DOD's Airborne Command Post ability to command and control strategic networks when needed. The program manager updated the reliability growth plan based on the FY15 OA results and OSD staff comments; however, the majority of reliability tracking hours occur after the planned IOT&E. Additionally, the preponderance of the planned hours for the ACPT originate from system integration labs that are not operationally representative of the dynamics experienced in an aircraft. The non-representative environment is unlikely to reveal additional terminal failure modes and may result in additional failure modes being discovered in the IOT&E or during operations.

System

- FAB-T consists of ground and aircraft communication terminals with two terminal types—CPTs and Force Element Terminals (FETs). FAB-T is part of the terminal and control segments of the Advanced EHF (AEHF) satellite system and is designed to operate with AEHF Low Data Rate (75 – 2,400 bits per second (bps)) and Extended Data Rate (up to 8.192 Megabits per second) waveforms.



- The CPT is intended to replace existing airborne (E-4B and E-6B), ground-fixed, and ground-transportable Milstar CPTs. The CPT will include satellite and network control functions, end-user telecommunication device interfaces, and the ability to operate the terminal from a distant location using a remote node.
- The FET is intended to be installed in airborne force elements (B-2, B-52, and RC-135). The FET is a program requirement but is currently neither funded nor on contract for development and production.

Mission

- The President, the SECDEF, Combatant Commanders, and supporting Air Force component forces will use FAB-T to provide strategic nuclear and non-nuclear command and control with EHF, wideband, protected, and survivable communications terminals for beyond line-of-sight communications.
- U.S. Strategic Command will use the FAB-T to perform satellite telemetry, tracking, and commanding functions for the AEHF constellation, including management of the satellites, communication networks, and cryptologic keys.

Major Contractor

Raytheon Net-Centric Systems – Marlborough, Massachusetts

Activity

- During the 2015 OA, the ACPT demonstrated a Mean Time Between Critical Failure of 131.2 hours against a threshold requirement of 665 hours.
- The program manager is executing the developmental test program in accordance with the DOT&E-approved Test and Evaluation Master Plan in preparation for the planned IOT&E.
- At the September 1, 2015, Milestone C decision review, USD(AT&L) directed the program manager to work with DOT&E, the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation, and the Deputy Assistant Secretary of Defense for Systems Engineering to determine the appropriate amount of reliability growth testing for the next phase of the program. The October 26, 2015, Acquisition Decision Memorandum tasked the program manager to deliver a plan to USD(AT&L) within 60 days for achieving and verifying the stated reliability requirements.
- The contractor developed Block-2 software and completed software qualification testing in December 2015. Block-2 software is designed to provide FAB-T the capability to perform satellite control functions.
- The 46 TS conducted NC3 developmental testing from March 8 – 11, 2016, with 2 FAB-Ts and 13 cooperating EHF terminals. The NC3 developmental testing employed FAB-T Engineering Development Model terminals.
- The 46 TS conducted an initial satellite control developmental test dry run using an Engineering Development Model terminal from April 4 – 8, 2016, at 4th Satellite Operations Squadron (4 SOPS) on Schriever AFB, Colorado. The program manager discovered integration problems and terminal function anomalies when integrating the satellite control terminal at 4 SOPS in preparation for initial satellite control developmental testing. The program manager postponed the test event pending resolution of integration problems and system anomalies. The program manager resolved the problems and conducted the initial satellite control test from September 8 – 9, 2016.
- The FAB-T Program Office conducted system-level functional qualification testing on the new ground-transportable terminal antenna from February through March 2016. The program manager plans to conduct environmental qualification testing on the ground-transportable antenna from September through December 2016.
- The contractor is developing a new airborne terminal antenna to replace the modified legacy antenna to improve reliability. The program manager plans to conduct environmental qualification testing on the new airborne antenna from September through December 2016.
- On July 16, 2016, USD(AT&L) approved the procurement of 12 antenna modification kits for installation with FAB-T CPTs. These modification kits are in addition to the 10 antenna modification kits USD(AT&L) authorized in September 2015 for low-rate initial production. The additional modification kits allow the program to keep in synchronization with airborne depot maintenance schedules and fielding of Initial Operational Capabilities.

Assessment

- The ACPT demonstrated low reliability in the FY15 OA and, if not improved, increases risk to the DOD's Airborne Command Post ability to command and control strategic networks when needed. The program manager updated the reliability growth plan based on the FY15 OA results and OSD staff comments; however, the majority of reliability tracking hours occur after the planned IOT&E. Additionally, the preponderance of the planned hours for the ACPT originate from system integration labs that are not operationally representative of the dynamics experienced in high-performance aircraft. The non-representative environment is unlikely to reveal additional terminal failure modes and may result in additional failure modes being discovered in the IOT&E or during operations. An Air Force-approved FAB-T reliability plan is still in development and has not been submitted to USD(AT&L).
- The 46 TS's NC3 developmental testing used tester personnel as operators and FAB-T terminals that were not production representative. The testing emulated operational networks and demonstrated interoperability between EHF terminals anticipated to operate in NC3 networks. The NC3 developmental testing provided initial risk reduction and problem identification but needs to be more operationally realistic to provide data for operational test use. The Program Office plans additional NC3 developmental testing in 2QFY17 using production-representative terminals to further reduce the risk of poor IOT&E performance and to achieve U.S. Strategic Command certification.
- The 46 TS's satellite control developmental testing employed testers as operators and used a non-production-representative FAB-T terminal. The test had limited objectives but provided the program manager with good risk reduction for an initial test event. The program manager plans for additional, more operationally realistic satellite control testing in preparation for IOT&E.
- The contractor experienced problems developing the new airborne antenna and with ground-transportable antenna servo control system integration. Completion of developmental testing on the fixed-price development effort is taking longer than planned due to cost pressures that limit test personnel and test assets.
- The IOT&E has slipped from 4QFY17 to 1QFY18 due to delays in developmental testing and the lead time needed to integrate production-representative terminals required for the operational test at user ground-fixed sites and in ground-transportable platforms.

Recommendations

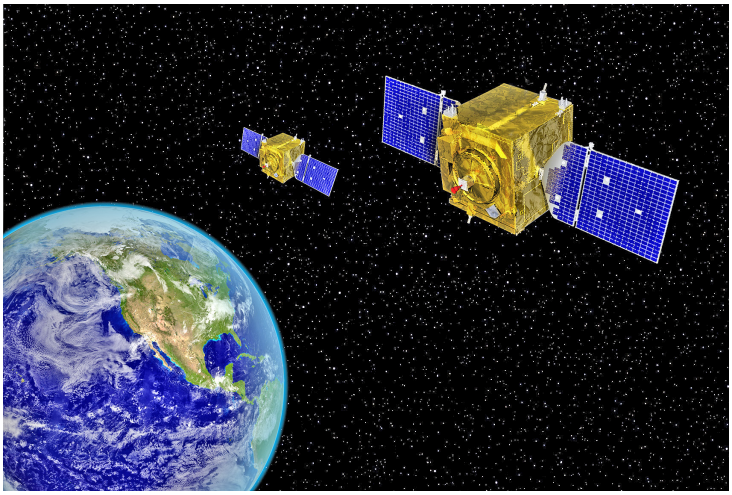
- Status of Previous Recommendations. The Air Force has addressed the previous three recommendations.
- FY16 Recommendation.
  1. The Air Force should continue to use reliability growth test periods to surface more failure modes and correct them to grow reliability and confidence in system performance prior to IOT&E.

Geosynchronous Space Situational Awareness Program (GSSAP)

Executive Summary
- The Air Force operationally accepted and declared Initial Operational Capability (IOC) for the Geosynchronous Space Situational Awareness Program (GSSAP) on September 29, 2015.
- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted IOT&E for GSSAP from August 2015 to January 2016 in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and operational test plan.
- Operational testing of GSSAP was adequate to support an initial but incomplete evaluation of the system's operational effectiveness, suitability, and survivability. The Air Force should conduct FOT&E with adequate threat representation and statistical rigor to resolve unassessed, inconclusive, and shortfall measures from IOT&E.
- GSSAP is effective for some intended operations, but not for others. GSSAP is not suitable due to the inadequacy of operator training and training systems, and dependence on other mission systems with reliability and availability shortfalls. GSSAP survivability is inconclusive.

System
- GSSAP is a space-based, space situational awareness (SSA) capability operating in near-geosynchronous orbit, supporting U.S. Strategic Command (USSTRATCOM) SSA operations as a dedicated Space Surveillance Network sensor.
- The GSSAP system consists of satellites and a ground segment that controls the satellites and receives and processes GSSAP mission data.

Mission
- The 1st Space Operations Squadron, of the Air Force Space Command's 50th Space Wing at Schriever AFB, Colorado, employs GSSAP to satisfy SSA mission tasking from USSTRATCOM's Joint Functional Component Command for Space.
- GSSAP is intended to track and characterize man-made orbiting resident space objects at and near the 22,236 mile (35,786 km) geosynchronous orbit altitude, to contribute to timely and accurate resident space object orbit predictions, knowledge of the geosynchronous orbit environment, and safety of space flight through satellite collision avoidance.



Major Contractor
Orbital ATK – Dulles, Virginia

Activity
- The Air Force operationally accepted and declared IOC for GSSAP on September 29, 2015.
- AFOTEC conducted IOT&E for GSSAP from August 2015 to January 2016 in accordance with the DOT&E-approved TEMP and operational test plan.
- Prior to the IOT&E, the Air Force conducted developmental T&E from August 2014 to July 2015, and integrated T&E from July 2015 to August 2015. In order to decrease the delay from launch to operational availability and to preserve spacecraft operational lifespan, with prior DOT&E approval, AFOTEC used data collected during both developmental and integrated T&E in its OT&E analysis and report.

Assessment
- Operational testing of GSSAP was adequate to support an initial but incomplete evaluation of the system's operational effectiveness, suitability, and survivability. The Air Force should conduct FOT&E with adequate threat representation and statistical rigor to resolve unassessed, inconclusive, and shortfall measures from IOT&E.

- GSSAP is effective for some intended operations, but not for others. GSSAP is not suitable due to the inadequacy of operator training and training systems, and dependence on other mission systems with reliability and availability shortfalls. GSSAP survivability is inconclusive.

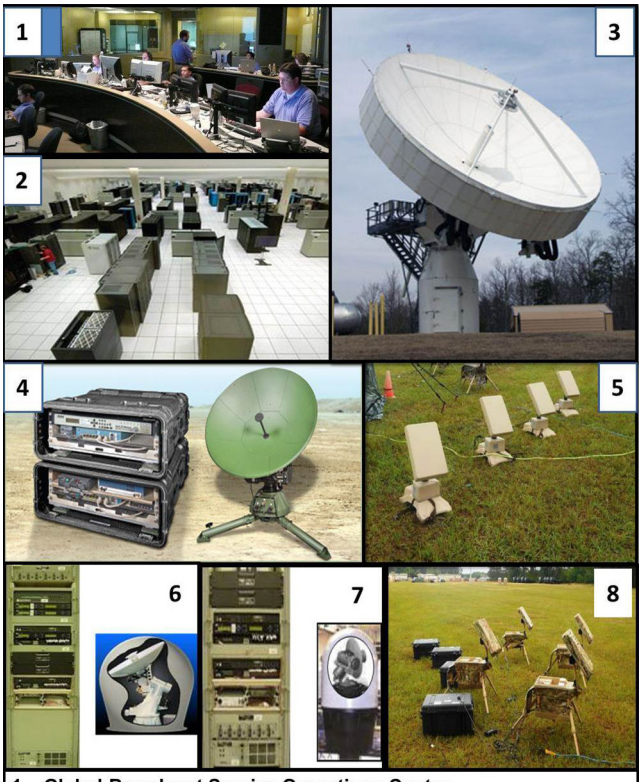
Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY16 Recommendations. The Air Force should:
  1. Conduct FOT&E with adequate threat representation and statistical rigor to resolve unassessed, inconclusive, and shortfall measures from IOT&E.
  2. Address the recommendations detailed in the classified DOT&E report.

Global Broadcast Service (GBS) System

Executive Summary

- The program manager is developing the Global Broadcast Service (GBS) Phase-IV capability that includes an upgraded Transportable Ground Receive Suite (TGRS), new Rucksack Portable Receive Suite (RPRS), new Suitcase Portable Receive Suite (SPRS), and integration of the Digital Video Broadcasting – Satellite – Second Generation (DVB-S2) waveform that should provide more efficient use of available satellite bandwidth.
- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted FOT&E-1 from May 25 through June 30, 2016, with participation from the Army Test and Evaluation Command, Marine Corps Operational Test and Evaluation Activity, and the Navy's Commander, Operational Test and Evaluation Force. FOT&E-1 included operators from the Air Force, Marine Corps, and Army operating and maintaining receive suites at Robins AFB, Georgia. The USS *Carl Vinson* (San Diego, California) and USS *Santa Fe* (Pearl Harbor, Hawaii) participated for the Navy, communicating over the Wideband Global Satellite Communications (WGS) system.
- The GBS receive suites are operationally effective in providing a continuous flow of high-speed, high-volume, multimedia communications for deployed and garrisoned forces.
- The GBS is not survivable against internal or external cybersecurity threats. The Army Threat Systems Management Office found 17 cybersecurity vulnerabilities on the GBS system that could be exploited by potential adversaries.
- The GBS receive suites are not suitable because the system did not demonstrate that it could meet reliability and maintenance repair times, and the documentation lacked adequate troubleshooting procedures. The systems can be made suitable once corrective actions to improve cable durability, system shutdowns, and technical documentation are made and verified. The program manager is in the process of updating technical orders and technical manuals, performing root cause analysis, and implementing corrective actions.



1 – Global Broadcast Service Operations Center
2 – Defense Enterprise Computing Center
3 – Primary Injection Point
4 – Transportable Ground Receive Suite
5 – Rucksack Portable Receive Suite
6 – Shipboard Receive Suite
7 – Subsurface Receive Suite
8 – Suitcase Portable Receive Suite

System

- The GBS is a satellite-based broadcast system providing near-worldwide, high-capacity, one-way transmission of operational military data.
- The GBS system consists of three segments:
  - The space segment includes GBS transponders on WGS, Ultra High Frequency Follow-On (UFO) satellites, and an additional government-leased commercial satellite capability to meet operational demand.
  - The transmit segment consists of the GBS Operations Center and Satellite Broadcast Manager (SBM). The GBS Operations Center, located at Peterson AFB, Colorado, remotely creates and manages the GBS broadcast through the primary and alternate SBM located at Oklahoma City, Oklahoma, and Mechanicsburg, Pennsylvania, respectively. The SBM receives data and video products from a variety of sources and packages that source material into a satellite broadcast. The SBM interfaces through DOD Teleport sites for the WGS satellites and fixed Primary Injection Points for the UFO satellites and commercial satellites.
  - The receive segment consists of ground- and sea-based mobile terminals that extract the appropriate information for distribution to the end users within selected areas of operation. The receive suite configurations include the TGRS, RPRS, SPRS, Shipboard Receive Suite, and the Subsurface Receive Suite.

Mission

- Combatant commanders and operational forces worldwide use GBS to provide a continuous high-speed and high

volume flow of data, audio, imagery, and video at multiple classification levels for sustained operations.
- Commanders use the GBS capability to provide intelligence and battlespace weather information, increasing the joint operations mission data available to deployed and garrisoned military forces across the globe.

Major Contractor
- General Dynamics C4 Systems – Taunton, Massachusetts
- AQYR Technologies – Hollis, New Hampshire

Activity
- The program manager is developing GBS Phase-IV capability that includes an upgraded TGRS, new RPRS, new SPRS, and integration of the DVB-S2 waveform that provides more efficient use of available satellite bandwidth.
- On November 13, 2014, the DOD Chief Information Officer instructed the Director, Defense Information Systems Agency to redirect the acquisition strategy of the Joint Internet Protocol Modem from a development program to a commercial off-the-shelf solution. The commercial solution is named the Enterprise Satellite Communications (SATCOM) Gateway Modem. The GBS program's Phase-V is intended to integrate the Enterprise SATCOM Gateway Modem in the GBS architecture to provide waveform protection through implementation of transmission security to prevent potential communications traffic analysis by adversaries.
- The GBS program manager, AFOTEC, and Service representatives updated the GBS Test and Evaluation Master Plan (TEMP) to include the Phase-IV capabilities and testing. DOT&E approved the TEMP update on March 21, 2016.
- The Air Force's 46th Test Squadron (46 TS) conducted a government Developmental Test and Evaluation 2 (DT&E-2) from October 19 through November 20, 2015, at Robins AFB, Georgia, and Naval Base San Diego, California, to assess the end-to-end broadcast and receive capabilities of the GBS receive suites using the DVB-S2 waveform.
- The 46 TS conducted a government DT&E-2 regression test from February 16 through March 18, 2016, at Robins AFB, Naval Base San Diego, and Pearl Harbor, Hawaii, to assess the end-to-end broadcast and receive capabilities of the GBS receive suites running the new GBS receive suite software. The GBS Program Manager delivered updated GBS receive suite software and technical manuals prior to the 46 TS DT&E regression test.
- The Air Force's 92nd Cyberspace Operations Squadron conducted a cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) from February 21 through March 12, 2016, during the program manager's developmental test period.
- AFOTEC conducted FOT&E-1 from May 25 through June 30, 2016, with participation from the Army Test and Evaluation Command, Marine Corps Operational Test and Evaluation Activity, and the Navy's Commander, Operational Test and Evaluation Force. FOT&E-1 included operators from the Air Force, Marine Corps, and Army operating and maintaining receive suites at Robins AFB. The USS *Carl Vinson* and USS *Santa Fe* participated for the Navy, communicating over WGS. AFOTEC conducted FOT&E-1 in accordance with the DOT&E-approved TEMP and test plan. The FOT&E-1 start date was preceded by a dry run period from May 16 – 30, 2016. Prior to the operational test, the program manager provided updated GBS operator manuals.
- The Army's Threat Systems Management Office conducted a cybersecurity Adversarial Assessment on the GBS system from June 1 – 20, 2016, during AFOTEC's FOT&E-1.
- DOT&E submitted a report for an Air Force Space Commander operational acceptance decision planned for November 2016.

Assessment
- The 46 TS conducted DT&E-2 to evaluate the receive capabilities of the TGRS, RPRS, and SPRS over the DVB-S2 broadcast and to document and report discovered deficiencies for the program manager to correct prior to the DT&E-2 regression test. The GBS successfully completed 26 of 29 test objectives. The GBS system did not verify three reliability objectives because the allotted test time was insufficient to provide data for evaluating reliability with statistical confidence. The testers also found that the receive suite technical orders troubleshooting steps were incomplete or inaccurate. The incorrect and missing procedures led to delays in users resolving problems and restoring the systems to operation.
- The DT&E-2 regression test demonstrated that the receive suites correctly received and processed data and video, but testers and users noted problems with reliability. Once set up, the GBS system is intended to operate without operator attention for a minimum of 24 hours, and up to 83 days. The reliability problems cause operators to intervene to restore the system to operations, diverting them from other mission needs. The updated documentation for troubleshooting still lacked clarity, with missing or incomplete troubleshooting steps.
- During the CVPA, the 92nd Cyberspace Operations Squadron discovered 54 potential vulnerabilities and compliance findings with the GBS system. The program manager corrected some of the discovered potential vulnerabilities and compliance findings, but many remained uncorrected or successfully mitigated in the operational test.
- The GBS receive suites are operationally effective in providing a continuous flow of high-speed, high-volume, multimedia communications for deployed and garrisoned forces.

- The GBS is not survivable against internal or external cybersecurity threats. The Army Threat Systems Management Office found 17 vulnerabilities on the GBS system that could be exploited by potential adversaries.
- The GBS receive suites were not suitable because the system did not demonstrate it could meet reliability and maintenance repair times, and documentation lacked adequate troubleshooting procedures. The systems can be made suitable once corrective actions to improve cable durability, system shutdowns, and technical documentation are made and verified. The program manager is in the process of updating technical orders and technical manuals, performing root cause analysis, and implementing corrective actions.

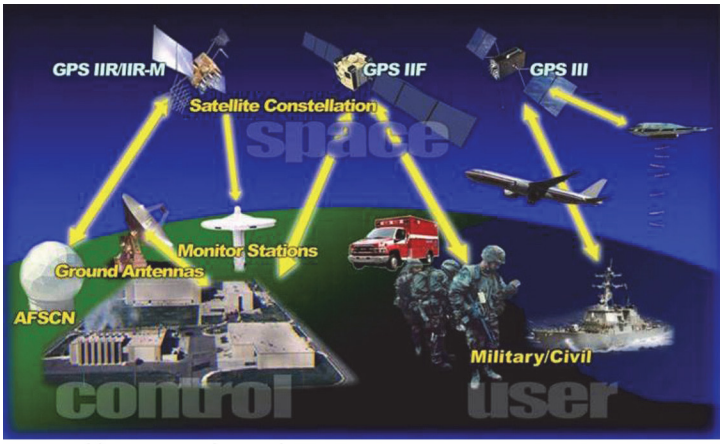
Recommendations

- Status of Previous Recommendations. The Air Force has addressed all previous recommendations.
- FY16 Recommendations. The Air Force should:
  1. Correct the problems with the cables, system shutdowns, and documentation, and verify the corrections in the GBS operational trial period and FOT&E-2.
  2. Correct the cybersecurity vulnerabilities and conduct a CVPA and Adversarial Assessment in the next operational test.

Global Positioning System (GPS) Enterprise

Executive Summary

- The Air Force conducted significant developmental test and evaluation (DT&E) for all three GPS enterprise segments (space, control, and user) in 2016, but did not conduct any operational testing for the GPS enterprise in 2016. DT&E included GPS III thermal vacuum test and post-thermal vacuum system performance and electromagnetic compatibility testing, Next Generation Operational Control System (OCX) Launch Checkout System DT&E, and the second of five phases of DT&E for Military GPS User Equipment (MGUE) Increment 1.
- Expected operational testing dates for all segments have been delayed from dates listed in prior DOT&E Annual Reports and the Enterprise Test and Evaluation Master Plan (ETEMP), approved by DOT&E in March 2012.
- The ETEMP requires an update to reflect test strategy, schedule, and resource changes due to segment delays, acquisition strategy changes, policy and threat changes, and the initiation of the GPS III Contingency Operations (COps) program. An updated ETEMP is in Military Service coordination with formal OSD review expected early 2017.
- Delays to the OCX have worsened since the FY14 DOT&E Annual Report, and the post-Nunn-McCurdy recertified, restructured OCX program cannot deliver OCX Block 1 in time for operational constellation sustainment. The Air Force has initiated the COps program to enable employment of GPS III, using a subset of their capabilities, satellites to sustain the operational constellation prior to OCX availability.
- Significant GPS Enterprise risks remain:
  - Ongoing risk that OT&E of GPS III satellites will not occur until after as many as eight of the satellites are built and on-orbit, increasing the risk that deficiencies will not be discovered until it is too late to correct them.
  - Ongoing risk that insufficient platform integration will occur in time for the operational assessment (OA) of MGUE Increment 1, jeopardizing acquisition decisions made on the basis of that OA.
  - Ongoing risk that the DOD has not assessed the degree to which designated Lead Platforms for MGUE Increment 1 cover the range of operational factors and integration challenges for the complete portfolio of DOD programs that will integrate MGUE Increment 1, and that Lead Platform and MGUE Increment 1 limitations will impede the pathfinding value of integration and OT&E on those platforms.
  - Ongoing risk to the integration and fielding of MGUE Increment 1 with the DOD portfolio posed by the lack of a plan for comprehensive risk-reduction integration testing with all platforms, munitions, and platform interfaces expected to integrate MGUE Increment 1.



AFSCN – Air Force Satellite Control Network
GPS IIR – Global Positioning System (GPS) Block II "Replenishment" Satellites
GPS IIR-M – GPS Block II "Replenishment – Modernized" Satellites
GPS IIF – GPS Block II "Follow-On" Satellites
GPS III – GPS Block III Satellites

  - Risk to adequate OT&E of MGUE Increment 1 posed by the apparent gap between the Air Force intent for delivered MGUE Increment 1 functional capabilities and Military Service operational environment-driven performance requirements.
  - Risk to sustainment of the operational GPS constellation posed by inadequate resource prioritization and commitment to ensure successful, low-risk execution of the COps program, and the absence of independent active monitoring of COps development progress.

System

- The GPS enterprise is an Air Force-managed, satellite-based radio navigation system of systems that provides military and civil users accurate position, velocity, and time within the multi-trillion cubic kilometer volume of near-earth space, earth atmosphere, and worldwide earth surface areas.
- The current GPS enterprise consists of three operational segments:
  - Space Segment – The GPS spacecraft constellation consists of a minimum of 24 operational satellites in semi-synchronous orbit. The Air Force has successfully launched 70 GPS satellites and currently operates 31 healthy GPS satellites, comprising Block IIR (1997-2004), Block IIR-M (2005-2009), and Block IIF (2010-present).
  - Control Segment – The GPS control segment consists of primary and backup GPS master control stations, satellite control antennas, a pre-launch satellite compatibility station, and geographically-distributed operational monitoring stations. The current GPS control segment includes the Operational Control System

(OCS)/Architecture Evolution Plan (AEP) supporting (1) operation of GPS Block IIR, IIR-M, and IIF satellites, (2) Selective Availability/Anti-Spoof Module capabilities in U.S. military and authorized Federal and allied military GPS User Equipment, the Launch/Early Orbit, Anomaly Resolution, and Disposal Operations (LADO) system, and the Selective Availability Anti-Spoofing Module (SAASM) Mission Planning System (SMPS).
  - User Segment – There are many versions of military GPS mission receivers fielded on a multitude of operational systems and combat platforms, including the most common Defense Advanced GPS Receivers and embedded Ground-Based GPS Receiver Application Modules (GB-GRAM), numbering in the hundreds of thousands.
- In 2000, the DOD approved initiation of a GPS enterprise modernization effort to include upgrades to all three segments, along with new civil and military signals (M-code). In addition to replenishment of the satellite constellation, this modernization is intended to improve both military and civil signal integrity and service quality in terrain- and geography-impeded environments, as well as in the presence of unintentional and deliberate interference. Modernized GPS enterprise improvements include:
  - Space Segment – GPS III satellites, an Acquisition Category (ACAT) 1D program, have a design life exceeding that of earlier blocks. GPS III satellites are intended to be capable of transmitting a fourth civil signal and higher-powered M-code, as well as all legacy military and civil navigation signals of previous satellite blocks.
  - Control Segment – OCX, an ACAT 1D program to be delivered in three blocks, replaces the current OCS/AEP control segment and LADO, is backward compatible with Block IIR and later satellites, and will interface with modified SMPS versions. OCX is intended to provide significant cybersecurity improvements over OCS, and through OCX Block 0 the ability to launch and check out GPS III satellites, through OCX Block 1 the ability to control GPS Block II and III satellites, and through OCX Block 2 the full control of modernized civil and M-code signals and navigation warfare functions.
  - User Segment – MGUE Increment 1 is an ACAT ID program and Increment 2 is a pre-Major Defense Acquisition Program, expected to be ACAT 1D. MGUE Increment 1 includes the GB-GRAM-Modernized form factor for ground and low-dynamic platforms such as small unmanned aircraft systems, and the GRAM-Standard Electronic Module-E/Modernized for maritime and aviation applications. The MGUE Increment 2 Capability Development Document is in development and presumed to address requirements and applications not addressed by MGUE Increment 1, including handheld, precision-guided munition, and standard space receiver applications.
- Delays in OCX Block I delivery led the Air Force in 2015 to initiate the COps program as a "bridge capability" to enable employment of GPS III satellites, using only legacy signals, for operational constellation sustainment until OCX Block 1 is available.

Mission
- Combatant Commanders, U.S. military forces, allied nations, and various civilian agencies rely on GPS to provide highly accurate, real-time, all-weather, position, navigation, and time information to operational users worldwide. GPS provides force enhancement for combat operations and military forces in the field on a daily basis throughout a wide variety of global strategic, operational, and tactical missions.
- Appropriately equipped military forces will employ modernized GPS capabilities to (1) determine or contribute to their determination of their location and velocity, (2) support precision munitions targeting and employment, and (3) synchronize operations and secure communications in all environments.

Major Contractors
- Space Segment
  - Block IIR/IIR-M/III satellites: Lockheed Martin Space Systems – Denver, Colorado
  - Block IIF satellites: Boeing, Network and Space Systems – El Segundo, California
- Control Segment
  - OCS: Lockheed Martin, Space Systems Division – Colorado Springs, Colorado
  - OCX: Raytheon Company, Intelligence, Information, and Services – Aurora, Colorado
  - COps: Lockheed Martin, Space Systems Division – Colorado Springs, Colorado
- User Segment (MGUE Increment 1)
  - L-3 Communications/Interstate Electronics Corporation – Anaheim, California
  - Raytheon Company, Space and Airborne Systems – El Segundo, California
  - Rockwell Collins – Cedar Rapids, Iowa

Activity
- The Air Force conducted significant DT&E for all three enterprise segments in 2016, including GPS III thermal vacuum test and post-thermal vacuum system performance and electromagnetic compatibility testing, OCX Launch Checkout System DT&E, and the second of five phases of DT&E for MGUE Increment 1. It did not conduct any operational testing for the GPS enterprise in 2016.
- Expected operational testing dates for all three segments have been delayed from dates listed in the current ETEMP approved in March 2012, and in prior DOT&E Annual Reports. Those

schedule changes resulted from development and delivery delays for all segments, as well as from Lead Platform integration-related delays caused or exacerbated by MGUE Increment 1 development delays and management decisions.
- OCX cost and schedule exceedance led to a Nunn-McCurdy Act program review and recertification.
- The Air Force currently expects to conduct operational tests for each GPS segment as follows:
  - The planned OA of MGUE Increment 1 has slipped to late 2017, primarily due to the immaturity of MGUE Increment 1 initial test articles and delayed delivery of follow-on test articles. That planned OA was previously accelerated from late 2016 to late 2015 to support a planned USD(AT&L) combined Milestone B/C decision under an accelerated schedule approved in the MGUE Increment 1 Acquisition Strategy Document (ASD). USD(AT&L) now plans to conduct a Milestone B-only Defense Acquisition Board for MGUE Increment 1 in early 2017, and it is unclear what post-Milestone B or Beyond Low-Rate Initial Production (BLRIP) decisions will occur for MGUE.
  - The planned IOT&E of MGUE Increment 1 has slipped to 2019 through 2020. This IOT&E will involve data gathered during testing in four separate operational utility evaluations (OUEs) of MGUE Increment 1 on the four designated Lead Platforms. The Air Force had previously accelerated the IOT&E from 2021 to 2017, to support the USD(AT&L) planned BLRIP decision for MGUE Increment 1, based on the schedule approved in the MGUE Increment 1 ASD.
  - The planned OUE of OCX Block I has slipped from early 2016, to early 2019, and now to no sooner than mid-2022, with low confidence in that schedule. This OUE was to combine with an OUE of GPS III satellite vehicle (SV)01 to support an Air Force fielding decision for OCX Block 1 and operational acceptance of GPS III SV01.
    - A December 2015 USD(AT&L) Acquisition Decision Memorandum directed a restructure and 24-month extension for OCX Block 1 delivery, to between mid-2021 and mid-2022. Indications of critical cost and schedule breaches led to a June 2016 Secretary of the Air Force Nunn-McCurdy notification for OCX to Congress.
    - In October 2016, USD(AT&L) recertified a restructured OCX program, rescinded the OCX Milestone B, and directed the Air Force to return for a Milestone B Defense Acquisition Board no later than June 30, 2017. The Air Force plans to propose an Acquisition Program Baseline with a mid-2022 delivery of OCX Block 1.
    - The OCX Block 1 delivery and GPS III SV01 delivery and launch are no longer aligned. The initial GPS III OUE, excluding test of modernized signals, will now occur concurrently with the OUE of COps, which must be developed and fielded to allow employment of GPS III satellites with legacy-only capability to sustain the operational constellation of 24 GPS satellites.
  - The COps OUE is currently planned for mid-2019, concurrent with the OUE of GPS III SV01, in support of a Program Executive Officer Space (Commander, Air Force Space and Missile Systems Center) limited fielding decision for COps and a Commander, Air Force Space Command operational acceptance decision for COps.
  - An initial GPS III OUE is currently planned for mid-2019, concurrent with the OUE of COps, in support of a USD(AT&L) limited fielding decision for GPS III SV01 excluding use of modernized GPS signals, and a Commander, Air Force Space Command operational acceptance decision for GPS III SV01, using legacy-only signals. Post-thermal vacuum chamber defect discovery on GPS III SV01 delayed the satellite's availability-for-launch, but it will still likely be ready for launch before the OCX Block 0 control segment will be ready to support GPS III launch and checkout.
  - Multi-Service OT&E (MOT&E) of the modernized GPS enterprise has slipped to an indeterminate date beyond 2022, and will be required after delivery of OCX Block 2-associated navigation warfare and modernized signal and messaging functions, supporting a fielding decision for OCX Block 2 and/or operational acceptance decisions for those capabilities. GPS Enterprise MOT&E was previously planned for 2020, but can occur no earlier than the delivery of OCX Block 2-associated functions.
- Although the GPS Program Office continues to support Service platform program office efforts to incorporate keyed military GPS receivers in their weapons, and the Services have made progress increasing integration of, training with, and reliance on keyed military receivers, the Joint Navigation Warfare Center-compiled data show many DOD weapon systems continue to use non-military receivers and some forces fail to routinely key and train with keyed military receivers.
- The next revision of the GPS ETEMP remains in coordination within the Air Force and Service Operational Test Agencies, and the Air Force plans to submit it for formal OSD review in early 2017. The approved GPS ETEMP is over 4 years old, and is outdated, but revision has been delayed by significant fluctuation in all enterprise segment delivery and availability schedules, as well as the OCX and MGUE acquisition strategies, and initiation of COps.

Assessment
- No OT&E test data are available at this point.
- In the FY14 Annual Report, DOT&E cited concerns identified in DOT&E's November 2014 memorandum to USD(AT&L) regarding sustainment and modernization of GPS capabilities. Those concerns remain valid, with some mitigation:
  1. OCX delays limit adequate, timely OT&E for GPS III satellites prior to extensive procurement and incorporation of the GPS III satellites into the operational constellation.
  2. Deferred platform integration jeopardizes adequate MGUE Increment 1 OA and risks late deficiency discovery.
  3. There is limited pathfinding value to Lead Platform testing compared to the represented portfolio of platforms.
  4. Limiting MGUE integration funding for each Lead Platform to the first available MGUE Increment 1 vendor card risks

limiting post-IOT&E competition and delays to MGUE Increment 1 fielding throughout the DOD portfolio.

5. There is inadequate articulation of program risks. This is being addressed. The Air Force has acknowledged the numerous schedule and performance risks to GPS outlined in this report; mitigation of those risks is incomplete.
6. The program schedules are inaccurate, implausible, and incoherent. This is being addressed. The Air Force has established a plausible schedule for MGUE Increment 1, with the exception of undefined Milestone Decision Authority (MDA) decisions for BLRIP activities on Lead Platforms and non-Lead Platforms. The GPS enterprise schedule appears to better reflect facts-in-being for each segment modernization effort.
7. The Air Force has overstated MGUE development maturity. This point has been demonstrated by the poor performance of initial MGUE Increment 1 test articles during the first phase of government DT&E in late 2015. MGUE Increment 1 has demonstrated marginal technical maturity and platform interoperability improvements to-date.

- In a January 2016 memorandum to the SECDEF, DOT&E identified concerns with the risk to U.S. GPS capability posed by delays to OCX and inadequate prioritization and resource allocation for COps development. DOT&E recommended that the SECDEF direct the Air Force to prioritize resources to ensure successful COps execution and require COps progress reporting in quarterly OCX reports to the Comptroller General, to facilitate active monitoring. The Air Force included cursory information but no detailed COps status in its first two quarterly OCX reports.
- In a January 2016 memorandum to USD(AT&L), DOT&E recommended against approving a combined Milestone B and C for MGUE Increment 1, stated that MGUE Increment 1 testing to-date did not indicate that current designs could be produced and would work, and that MGUE interoperability risk remained substantial and unmitigated. DOT&E further recommended expanded risk-reduction integration testing with all platforms, munitions, and platform interfaces expected to integrate MGUE Increment 1, and completion of DT&E and an adequate OA prior to USD(AT&L)'s Milestone C decision. USD(AT&L) has not approved MGUE Increment 1 Milestones B or C and has postponed until January 2017 the Milestone B Defense Acquisition Board previously scheduled for October 2016. USD(AT&L) has not directed, and the Air Force has not elected to conduct the DOT&E-recommended expanded risk-reduction testing.
- In a July 2016 memorandum to the SECDEF, DOT&E reiterated the urgent need for greater focus on COps, to ensure its availability to sustain GPS operations, and recommended the Air Force prioritize and commit resources to ensure successful, low-risk execution of the COps program and active monitoring of COps development progress. COps remains on DOT&E oversight and has not been placed on USD(AT&L) oversight.
- At the time of this report, the MGUE Increment 1 program is preparing for a Milestone B Defense Acquisition Board review with USD(AT&L). DOT&E concerns include:

1. The mismatch between the approved MGUE Increment 1 ASD, actual program execution, and the ETEMP-described acquisition and test strategies as well as the need for clarification on planned acquisition decisions. Specifically, DOT&E requires clarity on the criteria and timing of acquisition milestone decisions which will allow MGUE Increment 1 and derived components to be fielded on Lead Platforms and non-Lead Platforms. This is needed in order to recommend an appropriate OT&E strategy to provide assessment in support of fielding decisions.
2. The absence of a plan to assess MGUE Increment 1 performance across the wide variety of intended interfaces and platforms leaves significant unmitigated integration risk, and therefore fielding cost and schedule risk for the DOD.
3. An apparent gap between MGUE Increment 1 functional capabilities and Military Service operational requirements. For example, Army requirements for the D3/Stryker's operational environment exceed Air Force-planned MGUE Increment 1 functional capabilities. This jeopardizes the adequacy of MGUE Increment 1 OT&E on the D3/Stryker Lead Platform.

- When the Air Force returns in mid-2017 for the post-Nunn-McCurdy Milestone B Defense Acquisition Board, it plans to propose a mid-2022 delivery of OCX Block 1. The program's ability to deliver OCX Block 1 on that schedule, if possible, will be dependent on the successful execution of several test strategy and test resource changes. These changes include implementation of planned automated software testing, increases in contractor and Program Office skilled software subject matter expertise, and procurement of additional software development and testing environments to address resource constraints within and between GPS segments.
- Additional OT&E of MGUE will be required for non-Lead Platforms integrating MGUE and covering operational and environmental conditions for MGUE not evaluated during planned Lead Platform testing.
- Additional OT&E of all M-code-capable satellite blocks will be required once an M-code-capable control segment and user equipment are available, prior to the operational employment of M-code signals from those satellites. The M-code capabilities of GPS Block IIR, IIR-M, and IIF satellites have not previously been operationally tested, and should be included in OT&E, along with GPS Block III M-code capabilities, once OCX is available to support testing.

Recommendations

- Status of Previous Recommendations. The Air Force has partially addressed the five previous recommendations listed in the FY11 Annual Report:
  1. There has been no opportunity thus far for end-to-end testing of OCX with MGUE receivers, and the ETEMP requires revision to reflect updated planning for the MOT&E of the modernized GPS enterprise, which will address end-to-end testing. The Air Force does not have a plan for adequate integration on representative platforms

to enable timely OT&E in representative environments in support of acquisition and fielding decisions. The Air Force should continue to plan for end-to-end testing of the GPS enterprise, including integration on Lead Platforms and non-Lead Platforms, and DT&E and OT&E in realistic operational environments, in time to support acquisition decisions.

2. The Air Force has improved synchronization of the development of the Space, Control, and User segments, in that descriptions of the effect of delays in each segment upon the GPS enterprise and other segment schedules are more often clearly articulated. Delays in MGUE Increment 1 and OCX Block 1 will result in their delivery after most of the first block of GPS III satellites are built and launched. The Air Force should ensure that status and critical interdependencies of each enterprise segment are well understood, and should promptly assess and disseminate to all stakeholders those predicted enterprise impacts resulting from forecast changes in segment schedules.
3. The revised ETEMP still in Service coordination reflects improvements in planning for comprehensive and realistic cybersecurity testing of the GPS enterprise, although additional revisions will be necessary to reflect GPS segment changes and DOT&E's August 2014 guidance, Procedures for Operational Test and Evaluation of Cybersecurity in Acquisition Programs. The Air Force should continue to refine its cybersecurity testing approach to GPS.
4. The Military Services have made progress in emphasizing/enforcing the use of crypto-keyed GPS receivers, but should redouble their efforts, in accordance with Joint Navigation Warfare Center and United States Strategic Command recommendations.
5. The Military Services have made progress in developing concepts of operations and tactics, techniques, and procedures for keying GPS receivers, but that has not translated into use of encrypted receivers for all military operations.

- The Air Force has partially addressed the seven recommendations listed in the FY14 Annual Report:
  1. If COps is delivered as planned, it will support a partial OT&E of the first GPS III satellite, but substantial risk of undiscovered deficiencies will remain until completion of GPS III OT&E when OCX Block 2 is available. The Air Force should still mitigate this risk.
  2. The Air Force now intends to include data from integration and DT&E of MGUE Increment 1 on at least some Lead Platforms in an OA informing as-yet-undetermined MGUE Increment 1 acquisition decisions. The Air Force plans to propose at the next MGUE Defense Acquisition Board adoption of multiple "Technical Requirements Verification" decisions in lieu of a Milestone C decision for the program. The Air Force should still plan for an adequate OA encompassing integration and DT&E on at least one Lead Platform per form factor to inform these acquisition decisions.
  3. The Air Force is continuing the engineering, manufacturing, and development of MGUE Increment 1, and resumed government DT&E in mid-2016, but has no plan or direction to conduct comprehensive integration and interoperability testing on non-Lead Platforms to determine MGUE Increment 1 integration maturity. The Air Force should still plan for and conduct comprehensive risk-reduction integration testing with all platforms, munitions, and platform interfaces expected to integrate MGUE Increment 1.
  4. The Air Force has no plan to assess the degree to which designated Lead Platforms for MGUE Increment 1 cover the range of operational factors and integration challenges for the complete portfolio of DOD platforms each MGUE form factor is intended to support. The Air Force believes the DOD should conduct this assessment, but that it is out of scope for the MGUE program. USD(AT&L) should direct the Air Force or another organization to conduct this assessment.
  5. The Air Force does not plan to ensure each available MGUE Increment 1 vendor solution for a given form factor is integrated with all Lead Platforms for that respective form factor to support adequate MGUE IOT&E. The Air Force has recommended a "first card" strategy, in which each Lead Platform will integrate and complete DT&E and OT&E with the first vendor card available, with no provision for the follow-on integration and testing of the other vendor cards as each becomes available. The Air Force should still pursue an "each card" strategy, integrating and testing each MGUE Increment 1 vendor solution on applicable Lead Platforms as soon as those vendor solutions are available.
  6. The Air Force has identified risks to the GPS enterprise and has articulated plans of action and milestones for the mitigation of some risks, but not all. The Air Force should still identify and articulate mitigation plans for all significant risks to the GPS enterprise, in particular, for the risk that COps will not be delivered in time to support constellation sustainment.
  7. The Air Force has improved the coherence of its GPS enterprise schedule information, but these schedules are not always updated to reflect the most current government estimates, nor caveated to reflect un-validated assumptions. The Air Force should maintain and disseminate coherent, accurate, and timely schedule information for all segments, ensuring the schedules reflect segment interdependencies, most current government estimates, and caveats for un-validated assumptions.
- FY16 Recommendation.
  1. The Air Force should prioritize and commit resources to ensure successful, low-risk execution of the COps program, and ensure active independent monitoring of COps development progress.

Joint Space Operations Center (JSpOC) Mission System (JMS)

Executive Summary

- The Air Force has yet to conduct any OT&E for Joint Space Operations Center (JSpOC) Mission System (JMS) Increment 2, but conducted significant development and developmental testing for JMS Increment 2, Service Packs (SP) 9 and 11 in 2016, including three phases of functional developmental testing for SP9 and developmental cybersecurity assessments.
- The Air Force completed a Critical Change review for JMS Increment 2 in August 2016 due to both schedule and cost increases, and consequently descoped Increment 2 capabilities and deferred final delivery from July 2016 to May 2019. Descoped capabilities no longer being delivered with JMS Increment 2 include the Special Access Program (SAP)-level enclave, automated high-priority tasking, advanced space order of battle tools, and the capability to ingest and process data from non-traditional space situational awareness (SSA) sensors.
- The Air Force is planning an Operational Utility Evaluation (OUE) of JMS Increment 2, SP9 in 2017, following an integrated test and evaluation (IT&E) period, and the developmental testing campaign, which is in progress.
- The Air Force is finalizing a revision to the JMS Test and Evaluation Master Plan (TEMP) to reflect program schedule and content changes, including OT&E for SP11, necessitated by the addition of functional capabilities.
- Delayed interoperability testing between JMS and Space Fence Increment 1 adds risk to cost and delivery schedule for both programs.

System

- JMS is a net-centric, service-oriented architecture of hardware, software, data, and network connectivity that will process, integrate, store, and allow for the compilation, exploitation, sharing, and visualization of SSA sensor data and analysis to support command and control tasking and battle-management decisions for space forces.
- Operational JMS hardware strings and infrastructure are installed at Vandenberg AFB, California, and will be installed at a backup site at Naval Support Facility Dahlgren, Virginia. Additional non-operational instances and partial-instances of JMS are installed for development and developmental testing purposes at a multitude of other sites, including Vandenberg AFB, California, and Space and Naval Warfare Systems Center Pacific at the Point Loma Annex of Naval Support Center San Diego, California.
- JMS net-centric enterprise services, including data visualization, mission applications, and functional queries, are accessible to worldwide users running JMS client software on

non-JMS workstations connected through the Secret Internet Protocol Router Network (SIPRNET) and the Joint Worldwide Intelligence Communication System (JWICS) Network.
- JMS will replace legacy Space Defense Operations Center (SPADOC) and space specific portions of the Correlation, Analysis, and Verification of Ephemerides Network (CAVENet) systems.
- The Air Force is developing JMS in two increments.
  - Increment 1 delivered an initial service-oriented architecture infrastructure and user tools, including a client workstation-accessible User Defined Operational Picture that allows access to and analysis of data from legacy systems, integrated collaboration/messaging/data sharing tools, and space order of battle processing.
  - Increment 2 is being developed to deliver mission functionality in three SPs.
    - SP7 delivered updates and additions to Increment 1-delivered hardware and software infrastructure, including servers, space surveillance network (SSN) communications services connectivity, system security and message processing capabilities, and limited space surveillance data processing and visualization tools. SP7 was not operationally tested because it will not replace legacy SPADOC and CAVENet systems nor be used for mission critical functions.
    - SP9 is intended to update and expand JMS hardware and software to perform functions currently performed by SPADOC and CAVENet, with improved accuracy, efficiency, and responsiveness. Those functions include administration and maintenance of the space catalog, orbit determination for resident space objects (RSOs), assessment of conjunctions (collision risk) between

RSOs, and high-accuracy tasking of sensors for orbital safety, threat modeling, and operational decisions.
  - SP11 is intended to complete Increment 2 functionality on the Top Secret enclave. SP11 is intended to include the ability to ingest and integrate more highly-classified data, support routine Space Object Identification tasking, and support processing for critical events such as RSO Closely Spaced Operations, breakups, re-entries and de-orbits, launch processing, and processing of uncorrelated tracks. SP11 is also intended to encompass test, training, and exercise capabilities and availability and reliability improvements which had been planned for delivery in the descoped SP13.

Mission

The JSpOC uses JMS to enable the coordination, planning, synchronization, and execution of continuous, integrated space operations in response to tasking from the Commander, Joint Functional Component Command for Space (CDR JFCC SPACE), a component of U.S. Strategic Command, in support of national and Combatant Commander objectives. JSpOC will use JMS to provide the CDR JFCC SPACE with the ability to task sensors and process sensor data to monitor the space domain, predict, detect, and respond to space events, maintain, analyze, visualize, and disseminate SSA data, and collaborate with other forces.

Major Contractors

- Government prime contractor:
  - Air Force Space and Missile Systems Center – Los Angeles AFB, California
- System Integrator, Increments 1 and 2:
  - Space and Naval Warfare Systems Command – San Diego, California
- Increment 1 sub-contractors:
  - Intelligent Software Solutions, Inc. – Colorado Springs, Colorado
  - The Design Knowledge Company – Fairborn, Ohio
- Increment 2 sub-contractors:
  - Analytical Graphics Incorporated – Exton, Pennsylvania
  - Artificial Intelligence Solutions – Lanham, Maryland
  - Intelligent Software Solutions, Inc. – Colorado Springs, Colorado
  - The Design Knowledge Company – Fairborn, Ohio

Activity

- The Air Force has yet to conduct any OT&E for JMS Increment 2, but conducted significant development and developmental testing for JMS Increment 2, SP9 and 11 in 2016, including:
  - Three phases of functional developmental testing for SP9 between May and October 2016
  - Developmental cybersecurity assessment from February to March 2016 and testing of partial representations of JMS Increment 2 at the National Cyber Range as part of a continuum of cybersecurity assessment incorporated by the Program Office into the JMS development effort
- The Air Force Operational Test and Evaluation Center is planning an OUE of JMS Increment 2, SP9 following an IT&E period, and the developmental testing campaign, which is in progress.
- The Air Force completed a Critical Change review for JMS Increment 2 in August 2016, due to both schedule and cost increases. As a result of the review, the Air Force descoped JMS Increment 2, with a new final delivery date of May 2019 (originally July 2016). Descoped capabilities no longer being delivered with JMS Increment 2 include the majority of planned SP13 content, including a SAP-level enclave, automated high-priority tasking, advanced space order of battle tools, and the capability to ingest and process data from non-traditional SSA sensors.
- The Air Force is finalizing development of a revision to the JMS TEMP, to reflect program schedule and content changes, including the addition of OT&E for SP11, necessitated by the addition of functional capabilities.

Assessment

- As the Air Force has not conducted any OT&E for JMS Increment 2, there are no operational test data available.
- SP9 will require at least one more developmental testing phase than the three currently planned by the Air Force. The Program Office plans to reassess the SP9 and broader Increment 2 schedule at the completion of each developmental testing phase. DOT&E expects OT&E for SP9 to begin no earlier than June 2017.
- Delays in JMS Increment 2 capability delivery increase risk of late discovery of interoperability deficiencies between JMS and Space Fence Increment 1, and data processing capacity adequacy for JMS. Space Fence Increment 1 is currently in development, and a sub-scale Integration Test Bed representation of Space Fence is available for testing but is not connected nor prepared to connect to JMS. The deferral of Space Fence interoperability functionality to SP11 and the non-availability of JMS for interoperability testing between JMS and Space Fence will delay deficiency discovery and resolution for both JMS and Space Fence, and require the simulation of Space Fence-imposed workload in JMS testing, likely increasing cost and delivery schedule for both.
- The Air Force has deferred capability requirements from the validated JMS Capability Development Document, which were planned for delivery in SP13 and not included in SP11, to an undefined increment. The increment may overlap an as-yet-undefined program of record being planned to equip the new Joint Interagency Combined Space Operations Center (JICSPOC).

Recommendations

- Status of Previous Recommendations. The Air Force resolved one of the seven previous recommendations when it completed the planned technology refresh for Increment 1 equipment and continued acquisition, development, testing, and fielding of JMS Increment 2. The Air Force still needs to:
  1. Develop an acquisition strategy for delivery of capabilities post-Increment 2, including facilities and capabilities to support continuity of operations. This recommendation remains valid, given the restructure of Increment 2 and the nascent planning for a JICSPOC program of record.
  2. Investigate and resolve problems with external data source consistency, external interfaces, and support networks that will otherwise impede JMS end-to-end mission performance. The Air Force has made substantial progress in planning and assessing data source and external interface connectivity and interoperability, with the significant exception of JMS-Space Fence interoperability, as described above.
  3. Assess new Increment 2 capabilities and reassess JMS User Defined Operational Picture and net-centric capabilities to verify full JMS functionality. This is in progress and should be completed with SP11 OT&E.
  4. Develop and validate modeling and simulation tools to support evaluation of system capacity under high-user loading and evaluation of JMS high-accuracy catalog size and accuracy. This is in progress.
  5. Develop operationally-relevant measures to assess JMS system performance degradation due to cyber-attack. Provide capabilities to allow system administrators to monitor performance and take appropriate actions to mitigate operational impacts based on these measures. This recommendation remains valid and some progress has been made due to the Program Office's significant focus on cybersecurity assessment and hardening. Additional work remains to ensure JMS provides monitoring and insight sufficient to enable active cyber defense.
  6. Conduct independent, non-cooperative, threat representative penetration testing to assess protect, detect, react, and restore components of cybersecurity for Increment 2. This testing is planned for SP9 and SP11.
- FY16 Recommendation.
  1. The Air Force should commit resources to ensure interoperability testing between JMS and Space Fence Increment 1 in 2017, including dedicated schedule periods and use of partial- and full-hardware and software instances.

KC-46A

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted a second Operational Assessment (OA-2) from December 2014 through July 2016. The Air Force accomplished testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and the OA-2 test plan. DOT&E produced a KC-46A OA-2 report in August 2016.
- Initial air refueling (AR) testing in January and February 2016 uncovered unanticipated axial loads in the boom that approached the boom's structural limits, resulting in temporary suspension of further AR testing. Boeing redesigned the boom control system to address this problem and completed demonstration flights of the boom refueling system in July 2016.
- The KC-46A is trending to be an effective AR platform. It demonstrated a limited capability to refuel receiver aircraft (its primary mission) and to be refueled from tanker aircraft during OA-2. However, the demonstrations to date have been at a single point of the operational envelope for only five different receiver aircraft, during daylight only, and no aircraft have completed certification as a receiving platform. The AR boom receivers were the F-16, C-17, and A-10; the probe-drogue receivers were the F/A-18C and AV-8B.
- During OA-2 testing, the air refueling operators (AROs) identified a problem that can occur when the ARO station is set to "dual" operation such that the controls at both the primary and instructor station are active. When both positions apply a flight control stick command, the boom will move to a summed position due to the system's summation logic. There are situations where this could result in a rapid boom movement to the instructor-commanded position; if the receiver aircraft is in the path, the potential exists for the boom to inadvertently strike the receiver aircraft.
- The AROs also noted the long-wave infrared cameras produced an undesirable effect when interacting with the sun and clouds. For example, a solar trail occurs when the sun moves across the screen (such as during a turn) and leaves a persistent afterimage forming a line. Additionally, the ARO station screen overlays – which provide boom envelope position and other information – interfere with the ARO's ability to view and monitor AR operations.
- Testing during OA-2 did not identify any critical deficiencies with the cargo handling or aeromedical evacuation missions – though testing did identify deficiencies the Air Force should address.
- The KC-46A demonstrated satisfactory progress for operational suitability. The program is tracking better than planned on the reliability growth curve, as measured by Mean Time Between Inherent Failures. Several metrics are worse than thresholds, such as the aerial abort rate, cannot-duplicate rate for failures, Mean Time Between Unscheduled Maintenance, and break rate; however, these results are not surprising. The program is not planning to meet these requirements until 50,000 fleet flight hours, which will not occur until 2 to 3 years after Initial Operational Capability (IOC).

- During OA-2, testers discovered several cybersecurity vulnerabilities. The program plans to correct some of them prior to IOT&E. Corrections to others that are related to government-furnished equipment are under discussion.
- DOT&E evaluated the KC-46A survivability against kinetic and non-kinetic threats in four scenarios. Live fire test results, laboratory results, hardware-in-the-loop testing, and numerous vulnerability and susceptibility analyses provided source data for these evaluations. Results of these evaluations are in the classified annex to DOT&E's OA-2 report.
- DOT&E has previously assessed and continues to assess the KC-46A schedule as aggressive and unlikely to be executed as planned. At Milestone B, in February 2011, the Air Force had planned to be 66 percent complete by Milestone C. However, upon accomplishing Milestone C in August 2016, Boeing had completed only 30 percent of the total Engineering and Manufacturing Development (EMD) testing. Execution of the current schedule assumes historically unrealistic test aircraft fly and re-fly rates.

System

- The KC-46A aerial refueling aircraft is the first increment of replacement tankers (179) for the Air Force's fleet of more than 400 KC-135 tankers.
- The KC-46A design uses a modified Boeing 767-200ER commercial airframe with numerous military and technological upgrades, such as the fly-by-wire refueling boom, the remote AFO's station, 787 cockpit, additional fuel tanks in the body, and defensive systems.

- The KC-46A will provide both a boom and probe-drogue refueling capabilities. The KC-46A is equipped with an AR receptacle so that it can also receive fuel from other tankers, including legacy aircraft.
- The KC-46A is designed to have significant palletized cargo and aeromedical capacities; chemical, biological, radiological, and nuclear survivability; and the ability to host communications gateway payloads.
- Survivability enhancement features are incorporated into the KC-46A design.
  - Susceptibility is reduced with an Aircraft Survivability Equipment suite consisting of Large Aircraft Infrared Countermeasures (LAIRCM), a modified version of the ALR-69A Radar Warning Receiver (RWR), and a Tactical Situational Awareness System. The suite is intended to correlate threat information from pre-flight planning, the RWR, and other on- and off-board sources and to prompt the crew with an automatic re-routing suggestion in the event of an unexpected threat.
  - Vulnerability is reduced by adding a fuel tank inerting system and integral armor to provide some protection to the crew and critical systems.

Mission

Commanders will use units equipped with the KC-46A to perform AR to accomplish six primary missions to include nuclear operations support, global strike support, air bridge support, aircraft deployment, theater support, and special operations support. Secondary missions will include airlift, aeromedical evacuation, emergency AR, air sampling, and support of combat search and rescue.

Major Contractor

The Boeing Company, Commercial Aircraft in conjunction with Defense, Space & Security – Seattle, Washington

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Activity

- The KC-46A program successfully accomplished a Defense Acquisition Board Milestone C decision in August 2016.
- DOT&E approved the Milestone C TEMP in November 2016, with concerns about adequate calendar time for correction of discrepancies or deficiencies between the end of developmental testing and the beginning of IOT&E.
- AFOTEC conducted OA-2 from December 2014 through July 2016. The Air Force accomplished testing in accordance with the DOT&E-approved TEMP and the OA-2 test plan. DOT&E produced a KC-46A OA-2 report in August 2016.
- Initial AR testing in January and February 2016 uncovered unanticipated axial loads in the boom that approached the boom's structural limits, resulting in temporary suspension of further AR testing. Boeing redesigned the boom control system to address this problem and completed demonstration flights of the boom refueling system in July 2016.
- Only Boeing and subcontractor laboratory testing on the Tactical Situational Awareness System and the modified ALR-69A RWR system has been completed to date; initial flight testing on these systems began in the spring of 2016, and will not be completed until shortly before IOT&E.
- LAIRCM testing provided hit point distribution data to inform the vulnerability assessment and to verify that LAIRCM performance on the KC-46A has not been degraded from previously demonstrated performance on other aircraft. Both system configurations (Block 20 with ultraviolet missile warning system and Block 30 with two-color infrared missile warning system) were included in the evaluation.
- Boeing and the Air Force still need to complete several tests that assess areas that significantly influence the aircraft's survivability. These include ground and flight testing of the On-Board Inert Gas Generation System, Electromagnetic Pulse (EMP) (delayed until April 2017), and thermal testing of the nuclear flash curtains.

Assessment

- DOT&E has assessed and continues to assess the KC-46A schedule as aggressive and unlikely to be executed as planned. At Milestone B, in February 2011, the Air Force had planned to be 66 percent complete by Milestone C. However, upon accomplishing Milestone C in August 2016, Boeing had completed only 30 percent of the total EMD testing. Many subsystems have only been tested in the laboratory. Execution of the current schedule assumes historically unrealistic test aircraft fly and re-fly rates.
- The KC-46A is trending to be an effective AR platform. It demonstrated a limited capability to refuel receiver aircraft (its primary mission) and to be refueled from tanker aircraft during OA-2. However, the demonstrations to date have been at a single point of the operational envelope for only five different receiver aircraft, during daylight only, and no aircraft have completed certification as a receiving platform. The AR boom receivers were the F-16, C-17, and A-10; the probe-drogue receivers were the F/A-18C and AV-8B.
- The current boom is a prototype designed to solve boom axial load problems encountered in early testing and is not production-representative. Wing refueling pods that meet all Federal Aviation Administration qualification requirements will not be available for two years.
- During OA-2 testing, the AROs identified a problem that can occur when the ARO station is set to "dual" operation such that the controls at both the primary and instructor station are active. When both positions apply a flight control stick command, the boom will move to a summed position

due to the system's summation logic. There are situations where this could result in a rapid boom movement to the instructor-commanded position; if the receiver aircraft is in the path, the potential exists for the boom to inadvertently strike the receiver aircraft. The Air Force and Boeing are working to resolve this deficiency.

- The AROs also noted the long-wave infrared cameras produced an undesirable effect when interacting with the sun and clouds. For example, a solar trail occurs when the sun moves across the screen (such as during a turn) and leaves a persistent afterimage forming a line. Additionally, the ARO station screen overlays – which provide boom envelope position and other information – interfere with the ARO's ability to view and monitor AR operations. The Air Force and Boeing are working to resolve this deficiency.
- Testing during OA-2 did not identify any critical deficiencies with the cargo handling or aeromedical evacuation missions – though testing did identify deficiencies the Air Force should address. Other secondary missions have not been tested.
- The KC-46A demonstrated satisfactory progress for operational suitability; however, it is premature to make definitive conclusions. The program is tracking better than planned on the reliability growth curve, as measured by Mean Time Between Inherent Failures. Several metrics are worse than thresholds, such as the aerial abort rate, cannot-duplicate rate for failures, Mean Time Between Unscheduled Maintenance, and break rate; however, these results are not surprising. The program is not planning to meet these requirements until 50,000 fleet flight hours, which will not occur until 2 to 3 years after IOC. Other metrics, including availability, mission-capable rate, sortie generation rate, and maintainability, cannot be estimated at this point in the program. Boeing owned, operated, maintained, and supplied the aircraft rather than the Air Force. Consequently, operational aircrew had minimal involvement in aircraft operations and there was no operational maintenance.
- DOT&E evaluated the KC-46A survivability against kinetic and non-kinetic threats in four scenarios. These threats include ballistic threats, light anti-aircraft artillery, man-portable air defense system missiles, radar-guided surface-to-air and air-to-air missiles, chemical and biological weapons, high power microwave, low power lasers, and EMP. Detailed results of these evaluations are in the classified annex to DOT&E's OA-2 report.
- The KC-46A EMP design margin was based on Military Standard (MIL-STD) 464 and the threat defined in MIL-STD 2169. After the fixed-price contract was awarded, the DOD instituted a new MIL STD 3023 that requires tanker aircraft supporting the nuclear deterrent mission to meet a 20-decibel (dB) EMP design margin versus the contractually required 6-dB EMP design margin. Unless additional tests are resourced, the Air Force or the U.S. Strategic Command will not know if the KC-46A meets the 20-dB EMP hardening requirement in MIL STD 3023.
- During OA-2, testers discovered several cybersecurity vulnerabilities. The program plans to correct some of them prior to IOT&E. Corrections to others that are related to government-furnished equipment are under discussion. Details are presented in the classified annex to the DOT&E OA-2 report.

Recommendations

- Status of Previous Recommendations. The Air Force has addressed all FY12 through FY14 recommendations. The Air Force still needs to address the following FY15 recommendations:
  1. Ensure all AR receiver aircraft are certified for use by operational aircrew early enough in IOT&E to permit sufficient operational testing.
  2. In conjunction with U.S. Strategic Command, determine whether its personnel can conduct the nuclear deterrence and strike missions with a KC-46A only having 6-dB EMP shielding as per the contract. If additional EMP shielding is deemed necessary, the Air Force should conduct testing as part of FOT&E to determine the actual KC-46A EMP design margin.
- FY16 Recommendations. The Air Force should:
  1. Develop an executable schedule that is based on historical fly and re-fly rates.
  2. Address the recommendations presented in the unclassified DOT&E KC-46A OA-2 report.
  - Verify boom loads are satisfactory under all operational conditions.
  - Address deficiencies with the ARO cameras, ARO station screen displays, and instructor control stick logic.
  - Address cybersecurity vulnerabilities.

Massive Ordnance Penetrator (MOP)

Executive Summary
- In March 2016, the Air Force successfully completed one weapon drop from the B-2 aircraft, and in June 2016, completed three weapon drops from two B-2 aircraft on a representative target. These tests, conducted at the White Sands Missile Range, New Mexico, demonstrated weapon effectiveness after the Air Force incorporated the Enhanced Threat Response (ETR) Phase 3 enhancements. ETR Phase 3 testing is complete and ETR Phase 4 testing will begin in FY17.
- DOT&E published a classified Early Fielding Report summarizing the ETR Phase 3 test results in September 2016.

System
- The GBU-57 Massive Ordnance Penetrator (MOP) is a large, GPS-guided, penetrating weapon with the ability to attack deeply-buried and hardened bunkers and tunnels. The warhead case is made from a special high-performance steel alloy and its design allows for a large explosive payload while maintaining the integrity of the penetrator case during impact.
- The B-2 Spirit is the only aircraft in the Air Force programmed to employ the MOP.
- The GBU-57 warhead is more powerful than its predecessors, the BLU-109 and GBU-28.
- The MOP is an Air Force-led, Quick Reaction Capability that is a SECDEF special interest effort and is under DOT&E oversight.

Mission
Combatant Commanders use the B-2 equipped with MOP to conduct pre-planned, day or night attacks against defended point targets vulnerable to blast and fragmentation effects and requiring significant penetration, such as hardened and deeply-buried facilities.

Major Contractor
The Boeing Company, Defense, Space & Security – St. Louis, Missouri

Activity
- In March 2016, the Air Force conducted one live weapon drop at the White Sands Missile Range, New Mexico, on a representative target to evaluate weapon functionality with the ETR-3 modifications. An Air Force B-2 aircraft flew the mission.
- In June 2016, the Air Force conducted a three-weapon test on a representative target. This testing was to evaluate weapon effectiveness. Two Air Force B-2 aircraft each flew one sortie to complete the mission.
- These events completed the ETR Phase 3 test.
- DOT&E submitted a classified Early Fielding Report in September 2016 detailing the results of ETR Phase 3.

Assessment
- The ETR Phase 3 testing was successful in demonstrating weapon effectiveness with the current weapon configuration.
- Nonetheless, significant differences between pre-test modeling predictions and actual test results indicate the need for provision of additional modeling capacity, such as that available using the Department's High-Performance Computing facilities.
- The Air Force will continue with ETR Phase 4 testing in FY17.

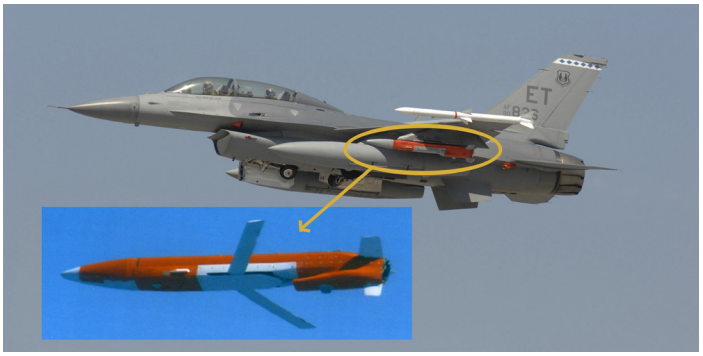
Recommendations
- Status of Previous Recommendations. There were no previous recommendations for this program.
- FY16 Recommendations. None.

Miniature Air Launched Decoy (MALD) and Miniature Air Launched Decoy – Jammer (MALD-J)

Executive Summary
- The Miniature Air Launched Decoy – Jammer (MALD-J) mission planning tools, with the latest software upgrades, can support the 72-hour Air Tasking Order (ATO) planning cycle.
- Flight testing of a navigational system upgrade was stopped because of an anomaly observed in June 2016. The Program Office has corrected the software errors and verified the correction in both ground and flight testing in August 2016 and September 2016, respectively.

System
- MALD is a small, low-cost, expendable, air-launched vehicle that replicates how fighter, attack, and bomber aircraft appear to enemy radar operators.
- MALD-J is an airborne close-in jammer for electronic attack with the ability to loiter on station.
- MALD-J will jam specific Early Warning/Ground Control Intercept/Acquisition radars while retaining the capabilities of the MALD.
- MALD-J will stimulate and degrade an enemy's integrated air defense system.
- The F-16 C/D and B-52H are the lead aircraft to employ MALD and MALD-J.

Mission
- Combatant Commanders will employ units equipped with MALD or MALD-J to improve battlespace access for airborne strike forces by deceiving, distracting, or saturating enemy radar operators and integrated air defense systems.



- MALD is designed to allow an airborne strike force to accomplish its mission by deceiving enemy radars and air defense systems to treat MALD as a viable target.
- MALD-J is designed to allow an airborne strike force to accomplish its mission by jamming specific enemy radars and air defense systems to degrade or deny detection of friendly aircraft or munitions.
- MALD J-equipped forces will be able to stimulate an enemy's integrated air defense system enabling friendly forces to target and engage enemy components.

Major Contractor
Raytheon Missile Systems – Tucson, Arizona

Activity
- In January 2016, the Air Force Operational Test and Evaluation Center (AFOTEC) completed ground testing of the GPS Aided Inertial Navigation System (GAINS) obsolescence upgrade (known as GAINS2) to the MALD-J at the National Radar Cross Section Test Facility, New Mexico, which included a side-by-side test between a GAINS unit and a GAINS2 unit.
- In June 2016, the 28th Test and Evaluation Squadron (TES) partially executed a Force Development Evaluation (FDE) at White Sands Missile Range, New Mexico, in conjunction with a MALD-J Reliability Assessment Program mission, to assess the performance of the GAINS2 obsolescence upgrade to the MALD-J. The 28th TES launched only two missiles: one in an uncontested environment and one in a GPS-contested environment.
- In July 2016, the Program Office and Raytheon Missile Systems completed a review for the navigation anomaly observed in a GPS-contested environment during the FDE in June 2016.
- From March through June 2016, the Program Office completed four data collection events with respect to mission planning for MALD-J on the F-16 and B-52 platforms; one at Barksdale AFB in Louisiana, one at Eglin AFB in Florida, one at Spangdahlem AFB in Germany, and one at Aviano AFB in Italy.
- The Program Office verified during ground testing in August 2016, and during flight testing in September 2016, that the software update corrected the software anomaly.

Assessment

- MALD-J (and MALD) testing was done in accordance with a DOT&E approved test plan.
- The latest mission planning data collections for the MALD-J program show marked reduction in the time needed to plan a full load of MALD-J vehicles. The mission planning tools, with the latest software upgrades, can support the 72-hour ATO planning cycle.
- Preliminary results from ground testing indicate improved performance of the GAINS2 system in a GPS-contested environment as compared to the GAINS.
- Due to a navigation anomaly observed during the FDE in June 2016, no assessment of the GAINS2 free flight performance in a GPS contested environment can be made.
- The Program Office concluded that the MALD-J failed to reacquire any GPS satellites when the navigation system exited the GPS contested environment because of software errors introduced by Raytheon Missile Systems.

Recommendations

- Status of Previous Recommendations. The Air Force satisfactorily addressed the one remaining FY14 recommendation and one of the three FY15 recommendations. The Air Force still should:
  1. Incorporate additional operational elements into the mission-level simulation in the Digital Integrated Air Defense System.
  2. Improve horizontal navigational accuracy of the MALD-J (and MALD) vehicle.
- FY16 Recommendation.
  1. Once the GAINS2 software corrections are verified, the Air Force should return to free flight testing of the GAINS2 in a GPS-contested environment.

MQ-9 Reaper Armed Unmanned Aircraft System (UAS)

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) completed FOT&E of the MQ-9 Block 5 Remotely Piloted Aircraft (RPA), Block 30 Ground Control Station (GCS), and Operational Flight Program (OFP) 904.6 software suite revision K in accordance with the DOT&E-approved test plan. The results from the FOT&E demonstrated the following:
  - The MQ-9 Unmanned Aircraft System (UAS) configuration tested is not operationally effective and not operationally suitable. The system was unable to conduct the all-weather hunter mission role operations using onboard systems.
  - The MQ-9 UAS evaluated in the FOT&E is not capable of conducting wide-area searches to hunt fixed or moving targets with the Lynx Synthetic Aperture Radar (SAR) system. The MQ-9 Lynx SAR does not provide a useful operation for the Block 5 RPA/Block 30 GCS due to unstable and unmanageable aircraft and GCS software configuration problems; human machine interface complexity; inadequate and incomplete technical orders; and persistent in-flight radar mode failures.
  - The Block 5 RPA/Block 30 GCS MQ-9 UAS retains the legacy MQ-9 capability to conduct cued area searches for fixed and moving targets with the Multi-spectral Targeting System (MTS) B electro-optical/infrared sensor, and to employ legacy AGM-114 HELLFIRE II missiles and GBU 12 laser guided bombs. Additionally, the FOT&E results demonstrated the MQ-9 UAS can effectively employ GBU-38 JDAM bombs against stationary targets, as long as target coordinates are provided by off-board sources.
  - The Block 5 RPA and Block 30 GCS are not operationally suitable. Testing showed these systems experience high abort rates and break often.
- The MQ-9 Block 5 RPA is subject to overheating problems in operationally relevant environments.
  - Block 5 RPA subsystems may overheat in hot weather prior to take-off, leading to mission aborts. The installation of an aircraft cooling plenum and addition of a new, more powerful ground-cooling cart in FY15 mitigates some of the RPA avionics bay overheating problems identified in FY14. However, these measures do not eliminate all overheating problems in hot weather operating environments.
  - Inherent Block 5 RPA design limitations lead to thermal management problems that were not fully resolved by the aircraft cooling plenum or the new ground-cooling cart. As highlighted in the DOT&E FY15 Annual Report, although these measures mitigated RPA forward avionics bay redundant control module and transmitter overheating shortfalls, power and thermal management problems that can preclude charging batteries on the ground can lead to depleted batteries prior to take-off and may force mission aborts.

- In FY15, the Air Force adopted a hybrid acquisition strategy for the MQ-9 program of record. The Air Force intended for the acquisition strategy to provide a series of bundled MQ-9 software/hardware releases under an accelerated development and testing schedule. The first release of planned capabilities under this construct envisioned for FY17 delivery is expected to deliver in FY18.
- The final configuration of the MQ-9 Increment One UAS continued to evolve. As of the end of FY16, the Air Force indicated it plans to incorporate an improved MTS-B electro-optical/infrared sensor, additional weapons, new avionics hardware, and further system software revisions into the existing program of record.
- General Atomics delivered the last of 195 Block 1 RPAs to the Air Force in 2QFY15, and then transitioned the production line to Block 5 RPAs. As of 3QFY16, General Atomics had delivered 12 of 155 planned Block 5 RPAs. Total Air Force MQ-9 deliveries as of 3QFY16 include 207 of 350 planned MQ-9s (Block 1 and Block 5 combined). General Atomics plans to deliver the final Block 5 RPA in FY21.
- The Air Force plans to field the Block 5 RPA and Block 30 GCS in 1QFY17, and will complete delivery of the MQ-9 program of record fleet under low-rate initial production.

System

- The MQ-9 Reaper UAS is a remotely piloted and armed aircraft system that uses optical, infrared, and radar sensors to locate, identify, target, and attack ground targets.
  - The MQ-9 RPA is a medium-sized aircraft that has an operating ceiling up to 50,000 feet, an internal sensor payload of 800 pounds, an external payload

of 3,000 pounds, and an endurance of approximately 12 hours.
  - Aircraft sensors include the MTS-B electro-optical and infrared targeting sensor and the Lynx SAR system.
  - The GCS commands the MQ-9 RPA for launch, recovery, and mission control of sensors and weapons. RPA launch and recovery operations use C band line-of-sight datalinks, and RPA mission control uses Ku band satellite links.
- The fielded Block 1 MQ-9 RPA carries AGM-114 HELLFIRE II anti-armor precision laser-guided missiles, and GBU-12 500-pound, laser-guided bombs.
- The Air Force is using an evolutionary acquisition approach for meeting Increment One Capability Production Document requirements, with Block 1 and Block 5 RPAs and Block 15 and Block 30 GCSs.
- The Air Force is currently fielding the Block 1 RPA and the Block 15 GCS and will field the Block 5 RPA and Block 30 GCS in 1QFY17.
- The Air Force designed the Block 5 RPA to incorporate improved main landing gear, an upgraded electrical system with more power, an additional ARC-210 radio, encrypted datalinks, a redesigned avionics bay and digital electronic engine control system, the BRU-71 bomb rack, high-definition video, and upgraded software to allow the two-person aircrew to operate all onboard sensors and systems.
- The Air Force designed the Block 30 GCS to incorporate upgraded flight control displays and avionics, secure digital datalinks, Integrated Sensor Control System, Continuous Look Attack Management for Predator, Control of Lynx and Analysis Workstation software, and high-definition multi-function displays.

Mission
- Combatant Commanders use units equipped with the MQ-9 to conduct armed reconnaissance and pre-planned strikes. When provided wide-area search cues from off-board sources, units equipped with MQ-9s can execute cued searches to find, fix, track, target, engage, and assess critical emerging targets (both moving and stationary).
- MQ-9 units can also conduct aerial intelligence gathering, reconnaissance, surveillance, and target acquisition for other airborne platforms.

Major Contractor
General Atomics Aeronautical Systems Inc. – San Diego, California

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Activity
- The Air Force conducted MQ-9 testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and test plan.
- AFOTEC completed FOT&E of the Block 5 RPA, Block 30 GCS, and OFP 904.6 in 4QFY16 in support of Air Force 1QFY17 planned operational fielding. Testing evaluated the MQ-9 all-weather, wide-area search capability across multiple operational mission sets to determine the system's ability to hunt and kill fixed and moving targets using system capabilities and weapons. Additional testing included a cybersecurity Adversarial Assessment and hot and cold weather tests.
  - During the FOT&E, AFOTEC discovered a deficiency in the ability of the MTS-B to track targets without breaking lock, and declared a test pause. During the pause, the Air Force determined the root cause of the deficiency was due to a software anomaly. The Air Force corrected the problem and evaluated the fix in subsequent developmental regression testing. Upon software fix incorporation, AFOTEC resumed the FOT&E and re-accomplished the MTS-B-related FOT&E test points.
  - AFOTEC terminated MQ-9 Lynx SAR FOT&E testing without completing the scope of planned Lynx SAR test events. Persistent GCS configuration problems, incomplete technical orders, and software complexities precluded contract maintainers from effectively configuring and troubleshooting, and precluded aircrews from effectively employing the system.
- In conjunction with the FY16 FOT&E, AFOTEC and the 57th Information Aggressor Squadron conducted a cybersecurity Adversarial Assessment of the MQ-9 Block 5 RPA/Block 30 GCS.
- In FY15, the Air Force adopted a hybrid acquisition strategy for the MQ-9 program of record. The Air Force intended for the acquisition strategy to provide a series of bundled MQ-9 software/hardware releases under an accelerated development and testing schedule. The first release of planned capabilities under this construct is expected to deliver in FY18.
- The final configuration of the MQ-9 Increment One UAS continued to evolve. As of the end of FY16, the Air Force indicated it plans to incorporate an improved MTS-B electro-optical/infrared sensor, additional weapons, new avionics hardware, and further system software revisions into the existing program of record.
- General Atomics delivered the last of 195 Block 1 RPAs to the Air Force in 2QFY15, and then transitioned the production line to Block 5 RPAs. As of 3QFY16, General Atomics had delivered 12 of 155 planned Block 5 RPAs. Total Air Force MQ-9 deliveries as of 3QFY16 include 207 of 350 planned MQ-9s (Block 1 and Block 5 combined). General Atomics plans to deliver the final Block 5 RPA in FY21.
- The Air Force plans to field the Block 5 RPA and Block 30 GCS in 1QFY17, and will complete delivery of the MQ-9 program of record fleet under low-rate initial production.

Assessment

- The FY16 MQ-9 FOT&E was intended to evaluate deferred Increment One system and operational mission capabilities not evaluated during the 2007 IOT&E. During IOT&E, the MQ-9 Lynx SAR system integration was immature, and the MQ-9 hunter mission role was not evaluated due to this shortfall. The Air Force intended to satisfy the hunter mission role through the acquisition of the Block 5 RPA and Block 30 GCS, and this configuration entered production in 2011. However, the MQ-9 Block 5 RPA as tested in the FY16 FOT&E and that will field to operational units in FY17 cannot conduct an all-weather hunter mission role using the Lynx SAR system.
  - FOT&E results demonstrated the MQ-9 Increment One UAS is not operationally capable of conducting wide-area searches to hunt fixed or moving targets with the Lynx SAR radar. The MQ-9 UAS is not operationally effective in this mission role.
  - Operational aircrews were not able to successfully conduct radar search and targeting tasks due to Lynx SAR radar instability, persistent aircraft and GCS software configuration problems, human machine interface complexity, inadequate and incomplete technical orders, and in-flight radar mode failures.
  - Deficient technical order publications further precluded aircrews and contractor maintainers from troubleshooting radar problems when they occurred during FOT&E missions.
  - Aircrews could not reliably execute legacy radar tasks that had been successfully demonstrated in 2013 Block 1 RPA operational testing (SAR spot imaging to support target location determination and ground moving target indicator detection and cueing) with the Block 5 RPA/Block 30 GCS system. As described above, software complexity, technical order deficiencies, and maintainer inability to troubleshoot radar problems precluded mission accomplishment using the radar system.
  - Based on the shortfalls realized in FOT&E, the MQ-9 Lynx SAR as tested does not provide an operationally useful capability to search for targets for the Block 5 RPA and Block 30 GCS UAS configuration.
- The MQ-9 Block 5 RPA demonstrated adequate MTS-B cued-search, track, and laser-guided weapons support capabilities during operational mission tasks executed in the course of FY16 FOT&E.
- The FY16 FOT&E confirmed the Block 5 RPA/Block 30 GCS system can successfully employ GBU-38 JDAM bombs (when target coordinates are provided by off-board sources), and can employ legacy AGM 114 HELLFIRE II laser-guided missiles and GBU 12 laser-guided bombs.
- FOT&E results established that the Block 5 RPA and Block 30 GCS are not operationally suitable. Testing showed this system breaks more often and is harder to maintain than the legacy Block 1 RPA and Block 15 GCS.
- The MQ-9 Block 5 RPA is subject to overheating problems in operationally relevant environments.
  - Block 5 RPA subsystems may overheat in hot weather prior to take-off, leading to mission aborts. The installation of an aircraft cooling plenum and addition of a new, more powerful ground-cooling cart in FY15 mitigates some of the RPA avionics bay overheating problems identified in FY14. However, it does not eliminate all overheating problems in hot weather operating environments.
  - Inherent Block 5 RPA design limitations led to thermal management problems that are not fully resolved by the installed aircraft cooling plenum or the new ground-cooling cart. As highlighted in the DOT&E FY15 Annual Report, although these measures mitigated RPA forward avionics bay redundant control module and transmitter overheating shortfalls, power and thermal management problems that can preclude charging batteries on the ground can lead to depleted batteries prior to take-off and forcing mission aborts.
- Aircrew Block 5 RPA and Block 30 GCS technical orders do not support proper system operations. Some areas of the technical orders are too long and complex (e.g., preflight checklists). Other areas lack proper instructions for accomplishing mission tasks (e.g., Lynx SAR operations) and problem resolution (e.g., fuel tank overheating cautions).
  - Contractor personnel maintained the Block 30 GCS during FOT&E. The Air Force plans to field the Block 30 GCS in 1QFY17 and maintain the system with only Air Force personnel. It is likely that Air Force personnel will encounter the same maintenance challenges that contractor maintenance personnel experienced during testing.
- The Air Force originally intended to fulfill the MQ-9 Increment One requirements with a final UAS configuration consisting of the Block 5 RPA, Block 30 GCS, and OFP 904.6. The Air Force currently plans to complete the MQ-9 Increment One system with a Block 50 GCS and a future system OFP. The Air Force delayed Block 50 GCS development, and initial production of Block 50 GCS units will not occur until FY19. Subsequent AFOTEC FOT&E of the Block 50 GCS and the system capabilities being developed under the Air Force hybrid acquisition strategy may not occur until FY21. A new TEMP will be required to document the incorporation of new program of record content, and the test strategy and resources necessary to develop and evaluate the Block 50 GCS and associated MQ-9 capabilities.

Recommendations

- Status of Previous Recommendations. In FY16, the Air Force completed the FOT&E. The Air Force made progress toward but did not satisfy the FY15 recommendations to resolve the hot weather operating shortfalls.
- FY16 Recommendations. The Air Force should:
  1. Correct the Block 5 RPA/Block 30 GCS Lynx SAR shortfalls identified during FY16 FOT&E. Once the radar problems are resolved, re-accomplish formal FOT&E to confirm the MQ-9 UAS ability to conduct wide-area search

tasks to hunt moving and fixed targets in a hunter mission role, and to demonstrate the ability to generate own-ship precision coordinates necessary for JDAM employment.
2. Resolve the remaining Block 5 RPA power and thermal management operating shortfalls to meet Air Force operating environment requirements.
3. Correct MQ-9 operator and maintainer technical orders deficiencies to enable effective system operation and maintenance.
4. Develop and submit a new TEMP for DOT&E approval, documenting the incorporation of new program of record content (e.g., the Block 50 GCS) and the T&E strategy and resources required to mature and test these capabilities and systems.

QF-16 Full-Scale Aerial Target (FSAT)

Executive Summary

- The Air Force completed QF-16 radar cross section (RCS) measurements in FY16.
- The Air Force has not accomplished cybersecurity testing in accordance with the DOT&E IOT&E recommendation and cybersecurity policy memorandum, dated August 1, 2014.
- The Air Force should continue, as it did in FY16 and FY17, to provide procurement funding for at least 25 Full-Scale Aerial Targets (FSATs) per year to meet Service-coordinated aerial target requirements, in compliance with Resource Management Decision 700.
- The Air Force should support the OSD-sponsored study to address shortfalls in testing against fifth-generation airborne threats, and be prepared to fund and implement the recommendations that are assigned for Air Force execution.

System

- The QF-16 is the latest FSAT designed to test and evaluate U.S. weapon systems and assist in developing tactics, techniques, and procedures to counter fighter-size airborne threats. The DOD is replacing the current FSAT, the QF-4, due to its increasing dissimilarity from current and projected air-superiority threats, declining supportability, and depletion of suitable F-4 airframes.
- The QF-16 system is composed of regenerated F-16 Block 15, 25, and 30 aircraft equipped with Drone-Peculiar Equipment to enable remote command and control, missile trajectory scoring, and safe flight termination. Like the QF-4, the QF-16 is capable of manned and Not Under Live Local Operator flight operations. It will operate from Tyndall AFB, Florida, using the Gulf Range Drone Control System, and Holloman AFB, New Mexico, using the White Sands Integrated Target System located at White Sands Missile Range, New Mexico.
- The QF-16 retains F-16 flight performance characteristics and payload capabilities including supersonic, after-burning engine, high-G maneuvering, complex electronic attack, and expendable countermeasures.

Mission

The DOD uses FSATs to:

- Provide threat-representative presentations for developmental and operational test and evaluation for U.S. weapon systems, as mandated by section 2366, title 10 U.S. Code.
- Continuously evaluate fielded air-to-air missile capabilities while providing live missile training for combat air crews through Air Force and Navy Weapon Systems Evaluation Programs.

Major Contractor

The Boeing Company – St. Louis, Missouri

Activity

- The Air Force completed RCS measurements in FY16 and demonstrated that the QF-16 meets the Capability Development Document requirements.
- The Air Force Life Cycle Management Center, with the support of the Air Force Operational Test and Evaluation Center, is in the process of test planning to comply with DOT&E cybersecurity testing requirements.

Assessment

- The QF-16 program currently lacks Air Force funding to complete additional cybersecurity testing. Using current program funding, the Air Force Life Cycle Management Center awarded a contract to Boeing to continue cybersecurity test planning in accordance with DOT&E guidance.
- The Air Force did not require QF-16 to represent fifth generation airborne threat systems (including radio frequency low-observability characteristics, internally-carried advanced electronic attack, and low probability of intercept sensors). DOT&E continues to emphasize that existing aerial targets, including the QF-16, are insufficient for adequate operational testing of U.S. weapon systems. Air Force RCS measurements show that QF-16 can only partially satisfy the test requirements for fifth generation full-scale targets.
  - In the Air Superiority Target Phase I Analysis of Alternatives Final Report (March 15, 2007), the Air Force recommended further study to produce user consensus on critical characteristics of future aerial targets and

to determine capabilities and shortfalls in existing test resources.
  - Multiple stakeholders within Congress, OSD, the Air Force, and the Navy, support the requirement for a fifth generation FSAT. OSD is leading a study to assess both short- and long-term fifth generation FSAT options, with a scheduled completion of March 2017.
- Vector Scoring System (VSS) reliability was noted as a problem in the 2015 QF-16 IOT&E report. The Air Force continues to monitor VSS reliability. The VSS hardware changes made for production aircraft, along with checkout and maintenance procedure updates, have shown improvement in VSS reliability. Additional data collection is ongoing to fully assess if the system will support compliance with the QF-16's Mean Time Between Failure requirement.
- In late June 2015, Boeing performed sample inspections on a QF-16 at Cecil Field, Florida, and discovered workmanship deficiencies with wire splices, termination, and routing. As a result of these findings, they broadened the inspection population to the first three production aircraft already delivered to Tyndall AFB, Florida, and found similar problems. Corrective actions were completed and the Program Office received clearance in FY16 to provide full QF-16 services. Air Combat Command declared QF-16 Initial Operational Capability at Tyndall AFB, Florida, in September 2016, with a total of 15 QF-16s available for target operations.

Recommendations

- Status of Previous Recommendations. The Air Force completed RCS measurements in FY16 and has continued to monitor and improve VSS reliability. The Air Force still needs to address the recommendations to accomplish cybersecurity testing in accordance with the DOT&E cybersecurity policy memorandum, dated August 1, 2014.
- FY16 Recommendations. The Air Force should:
  1. Support the OSD-sponsored study to address shortfalls in testing against fifth-generation airborne threats, and be prepared to fund and implement the recommendations that are assigned for Air Force execution.
  2. Continue to monitor VSS reliability to ensure the corrections that were implemented in production aircraft will support compliance with the QF-16's Mean Time Between Failure requirement.

RQ-4B Global Hawk High-Altitude Long-Endurance Unmanned Aerial System (UAS)

Executive Summary

- The RQ-4B Block 40/Multi-Platform Radar Technology Insertion Program (MP-RTIP) IOT&E began in September 2015 and completed in January 2016. DOT&E assessed that the system demonstrated the capability to provide exploitable synthetic aperture radar (SAR) and Ground Moving Target Indicator (GMTI) data. The system met joint interoperability requirements. A cybersecurity Adversarial Assessment conducted in conjunction with the IOT&E identified vulnerabilities that are documented in the classified DOT&E IOT&E report. The RQ-4B Global Hawk Block 40 is operationally suitable and can generate and sustain the long-endurance missions necessary to support non-continuous operations representative of the current combat tempo. The RQ-4B Global Hawk Block 40 suitability has significantly improved over both the 2013 RQ-4B Block 40 Operational Utility Evaluation (OUE) and 2010 RQ-4B Block 30 IOT&E results. MP-RTIP sensor stability has also significantly improved since the RQ-4B Block 40 OUE.
- DOT&E approved the Air Force Capstone Test and Evaluation Master Plan (TEMP) in June 2016, which provides an overarching test approach for the system architecture and capability upgrades included in the new program baseline and future modernization programs. DOT&E anticipates the program will develop TEMP annexes according to the requirements and schedule documented in the approved Capstone TEMP.
- The Air Force is currently planning to conduct RQ-4B Block 30/Airborne Signals Intelligence Payload (ASIP) FOT&E in conjunction with the initial phases of the RQ-4B modernization program in FY18. This test will include a re-evaluation of the RQ-4B Block 30 Signals Intelligence (SIGINT) mission capabilities with the ASIP sensor as well as an assessment of previously identified ground station, air vehicle, communication system, interoperability, and cybersecurity shortfalls.

System

- The RQ-4B Global Hawk is a remotely-piloted, high-altitude, long-endurance airborne intelligence, surveillance, and reconnaissance (ISR) system that includes the Global Hawk unmanned air vehicle, various intelligence and communications relay mission payloads, and supporting command and control ground stations.
- The RQ-4B Global Hawk Block 30 system is equipped with a multi-intelligence payload that includes both the Enhanced Integrated Sensor Suite imagery intelligence payload and ASIP SIGINT sensor.
- The RQ-4B Block 40 system is equipped with the MP-RTIP synthetic aperture radar payload designed to simultaneously collect imagery intelligence on stationary ground targets and track ground-moving targets.
- All RQ-4B systems use line-of-sight and beyond line-of-sight communication systems to provide air vehicle command and control and transfer collected intelligence data to grounds stations for exploitation and dissemination.
- The Air Force Distributed Common Ground System (AF DCGS) supports ISR collection, processing, exploitation, analysis, and dissemination for both Block 30 and 40 RQ-4B Global Hawk systems. The AF DCGS employs global communications architecture to connect multiple intelligence platforms and sensors to numerous Distributed Ground Stations where intelligence analysts produce and disseminate intelligence products.

Mission

- Commanders use RQ-4 Global Hawk reconnaissance units to provide high-altitude, long-endurance intelligence collection capabilities to support theater operations. Units equipped with RQ-4B Global Hawk use line-of-sight and beyond line-of-sight satellite datalinks to control the Global Hawk system and transmit collected intelligence data.
- Operators collect imagery and SIGINT data to support ground units and to identify intelligence-essential elements of information for theater commanders.
- Ground-based intelligence analysts exploit collected imagery, ground-moving target, and SIGINT to provide intelligence products that support theater operations.
- Forward-based personnel can receive imagery intelligence directly from Global Hawk.

Major Contractor
Northrop Grumman Aerospace Systems, Strike and Surveillance Systems Division – San Diego, California

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Activity
- As of September 2016, the Air Force has taken delivery of 18 of 21 RQ-4B Block 30 air vehicles and all 11 RQ-4B Block 40 air vehicles, along with 9 Mission Control and 10 Launch and Recovery ground stations.
- The Air Force is currently planning to conduct FOT&E in conjunction with the initial phases of the RQ-4B modernization program in FY18. This test will include a complete re-evaluation of the RQ-4B Block 30 SIGINT mission capabilities with the ASIP sensor as well as an assessment of previously identified ground station, air vehicle, communication system, interoperability, and cybersecurity shortfalls.
- DOT&E approved the Air Force Capstone TEMP in June 2016, which provides an overarching test approach for the system architecture and capability upgrades included in the new program baseline and future modernization programs. DOT&E anticipates the program will develop TEMP annexes according to the requirements and schedule documented in the approved Capstone TEMP.
- The Air Force did not conduct any RQ-4B Block 30 operational testing in FY15. The Air Force continued to sustain operations for 18 Block 30 aircraft at Beale AFB, California, and at forward operating bases in U.S. Pacific Command, U.S. Central Command, and U.S. European Command operating areas.
- The Air Force is currently developing a comprehensive program test strategy and TEMP to correct previously identified RQ-4B Block 30 capability shortfalls and test a series of modernization upgrades. This strategy will identify the next collection of significant RQ-4B Block 30 FOT&E events planned for FY18. Events include re-evaluation of previously identified ASIP/SIGINT mission capability shortfalls, interoperability deficiencies, MS-177 sensor integration, weather radar integration, mission planning upgrades, and other system modernization changes.
- The RQ-4B Block 40/MP-RTIP IOT&E began in September 2015 and completed in December 2015. The Air Force conducted testing in accordance with the DOT&E-approved test plan. DOT&E approved the Block 40 IOT&E test plan in May 2015.

Assessment
- In July 2016, DOT&E published the classified RQ-4B Global Hawk Block 40 IOT&E report based on test results from the RQ-4B Block 40/MP-RTIP IOT&E conducted from September 2015 through January 2016.
  - The system demonstrated the capability to provide exploitable SAR and GMTI data. Both SAR and GMTI data met most operational requirements and provided actionable intelligence products to operational users. However, inadequate training, procedures, tools, communication, and management hindered the ability of the AF DCGS to exploit GMTI data in near real-time.
  - The system met joint interoperability requirements.
  - A cybersecurity Adversarial Assessment conducted in conjunction with the IOT&E identified vulnerabilities that are documented in the classified IOT&E report.
  - The RQ-4B Global Hawk Block 40 is operationally suitable and can generate and sustain the long-endurance missions necessary to support non-continuous operations representative of the current combat tempo. The RQ-4B Global Hawk Block 40 suitability has significantly improved over both the 2013 RQ-4B Block 40 OUE and 2010 RQ-4B Block 30 IOT&E results. However, the Air Force continues to operate the RQ-4B Global Hawk Block 40 at a rate of three missions per week based on the suitability results from the 2010 RQ-4B Block 30 IOT&E. Despite initial expectations (requirements) that called for a single Global Hawk orbit to provide near-continuous on-station coverage for 30 days, the Air Force has since adopted a combat tempo of 3 long duration (approximately 28 hours) sorties a week over 30 days or more.
  - MP-RTIP sensor stability has also significantly improved since the RQ-4B Block 40 OUE.

Recommendations
- Status of Previous Recommendations. The Air Force made progress toward addressing FY15 recommendations. The Air Force completed an RQ-4B Capstone TEMP to guide developmental and operational testing of these systems. The Air Force has not completed a plan to complete the FOT&E for the RQ-4B Block 30 SIGINT mission using the ASIP sensor.
- FY16 Recommendations. The Air Force should:
  1. Develop RQ-4B program Capstone TEMP annexes to guide execution of the RQ-4B Global Hawk Block 30 FOT&E and to define operational test requirements for future Block 30 and Block 40 system upgrades.
  2. Develop a plan to complete the FOT&E for the RQ-4B Block 30 SIGINT mission using the ASIP sensor.
  3. Develop a comprehensive plan to address cybersecurity deficiencies observed during RQ-4B Global Hawk Block 40/MP-RTIP IOT&E.
  4. Develop AF DCGS training, procedures, tools, communication, and management enhancements to allow exploitation of RQ-4B Global Hawk Block 40 GMTI data in near real-time.

Small Diameter Bomb (SDB) II

Executive Summary

- The Small Diameter Bomb (SDB) II developmental testing is ongoing. Government Confidence Testing (GCT) began in October 2016. The Air Force awarded the Low-Rate Initial Production Lot 2 contract for 250 weapons in September 2016.
- SDB II is progressing towards meeting its effectiveness, reliability, and lethality requirements in the Normal Attack (NA) mode, which is the primary employment method for SDB II. The Air Force also successfully demonstrated Laser Illuminated Attack (LIA) and Coordinate Attack (CA) in 2016.
- The program has implemented corrective actions and fixes for all failure modes discovered in test. The weapon failed one environmental test related to the shipboard environment. The program implemented corrective action and successfully qualified design changes in corrosion, temperature, altitude and humidity, and vibration environments.
- IOT&E is scheduled to begin 4QFY17 with an adequately resourced test program.

System

- The SDB II is a 250-pound, air-launched, precision-glide weapon that uses deployable wings to achieve stand-off range. F-15E aircraft employ SDB IIs from the BRU-61/A four weapon carriage assembly.
- SDB II is designed to provide the capabilities deferred from SDB I. It includes a weapon datalink allowing for post-launch tracking and control of the weapon, as well as a tri-mode seeker to provide the ability to strike mobile targets in all weather.
- SDB II combines Millimeter-Wave radar, imaging infrared, and laser-guidance sensors in a terminal seeker, in addition to a GPS and an Inertial Navigation System to achieve precise guidance accuracy in adverse weather.
- The SDB II incorporates a multi-function warhead (blast, fragmentation, and shaped charge jet) designed to defeat armored and non-armored targets. The weapon can be set to initiate on impact, at a preset height above the intended target, or in a delayed mode.

- SDB II provides increased weapons load per aircraft compared to legacy air-to-ground munitions used against offensive counter-air, strategic attack, interdiction, and close air support targets in adverse weather.
- SDB II is intended to provide reduced collateral damage while achieving kills across a broad range of target sets by precise accuracy, small warhead design, and focused warhead effects.
- There are three principal attack modes: NA, LIA, and CA. SDB II can be used against moving or stationary targets using its NA (radar/ infrared sensors) or LIA modes, and fixed targets with its CA mode.

Mission

- Combatant Commanders will use units equipped with SDB II to attack stationary and moving ground targets in degraded weather conditions at stand-off ranges.
- An SDB II-equipped unit or Joint Terminal Attack Controller will engage targets in dynamic situations and use a weapon datalink network to provide in-flight target updates, in-flight retargeting, weapon in-flight tracking, and, if required, weapon abort.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- As of 2016, the Air Force has successfully completed 16 NA Guided Test Vehicle (GTV) and 10 Live Fire (LF) developmental tests against moving and stationary targets. Four GTV and 6 LF tests were conducted with Ultra High Frequency updates; 12 GTV and 4 LF test shots were conducted with Link 16 updates. NA is the primary employment method for SDB II. Also, in 2016, the Air Force completed three CA and four LIA GTV tests.
- The Program Office completed 15 rounds of seeker Captive Flight Tests, resulting in over 2,260 target runs in a wide variety of terrain and environmental conditions. These tests provided terabytes of seeker performance data and logged over 483 hours of seeker operation without a single failure.
- The program has augmented and refined the Integrated Flight System (IFS) model by incorporating the results of over 2,260 Captive Flight Test runs as well as weapon flight

tests. IFS model verification and validation is expected to be complete by the end of March 2017, and the Air Force Operational Test and Evaluation Center is expected to accredit it prior to the start of operational testing.
- The Program Office completed over 2,000 hours of ground reliability testing and nearly 200 hours of in-flight reliability testing.
- The program began a 28-shot NA mode GCT program in October 2016, which will test the weapon in more operationally realistic environments with operationally representative hardware and software. GCT will test the weapon versus maritime targets, countermeasures, and GPS-degraded environments.
- The Air Force awarded the $49 Million Low-Rate Initial Production Lot 2 contract on September 8, 2016, for 250 weapons.
- The Air Force conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan.

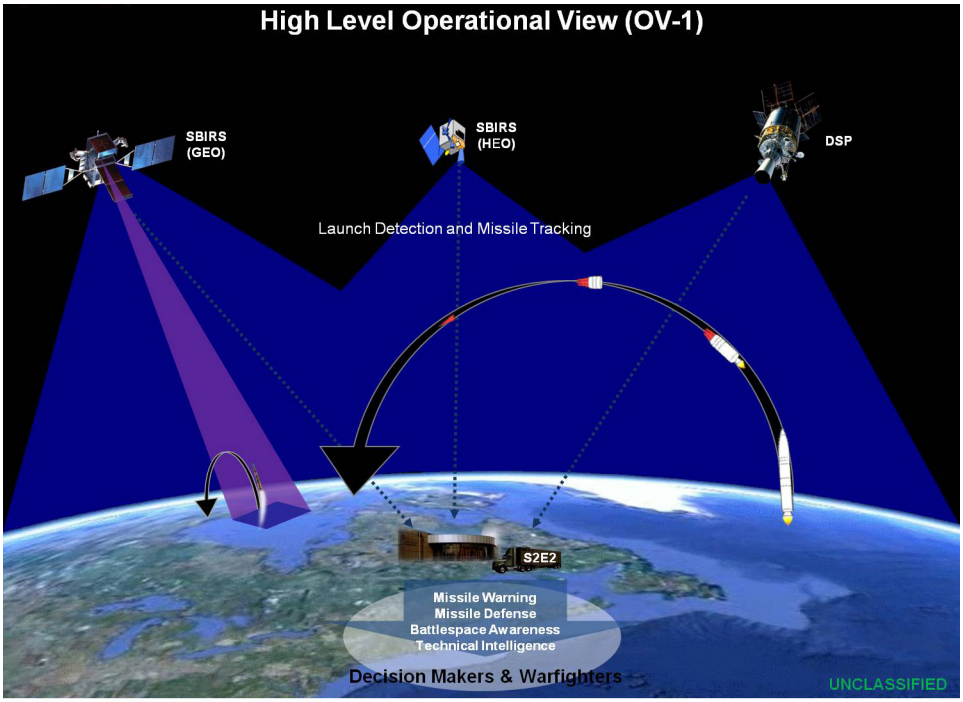
Assessment
- SDB II is progressing towards meeting its effectiveness, reliability, and lethality requirements in the NA mode, which is the primary employment method for SDB II. SDB II successfully engaged both moving and stationary targets, including proper classification of target type (wheeled versus track) on 15 of 19 GTV flight tests; 1 GTV struck the secondary target and 3 events had failures. The program has aggressively and thoroughly implemented corrective actions and fixes for all failure modes discovered in test.
- The SDB II Program Office is preparing for IOT&E with an adequately resourced test program and no unresolved major programmatic testing problems. IOT&E is scheduled to begin in 4QFY17.
- Three GTV missions and one LF mission required additional attempts and were successfully repeated after completion of the failure investigation and implementation of corrective actions. All corrective actions to date have been successful in preventing repeats of the observed failure modes. LF-5, which the Air Force conducted on September 14, 2015, did not detonate. The investigation was completed and corrective actions implemented. The test was successfully repeated along with two other remaining LF shots September 17, 2016, to assess the lethality of the SDB II.
- LF-10, which was attempted on October 3, 2016, detonated but failed to guide to the target. LF-10 was the first LF mission using LIA. The failure investigation is ongoing.
- The Air Force successfully completed two LIA tests and two CA attacks in 2016. A third CA test, CA-3, was conducted on May 19, 2016. The weapon successfully guided to the target, but the height-of-burst fuze functioned prematurely. The SDB II Program Office determined the likely root cause of the anomaly and implemented corrective action, which was successfully demonstrated on CA-2 in September 2016. The program has met the requirements to award Lot 2 of the contract.
- The Air Force successfully conducted the first GCT of SDB II on October 18, 2016, using NA versus a static target and demonstrated in-flight retargeting of the weapon.
- The weapon failed one environmental test related to the shipboard environment. The program implemented corrective action and successfully qualified design changes in corrosion, temperature, altitude and humidity, and vibration environments.
- Continued comparisons of the IFS model pre- and post-flight predictions indicate the model is adequate for the kinematics flown in-flight test to date. Raytheon Missile Systems will continue to develop and update the IFS model, which will be essential to the assessment of the results of live fire and operational testing. IFS, in combination with lethality data, will produce single shot kill probability values needed to assess end-to-end weapon effectiveness against a range of operationally relevant targets.
- The weapon is progressing towards demonstrating the required reliability by the start of IOT&E. Further testing in GCT, LF, and the Captive Carry Reliability Test program is expected to increase confidence in weapon reliability.

Recommendations
- Status of Previous Recommendations. The Air Force completed all previous recommendations.
- FY16 Recommendation.
  1. The Air Force should continue to use the results of GCT to further refine the IOT&E test plan.

Space-Based Infrared System Program, High Component (SBIRS HIGH)

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted an Operational Utility Evaluation (OUE) of the Space-Based Infrared System (SBIRS) Increment 2, Block 10 from June 12 through August 30, 2016, in accordance with a DOT&E-approved test plan. Testing focused on the SBIRS ground architecture, and included two SBIRS geosynchronous Earth orbit (GEO) satellites, two hosted infrared payloads in highly elliptical orbit (HEO), and legacy Defense Support Program (DSP) satellites.
- DOT&E sent classified memoranda regarding cybersecurity issues discovered in OT&E to Air Force leaders.
- DOT&E is planning to publish a classified report on the OUE to inform Air Force employment and follow-on development decisions.



DSP - Defense Support Program
GEO - Space Based Infrared System (SBIRS) Geosynchronous Earth Orbiting Satellite
HEO - SBIRS Highly-Elliptical Orbit Payload
S2E2 - SBIRS Survivable/Endurable Evolution Program

System

- SBIRS is an integrated system of systems consisting of both survivable and non-survivable space and ground elements, designed to provide infrared sensing from space to support the DOD and other customers. SBIRS replaces or incorporates legacy DSP ground stations and satellites and is intended to improve upon DSP timeliness, accuracy, and threat detection sensitivity. SBIRS is being developed in two system increments.
  - Increment 1 used the SBIRS fixed-site ground Control Segment, operating with DSP satellites, to sustain legacy DSP military capability. The Air Force attained Initial Operational Capability for Increment 1 on December 18, 2001, consolidating the operations of the DSP and Attack and Launch Early Reporting to Theater systems.
  - At full capability delivery, Increment 2 will include a space segment consisting of two hosted payloads in HEO and four satellites in GEO, new Mission Control Station (MCS) fixed-site ground system software and hardware for consolidated data processing across all sensor families, and a new SBIRS Survivable Endurable Evolution (S2E2) mobile ground capability to replace the legacy Mobile Ground System (MGS). These Increment 2 capabilities are being delivered in multiple, discrete blocks, which each require dedicated test and evaluation.
    - SBIRS Increment 2, Block 10 has been delivered. Block 10 introduces new ground station software and hardware, enabling for the first time the integrated processing of DSP, GEO, and HEO sensor data at the MCS and MCS Backup (MCSB), and allowing the integration of GEO Starer sensor data.
    - SBIRS Increment 2, Block 20 and S2E2 remain in development.
      - Block 20 is scheduled for delivery in late 2018, and is intended to further improve ground station software at the MCS and MCSB. The software is intended to enable optimized sensor data clutter and background suppression to detect dimmer targets, and auto-cueing of GEO Starer sensors to provide better threat tracking and impact point prediction accuracy.
      - S2E2 is scheduled for delivery in late 2019.
  - The Air Force is currently operating two HEO payloads and two SBIRS GEO satellites on-orbit, and is preparing a third GEO satellite for launch. The Air Force will continue to launch additional GEO satellites to complete and sustain the SBIRS constellation over the next few years, and will use SBIRS Increment 2 to operate legacy DSP satellites until each is decommissioned, and to interoperate with MGS until S2E2 is delivered.

Mission
The Joint Functional Component Command for Space, a component of U.S. Strategic Command, employs SBIRS to provide reliable, unambiguous, timely, and accurate missile warning and missile defense information, as well as technical intelligence and battlespace awareness to the President of the United States, the SECDEF, Combatant Commanders, and other users.

Major Contractors
- Lockheed Martin Space Systems – Sunnyvale, California
- Northrop Grumman Electronic Systems – Azusa, California
- Lockheed Martin Information Systems and Global Solutions – Denver, Colorado

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Activity
- AFOTEC conducted a SBIRS Block 10 dedicated OUE from June 12 through August 30, 2016, at Buckley and Schriever AFBs, Colorado, in accordance with the DOT&E-approved Enterprise Test and Evaluation Master Plan (ETEMP) and OUE test plan. Preceding the OUE and with DOT&E approval, AFOTEC collected operationally relevant effectiveness and suitability data for its OUE evaluation during the integrated test and evaluation conducted by the contractor and Air Force Program Office from January 30 through May 17, 2016.
  - AFOTEC conducted the OUE concurrently with an AFSPC Trial Period of operational use, in parallel with continued operation of the legacy SBIRS ground system. The OUE included both observed real-world mission performance against actual events, and use of accredited high-fidelity simulations of satellite sensor data and playbacks of previously recorded events to represent real-world scenarios.
  - AFOTEC has prepared a classified OUE report.
- DOT&E is planning to publish a classified test report on the OUE to inform Air Force employment and follow-on development decisions.
- The Air Force is drafting an update to the ETEMP for coordination in early 2017, which must incorporate test design refinements for a design of experiments-based OT&E for SBIRS Increment 2, Block 20 and SBIRS S2E2, including adequate threat representation and cybersecurity measures to complete a SBIRS survivability evaluation.

Assessment
- DOT&E sent classified memoranda regarding SBIRS cybersecurity issues discovered in OT&E to the Commanders of AFSPC, the Air Force Space and Missile Systems Center, and AFOTEC on May 19, 2016, and to the Secretary of the Air Force on June 27, 2016.
- DOT&E's classified OUE test report will include detailed effectiveness, suitability, and survivability assessments, as well as observations, detailed findings, and recommendations.

Recommendations
- Status of Previous Recommendations. The Air Force made significant progress on or satisfactorily addressed all nine previous recommendations contained in the FY12 Annual Report and the December 2012 classified DOT&E OUE report.
- FY16 Recommendations. The Air Force should:
  1. Fully resource dedicated cybersecurity personnel and tools to ensure active defense of SBIRS.
  2. Plan and execute Cooperative Vulnerability and Penetration Assessments (CVPAs) for cybersecurity in accordance with published DOT&E guidance. The Air Force should conduct the CVPAs with sufficient time prior to dedicated OT&E and the associated cybersecurity Adversarial Assessment to ensure the Air Force has the opportunity to correct or mitigate deficiencies identified during the CVPAs.
  3. Plan for adequate OT&E of SBIRS Block 20 and S2E2, including comprehensive threat representation and a thorough, rigorous design of experiments-based test design in accordance with published DOT&E guidance, to inform the operational acceptance and Full Operational Capability decisions for SBIRS Increment 2.