

Global Positioning System (GPS) Enterprise

Executive Summary

- The Air Force conducted developmental test and evaluation (DT&E) for all three GPS enterprise segments (space, control, and user), but did not conduct operational testing in 2017. DT&E included GPS III Satellite Vehicle (SV) 02 acoustic and thermal testing, Next Generation Operational Control System (OCX) Launch Checkout System testing, and Military GPS User Equipment (MGUE) Increment 1 card testing.
- Schedule slips have caused operational testing delays for all GPS segments from dates listed in prior DOT&E Annual Reports.
- The Program Office has updated the Enterprise Test and Evaluation Master Plan (ETEMP) Revision B to reflect test strategy, schedule, and resource changes due to segment delays, acquisition strategy changes, and initiation of the Contingency Operations (Cops) baseline. The ETEMP has been in coordination with the Services since November 2014.
- While progress has been made across the segments, significant GPS Enterprise operational risks remain:
 - OCX delays will limit adequate and timely operational testing for the full capabilities of GPS III satellites prior to extensive procurement and incorporation of the satellites into the operational constellation.
 - The Program Office has not planned for operational cybersecurity testing of the OCX Launch Checkout System (Block 0) baseline due to their concerns that cyber testing could place the non-redundant system (used for satellite launch and initialization) at risk. While Block 0 will not be used for operational employment of GPS III satellites, this ground control baseline will have command, control, and cyberspace access to future operational satellites.
 - While the program has a Lead Developmental Test Organization, it is a part of the Program Office instead of fully independent, which has resulted in a lack of insight to OCX developmental testing.
 - Due to the delays in the ground-based parts of the GPS Enterprise, there is ongoing risk that adequate OT&E of GPS III satellites will not be possible until as many as five satellites are on orbit, increasing the risk that testing will not discover deficiencies until it is too late to correct them.
 - GPS III lacks sufficient test resources for realistic operational testing, including on-orbit threats.
 - The GPS III Follow-On Production Acquisition Strategy Document, amended in 2017, lacks any description of integration, interdependencies, or risks between the GPS III Follow-On Production satellites and the ground control and user segments. Additionally, the Air Force has proposed a Milestone C decision in 2020, before any GPS III Follow-On Production satellites have been developed or tested. The continued lack of an enterprise



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

strategy and integrated approach to program execution places the nation’s GPS capability at significant risk.

- The pathfinding value of the currently planned MGUE Lead Platform operational testing is limited since the Army and the Marines may not deploy their nominated Lead Platforms in the tested configurations.

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 comprised of Block IIR (1997-2004), Block IIR-M (2005-2009), and Block IIF (2010-2016).
 - 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 GPS control segment includes the Operational Control System (OCS)/Architecture Evolution Plan, which supports operations of the current satellite constellation; the Launch/Early Orbit, Anomaly Resolution, and Disposal Operations (LADO) system;

FY17 AIR FORCE PROGRAMS

Selective Availability/Anti-Spoof Module (SAASM) capabilities in U.S. and allied military GPS user equipment; and the 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 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. Modernized GPS enterprise improvements include:
 - Space Segment – The Air Force intends for the GPS III satellites, an Acquisition Category (ACAT) 1D program, 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 – The Air Force plans to deliver OCX, an ACAT 1D program, in three blocks. OCX is intended to replace the current ground control segment and LADO, be backward compatible with Block IIR and later satellites, and interface with modified SMPS versions. OCX Block 0 is being developed to launch and initialize GPS III satellites, while OCX Block 1 is being developed to command and control GPS Block II and III satellites. OCX Block 2 is intended to provide full control of modernized civil and M-code signals and navigation warfare functions. OCX is intended to provide significant cybersecurity improvements over the current ground control system.
 - User Segment – MGUE Increment 1 is an ACAT 1D program and Increment 2 is, currently, a pre-Major Defense Acquisition Program. MGUE Increment 1 includes the GB-GRAM-Modernized form factor

for ground and low-dynamic platforms and the GRAM-Standard Electronic Module-E/Modernized for maritime and aviation applications. The MGUE Increment 2 Capability Development Document is in coordination.

- Due to delays in OCX Block I delivery, the Air Force initiated the COps program as a “bridge capability” to enable employment of GPS III satellites using legacy (pre-M-Code) signals for operational constellation sustainment until OCX Block 1 is available.
- In September 2017, the Air Force placed M-Code Early Use (MCEU) on contract. MCEU will deliver early operational use of core M-Code, with full M-Code functionality delivered in OCX Block 1.

Mission

Combatant Commanders of U.S. and allied military forces use GPS to provide accurate, position, navigation, and time information to operational users worldwide.

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 and MCEU: Lockheed Martin, Space Systems Division – Colorado Springs, Colorado
- User Segment (MGUE Increment 1)
 - L-3 Technologies/Interstate Electronics Corporation – Anaheim, California
 - Raytheon Company, Space and Airborne Systems – El Segundo, California
 - Rockwell Collins – Cedar Rapids, Iowa

Activity

- Planning and preparation for operational testing of the space, ground, and user segments, beginning in 2019, is ongoing.
- The Air Force conducted DT&E for all three GPS enterprise segments (space, control, and user), but did not conduct operational testing in 2017. DT&E included GPS III SV02 acoustic and thermal testing, OCX Launch Checkout System testing, and MGUE Increment 1 card testing.
- Schedule slips in the development of all GPS segments have caused operational testing delays from dates listed in prior DOT&E Annual Reports.
- The Program Office has updated the ETEMP Revision B to reflect schedule and resource changes due to segment delays,

acquisition strategy changes, and initiation of the COps baseline. The ETEMP has been in coordination with the Services since November 2014. The revision has been delayed by significant fluctuation in all enterprise segment delivery and availability schedules, OCX and MGUE acquisition strategies, initiation of COps, and Army concerns related to its Assured Precision Navigation and Timing program.

OCX

- The Air Force conducted an OCX Block 0 system acceptance in October 2017, but does not plan to declare OCX operational until Block 1 delivery.

FY17 AIR FORCE PROGRAMS

- Following the 2016 Nunn-McCurdy review and recertification, the Air Force proposed OCX Block 1 and Block 2 delivery in April 2022 in an updated Milestone B Acquisition Program Baseline (APB). The Air Force expects the Milestone B and APB approval in late 2017.

COps

- The Air Force placed COps on contract in August 2017 and the Air Force Operational Test and Evaluation Center (AFOTEC) is planning operational testing in July 2019, concurrent with GPS III SV01 operational tests.

MCEU

- Following the September 2017 MCEU approval, the Air Force modified the contract to address M-Code “hot start” requirements for the GPS enterprise. Hot start is the capability of M-Code receivers to initialize legacy receivers with data derived from a modernized navigation signal.
- AFOTEC plans to conduct operational testing of MCEU in conjunction with MGUE operational testing in 2020.

GPS III and GPS III Follow-On Production

- The first of 10 GPS III satellites is in storage and planned for launch in May 2018.
- The Air Force amended the GPS III Follow-On Production Acquisition Strategy Document in 2017. The amendment addresses the second phase of the procurement strategy and outlines new capabilities for the next 22 GPS III satellites.

MGUE

- MGUE Increment 1 received Milestone B approval in January 2017.
- The Air Force conducted successful early developmental testing on the B-2 platform with a prototype MGUE card. Additionally, the Army’s Program Executive Office for Ammunitions conducted field tests to assess the maturity of MGUE Increment 1 technology for precision-guided munitions.
- The Program Office is planning to conduct a developmental field test of MGUE card maturity in April 2018.
- The planned operational assessment of MGUE Increment 1 has slipped to 2019 due to delayed delivery of test receiver cards and software increments. As a result, MGUE Increment 1 IOT&E has slipped to 2020. This IOT&E will include data collection from separate MGUE Increment 1 OUEs on the four designated Service Lead Platforms.
- A Joint Service Working Group is developing courses of action to inform the MGUE Increment 2 acquisition strategy. The Air Force has been tasked to provide the strategy by March 2018.

Assessment

- The Air Force has improved the GPS enterprise schedule and addressed numerous schedule and performance risks; however, the articulation of program risks with stakeholders is incomplete, increasing the probability of unmitigated risks causing further program problems and delays.

OCX

- OCX delays will limit adequate and timely operational testing for the full capabilities of GPS III satellites prior

to extensive procurement and incorporation of the GPS III satellites into the operational constellation.

- While the program has a Lead Developmental Test Organization, it is a part of the Program Office instead of fully independent, which has resulted in a lack of insight to OCX developmental testing.
- The Program Office has not planned for operational cybersecurity testing of the OCX Launch Checkout System (Block 0) baseline due to their concerns that cyber testing could place the non-redundant system at risk. While Block 0 will not be used for operational employment of GPS III satellites, this ground control baseline will have command, control, and cyberspace access to future operational satellites.
- Since the 2016 Nunn-McCurdy review, the Program Office has attempted to reduce future schedule risk by increasing manpower, improving system engineering and configuration management processes, and evolving its testing approach. However, it is not clear the Air Force has enough resources to conduct developmental testing on COps and OCX in parallel, which is required to keep both programs on the current schedule.

GPS III and GPS III Follow-On Production

- GPS III lacks sufficient test resources for realistic operational testing, including on-orbit threats.
- Due to the delays in the ground-based parts of the GPS Enterprise, there is ongoing risk that adequate OT&E of GPS III satellites will not be possible until as many as five satellites are on orbit, increasing the risk that testing will not discover deficiencies until it is too late to correct them.
- The Program Office is planning for the GPS III Follow-On Production Non-flight Satellite Testbed (GNST+) in the GPS III Follow-On Production program. However, GNST+ will not provide full capability for realistic threat testing. The program plans to conduct environmental testing at the component level; but, the program is not planning for test articles that would support characterization of man-made threats against the system.
- The GPS III Follow-On Production Acquisition Strategy Document, amended in 2017, lacks any description of integration, interdependencies, or associated risks between the GPS III Follow-On Production satellites and the ground control and user segments. Additionally, the Air Force has proposed a Milestone C decision in 2020, before any GPS III Follow-On Production satellites have been developed or tested. The continued lack of an enterprise strategy and integrated approach to program execution places the nation’s GPS capability at significant risk.

MGUE

- The pathfinding value of the currently planned MGUE Lead Platform operational testing is limited, since the Army and the Marines may not deploy their nominated Lead Platforms in the tested configurations.
- MGUE OUE requires testing of a production-representative card in an operational configuration in an operationally

FY17 AIR FORCE PROGRAMS

realistic environment to determine MGUE operational effectiveness, suitability, and mission capability.

- The need to include an MGUE “hot start” capability has driven new contracts for each of the three card vendors. This necessary change could adversely affect the card’s power profiles (already of concern) and add to cost and schedule. An additional software change to the MGUE cards will be required to implement the subsequent enterprise hot start solution.
- The MGUE program continues to face challenges in transitioning card technology, to include new requirements and a lengthy security certification process for approving vendor changes to cards.

Recommendations

- Status of Previous Recommendations. The Air Force has partially addressed the recommendations from the 2011, 2014, and 2016 Annual Reports; however, the Air Force should still:
 1. Continue to plan for GPS enterprise end-to-end testing, including Lead Platform and non-Lead Platform integration, and DT&E and OT&E in realistic operational environments in time to support acquisition decisions.
 2. Ensure status; critical dependencies; and enterprise risks, impacts, and mitigation plans are well understood and promptly disseminated to all stakeholders.
 3. Maintain and disseminate accurate and timely schedule information for all segments, ensuring the schedules reflect segment interdependencies, current government estimates, and caveats for assumptions.
 4. Prioritize and commit resources to ensure successful execution of the COps program, including active and independent monitoring of the COps development progress.
 5. Plan for an adequate MGUE Increment 1 operational assessment encompassing integration and DT&E on at least one Lead Platform per form factor to inform these acquisition decisions.
- FY17 Recommendations.
 1. The Air Force should plan to demonstrate GPS III satellite capability against on-orbit threats with operationally representative test articles, including a full-scale GPS test resource (or “iron bird”) for realistic operational testing of on-orbit threats.
 2. The Program Office should plan for operational cybersecurity testing of OCX Block 0 to ensure a comprehensive cyber assessment of the ground control system that will access GPS III satellites on-orbit prior to their operational employment.
 3. The Air Force should develop an integrated, enterprise strategy for GPS III Follow-On Production and clearly articulate satellite, ground, and user segment interdependencies and risks.
 6. Plan for and conduct comprehensive risk reduction integration testing with all platforms, munitions, and interfaces expected to integrate with MGUE Increment 1.
 7. Conduct an assessment to determine 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 supported DOD platforms.
 8. Integrate and test each MGUE Increment 1 vendor solution on applicable Lead Platforms as soon as those vendor solutions are available. 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.