

# Global Positioning System (GPS) Enterprise

## Executive Summary

- Ongoing schedule slips for all GPS segments have caused operational testing delays from dates listed in prior DOT&E Annual Reports. The Air Force plans to conduct operational testing of the GPS Enterprise in 2020.
- The Air Force conducted developmental test and evaluation (DT&E) for all three GPS enterprise segments (space, control, and user) in 2019. DT&E included the GPS III Satellite Vehicle (SV) 01 On-Orbit Checkout Test, Next Generation Operational Control System (OCX) Block 1 testing, and Military GPS User Equipment (MGUE) Increment 1 circuit card testing.
- While the Air Force has made progress across the segments, significant GPS Enterprise operational risks remain:
  - More work is needed to comprehensively replicate space threats, their effect on the space segment, mitigation efforts, and the strategy to conduct operational space segment testing using realistic threats.
  - The MGUE program continues to experience delays integrating the new technology into the lead platforms and in developing final software and hardware builds by MGUE vendors.
  - Ongoing schedule slips with MGUE lead platform testing increases integration risks for non-lead platforms seeking to implement MGUE before lead platform testing is complete.

## 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 Earth atmosphere, space, and worldwide Earth surface areas.
- The current GPS enterprise consists of three operational segments:
  - Space Segment – The GPS spacecraft constellation consists of satellites in semi-synchronous orbit. The Air Force has successfully launched 72 GPS satellites and currently operates 31 operational GPS satellites. The operational constellation is comprised of Block IIR (1997-2004), Block IIR-M (2005-2009), and Block IIF (2010-2016). The GPS III satellite (SV01) is in orbit and is now available to operationally join the GPS constellation pending planned upgrades to the Control Segment.
  - Control Segment – The GPS control segment consists of primary and backup GPS master control stations, satellite ground antennas, a pre-launch satellite compatibility station, and geographically distributed monitoring/tracking stations. The GPS control segment includes:
    - The Operational Control System (OCS)/Architecture Evolution Plan, which supports operations of the current satellite constellation



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

- The Launch and Checkout Capability (LCC)/Launch and Checkout System (LCS) (also known as OCX Block 0), which launches and initializes GPS III satellites
- The Selective Availability/Anti-Spoof Module (SAASM) Mission Planning System (SMPS), which provides mission planning capability in the Combined Space Operations Center
- 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). These military GPS mission receivers provide secure position, navigation, and timing for both the U.S. and allied/partner nations.
- In 2000, the Air Force initiated 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 will 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 to deliver better accuracy and provide improved anti-jamming capabilities, transmit a fourth civil signal to enable interoperability with other international global navigation satellite systems, higher powered M-code for military use, as well as all legacy military and civil navigation signals of previous satellite blocks. The Air Force plans for 10 GPS III satellites and subsequently 22 GPS III Follow-On Production (GPS IIF) satellites. GPS IIF will have enhancements, such as regional

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military protection, support for search and rescue services, and laser retro-reflector arrays for better on-orbit position determination.

- Control Segment – The Air Force plans to deliver OCX, an Acquisition Category ID program, in several increments. OCX will replace OCS and LCC/LCS, be backward compatible with legacy and modernized satellites, and interface with updated SMPS versions. OCX Block 0 launches and initializes GPS III satellites, while OCX Block 1 will command and control GPS Block II and III satellites. OCX Block 2 (now merged and scheduled concurrently with OCX Block 1 delivery) will provide full control of modernized civil and M-code signals and navigation warfare functions. OCX is intended to provide significant cybersecurity improvements over OCS. OCX Block 3F will fly the GPS III F spacecraft once available.
- User Segment – 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 Air Force approved MGUE Increment 2 in November 2018 as two separate Middle Tier of Acquisition/Section 804 programs of record. Under MGUE Increment 2, the Air Force will develop (1) the Miniaturized Serial Interface form factor with a smaller Next Generation Application-Specific Integrated Circuit (ASIC) as core GPS receiver technology to support low-power applications, such as guided munitions, and address ASIC obsolescence; and (2) the joint modernized handheld receiver end-item, which improves anti-jam and anti-spoof during acquisition and tracking, as well as longer battery life.

- Due to delays in OCX Block 1 delivery, the Air Force initiated the GPS III Contingency Operations (COPs) program as a “bridge capability”/risk mitigation effort to enable employment of GPS III satellites using legacy (pre-M-code) signals for operational constellation sustainment until OCX is delivered. Additionally, M-code Early Use (MCEU) will deliver early operational use of core M-code, with full M-code functionality delivered in OCX Blocks 1 and 2.

## Mission

Combatant Commanders of U.S. and allied military forces use GPS to provide accurate position, navigation, and time information to operational users worldwide. GPS also supports a myriad of non-military users worldwide.

## Major Contractors

- Space Segment
  - Block IIR/IIR-M/III/IIIF satellites: Lockheed Martin Space Systems – Denver, Colorado
  - Block IIF satellites: Boeing, Network and Space Systems – El Segundo, California
- Control Segment
  - OCS, COPs, and MCEU: Lockheed Martin Space Systems Division – Denver, Colorado
  - OCX: Raytheon Company, Intelligence, Information, and Services – Aurora, Colorado
- User Segment (MGUE Increment 1)
  - L3Harris Technologies, Inc. – Melbourne, Florida
  - Raytheon Company, Space and Airborne Systems – El Segundo, California
  - Collins Aerospace – West Palm Beach, Florida

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## Activity

- Schedule slips have caused operational testing delays for all GPS segments from dates listed in prior DOT&E Annual Reports. The Air Force plans to begin operational testing of the space, ground, and user segments in 2020.
- In FY19, the Air Force conducted DT&E for all three GPS enterprise segments (space, control, and user). Testing included the GPS III SV01 Mission Readiness Test and On-Orbit Checkout Test, OCX Block 1 testing, and MGUE Increment 1 card testing.
- The Program Office is working on additional revisions to the Enterprise Test and Evaluation Master Plan to address an updated space threat strategy, cyber testing, concurrent delivery of OCX Blocks 1 and 2, MGUE Increment 2, upgraded Nuclear Detonation Detection System control system, GPS III F, and OCX Block 3F.

## OCX

- The Air Force Operational Test and Evaluation Center will conduct OT&E of OCX in 2022 as the first of a

two-phase GPS Enterprise Multi-Service OT&E (MOT&E) that will include OCX and GPS III. This will inform both the Positioning, Navigation, and Timing Initial Operating Capability (IOC) as well as the Constellation Management IOC. Testing will be conducted to support OCX Operational Acceptance following transition of constellation control from OCS to OCX, followed by full-M-code MOT&E to include M-code User segment systems.

## GPS III COPs

- AFOTEC is planning operational testing of COPs in 2020, concurrent with GPS III SV01 operational testing, to support COPs Operational Acceptance later that year. Integrated system testing for COPs began in 2019.

## MCEU

- AFOTEC plans to conduct operational testing of MCEU in 2020. Control Segment testing will include the worldwide distributed GPS M-code capable monitoring stations.

## GPS III and GPS III Follow-On Production

- The Air Force successfully launched the first (SV01) of 10 GPS III satellites into orbit on December 23, 2018. It has undergone successful checkout and is now available to operationally join the GPS constellation upon planned upgrades to the Control Segment. The second satellite launched on August 22, 2019, and the third is scheduled for early 2020.
- The Air Force contracted Lockheed Martin to build 22 GPS IIIIF satellites in 2018. The first IIIIF will be available for launch (AFL) no later than 2028, but current estimates forecast AFL in 2026.

## MGUE

- In 2018, the Air Force Service Acquisition Executive approved the MGUE Increment 2 acquisition strategy. This approval resulted in the release of a draft Request for Proposal announcement for the MGUE Increment 2 receiver card in 2019.
- Ground-based developmental field testing of MGUE card maturity in 2019 will inform MGUE card development and support preparations for MGUE lead platform developmental field testing scheduled to begin in 2020. The Air Force terminated the airborne developmental field test in 2019 early due to a fire in the test airframe. MGUE Lead Platform OT&E will include data collection from separate MGUE Increment 1 Operational Utility Evaluations on the four designated Service lead platforms. MGUE OT&E will be followed by the two-phase GPS Enterprise MOT&E in 2022 and 2023. The second phase of the MOT&E will incorporate user equipment, both lead and non-lead platforms.

sustainment software immediately after COps OT&E and operational acceptance will result in a lack of time to fix major discrepancies that testing uncovers.

## GPS III and GPS IIIIF

- GPS III lacks a testing plan with adequate space threat representation. The Program Office plans to conduct environmental testing, but it is not currently planning for sufficient test articles to support full characterization of adversary threats against the system.
- The Air Force has proposed a Milestone C decision in 2020, prior to development or testing of any GPS IIIIF satellites. The first GPS IIIIF is currently scheduled for launch in 2026-2028.

## MGUE

- The first MGUE card has been completed. It was verified by the government in 2019 and all associated discrepancies will be addressed in future updates. The MGUE program continues to face challenges meeting technical requirements with some cards, resulting in delays to development of final software and hardware builds by some MGUE vendors.
- The ongoing delays of final software and hardware builds by MGUE vendors continue to cause delays to MGUE lead platform test schedules, which increases the risk for platforms seeking to implement MGUE before lead platform testing is complete. The utility of the lead platforms to act as pathfinders will also diminish due to these delays. Lead platform test schedule slips also increase risk for the DOD because non-lead platforms might delay ordering MGUE cards. The MGUE trusted foundry production lines are scheduled to shut down due to the GPS Programs' use of now obsolete ASIC technologies.

## Assessment

- The Air Force has improved the GPS Enterprise schedule by addressing schedule and performance risks; however, articulation of program risks with stakeholders continues to be incomplete, increasing the probability of unmitigated risks causing further program problems and delays.
- The Lead Developmental Test Organization is effectively managing the breadth of developmental testing activities, emerging test requirements, and significant changes to test plans.

## OCX and COps/MCEU

- Delays in COps software delivery have driven increasingly tight and compressed testing schedules. The deployment of

## Recommendations

The Air Force should:

1. Conduct operational testing of the GPS Enterprise against current and emerging space threats, to assess the ability of the system and its operators to support DOD missions in a contested space environment.
2. Inform users of GPS across the DOD of GPS Enterprise test results and schedule delays, to enable users to plan for integration of new GPS capabilities.

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