

Global Positioning System (GPS) Enterprise

The U.S. Space Force successfully upgraded the current Operational Control System (OCS) Architecture Evolution Plan with M-code Early Use (MCEU) and Contingency Operations (COps), enabling command and control of core Military Code (M-code) capability from the existing GPS constellation as well as the employment of GPS III satellites for constellation sustainment. Full control of modernized civil and M-code signals and navigation warfare functions, as well as improved cybersecurity, continue to be delayed due to ongoing development and deployment delays of the next generation Operational Control System (OCX), along with delays in the fielding of M-code capable receivers for use by the U.S. and allied warfighters.



System Description

The GPS Enterprise is a satellite-based global radio navigation system of systems intended to provide accurate and secure positioning, navigation, and timing (PNT) information to military and civilian users worldwide. The GPS Enterprise consists of three operational segments: space, control, and user segments. The space segment includes the GPS constellation of 31 satellites. The control segment (primary and alternate) operates the GPS constellation; supports launches, anomaly resolution, and disposal operations; and tasks navigation warfare effects in support of Combatant Commands. The user segment includes the Military GPS User Equipment (MGUE) intended to modernize military GPS receivers, including the ability to receive M-code.

Program

The GPS Enterprise consists of multiple programs pursuing a wide range of acquisition strategies to advance the space, control, and user segments:

- GPS III – Acquisition Category IC program entered Milestone C in January 2011. The U.S. Space Force has successfully launched five GPS III satellites since 2018 and plans to launch five more by 2025.
- GPS III Follow-On Production (GPS IIIF) – Acquisition Category IB program, intended to provide enhanced regional military protection signals and support for search and rescue services. The Air Force made the GPS IIIF Milestone C decision in July 2020 based on the completion of Critical Design Review and prior to development or testing of any GPS IIIF satellites. The first launch is expected in 2026, followed by 21 additional GPS IIIF satellites over the subsequent decade.

- Operational Control System (OCS) Architecture Evolution Plan fielded two Acquisition Category III upgrades: M-code Early Use (MCEU) to command and control core M-code capability from the existing GPS constellation (GPS IIR-M, GPS IIF, and GPS III), and Contingency Operations (COps), delivered in March 2020 as a “bridge capability” and risk mitigation effort to enable employment of GPS III satellites using legacy and M-code signals for operational constellation sustainment.
- MGUE Increment 1 – Acquisition Category IC program entered Milestone B in January 2017 (relieved of Milestone C requirements). The program is intended to deliver M-code capability, which will improve GPS signal availability in degraded threat environments. Ongoing delays of final software and hardware builds by MGUE Increment 1 vendors continue to cause delays to MGUE Increment 1 lead platform test schedules, which increases the risk for platforms seeking to implement MGUE. Consequently, the Army and Marine Corps decided not to field their respective platforms with the ground-based MGUE Increment 1 card. Due to Application-Specific Integrated Circuit obsolescence and limited production, the Services have turned to commercially available, MGUE-derived M-code receivers to continue meeting PNT requirements. Those systems will undergo operational testing outside of the MGUE Increment 1 program of record.
- MGUE Increment 2 – Middle Tier Acquisition program, intended to support low-power applications such as guided munitions and hand-held devices, and address MGUE Increment

1 Application-Specific Integrated Circuit hardware obsolescence.

- Operational Control System (OCX) – Acquisition Category ID program entered Milestone B in June 2017 (relieved of Milestone C requirements) and is intended to provide full control of modernized civil and M-code signals and navigation warfare functions, as well as improved cybersecurity. The subsequent OCX Block 3F upgrade will allow OCX to command and control GPS IIIIF satellites. The U.S. Space Force plans to replace OCS with OCX in FY23 following a successful IOT&E in January 2023.

DOT&E approved the GPS Enterprise Test and Evaluation Master Plan (E-TEMP) Revision B on August 9, 2018 and the partial E-TEMP Revision C on August 25, 2021. The Program Office continues to revise the GPS E-TEMP to align space threat requirements, address cyber testing, and enable the concurrent delivery of OCX, MGUE Increment 2, upgraded Nuclear Detonation Detection System control system, GPS IIIIF satellites, and OCX Block 3F. Figure 1 summarizes the GPS Enterprise major events and testing through FY26. The next GPS operational test is an OCX cyber assessment scheduled for late 2022, followed by the initial operational testing of OCX in January 2023 and GPS Enterprise IOT&E later in 2023. The MGUE Increment 1 aviation/maritime card will undergo operational testing in 2024 as integrated on the B-2 platform although, given the sundown plans for the Air Force to retire the B-2 in the early 2030 timeframe, any future schedule slips may warrant the Air Force to select another platform to support the

Figure 1.

GPS Enterprise Schedule (FY21 to FY26)



planned integration of the MGUE Increment 1 card. The GPS Enterprise Multi-Service Operational Test and Evaluation (MOT&E), designed to assess all three third generation segments together, is scheduled for 2025.

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: Lockheed Martin Space Systems Division – Denver, Colorado
- OCX: Raytheon Technologies, Intelligence, Information, and Services – Aurora, Colorado
- OCX 3F: Raytheon Technologies, Intelligence, Information, and Services – Aurora, Colorado

User Segment (MGUE Increment 1 and 2)

- MGUE Increment 1 and 2:
 - L3Harris Technologies, Inc. – Anaheim, California
 - Raytheon Technologies, Space and Airborne Systems – El Segundo, California
 - BAE Systems – Cedar Rapids, Iowa
- MGUE Increment 2 Handheld Device:
 - Technology Advancement Group – Dulles, Virginia
 - Raytheon Technologies, Space and Airborne Systems – El Segundo, California
 - BAE Systems – Cedar Rapids, Iowa

Test Adequacy

In 2020, the U.S. Space Force Space Training and Readiness Space Delta 12, 4th Test and Evaluation Squadron conducted operational and cybersecurity testing of the two upgrades to OCS, COps, and MCEU at the GPS Master Control Station at Schriever Space Force Base, the GPS Alternate Master Control Station at Vandenberg Space Force Base, and the GPS monitoring and ground antenna facility at Canaveral

Space Force Station. The 4th Test and Evaluation Squadron also conducted cyber-resiliency testing of the GPS III satellite simulator at a Lockheed contractor facility. Operational and cyber testing were conducted in accordance with the DOT&E-approved TEMP and test plans.

Performance

Effectiveness

The OCS Architecture Evolution Plan upgrades, MCEU, and COps, are operationally effective, enabling the constellation to use both legacy signals and M-code signals. The GPS operators at the Master Control Station can successfully command and control the GPS III satellites as part of the full GPS constellation, allowing the OCS to produce a global core M-code signal in space usable by M-code capable receivers. While the U.S. Space Force demonstrated the ability to employ both legacy (pre-M-code) signal and M-code signals through MCEU, the lack of M-code capable receivers limits the M-code use by U.S. and allied warfighters.

Suitability

The GPS III, OCS Architecture Evolution Plan upgrades, COps, and MCEU are operationally suitable. While operator surveys identified concerns with initial training, documentation, and the user interface, COps and MCEU are fully mission-capable. Future operational tests will continue to focus on training, job aids, and technical order documentation.

Survivability

COps and MCEU are vulnerable in a cyber-contested environment. Despite the lack of specifically defined cyber survivability requirements, the GPS Enterprise will operate in a cyber-contested environment, warranting an adequate cyber assessment of the GPS Enterprise, to include GPS vehicles prior to launch. The Program Office continues to develop a space threat plan to adequately evaluate the survivability of the entire GPS Enterprise in a contested space environment that includes kinetic engagements, cyber, electromagnetic spectrum fires, nuclear, and directed energy weapons.

Recommendations

The U.S. Space Force should:

1. In coordination with DOT&E and respective Service operational test agencies, support the development of operational test procedures to standardize the characterization of the GPS M-code derived PNT performance of all DOD systems equipped with M-code capable GPS receivers.
2. Continue to plan to conduct operational testing of the GPS Enterprise against current and emerging space threats to assess its ability to support DOD missions in a contested space environment.
3. Plan to conduct regular Enterprise-wide testing events leveraging existing exercises and navigation warfare events to gauge the GPS Enterprise's ability to support the warfighter using the new M-code capabilities.
4. Plan to conduct a no-notice transfer from the Master Control Station to the Alternate Master Control Station, during the GPS Enterprise IOT&E of the space segment and OCX run control segment, to verify system survivability.
5. Include cyber survivability requirements in all GPS Enterprise acquisition programs to ensure the Enterprise is designed to respond to adversarial threats.