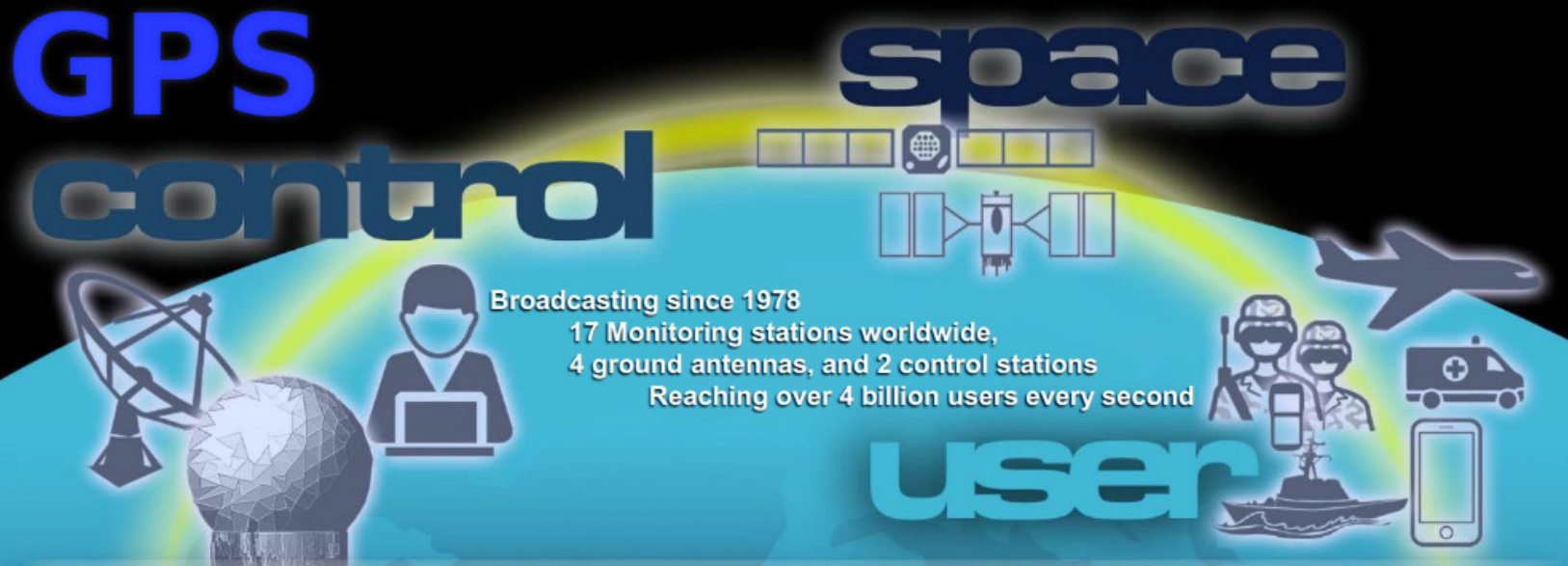


# Global Positioning System (GPS) Enterprise



The U.S. Space Force's Operational Control System (OCS) Architecture Evolution Plan (AEP) commands and controls the current GPS satellite constellation, including GPS III satellites, and has the ability to provide Military Code (M-Code) to appropriately equipped users in the field. As was reported last year, full control of modernized civil and M-code signals and navigation warfare functions have continued to be delayed, due to ongoing development delays of the Next Generation Operational Control System (OCX), along with delays in the fielding of M-code capable receivers. These ongoing delays increase the risk that U.S. and allied warfighters will not be able to conduct operations with GPS-derived position, navigation, and time (PNT) information.

## SYSTEM DESCRIPTION

The GPS Enterprise is a satellite-based global radio navigation system of systems that provides accurate and secure PNT information to users worldwide.

The GPS Enterprise consists of three operational segments: space, control, and military users. The space segment includes the GPS constellation of 31 operational satellites. The control segment (primary and alternate sites) 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.

## MISSION

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GPS provides PNT information to military and civilian users globally. Military commanders use the position, navigation, and timing signals provided by GPS for a wide variety of missions. Units equipped with GPS military receivers can navigate and maneuver forces in strategic, operational, and tactical theaters. Units with GPS-equipped munitions can employ them with precision, reducing both collateral damage and the number of expended munitions needed to accomplish a military objective. MGUE Increment 1 based receivers will allow military users to access the more secure M-Code signal. MGUE Increment 2 receivers will use Regional Military Protection, which concentrates higher M-code signal power broadcast by GPS IIF satellites in a targeted region to ensure the warfighter has continued access to PNT data in contested environments.

## PROGRAM

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The GPS Enterprise consists of multiple programs pursuing different acquisition strategies to advance the space, control, and user segments.

- GPS III Satellite – Acquisition Category IC program which achieved Milestone C in January 2011. The U.S. Space Force has successfully launched five GPS III satellites since 2018 and plans to launch the sixth satellite in January 2023, with the last of the remaining four GPS III satellites

being available to launch by early 2QFY23.

- GPS III Follow-On Production (GPS IIF) Satellite – Acquisition Category IB program that will provide enhanced Regional Military Protection signals and support for search and rescue services. The Air Force made the GPS IIF Milestone C decision in July 2020 based on the completion of a Critical Design Review. The first GPS IIF will be available for launch in 2QFY26.
- OCS AEP – The Air Force fielded OCS AEP in 2007. It features two recent Acquisition Category III upgrades: M-code Early Use (MCEU) and the Contingency Operations (COps). The upgrades allow the system to command and control core M-code capability from the existing GPS constellation consisting of GPS IIR, GPS IIR-M, GPS IIF, and GPS III satellites.
- OCX – Acquisition Category ID program that achieved Milestone B in June 2017 (relieved of Milestone C requirements) and will provide full control of modernized civil and M-code signals and navigation warfare functions. OCX will replace OCS AEP following a successful IOT&E in October and November of 2023, a delay of 9 months from last year's IOT&E scheduled release of January 2023. Following successful OCX deployment, the subsequent OCX Block 3F upgrade will allow OCX to launch as well as

command and control GPS IIF satellites.

- MGUE Increment 1 – Acquisition Category IC program that achieved Milestone B in January 2017 (relieved of Milestone C requirements). The program will deliver M-code capability to the warfighter, improving GPS signal availability in degraded threat environments. Delays with final software and hardware builds by MGUE Increment 1 vendors continue to cause delays to the two remaining MGUE Increment 1 lead platforms (B-2 aircraft and the *Arleigh Burke*-class naval destroyer) test schedules for the Navy and the Air Force. The MGUE Increment 1 program delivered a fully functional aviation/maritime receiver card in September 2022. The Army and Marine Corps will not field their respective lead platforms (Joint Light Tactical Vehicle and Stryker) with the ground-based MGUE Increment 1 receiver cards. Due to Application-Specific Integrated Circuit (ASIC) obsolescence and limited production, the Services plan to use commercially available, MGUE-derived M-code receivers. Those receivers will undergo operational testing outside of the MGUE Increment 1 program of record.
- MGUE Increment 2 – The program is currently structured as two Middle Tier of Acquisition rapid prototyping efforts. The Miniaturized Serial Interface receiver with next-

generation ASIC will deliver improved jam resistance, address MGUE Increment 1 ASIC hardware obsolescence, support the enhanced regional military protection offered by the GPS IIIF program, and support low-power applications (e.g., guided munitions). The handheld receiver will incorporate the Miniaturized Serial Interface receiver with the prototype handheld unit planned to be available in late 2026.

DOT&E approved the GPS Enterprise Test and Evaluation Master Plan (E-TEMP) Revision C on August 25, 2021. Space Systems Command continues to revise the GPS E-TEMP to update threat requirements, address cyber testing, and define the test strategies for OCX, MGUE Increment 2, Nuclear Detonation Detection System control system upgrades, GPS IIIF satellites, and OCX Block 3F. To improve test development, future E-TEMPs will include tailored annexes for each program, including updates to MGUE Increment 1 and Increment 2 programs, GPS IIIF and OCX 3F programs, and civil testing requirements on OCX. The next annex for review and approval is the GPS IIIF and OCX 3F Enterprise and Operational Test annexes signed in November 2022.

The next GPS operational test is an OCX cyber assessment scheduled for August 2023. The GPS Enterprise IOT&E is scheduled to commence in 4QFY23.

The Air Force B-2 Spirit bomber program and the Navy *Arleigh Burke*-class destroyer program plan to operationally test the MGUE Increment 1 aviation/maritime cards in 1QFY23 and 3QFY24 respectively. The GPS Enterprise Multi-Service Operational Test and Evaluation (MOT&E), designed to assess all three third-generation segments together, is scheduled for early 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

No operational testing was conducted in 2022 across the GPS Enterprise. While not an operational cyber test, the 4th Test and Evaluation Squadron (4 TES) conducted cyber-resiliency testing of the GPS III satellite simulator at a Lockheed contractor facility in accordance with the DOT&E-approved E-TEMP. DOT&E plans to observe OCX operational testing through late FY23.

The Department of Transportation and the Federal Aviation Administration (FAA) have responsibilities for testing PNT systems that control navigation and traffic control, per the 2019 Federal Radionavigation Plan. DOT&E is working with the FAA to incorporate their OCX test requirements into a GPS OCX civilian test annex to the DOT&E-approved E-TEMP.

## PERFORMANCE

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### » EFFECTIVENESS

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Based on previous operational testing, the current OCS AEP control segment is operationally effective, enabling the constellation to use both legacy signals and M-code signals. GPS operators can command and control legacy and 3rd generation GPS III satellites as part of the full GPS constellation, allowing OCS AEP to produce a global core M-code signal usable by M-code capable receivers. The lack of M-code capable receivers currently limits M-Code use by U.S. and allied warfighters.

The Marine Corps Field User Evaluation for the MGUE Increment 1 ground receiver card reported mixed effectiveness and suitability results, which the MGUE Increment 1 Program Office is working to address. The MGUE Increment 1 aviation/maritime receiver card is still under development, with the latest software update delivered in September 2022. MGUE Increment 1 program operational effectiveness will be assessed during operational testing of the B-2 and *Arleigh Burke*-class, currently scheduled for 1QFY23 and 3QFY24 respectively.

### » SUITABILITY

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Based on previous operational testing, GPS III satellites and

OCS AEP are operationally suitable. Developmental testing has revealed maintenance and sustainment concerns with the OCX simulator, technical orders, and training materials that the Program Office is working to address. MGUE Increment 1 program suitability will be determined during operational testing of the B-2 and *Arleigh Burke*-class in 2QFY23 and 4QFY24 respectively.

### » SURVIVABILITY

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Since the 2016 independent assessment of the OCX program, the Air Force funded and implemented additional cyber security improvements to OCS AEP as well as provided for integrated cyber security reporting. The cyber survivability operational testing planned for late 2025 should assess whether the cyber survivability of OCX is at least as good as that of OCS AEP. To ensure cyber survivability, OCX will have to be integrated with Space Force cyber security reporting, and OCX cyber defenders must be integrated into space operations.

To ensure continuity of GPS operations, the U.S. Space Force needs to conduct a no-notice transfer of control from the primary OCX control station to the backup.

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, cyber, electromagnetic spectrum, nuclear, and directed energy threats.

## RECOMMENDATIONS

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The U.S. Space Force should:

1. Work with DOT&E and the FAA to make sure that civilian GPS user equities are adequately tested.
2. Develop an operational cyber assessment plan to compare OCS AEP and OCX cyber survivability.
3. In coordination with 4 TES, plan to conduct an early end-to-end operational test event to assess the GPS Enterprise's ability to support the warfighter using M-code capabilities under OCX command and control.
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.