Global Positioning System Program Status

Stanford University Center for PNT
13th Annual PNT Symposium
30 Oct 2019

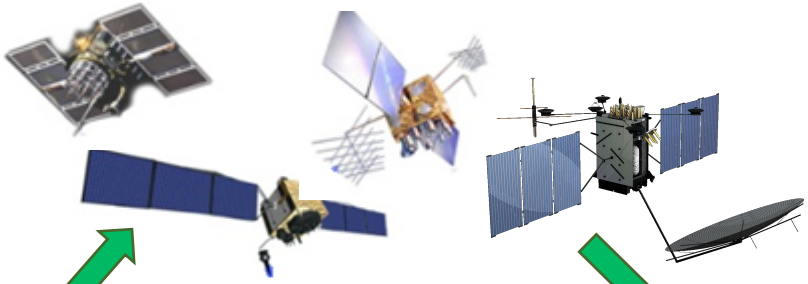
Col John Claxton
Chief, PNT Mission Integration
Space and Missile Systems Center

APPROVED FOR PUBLIC
RELEASE

GPS Overview

SPACE AND MISSILE SYSTEMS CENTER

Space Segment



Broadcasting since 1978

Control Segment

20 monitoring and control stations worldwide

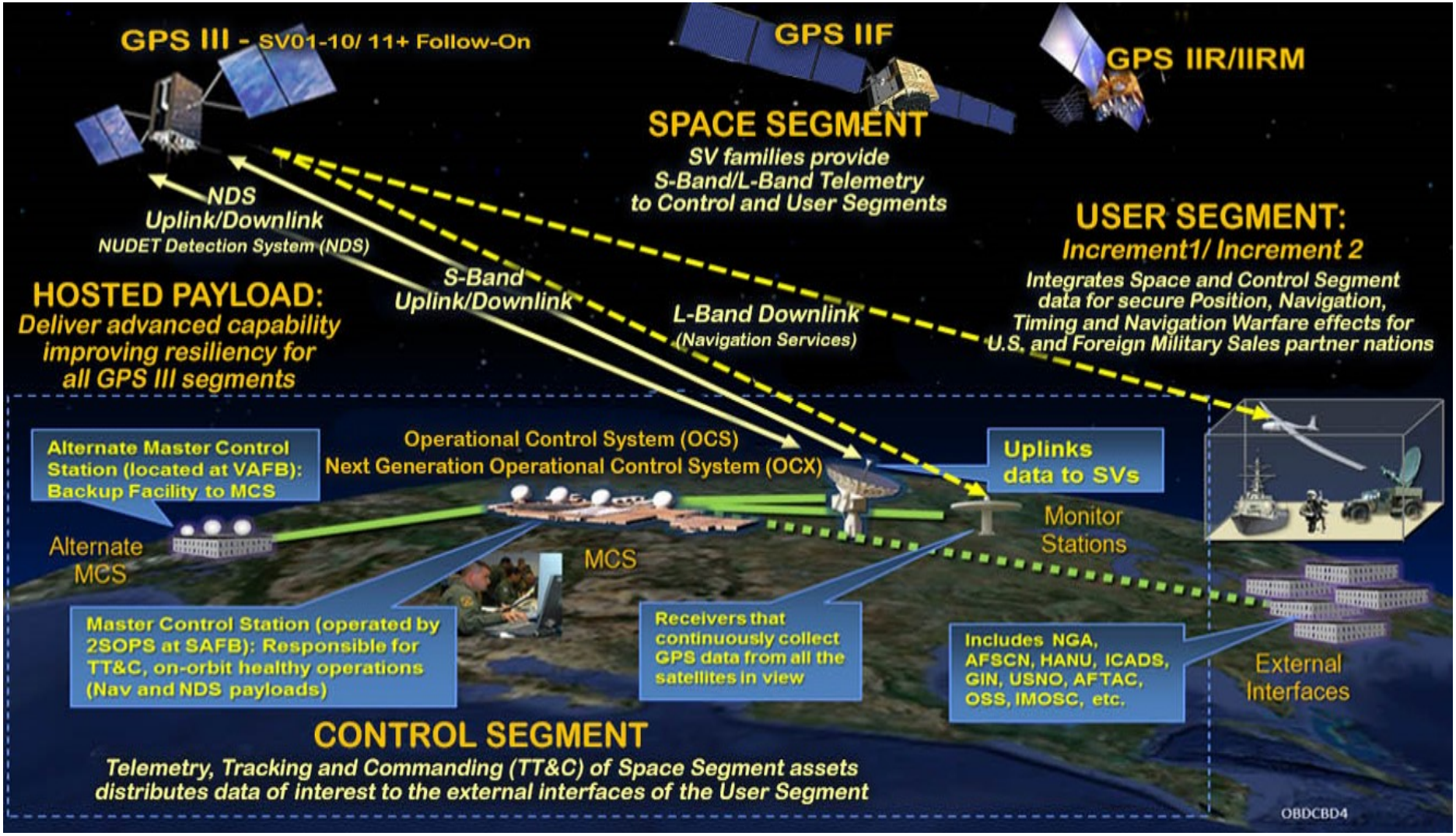
User Segment

Reaching over 4 billion users every second

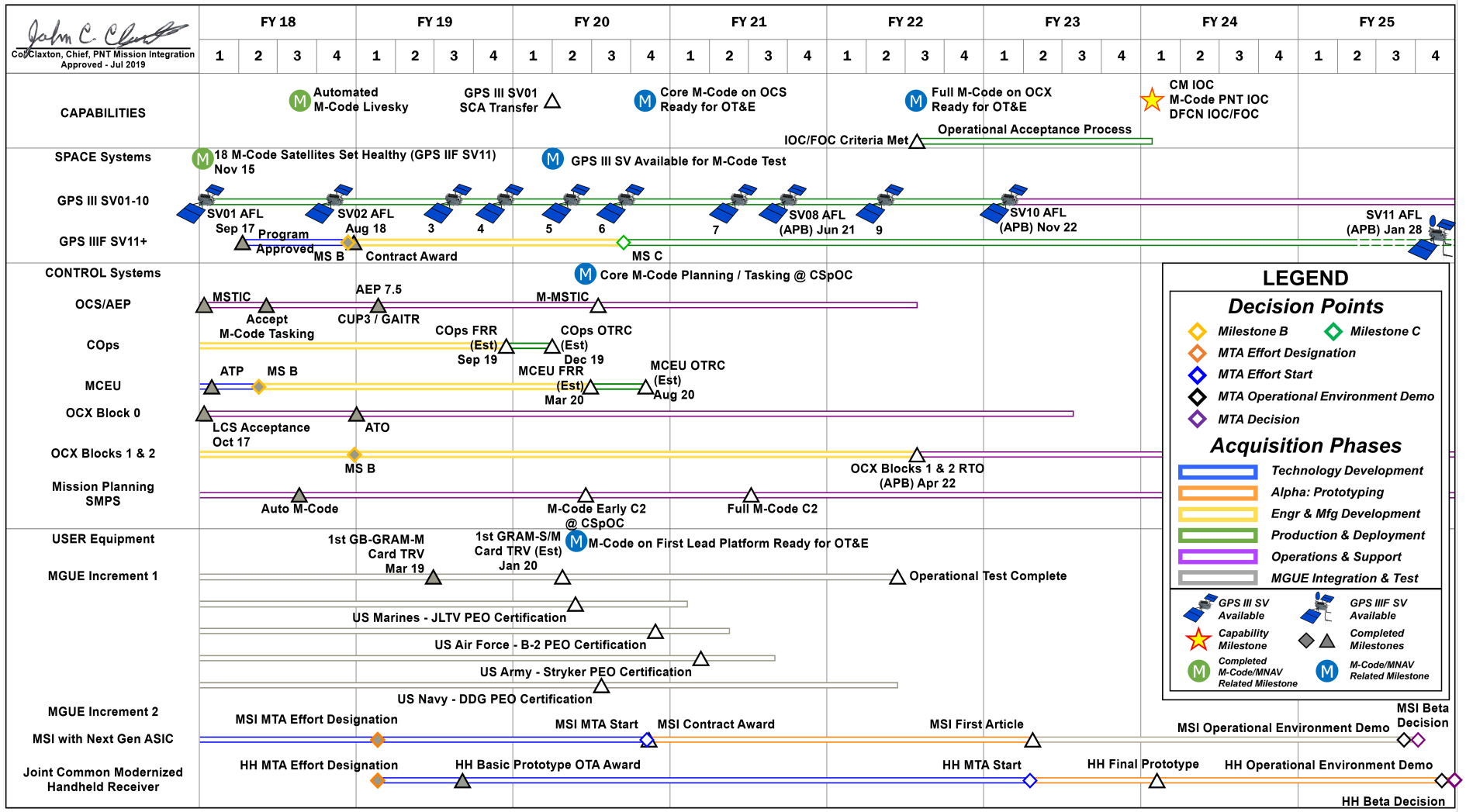
Committed to Cooperation

Department of Defense • Army • Navy • Air Force • USMC • NGA • DISA • USNO • **PNT EXCOM**
Department of Transportation • Federal Aviation Administration • **Department of Homeland Security** • U.S. Coast Guard
International Telecommunication Union • **International Committee on GNSS** • **International Civil Aviation Organization**
Global Navigation Satellite Systems (GNSS) • Galileo • Beidou • GLONASS • QZSS • NAVIC

GPS Enterprise Operational View



GPS Enterprise Roadmap



AEP	Architecture Evolution Plan	CSpOC	Combined Space Operations Center	GB-GRAM-M	Ground Based GPS Receiver Application Module – Modernized	MGUE	Military GPS User Equipment	OT&E	Operational Test and Evaluation
AFL	Available for Launch	CUP	COTS Upgrade Project	M-MSTIC	Modernized-Monitor Station Tech Improvement & Capability	OTRC	Ops Test Readiness Certification
APB	Acquisition Program Baseline	DDG	Arleigh Burke Guided Missile Destroyer	GRAM-S/M	GPS Receiver Application Module – Standard Elec Module/Modernized	MS	Milestone	PEO	Program Executive Officer
ASIC	Application-Specific Integrated Circuit	DFCN	Dual-Frequency Civil Navigation	HH	Handheld	MSI	Miniature Serial Interface	PNT	Positioning, Navigation & Timing
ATO	Authority to Operate	Est	Forecast Estimate	IOC	Initial Operating Capability	MTA	Middle Tier Acquisition	RTO	Ready for Transition to Ops
ATP	Authority to Proceed	FOC	Full Operational Capability	JLTV	Joint Light Tactical Vehicle	OCS	Operational Control System	SCA	Spacecraft Control Authority
C2	Command & Control	FRR	Fielding Readiness Review	LCS	GPS III Launch & Checkout System	OCX	Next Gen Operational Control System	SMPS	SAASM Mission Planning System
CM	Constellation Management	GAITR	Ground Antenna Interface	MCEU	M-Code Early Use	OTA	Other Transaction Agreement	SV	Space Vehicle
COps	GPS III Contingency Operations		Technical Refresh					TRV	Technical Requirements Verification

GPS Modernization

SPACE AND MISSILE SYSTEMS CENTER

Space Segment

SV families provide L-Band broadcast to User Segment

GPS IIA/IIR
- Basic GPS
- Nuclear Detonation Detection System (NDS)

GPS IIR-M
- 2nd Civil Signal (L2C)
- New Military Signal
- Increased Anti-Jam Power

GPS IIF
- 3rd Civil Signal (L5)
- Longer Life
- Better Clocks

GPS III (SV01-10)
- Accuracy & Power
- Increased Anti-Jam Power
- Inherent Signal Integrity
- 4th Civil Signal (L1C)
- Longer Life
- Better Clocks

GPS IIIF (SV11-32)
- Unified S-Band Telemetry, Tracking & Commanding
- Search & Rescue (SAR) Payload
- Laser Retroreflector Array
- Redesigned NDS Payload

Control Segment

TT&C of Space Segment assets & distribution of data to user interfaces

Legacy (OCS)
- Mainframe System
- Command & Control
- Signal Monitoring

Architecture Evolution Plan (AEP)
- Distributed Architecture
- Increased Signal Monitoring Coverage
- Security
- Accuracy

OCX Block 0
- GPS III Launch & Checkout System

GPS III Contingency Ops (COps)
- GPS III Mission on AEP

M-Code Early Use (MCEU)
- Update OCS to operationalize Core M-Code

OCX Block 1
- Fly Constellation & GPS III
- Begin New Signal Control
- Upgraded Information Assurance

OCX Block 2+
- Control all signals
- Capability On-Ramps
- GPS IIIF Evolution

User Segment

Applies Space and Control Segment data for PNT applications

Continued support to an ever-growing number of applications
- Annual Public Interface Control Working Group (ICWG)
- Standard Positioning Service (SPS) Performance Standard Updates
- Sustained commitment to transparency
- Visit GPS.gov for more info

Modernized Civil Signals
- L2C (Various commercial applications)
- L5 (Safety-of-life, frequency band protected)
- L1C (Multi-GNSS interoperability)

GPS Constellation Status

35 Satellites • 30 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIA	(2*)	25.8	26.0
GPS IIR	11	17.7	22.2
GPS IIR-M	7 (1*)	12.0	14.1
GPS IIF	12	5.7	9.4
GPS III	(2*)	0.5	0.8

*Ops capable; not set healthy

As of 12 Oct 19

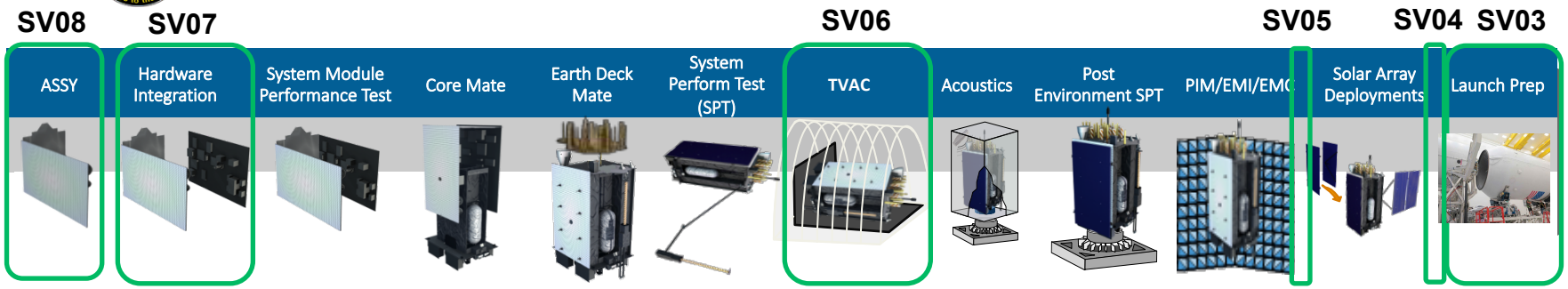
GPS Signal in Space (SIS) Performance

From 13 Oct 18 to 12 Oct 19

Average URE*	Best Day URE	Worst Day URE
51.5 cm	36.2 cm (21 Sep 19)	66.2 cm (21 Jun 19)

*All User Range Errors (UREs) are Root Mean Square values

GPS III Space Vehicles (SVs)



- GPS III features
  - Increased accuracy and power
  - Inherent signal integrity
  - New L1C civil signal
  - Longer design life (15 years)
- SV01 launched 23 Dec 18; completed on-orbit check out
  - IST 2-5 Phase 1 Complete; Phase 2 started 21 Oct 19
  - Expected to be added to constellation mission operations in early 2020
- SV02 successfully launched 22 Aug 19; completed on-orbit check out
- SV03 ready for shipment to Cape Canaveral; Launch forecast Mar 2020
- SV04 declared Available for Launch 10 Sep 19; Launch forecast 3Q 2020
- SV05 – 10 are in various phases of production

Second GPS III satellite successfully launched in Aug 2019

GPS III Follow-On (GPS IIIF)

SPACE AND MISSILE SYSTEMS CENTER

- GPS IIIF additional features
  - Regional Military Protection (RMP) - delivers higher-power/jam resistant military signal to the warfighter
  - Search-and-Rescue (SAR) payload - faster detection and location of distress signals (International Partnership w/Canada)
  - Laser Retroreflector Array (LRA) - provides more precise ranging data
  - Redesigned Nuclear Detonation Detection System (NDS)
- Partnering with Air Force Research Laboratory (AFRL) for technology opportunities
  - Digital Payloads
  - Near Real-Time Commanding/Crosslinks
- Program strategy allows for technology insertion to remain aligned with future requirements
- Currently in detailed design phase; Space Vehicle Critical Design Review planned for Feb 2020
- SV11 launch forecasted for 2026

The GPS IIIF team is committed to maintaining the Gold Standard of PNT

Next Generation Operational Control System (OCX)

- Next-generation command, control and cyber-defense for GPS
  - Worldwide, 24 hr/day, all weather, Positioning, Navigation, and Timing (PNT) source for military and civilian users
  - Enhanced command and control capability
  - Modernized architecture
  - Robust information assurance and cyber security
- Incremental Development
  - OCX Block 0: Launch and Checkout System (LCS) for GPS III
  - OCX Blocks 1 and 2: Operate and manage modernized GPS constellation, control and monitor modernized signals
- Current Status
  - LCS successfully supported GPS III SV01 and SV02 Launch and Checkout
    - Exceeding operational requirements for availability and dependability
  - OCX Block 1 software coding complete – 12 Aug 19
  - System Integration and Verification ongoing
  - Ready to Transition to Operations: 2Q22

OCX program continues to execute and meet schedule

GPS III Contingency Operations (COps)

- Upgrade to current control system that enables limited operations on GPS III vehicles until OCX Block 1/2 delivery
  - Provides legacy and modernized signal (M-Code test, L2C, L5) operations
  - Uses OCX Block 0 for GPS III launch, major anomaly, & disposal capabilities
- Software Development
  - Risk reduction modification to current operational control system
  - Formal Qualification Test of the software builds completed 20 May 19
- Current Status
  - Began Integrated System Test (IST) on 21 Oct 19 - IST is an evaluation of COps software and the GPS III Space Vehicle
  - Operational Test and Evaluation of COps is scheduled to complete in Feb 2020
  - COps Operational Acceptance: Apr 2020

COps is an important bridge, enabling sustainment of legacy signals for GPS III

GPS Military Code Early Use (MCEU)

- Description
  - Provide early use of GPS M-Code signal from 2020 until OCX Block 1 Ready for Transition to Operations
  - Enable and operate M-Code messaging on capable satellites, including GPS IIR-M, GPS IIF, and GPS III (at a GPS IIF performance level)
  - Process Combined Space Operations Center (CSPOC) M-Code directives and monitor M-Code message sets
- Software Development
  - Updates to current Operational Control System (OCS)
  - Integration of M-Code Keying and Modernized Monitoring Stations
- Current Status
  - Software Development and Integration Complete
  - Currently conducting Factory Qualification Test: Dec 2019
  - Operational Acceptance: Nov 2020

MCEU is operationalizing Core M-Code in 2020

Military GPS User Equipment (MGUE)

- Competitive market-driven acquisition approach
- MGUE Increment 1 involves three vendors developing modernized receiver cards
  - Ground form factor
  - Aviation/maritime form factor

- MGUE Increment 2 addresses GPS receiver card obsolescence issue, and extends M-Code to space receivers, Precision-Guided Munitions, and a joint, common modernized Handheld receiver
- Current Status:
  - Increment 1 on track to support Core M-Code Operations in 2020
    - Government qualified first card in Mar 2019
  - Increment 2 Acquisition Strategy approved in Nov 2018 as two Middle Tier Acquisition rapid prototyping efforts:
    - Miniature Serial Interface (MSI) receiver card w/ Next Generation Application-Specific Integrated Circuit (ASIC)
    - Joint Modernized Handheld receiver

Modernizing to provide accurate and resilient PNT to military users

Preparing for Next Generation GPS

- GPS Week Rollover Event – 6 Apr 19
  - 10-bit GPS Week Number rollover from 1023 back to 0
  - GPS constellation signal unaffected by control system reset
  - Multiple reports of civilian receiver malfunctions due to non-ICD compliant GPS receivers

- Many improvements are coming to GPS over the next year
  - All changes remain ICD compliant and within specification/standards
  - Communicating these changes to the Civil User Community and manufacturers early and often is accomplished through many forums

Critical for civil users to ensure their receivers are ICD compliant

PNT Mission Integrator Perspectives

- GPS is “The Gold Standard”
- Continue to enhance GPS resiliency by:
  - Addressing near-term needs with current efforts
  - Identifying opportunities for resiliency improvements
- Explore alternative PNT sources
  - Challenge the community (labs, industry, others) to propose alternative PNT solutions
- Expand Multi-GNSS potential


global utility
uninterrupted service
strength through partnership
gold standard
GPS