Military Communications & Positioning, Navigation, and Timing Overview with GPS Update

PNT Advisory Board

4 May 2022

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Program Executive Officer for MilComm & PNT

Agenda

- Space Systems Command Overview
- Military Communications & PNT Directorate Overview
- GPS Enterprise Update

Space Systems Command (SSC) Overview

SSC Mission & Vision

Mission

Pioneer, develop and deliver sustainable joint space warfighting capabilities to defend the nation and its allies and disrupt adversaries in the contested space domain

Vision

To become the premier global source for resilient joint space warfighting capabilities

SSC Enduring Priorities: Six key roles SSC fulfills for the United States Space Force

Acquisitions: Develop and acquire space systems that allow the USSF to outpace adversaries in space

Capability Development: Drive innovation through superior research capabilities and develops future technologies through collaboration with allies and industry in support of the joint warfighter

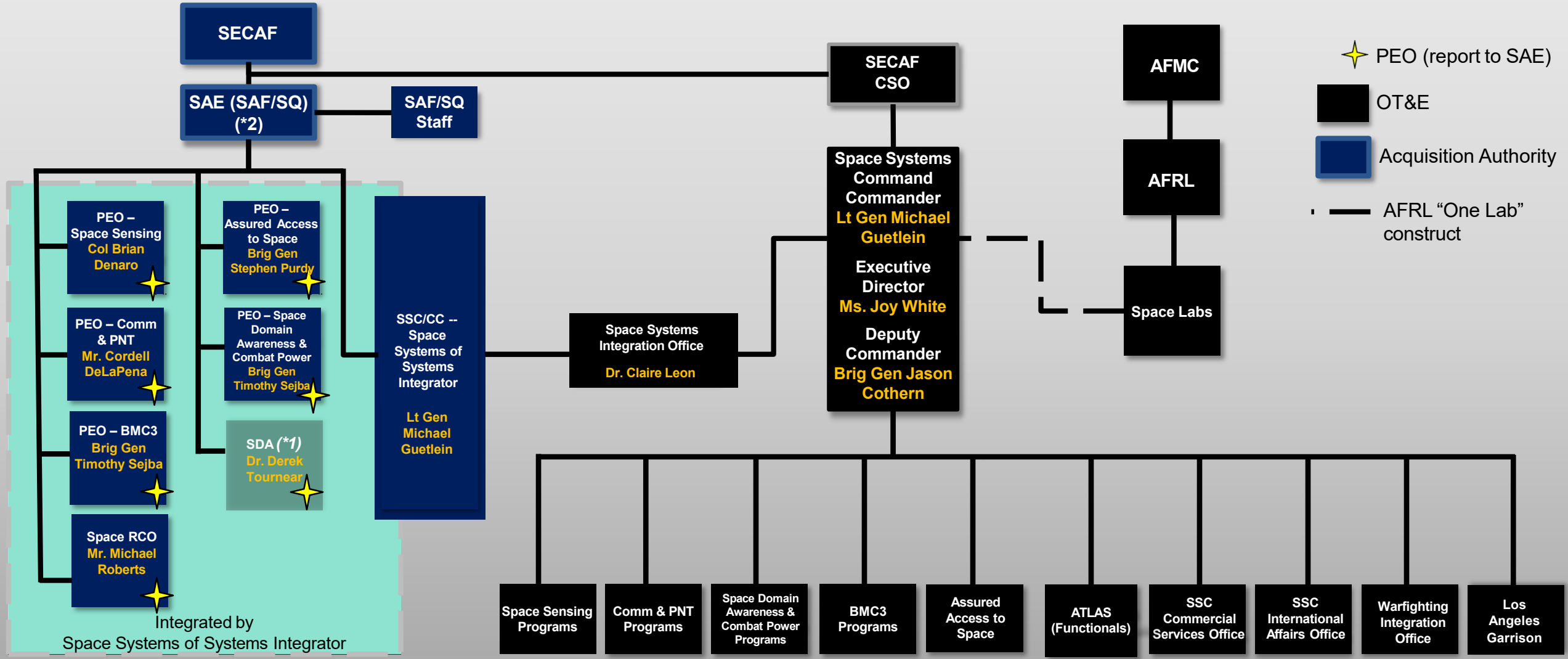
Space Systems Talent: Build and maintain a diverse pool of space systems talent that is bound by an agile and bold acquisitions culture

Launch: Provide assured access to space with space launch capabilities for both commercial and military assets

Systems Architecture: Contribute to the development of a resilient, integrated national security space architecture that outpaces current and future threats from adversary systems

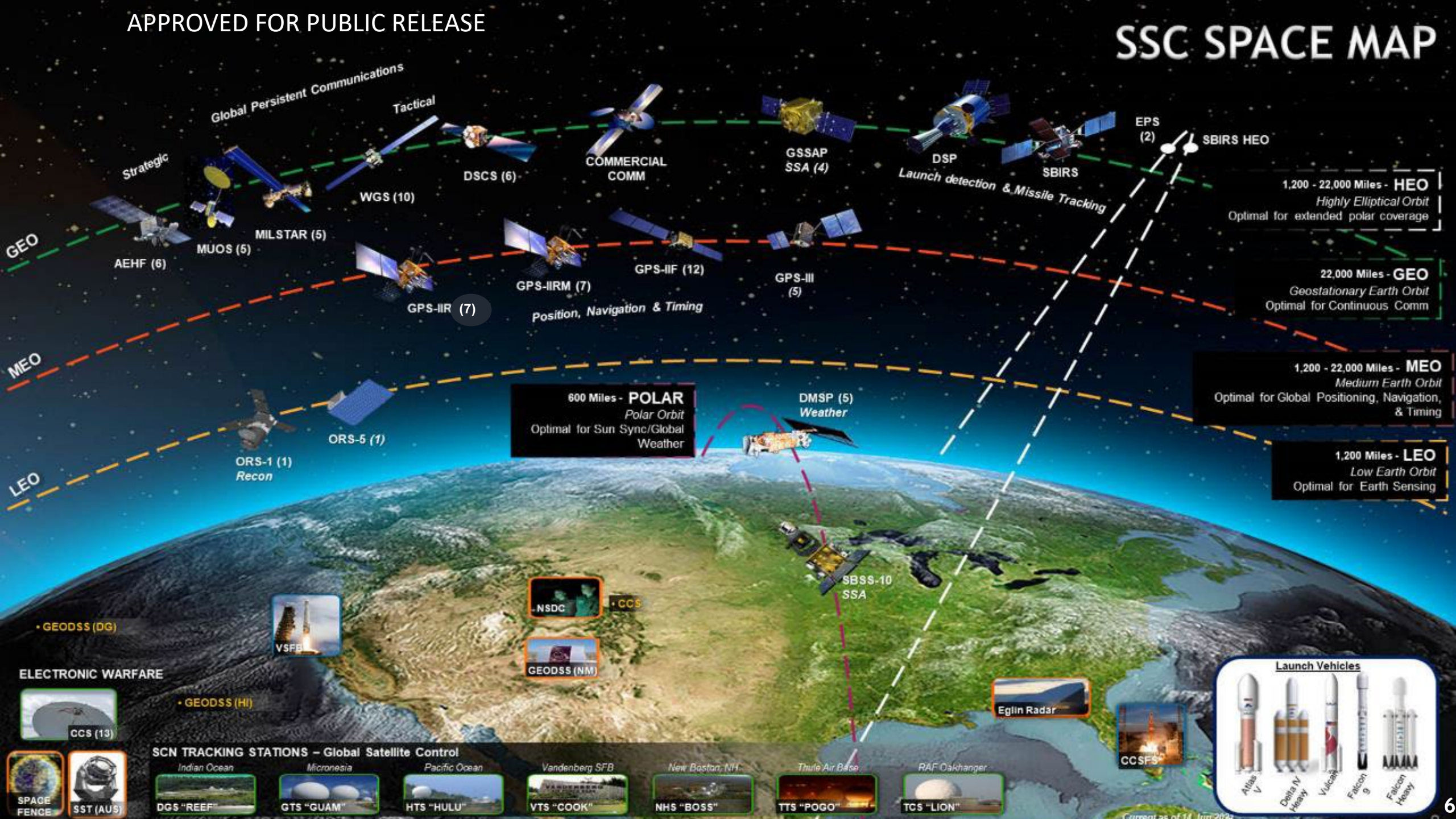
Sustainment: Provide sustainment activities to support space system development and launch capabilities

Space Systems Command Organization



*1 - Effective 1 Oct 22, SDA will transfer to DAF and report to SAF/SQ for acquisitions and CSO for all other matters *2 - SAE will transfer to SAF/SQ as specified by 10 USC 9016

SSC SPACE MAP



Military Communications (MilComm) & Positioning, Navigation and Timing (PNT) Directorate Overview

MilComm & PNT Mission & Vision

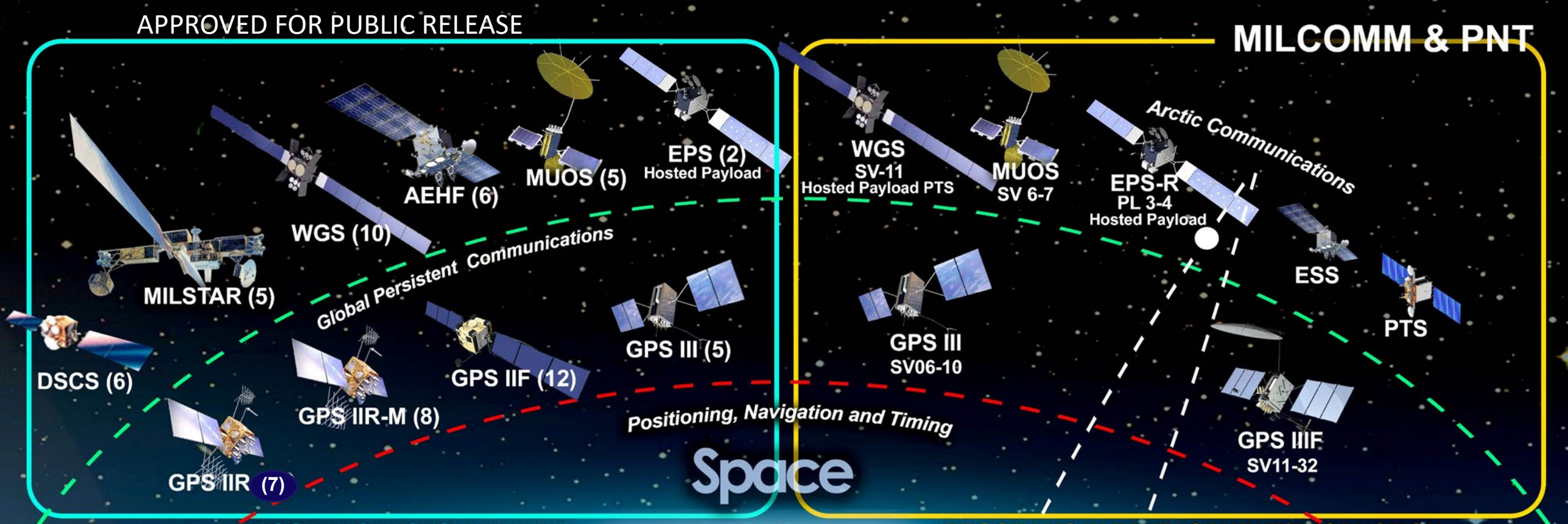
Mission

Rapidly deliver premier MilComm and PNT capabilities resilient to the threat by the relentless pursuit of warfighter needs and acquisition excellence.

Vision

World-class space professionals connecting people and systems, any time any place, to enable unity of effort across all warfighting domains.

MILCOMM & PNT



PROGRAMS IN SUSTAINMENT

Terminals

- A3M
- AFWET

Ground Systems

- PTES
- ACA
- OCX
- OR2/2B
- OCX 3F
- AEP
- OCS

PROGRAMS IN DEVELOPMENT/PRODUCTION

User Products

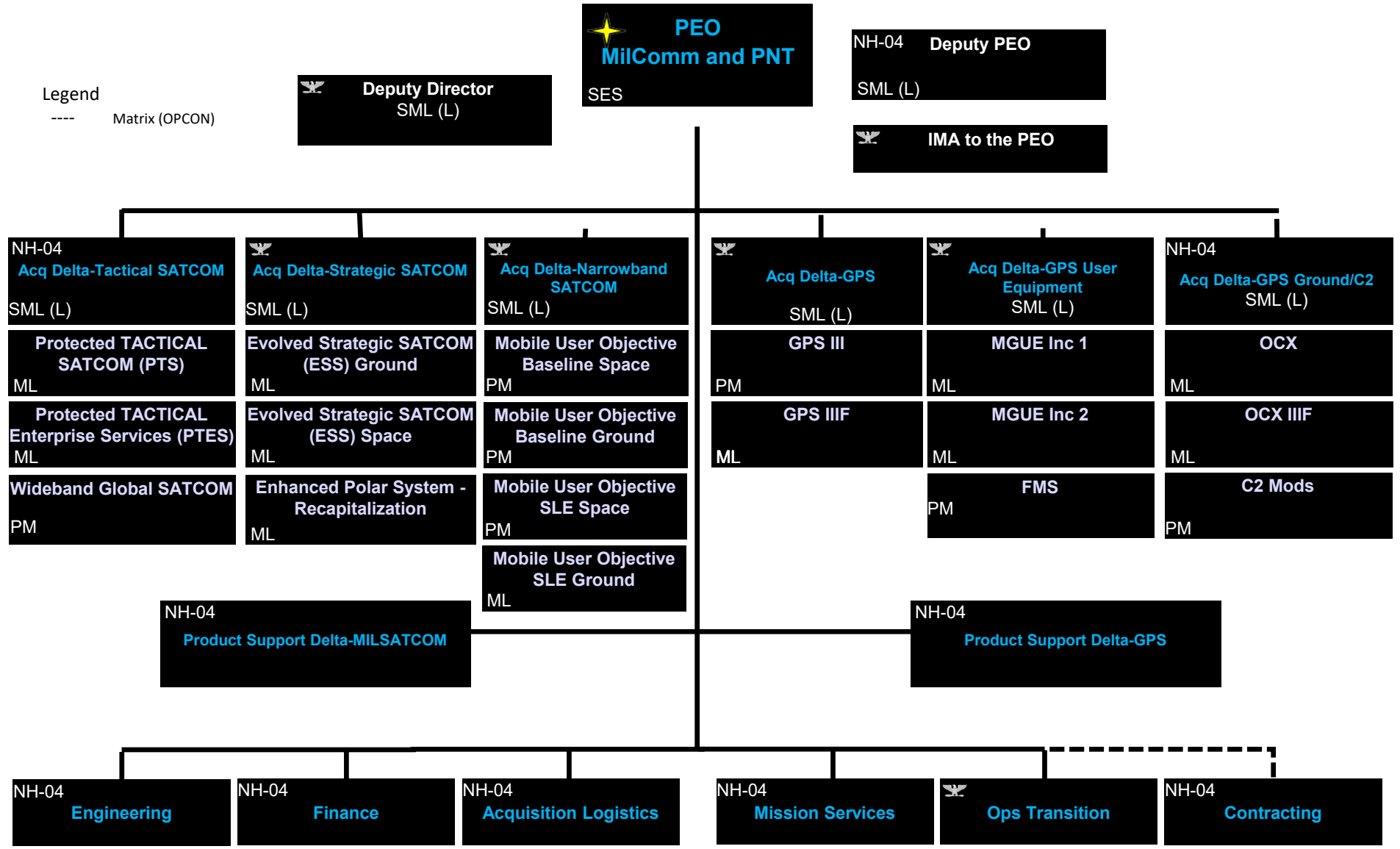
- MGUE Inc 1
- MGUE Inc 2 MSI
- MGUE Inc 2 HH
- GPS UE FMS

ACRONYM KEY

AEP - Architecture Evolution Plan
A3M – Air Force and Army Anti-Jam Modem
ACA – AEHF Capability Augmentation
AEHF – Advanced Extremely High Frequency Satellite
AFWET – Air Force Wideband Enterprise Terminals
DSCS – Defense Satellite Communications System
ESS – Evolved Strategic SATCOM
EPS – Enhanced Polar System
EPS-R – Enhanced Polar System – Recapitalization
GPS – Global Positioning System
GPS UE FMS – Global Positioning System User Equipment Foreign Military Sales
MGUE Inc 1 – Military GPS User Equipment Increment 1
MGUE Inc 2 HH – MGUE Increment 2 HandHeld
MGUE Inc 2 MSI – MGUE 2 Miniature Serial Interface
MUOS – Mobile User Objective System
OCS – Operational Control System
OCX – Next Generation Operational Control System
OCX 3F – Next Generation Operational Control System 3F
OR2/2B – Operational Resiliency 2/2B
PTS – Protected TACTICAL SATCOM
PTES – Protected TACTICAL Enterprise Services
WGS-Wideband Global SATCOM Communications

Current as of Mar 2022

MilComm & PNT Org Chart



Military Communications & PNT by the Numbers

- FY22-27 total budget $20.9 billion; 26 active Programs, 9 Systems in Sustainment
  - 7 ACAT I Programs; 1 ACAT II Program; 4 ACAT III Programs; 5 MTAs; 9 AML Exempt
- Satellite Systems in Sustainment: 37 PNT satellites (12 GPS IIR, 8 GPS IIR-M, 12 GPS IIF, 5 GPS III)
- Satellite Systems in Sustainment: 34 SATCOM satellites (6 AEHF, 2 EPS, 5 MUOS, 6 DSCS, 5 MILSTAR, 10 WGS)
- 29 SATCOM Ground Antennas, 4 GPS Monitoring Stations, Mission Planning Systems, & primary/ backup Control Stations
- 17 Satellites/Payloads in production (WGS 11+ (1), GPS III (5), GPS IIIF (7), MUOS (2), EPS-R (2))
- 8 Ground Systems
- Over 2 Million Units of GPS User Equipment (UE) fielded with next-gen Military GPS UE starting to field
- Over 400,000 GPS User Equipment (UE) sold through GPS Foreign Military Sales (FMS)
- More than 75 GPS FMS cases in work and active engagement with 59 allied nations
- 2600+ SATCOM Terminals
- 1800+ active duty, civilian and contractor employees

GPS Enterprise Updates

GPS Constellation Status

37 Satellites • 30 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	7 (5*)	20.3	24.7
GPS IIR-M	7 (1*)	14.5	16.5
GPS IIF	12	8.2	11.8
GPS III	4 (1*)	2.0	3.3

*Not set healthy

As of 01 Apr 22

GPS Signal in Space (SIS) Performance

From 01 Apr 21 to 01 Apr 22

Average URE*	Best Day URE	Worst Day URE
45.4 cm	31.5 cm (20 Apr 21)	67.7 cm (05 Apr 21)

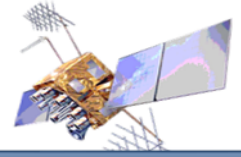
*All User Range Errors (UREs) are Root Mean Square values

GPS Modernization

SPACE SEGMENT (SATELLITES)

Legacy (GPS IIA/IIR)
- Basic GPS
- NUDET (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
- Regional Military Protect (RMP)

CONTROL SEGMENT (GROUND)

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

Architecture Evolution Plan (AEP)
- Distributed Architecture
- Increased Signal Monitoring Coverage
- Security & Accuracy
- Launch And Disposal Operations

OCX Block 0
- GPS III Launch & Checkout

GPS III Contingency Ops (COps)
- GPS III Mission on AEP
- Updated OCS to operationalize Core M-Code on AEP

OCX Block 1
- Fly Constellation & GPS III
- Control New Signals
- Upgrade Cyber Security

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

OCX Block 3F
- Incorporates GPS IIIF Command & Control
- Integrates new capabilities

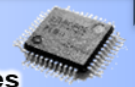
USER SEGMENT (RECEIVERS)

Legacy (PLGR/GAS-1/MAGR)
- First Generation System

User Equipment
- Improved Anti-Jam & Systems
- Reduced Size, Weight, & Power

Upgraded Antennas
- Improved Anti-Jam Antennas

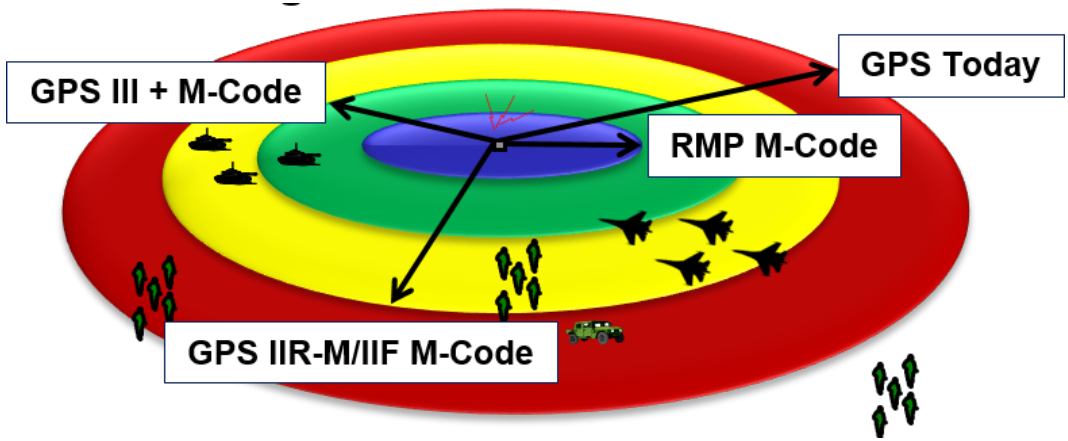
Modernized
- M-Code Receivers
- Common GPS Modules
- Increased Access Power w/ M-Code
- Increased Accuracy
- Increased Availability
- Increased Anti-Tamper Anti-Spoof
- Increased Acquisition in Jamming



Blue Font: Current PC Programs **Black Font:** Completed PC Programs Visit GPS.gov for more info

Benefits of Military Code

- A fully populated M-Code constellation increases the warfighters ability to receive PNT in a contested environment, specifically in regard to:
  - Jam-resistance
    - M-Code receivers do not rely on other signals.
    - M-Code military receiver can determine its position with the M-Code alone while with the P(Y) Code, the receiver has to acquire the C/A code first
  - Security and Anti-spoofing
    - The M-Code signals are encrypted and their receivers are able to detect and reject false signals
    - M-Code enables an over-the-air-rekey capability for the warfighter

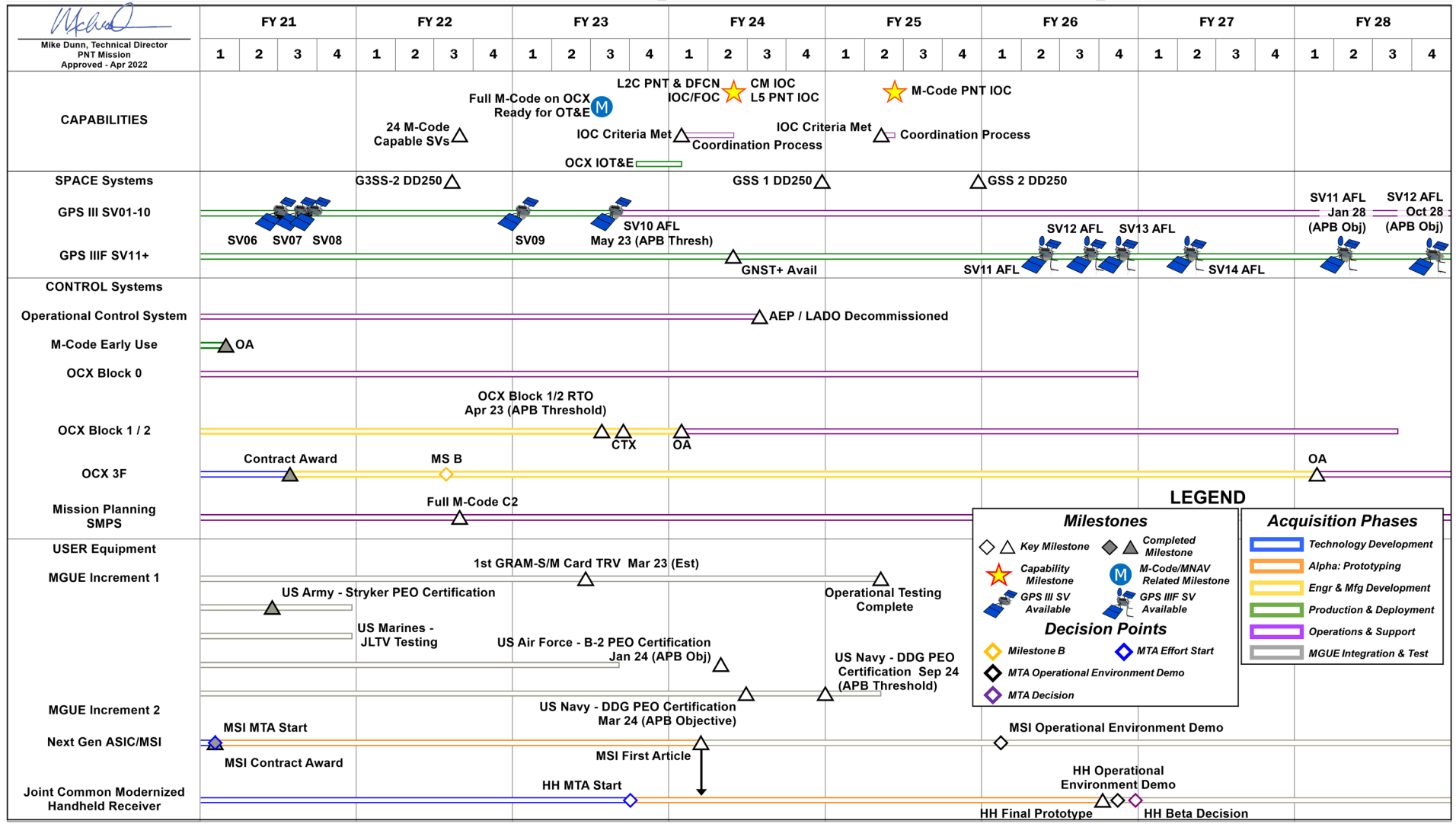


Red – GPS Today
Yellow – M-Code
Green – M-Code with GPS III
Blue – GPS Regional Military Protection (RMP)

Benefits of Improved Civil Signals

- One focus of the GPS modernization program is the addition of new navigation signals to the satellite constellation
- The Enterprise is fielding three new signals designed for civilian use: L2C, L5, and L1C. The legacy civil signal, called L1 C/A or C/A at L1, will continue broadcasting, for a total of four civil GPS signals
  - L2C is the second civilian GPS signal, designed specifically to meet commercial needs; combined with L1 C/A in a dual-frequency receiver, L2C enables ionospheric correction improving accuracy
  - L5 is the third civilian GPS signal, designed to meet demanding requirements for safety-of-life transportation and other high-performance applications
  - L1C is the fourth civilian GPS signal, designed to enable interoperability between GPS and international satellite navigation systems

GPS Enterprise Roadmap



AEP	Architecture Evolution Plan	DDG	Arleigh Burke Guided Missile Destroyer	GSS	GPS Satellite Simulator	MGUE	Military GPS User Equipment	OT&E	Operational Test and Evaluation
AFL	Available for Launch	DFCN	Dual-Frequency Civil Navigation	HH	Handheld	MNAV	Military Navigation	PEO	Program Executive Officer
APB	Acquisition Program Baseline	FOC	Full Operational Capability	IOC	Initial Operating Capability	MS	Milestone	PNT	Positioning, Navigation & Timing
ASIC	Application-Specific Integrated Circuit	GRAM-S/M	GPS Receiver Application Module – Standard Elec Module/Modernized	IOT&E	Initial Operational Test & Evaluation	MSI	Miniature Serial Interface	RTO	Ready for Transition to Ops
C2	Command & Control			JLTV	Joint Light Tactical Vehicle	MTA	Middle Tier Acquisition	SMPS	SAASM Mission Planning System
CM	Constellation Management	G3SS	GPS III Satellite Simulator	LADO	Launch, Anomaly, and Disposal Operations	OA	Operational Acceptance	SV	Space Vehicle
CTX	Constellation Transfer	GNST+	GPS IIIF Non-Flight Satellite Testbed	MCEU	M-Code Early Use	OCX	Next Gen Operational Control System	TRV	Technical Requirements Verification

Next Generation Operational Control System (OCX)

- Current Status
  - GPS III Launch & Checkout System (LCS) successfully supported launch of GPS III SV01-05; transferred to 2SOPS (Jun 2021)
  - Completed global deployment of 17 of 17 Monitor Station (Jul 2021)
  - Qualified OCX mission software on its original IBM baseline & completed other element tests - Certificate of Conformance Completed (Dec 2021)
  - Completed global installation of all 4 Legacy Ground Antenna Element sites (Mar 2022)
  - Hewlett Packard (HP) Segment Integration, Formal Qualification Test (FQT) and Site Acceptance Test (SAT) preparations underway
- Upcoming Milestones
  - DD250 acceptance projected Oct 22
  - Ready to Transition to Operations projected 2QCY23

OCX is looking forward to a robust OCX Integrated Systems Test next summer

Next Generation Operational Control System (OCX) 3F

- Current Status
  - Awarded Next Generation Operational Control System (OCX) 3F Contract Award ($234M, Apr 2021)
  - Startup Activities ongoing; program will modify adaptive architecture of OCX Blocks 1 and 2 software baseline to launch and control enhanced GPS IIIF satellite capabilities
  - Delivered OCX 3F Development Readiness Review to the Space Systems Command on (Nov 2021)
  - Integrated Baseline Review (IBR) completed (Apr 2022)

- Upcoming Milestones
  - Milestone B (2QCY22)
  - OCX 3F Launch & Checkout s/w complete (1QCY24)
  - OCX 3F s/w Ready for Enterprise Int & Test (3QCY25)
  - Operational Acceptance (4QCY27)

OCX 3F program continues to execute and meet schedule

User Equipment

AIR FORCE B2 SPIRIT

NAVY DDG ARLEIGH BURKE

MGUE Inc 1

MARINE CORPS JLTV

ARMY STRYKER

MGUE Inc 2


global utility
uninterrupted service
strength through partnership
gold standard
GPS

Questions