

The Future of Assured PNT

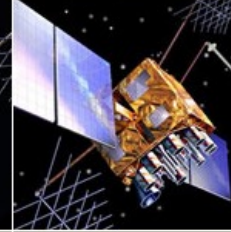
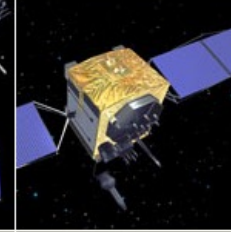
Oct 27, 2021

Presenter: Tonya Ladwig, Vice President, Navigation Systems, Lockheed Martin Space



Current GPS Constellation Status

- Currently, only four next generation GPS III satellites are part of the Operational GPS satellite constellation.
- GPS III satellites have 3x greater accuracy, up to 8x improved anti-jamming and the new L1C civil signal, over the rest of the constellation.
- GPS III Space Vehicle 05 (GPS III SV05) launched June 17, 2021 was turned over (Satellite Control Authority) to the Space Force on June 28, 2021.
 - USSF continues extended operational testing of SV05

LEGACY SATELLITES		MODERNIZED SATELLITES		
				
BLOCK IIA	BLOCK IIR	BLOCK IIR-M	BLOCK IIF	GPS III/IIIF
0 operational	8 operational	7 operational	12 operational	4 operational
- Coarse Acquisition (C/A) code on L1 frequency for civil users - Precise P(Y) code on L1 & L2 frequencies for military users 7.5-year design lifespan - Launched in 1990-1997 - Last one decommissioned in 2019	- C/A code on L1 - P(Y) code on L1 & L2 - On-board clock monitoring 7.5-year design lifespan - Launched in 1997-2004	- All legacy signals 2nd civil signal on L2 (L2C) LEARN MORE → - New military M code signals for enhanced jam resistance - Flexible power levels for military signals 7.5-year design lifespan - Launched in 2005-2009	- All Block IIR-M signals 3rd civil signal on L5 frequency (L5) LEARN MORE → - Advanced atomic clocks - Improved accuracy, signal strength, and quality 12-year design lifespan - Launched in 2010-2016	- All Block IIF signals 4th civil signal on L1 (L1C) LEARN MORE → - Enhanced signal reliability, accuracy, and integrity - No Selective Availability LEARN MORE → 15-year design lifespan - IIIF: laser reflectors; search & rescue payload - First launch in 2018

Graphic Courtesy of GPS.gov

GPS III & IIF Program Status

- **Five GPS III Space Vehicles On-Orbit**
 - SV01-05
- **Three GPS III satellites are completed, declared Available for Launch (AFL) by the Space Force, and in storage:**
 - SV06 - AFL 05 Apr
 - SV07 - AFL 20 May
 - SV08 - AFL 10 June
- **The final two GPS III satellites are in production**
 - SV09 Core Mate (12 May)
 - SV10 In Component Build Up
- **Four GPS III Follow On (GPS IIF) satellites are under contract & in production**
 - SV11-14



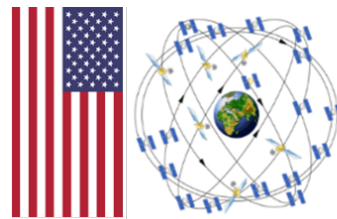
Need For Modernization: Competition & Emerging Threats

Constellation Sustainment No Longer Only Consideration

- GPS satellites operating 2-3x beyond design life – dated capabilities
- Emerging threats represent unplanned risks
- Chinese SatNav drives military and economic competition

GPS Must Transition From Focus on Sustainment to Focus on Deploying New Capabilities

- GPS is a key underpinning of our critical national infrastructure
- Must support military operations in GPS-contested domains



GPS
31 Operational MEO Satellites
(2R, 2R/M, 2F, 3)

Additional Modernization – Capability Development Must be a Top Priority

- Transition to LM2100 Combat Bus™ with size, weight, and power capacity for hosted payloads
- Deliver On-Orbit Re-programmability to counter jamming / spoofing
- Employ Inter-Satellite Links for rapid warfighter effects and constellation autonomy
- Work across U.S. Government and allies for complementary, resilient LEO and GEO PNT capabilities



BeiDou-3
30 MEO/GEO/IGSO Satellites
(24 MEO, 3 IGSO, 3 GEO)

GPS III/IIIF

GPS III SV01-10

- M-code Anti-Jam power increased by 8x over Block II SVs
- Timing accuracy increased by 3x over Block II SVs
- Design life 15 years
- L1C signals compatible with Galileo L1 Open Service
- Modular design allows new technologies/capabilities

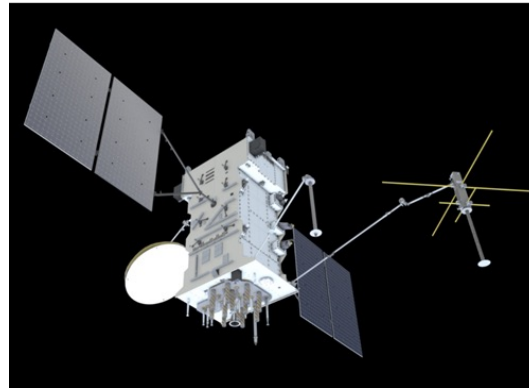


GPS IIIF SV11-12

- Regional M-code Anti- Jam (AJ) power improved up to 60x over Block II SVs
- Emergency transponder location via Search & Rescue (SAR) payload
- SV ranging verification via Laser Retroreflector Array (LRA)

GPS IIIF SV13-32 Combat Bus

- Significant size, weight, and power capacity for additional hosted payloads
- General Purpose Interface for hosted payloads
- Access for late hardware insertion
- Studies underway to incorporate new tech/capabilities for 22 GPS IIIF SVs:
 - Signal reprogrammability; Enhanced Command & Control (EC2)



GPS III Modular Bus Supports Integration of New Technologies & Capabilities

Capability Modernizations

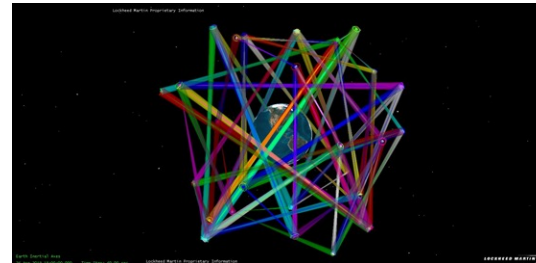
On-Orbit Reprogrammability (OOR)

- Provides the capability to deploy advanced waveforms in support of the warfighter and civilian users
 - Improved signal resiliency (Anti-jam, Authentication)
 - Improved signal performance (Improved Accuracy)



Enhanced Command & Control (EC2)

- EC2 enhances PNT mission capabilities & augment space enterprise
 - Improve mission performance – lower age-of-data
 - Increase mission resilience & system autonomy
 - Decrease timeline for Rapid Warfighter Effects



Modular Open System Approach (MOSA)

- Reduce NRE to integrate future capabilities and ease the ability for late integration in production flow of payloads
 - Provide implementation flexibility
 - Common CoPaIS compatible interfaces/standards
 - Minimize SV changes due to new capability insertion

Opportunity for Greater US-International PNT Cooperation

Multiple Nations are Reviewing Their PNT Requirements for Critical Infrastructure and Defense Needs

- As an example, the UK is looking at options for greater PNT capability based upon their current position with the Galileo program
- Other nations around the globe are doing similar evaluations of their PNT capabilities and needs

GPS Team is Working with International Partners to Optimize Solutions

- We have responded to official Information Requests
- We have held multiple discussions with the UK about providing them an assured PNT system in lieu of their previous involvement in Galileo.
- Continuing collaboration with the US Government to augment and improve GPS performance while meeting international sovereign needs

Overarching Goals

- Increase resiliency while reducing impact to PNT infrastructure
- Generate greater collaboration between US and International Partners in meeting PNT needs



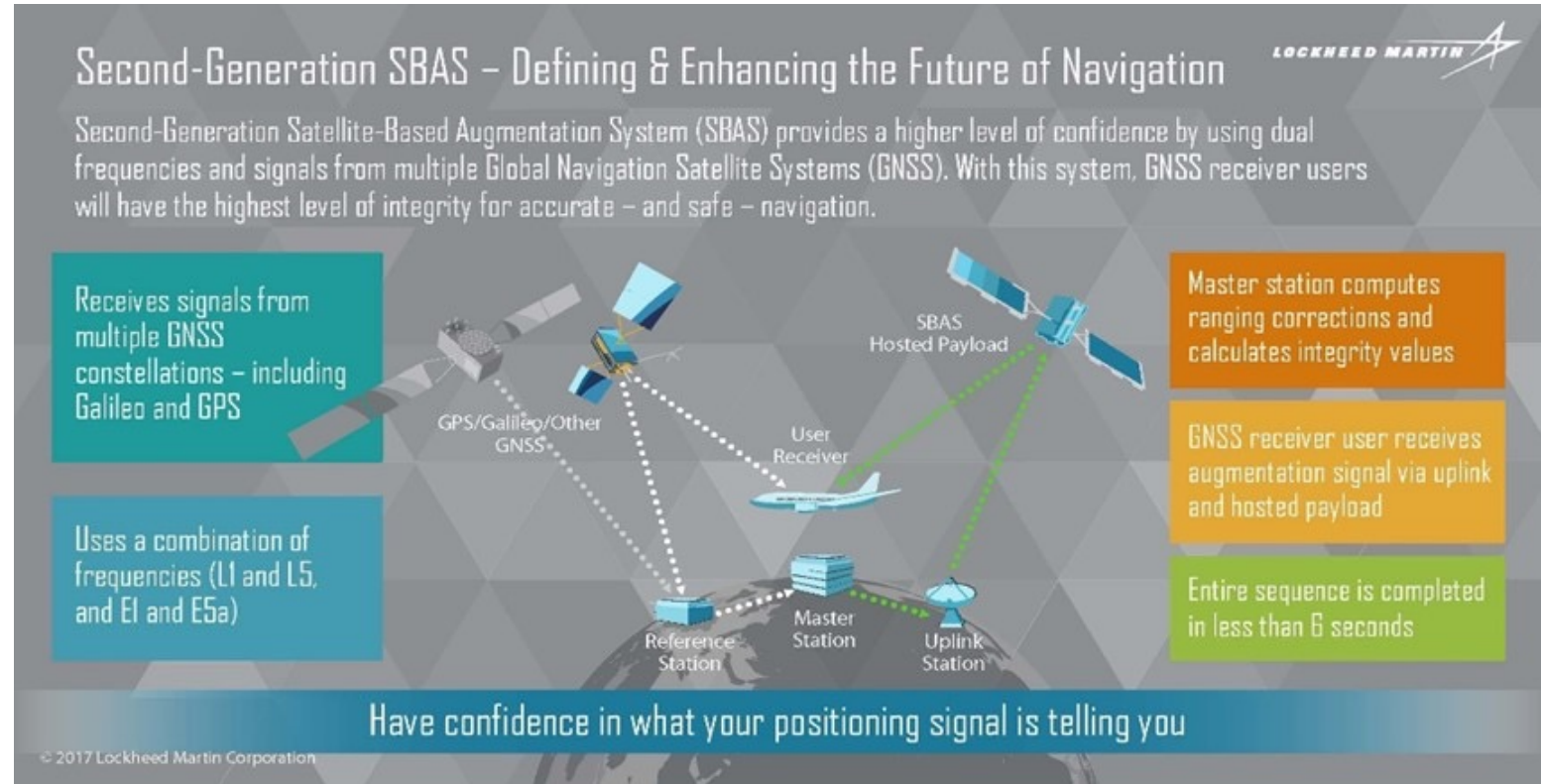
Second Generation SBAS

Objective

- Lockheed Martin initiative to be “first mover” to exploit:
 - L5 FOC capability being completed by GPS III
 - Galileo deployment
- Developed first prototype of Dual Frequency Multiple Constellation (DFMC) SBAS
 - L1/L5 GPS
 - E1/E5 Galileo
 - Precise Point Positioning (PPP), eventually on E5b

Activity Status

- Successful Testbed from Uralla, NSW Australia
- Assessing options for addressing military requirements
- Partnership with Stanford Center for PNT



Modernization Next Steps

Enhance GPS as Critical National Infrastructure (CNI)

- GPS underpins ~\$1B/day in economic benefits (2019 NIST Report)
- U.S. military dominance underpins U.S. security with precision weapons, troop maneuvers, and logistics
- New GPS capabilities are required to maintain U.S. military dominance

Launch for Capability Rather than Sustainment

- Address emerging threats and adversary competition



Make GPS an Active and Resilient Foundation for Assured PNT

- On-ramp NTS-3 capabilities to the GPS program of record
- Integrate autonomy and resilience capabilities – crosslinks and on-orbit reprogrammability
- Leverage international partnerships to strengthen and augment GNSS systems

Utilize GPS as a MEO Platform

- Leverage demonstrated ability to integrate new missions
- GPS IIIF design and fielding approach presents unique opportunity