

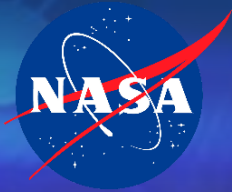
National Aeronautics and
Space Administration



Introduction of ICG Liaisons to Interagency Operations Advisory Group: The Importance of GNSS for Space Ops & Science: Keep Advancing!!

James J. Miller (NASA) ICG Agency Lead
Joel Parker (NASA) – ICG-IOAG Liaison
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June 2023



Celebrating 50 Years of Societal Benefits from GPS

- The NASA-sponsored National Space-Based PNT Advisory Board held 27th session on Nov. 16-17, 2022, and developed recommendation¹ for a National-level event to mark the 50th Anniversary of the 1973 commencement of the GPS program. Supporting White Paper approved at 28th session on May 3-4, 2023.
- In 1978 the first GPS satellite was launched, and in 1995 GPS was declared fully operational
- In 2011, the International Astronautical Federation celebrated its 60th Anniversary by giving out a special one-time award² to the GPS Program for its uniqueness and the exemplary role it has played in building international collaboration for the benefit of humanity
- In 2018 a National Institute of Standards and Technology study³ found that:
 - GPS has generated ~ \$1.4 trillion in economic benefits since made available for civilian & commercial use in the 1980s
 - About \$1B/day would be lost in the U.S. economy should GPS not be available

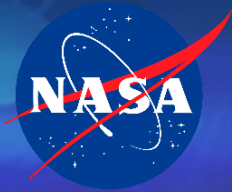


First Director of the GPS Joint Program Office, Dr. (Col, USAF) Bradford Parkinson, in discussions with his deputies (1973)



Dr. Parkinson (1st Vice Chair, National Space-Based PNT Advisory Board) addressing the UAG on the role of PNT (2019)

(1) <https://www.gps.gov/governance/advisory/recommendations/2023-01-PNTAB-27-chair-memo.pdf>
(2) <https://www.iafastro.org/activities/honours-and-awards/special-award-iaf-60th-anniversary-award.html>
(3) <https://www.space.commerce.gov/doc-study-on-economic-benefits-of-gps/>



Implementation of Laser Retro-reflector Arrays on GPS

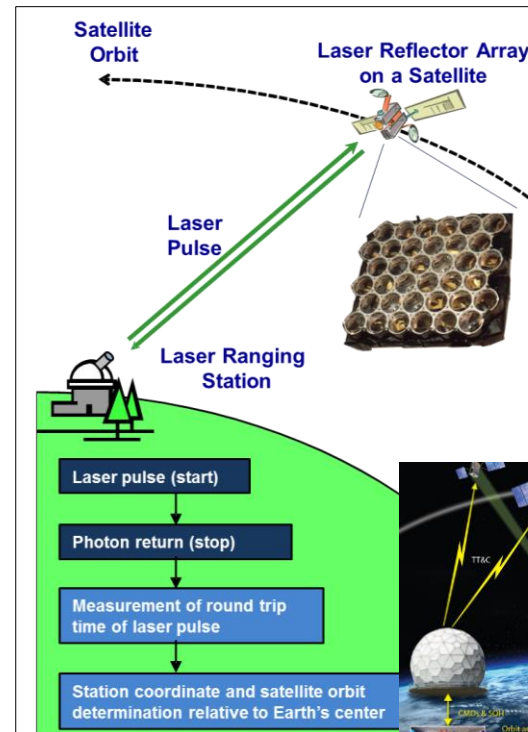
Background

- In 2007 NASA submitted requirement to equip GPS satellite vehicles (SVs) with Laser Retro-reflector Arrays (LRAs) to enable precision orbit determination
- In 2013 NASA, U.S. Air Force Space Command, and U.S. Strategic Command signed a Memorandum of Understanding to equip GPS Block IIF SVs (GPS Block III SV 11+), with new-design LRAs
 - LRA design & manufacture funded by NASA. At least 27 to be provided (~ \$500K each).
 - National Geospatial-Intelligence Agency funded integration costs (~\$12M)
 - GNSS Satellite Laser Ranging operations coordinated through the International Laser Ranging System (ILRS) Central Bureau, operated by NASA
- GPS SLR Concept of Operations signed on June 23, 2020

Latest Developments

- On February 22, 2023, NASA successfully completed the pre-ship review of the LRA payloads for GPS Block III SVs 11 & 12 (to be delivered in late June)
- On May 12, 2023, NASA received formal notification from the U.S. Space Force (USSF) Space Systems Command that the Authority to Proceed (ATP) was awarded for addition of LRAs to GPS III SV 09 & SV 10

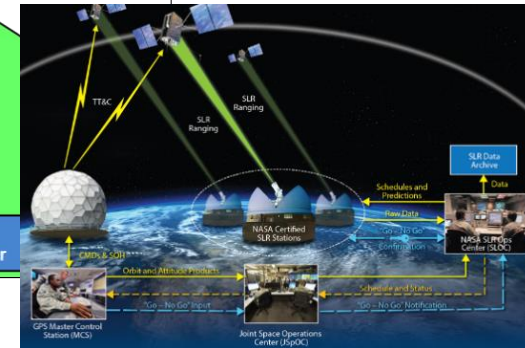
SLR Operations



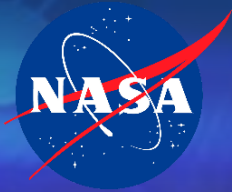
NASA Next Generation SLR Ground Station



GPS SLR CONOPS



Collaboration between the GPS program and LRA stakeholders (NASA, NGA, and NRL) was successful to get LRA units in orbit earlier than GPS III SV 11, achieving goals for both the USSF and the LRA community



Public Release of GNSS Transmit Antenna Patterns

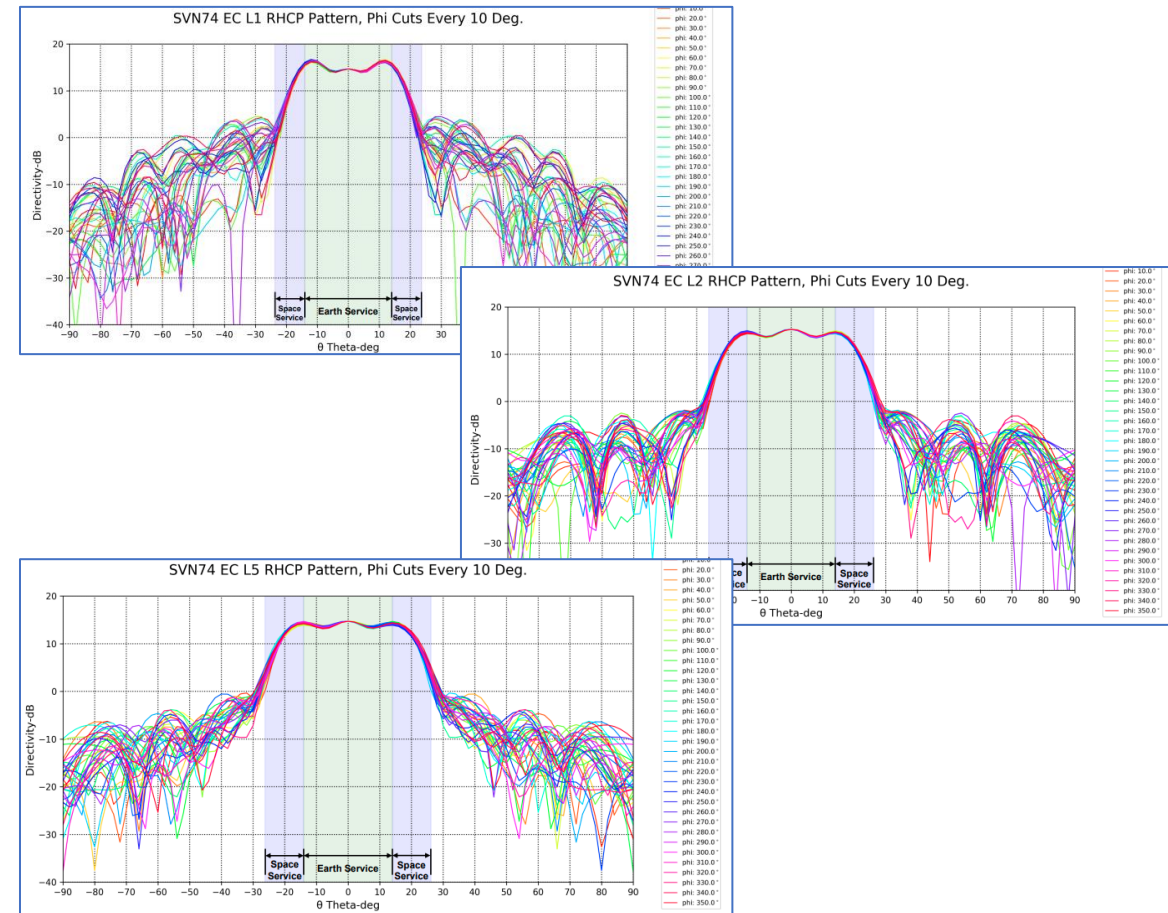
Background

- Knowledge of GNSS transmit antenna patterns is critical to support high-accuracy applications & use of GNSS signals within the Space Service Volume (SSV) and beyond into Cislunar Space
- As of ICG-16 NASA, working with the U.S. Coast Guard Navigation Center (NAVCEN), had recured the public release of the transmit antenna patterns for GPS Block IIR and IIR(M)

Latest Developments

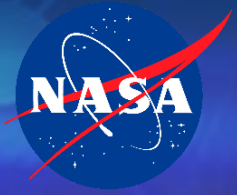
- In October 2022 secured the public release of the GPS Block III transmit antenna patterns
- In May 2023 secured the public release of the GPS Block IIF transmit antenna patterns
- The antenna patterns of all active GPS satellites is now available at the NAVCEN GPS portal:
<https://www.navcen.uscg.gov/gps-technical-references>

GPS SVN74 (GPS III SV01) L1, L2, L5 Transmit Antenna Patterns



Public availability of all GNSS transmit antenna patterns will enable space mission planners to better estimate PNT performance within and above the GNSS SSV

Multi-GNSS Flight Experiments to Improve PNT Capabilities for Space Users



- **BobCat-1 CubeSat:**

- GNSS receiver furnished by Italian Space Agency (ASI) to demonstrate nanosecond-level precision in GPS-Galileo Time Offset
- In Jan. 2022 successfully completed 13 months of operations since release from ISS

- **Space Loft 15 Sounding Rocket:**

- Collaboration with ASI & European Space Agency (ESA) to test GPS-Galileo receivers under highly dynamic conditions for range safety applications
- Follow-on to successful GNSS experiment on SL-14 in 2019
- SL-15 launch currently planned for late 2023

- **Lunar GNSS Flight Receiver Experiment:**

- ASI-furnished GNSS receiver payload on NASA Commercial Lunar Payload Services Mission 19D (Blue Ghost Mission-1) to validate use of GPS-Galileo all the way to the *lunar surface*
- Flight Model delivered to Firefly Aerospace on Feb. 23, 2023 / Launch 2024

- **NASA-furnished Laser Retro-reflector Array on ESA Lunar Pathfinder:**

- Demonstrate two-way laser ranging in support of precision orbit determination
- Improve the tie between Terrestrial Reference Frame & Lunar Reference Frame
- Improve determination of Universal Time
- LRA delivered to ESA on Nov. 4, 2022 / Launch planned 2025

