



Development of an Interoperable GNSS Space Service Volume – The GNSS SSV Booklet

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International Committee on
Global Navigation Satellite Systems

International Committee on GNSS (ICG)

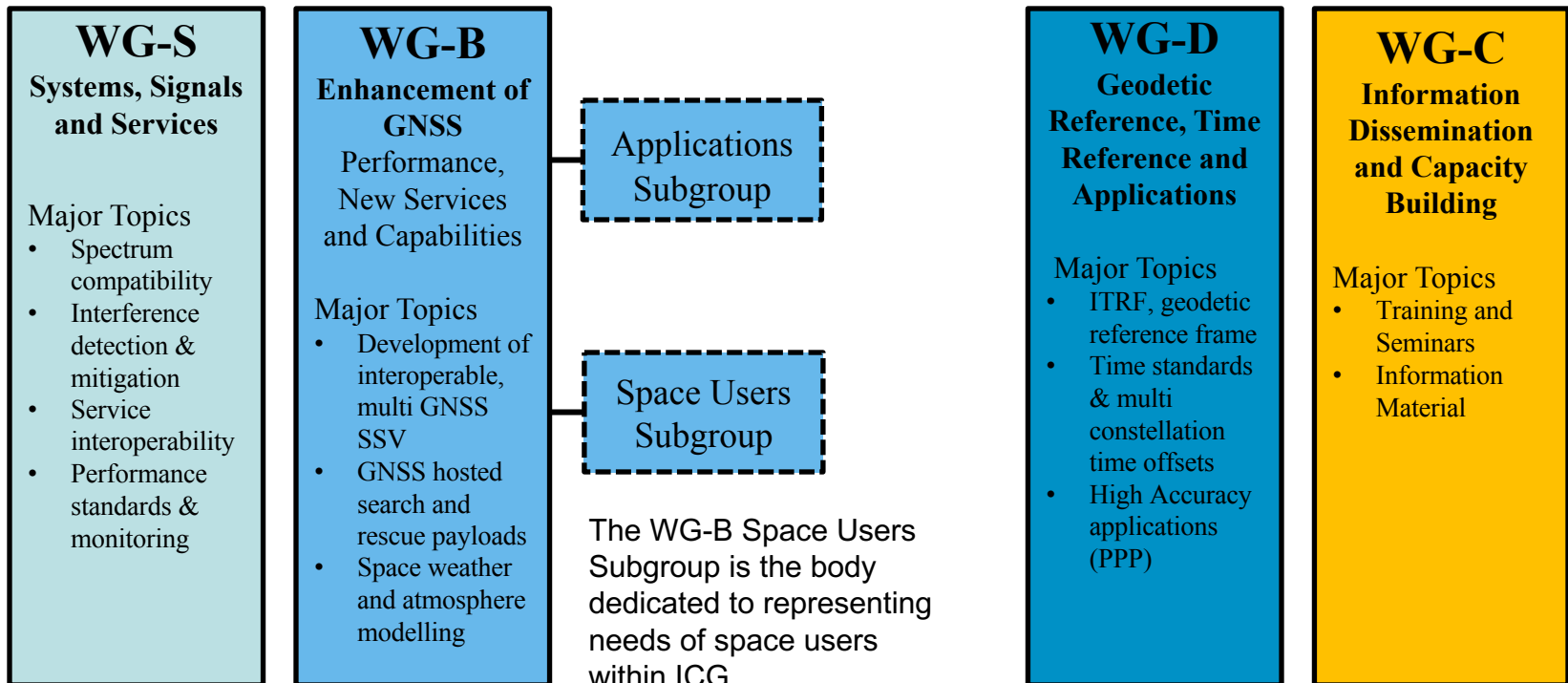


- The ICG emerged from 3rd UN Conference on the Exploration and Peaceful Uses of Outer Space in July 1999
- The ICG brings together all six GNSS providers (United States–GPS, European Union–Galileo, Russia–GLONASS, China–BeiDou, India–NavIC and Japan–QZSS), as well as other members and observers to:
 - *Promote the use of GNSS and its integration into infrastructures*
 - *Encourage compatibility and interoperability among global and regional systems*
- Observers: International organizations and associations (BIPM, IOAG, ITU, IGS, etc.,)

<https://www.unoosa.org/oosa/en/ourwork/icg/icg.html>

International Committee on GNSS (ICG)

The ICG consist of the GNSS Service Providers Forum and four Working Groups (WG-S, WG-B, WG-C and WG-D).



(Subgroups of WG-S, WG-D, WG-C not shown.)

International Committee on GNSS (ICG)

- Working Logic of the different WGs
 - Spring meeting in Vienna – not all WGs are present
 - Meeting in June in Vienna – not all WGs are present
 - Nov/Dec - annual ICG meeting different locations – all WGs are present physically
 - As needed--physical or virtual WG meetings—individually or jointly
- Previous meetings:
 - ICG-11, 2016 – Sochi, Russian Federation
 - ICG-12, 2017 – Kyoto, Japan
 - ICG-13, 2018 – Xi'an, China
 - ICG-14, 2019 – Bangalore, India
 - ICG-15, 2020 – Vienna, Austria (Covid 19 delay to 2021)
 - ICG-15, 2021 – Vienna, Austria

ICG – WG-B Space Users Subgroup (SUSG) – Historical Background

- Until the ICG-10 in 2015, the GNSS Space Service Volume (SSV) topic was handled within the WG-B
- In 2015, at the ICG-10 a dedicated GNSS SSV Action Group was formed within WG-B
- In 2018 a dedicated working group called Space Applications Sub-Group was implemented, which changed the name in early 2019 to Space Users Subgroup (SUSG)
- The Space Users Subgroup is co-chaired by Europe/ESA, US/NASA, and China/CAST
- The SUSG has monthly meetings organized by one of the co-chairs on a rotating basis

ICG – WG-B Space Users Subgroup (SUSG) – Main Objectives

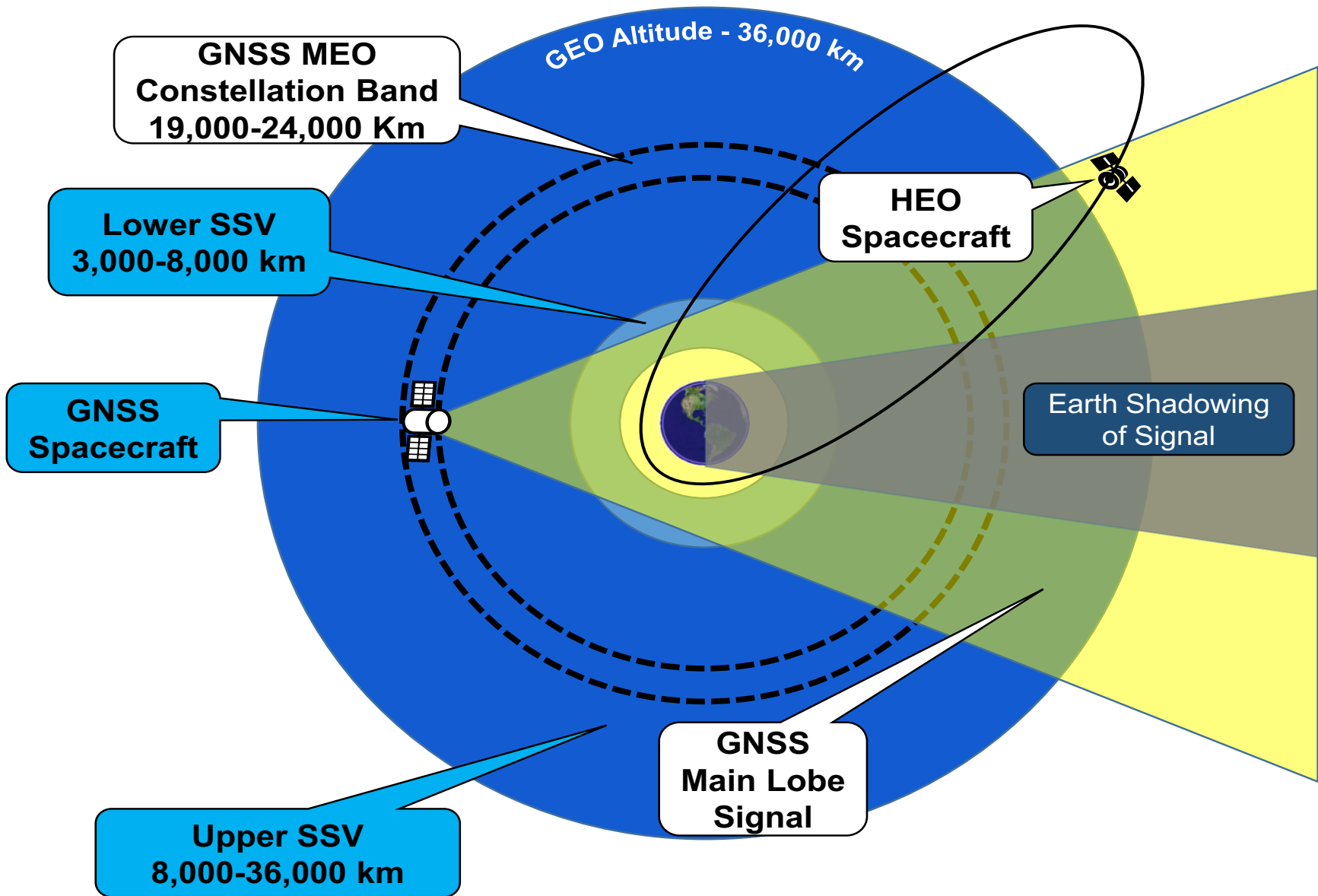
Main Objectives of SUSG, as defined in the ToR

- Lead evolution of the Interoperable Multi-GNSS Space Service Volume including the use of GNSS for missions beyond the existing SSV (e.g. lunar).
- Encourage developments of space-based user equipment and emerging user community.
- Encourage coordination with Interagency Operations Advisory Group (IOAG) and International Space Exploration Coordination Group (ISECG).
- Encourage development of new services and augmentations beneficial to space users.
- Promote space user community needs within ICG.

ICG – WG-B Space Users Subgroup (SUSG) – Main achievements of SUSG in 2018/2019

- Definition of an initial Multi-GNSS interoperable Space Service Volume
- Conduct a series of simulations for realistic mission scenarios (GEO, HEO and Lunar)
- Successful release of the first edition of the GNSS SSV Booklet on 1 Nov 2018 at ICG-13, fully supported by all GNSS Service Providers
- **Made a recommendation to ICG for expansion of GNSS SSV for exploration in cislunar space and beyond – recommendation was adopted**
- Conducted various outreach activities
 - Presentations at conferences
 - Key note address
 - Articles in journals
 - 1st dedicated international conference on GNSS SSV will be held in May 2022 organized by ESA/ESOC and co-organized by NASA

Definition of GNSS Space Service Volume



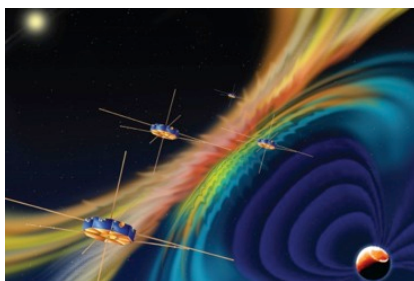
The Growing Promise of GNSS for Real-time Navigation in the SSV & Beyond

Benefits of GNSS use in SSV:

- Enables **continuous navigation capability**
- **Significantly improves navigation performance**
- Supports **increased satellite autonomy and lowering mission operations costs**
- Supports **quick trajectory maneuver recovery**
- Enables **new/enhanced capabilities and better performance** for missions such as:



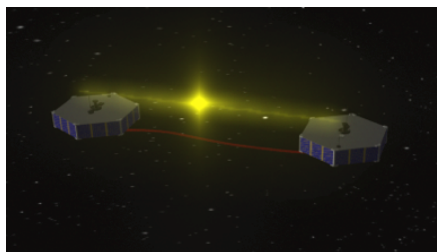
Earth Weather Prediction using
Advanced Weather Satellites



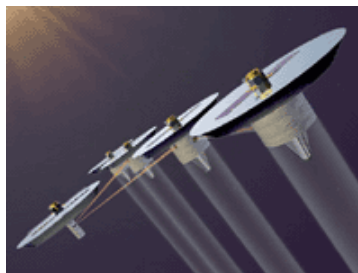
Space Weather Observations



Precise Relative Positioning



Precise Position Knowledge
and Control at GEO

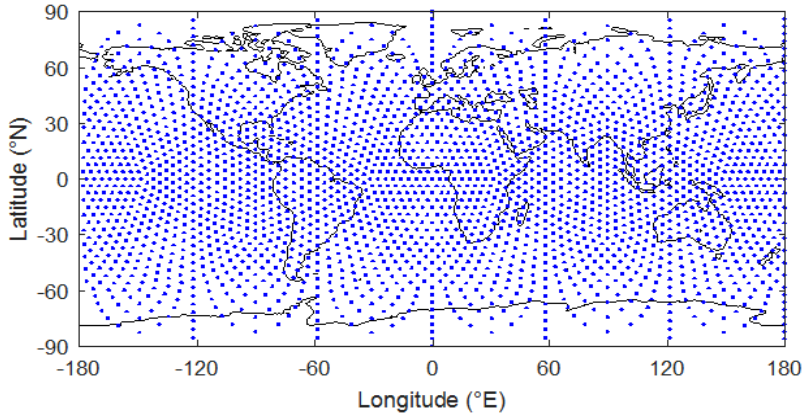


Formation Flying, Space Situational
Awareness, Proximity Operations

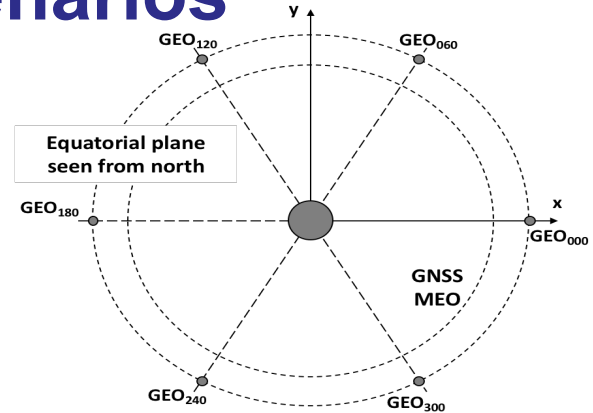


Beyond GEO / Cislunar Space

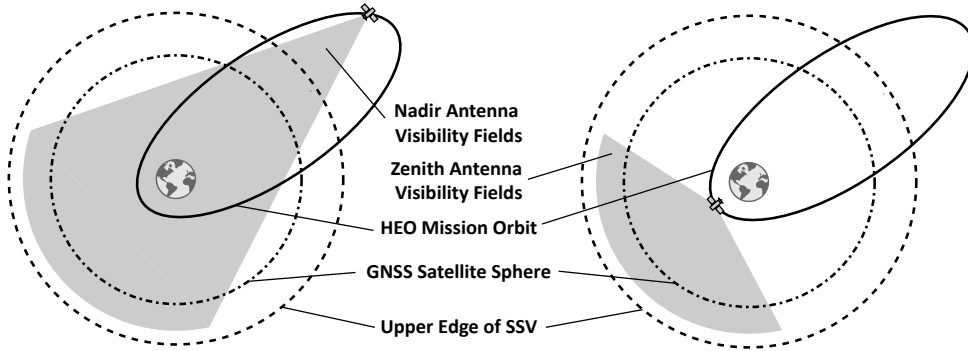
User Signal Availability Simulation Scenarios



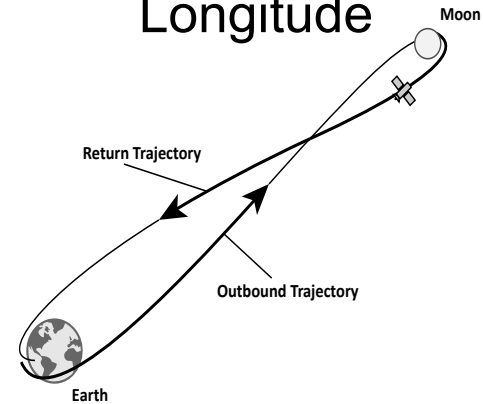
Global Average— Fixed Grid Points in Space



Mission Specific – 6 GEO Satellites Phased 60° Longitude

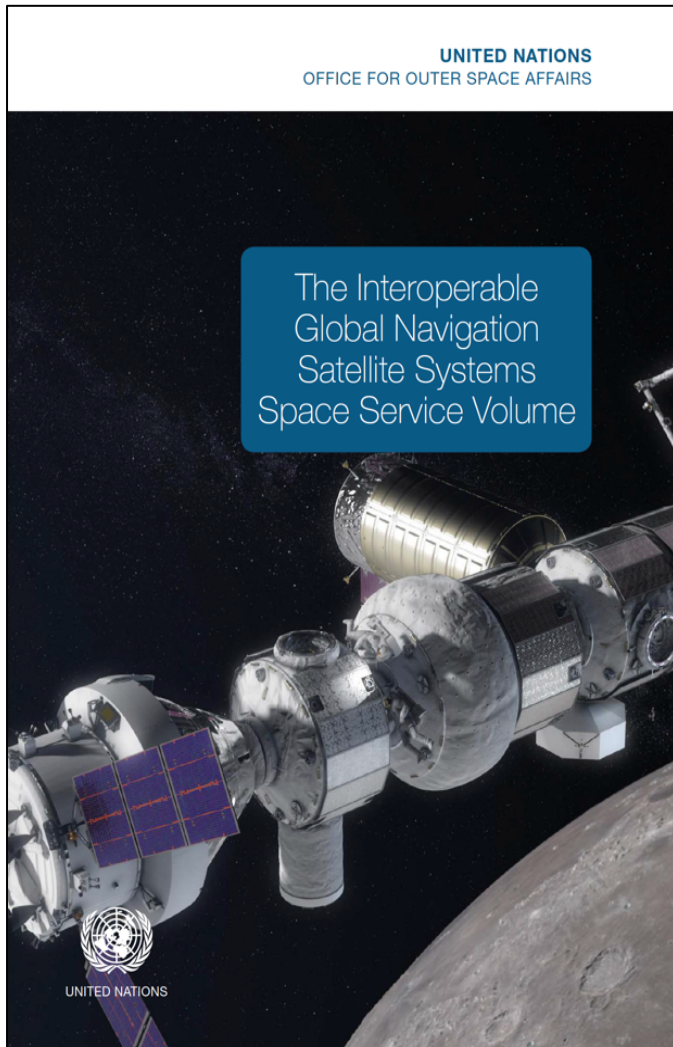


Mission Specific – Space User in HEO



Mission Specific – Space User Lunar Transfer Trajectory

Interoperable Multi GNSS SSV Booklet



- Booklet was published on 01 Nov 2018
- Identifier: ST/SPACE/75
- Electronically available at:
 - <http://www.unoosa.org/oosa/en/ourwork/icg/documents/publications.html>
 - http://www.unoosa.org/res/oosadoc/data/documents/2018/stspace/stspace75_0.html/st_space_75E.pdf
 - <https://undocs.org/st/space/75>
- Hard copies are provided to UNHQ (New York) for public sales.

Space Users Subgroup (SUSG) – Work Plan 2019 to 2021

- **Update of Booklet – 2nd Edition to be published in 2021**
 - Full revision and update of all chapters, including GNSS constellation updates
 - New Content
 - Flight Experience
 - Geometric Dilution Indicator (GDI)
 - **Current status:**
 - Full draft reviewed by SUSG and undergoing minor amendments
 - SSV Booklet planned release (mid 2021)

Space Users Subgroup (SUSG) GNSS SSV Video

- Four minute video, developed as an outreach tool to:
 - Explain utility and benefits of a multi-GNSS SSV
 - Show how it will transform navigation use in space, and
 - Describe how it will impact humanity—in space and on Earth
- Co-Sponsors: NASA and National Coordination Office for Space-based Positioning, Navigation and Timing
- **Current status:** Final production underway; early 2021 release

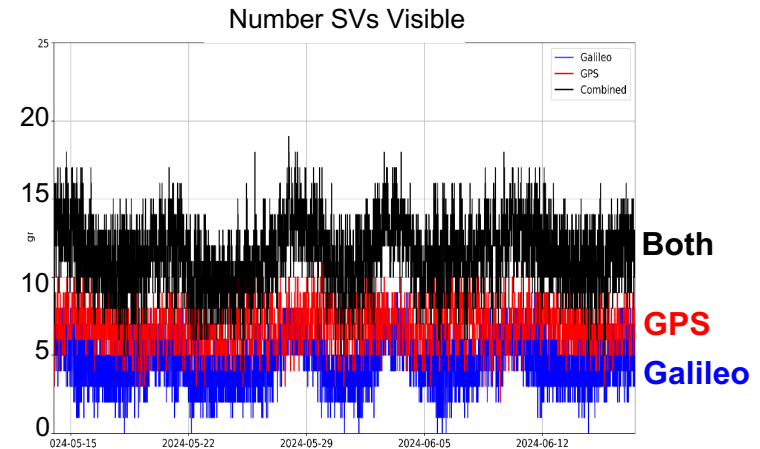
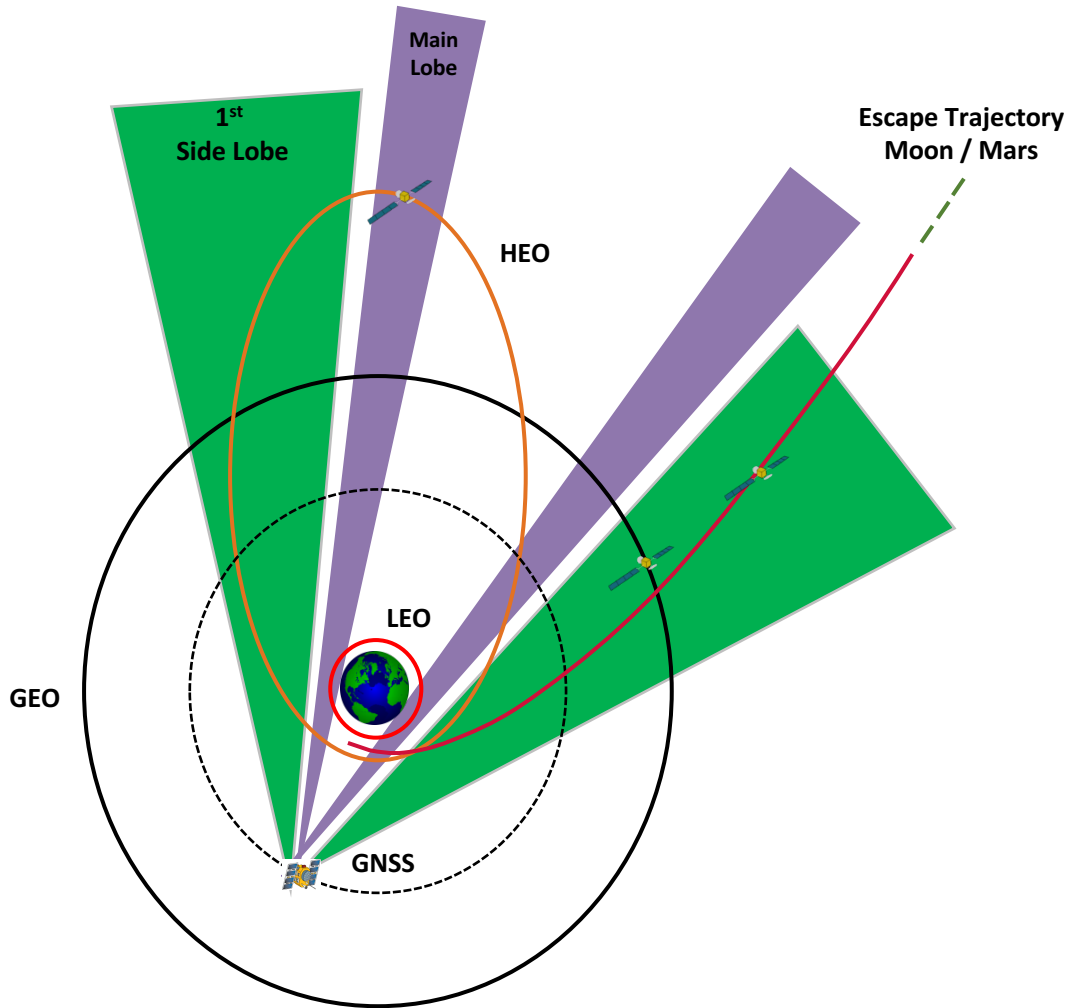


Space Users Subgroup (SUSG) – Work Plan 2019 to 2021

Main new activities for 2021

- Inclusion of GNSS Transmitter antenna side lobes in simulations, based on models, in orbit measurement and/or data released by the GNSS Service Providers
- Identification of Space Users requirements for development of interoperable multi-GNSS time reference
- Review, Adoption, Augmentation and Development of new GNSS space user standards (e.g. CCSDS, RINEX, ...)
- Numerous cislunar initiatives
- **Current status:** Revised work plan to be adopted early 2021

Inclusion of GNSS Side Lobes Signals in Simulations*



**Predicted Gateway
GPS/Galileo visibility**
(20 dB-Hz; ESA/ESOC)

*Based On Models, In Orbit Measurement And/Or Data
Released By The GNSS Service Providers

Conclusions

- The interoperable multi-GNSS Space Service Volume offers enormous benefits for space users and can be seen as an enabler for future advanced missions
 - Improved signal availability
 - Improved navigation performance
- The number of Space Users in all orbital regimes, which are relying on GNSS will grow significantly over the next 5 years
- With advanced GNSS equipment, GNSS signals can be tracked and used for navigation even for Lunar missions
- Coordination of international activities including standardization is considered as a key for the definition, generation and utilization of an interoperable Multi-GNSS Space Service Volume