



WG-B

Space Use Subgroup - Status Update

**ICG 15 - Vienna, Austria, 27 Sept. – 01 Oct 2021
(Hybrid Mode)**



International Committee on
Global Navigation Satellite Systems

The Multi-GNSS Space Service Volume: Earth's Next Navigation Utility

- Announcing inaugural presentation of finalized SSV Video
- Four-minute outreach tool; conveys utility & benefits of a Multi-GNSS SSV, describes its transformative use to navigate in space and shows how it will impact humanity—in space and on Earth
- Co-sponsors: NASA and National Coordination Office for Positioning, Navigation and Timing

THE INTEROPERABLE GLOBAL NAVIGATION SATELLITE SYSTEMS SPACE SERVICE VOLUME

SECOND EDITION



- Announcing publication of 2nd edition of “**The Interoperable GNSS SSV**”
- Product of 3 years of work by ICG WG-B Space Use Subgroup
- Thoroughly reviewed and updated throughout:
 - Latest GNSS constellation data
 - Discussion and analysis of geometric aspects in SSV
 - Addition of profiles of five real-world SSV and multi-GNSS missions
- Available at:

<https://undocs.org/ST/SPACE/75/REV.1>

Space Use Subgroup (SUSG)

- **Structure:**
 - Space Use Subgroup was created in 2018 from former WG-B 'SSV Taskforce' members
 - Three co-chairs: China, Europe, US
 - Monthly meetings by teleconference (or face-to-face)
 - Main activities to-date:
 - Focus on GNSS SSV
 - Publication of SSV Booklet 2nd
 - Generation of SSV Video
 - Identification of new activities - see agreed Work Plan 2021/2022

Space Use Subgroup (SUSG)

- **Current Status:**
 - The Space Use Subgroup has been working on an agreed Work Plan 2019/2020 since Jan. 2019
 - Renaming of this subgroup in April 2021
 - Original name: Space Applications Subgroup
 - Current name: Space Use Subgroup
 - SSV video has been generated by NASA
 - GNSS SSV Booklet – release of 2nd edition at ICG-15
 - Interaction with Interagency Operations Advisory Group (IOAG) – formally established via IOAG-ICG liaison
 - Interactions with International Space Exploration Coordination Group (ISECG) – work in progress (interactions took place and we wait for formalization by ISECG)

ToR for Space Use Subgroup – Adopted in April 2021

1. Scope of the Space Use Subgroup

- This Terms of Reference (ToR) defines the “Space Use Subgroup” of ICG WG-B and its associated activities.

2. Objectives of Space Use Subgroup

- 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.

ToR for Space Use Subgroup – Updated in April 2021

3. Participants

| Provider | POC | Email |
|---------------|--|--|
| China | Xinuo Chang (CAST) | chang_xinuo@foxmail.com |
| EU | Werner Enderle (ESA) Juan-Pablo Boyero (EC) | werner.enderle@esa.int Juan-Pablo.BOYERO@ec.europa.eu |
| US | Joel Parker (NASA) | joel.j.k.parker@nasa.gov |
| India | P.S.Sura (ISRO) | pssura.ursc.gov.in |
| Japan | Satoshi Kogure (JAXA) | satoshi.kogure.e7f@jaxa.jp |
| Russia | Ivan Revnivykh (Roscosmos) | revnivykh.is@roscosmos.ru |

ToR for Space Use Subgroup – Updated in April 2021

4. Regulatory Framework

- This ToR is applicable to all related documents under the Space Use Subgroup of WG-B.

5. Milestones

- Draft ToR for the Space Applications Subgroup – completed 1 Nov 2018
- Submission of the ToR for the Space Applications Subgroup to ICG – completed 6 Nov 2018
- Launch of activities for Space Applications Subgroup
- Renaming of Subgroup in line with its objectives and adaption of ToR accordingly – proposal made 15 April 2021

• Annexes

Space Use Subgroup Work Plan 2021-2022

Agreed Lead and Participation Responsibility Matrix

| Activity | Lead | Participation |
|---|--------|------------------------------------|
| Public availability of provider antenna/signal technical data and requisite models | India | China Japan Europe USA |
| GNSS space user mission data and profile | China | USA Europe |
| GNSS space user timing requirement analysis and space user operations recommendations | Europe | USA China Japan India |
| Expansion of GNSS SSV to Support Lunar Operations | USA | Russia China Japan Europe |
| GNSS space user Standards | Europe | Russia USA China India |

Space Use Subgroup Work Plan 2021-2022

| Title | Objective | Approach | Outcome | Potential Need for Coordination with WG |
|---|--|---|---|---|
| Public availability of provider antenna/signals technical data and requisite models | - Improving the use of GNSS in SSV(Space Service Volume) by considering the publically available GNSS antenna pattern data (includes main lobe and side lobe) or equivalent representative modeling information. | <ul style="list-style-type: none"> a) Assemble the list of available GNSS antenna patterns and equivalent antenna modelings. b) GNSS service providers are invited to share the GNSS antenna pattern of current operational civilian GNSS signals. c) Simulations will be done to generate variable transmit EIRP and the received C/No for SSV user. d) This work plan approach increases the GNSS signal availability for SSV applications. | <ul style="list-style-type: none"> a) Provides accurate simulation data for GNSS satellite availability and signal received power levels to space users. b) Publication of simulation results in SSV booklet version 3.0. | <ul style="list-style-type: none"> • WG-B • WG-S |
| GNSS space user mission data and profile | <ul style="list-style-type: none"> - identify and consolidate the existing and emerging GNSS space user community - collect information and data of flight and planned space missions using GNSS and maintain a sustainable database | <ul style="list-style-type: none"> a) To collect public available information and data of flight and planned space missions using GNSS and form a common database b) To characterize and categorize the user profiles based on data collected c) To cooperate with the space user community and implement a survey on GNSS space use requirement | GNSS space user catalogue and summary analysis on current capabilities, GNSS space user requirements satisfaction analysis, GNSS operation or enhancement recommendation | <ul style="list-style-type: none"> • WG-B • WG-B Application Subgroup |
| GNSS space user timing requirement analysis and space user operations recommendations | Perform analysis to develop a GNSS space user timing requirement analysis and develop GNSS space user timing operational recommendations | <ul style="list-style-type: none"> a) Work to collect space user requirements for timing interoperability; b) Work with WG-D and develop proposed timing interoperability solutions; c) Present to SUSG for approval, rejection or modification; d) Socialize ideas with international providers e) Action: Include/coordinate with other ICG time-related WGs | Development of space user timing capabilities and requirements; space user operations recommendations | <ul style="list-style-type: none"> • WG-S (interoperable GNSS time) • WG-D (time reference) |

Space Use Subgroup Work Plan 2021-2022

| Title | Objective | Proposed Approaches | Outcome | Potential Need for Coordination with WG |
|---|---|---|---|--|
| Expansion of GNSS SSV to Support Lunar Operations | Expand interoperable GNSS SSV to support Lunar transit, surface, Earth-Moon LaGrange points, and orbital operations (cis-lunar region); develop a formal definition of the expanded SSV | a) Frequency & Code coordination; working in concert with the Space Frequency Coordination Group (SFCG) & ICG WG-S b) Assess Cis-lunar user needs c) Develop a draft Lunar SSV definition d) Recommend and support lunar GNSS flight experiments commensurate with user needs; publish results and lessons learned e) Leverage publicly available trade studies and performance analyses; if necessary, perform narrow analyses/trades via ICG region study team(s) f) Recommend updated provider requirements and/or augmentations as needed <ul style="list-style-type: none"> – Recommend roles for GNSS providers and space agencies to support lunar PNT – For each use case, list needed space user capabilities (GNSS receivers, antenna types, required augmentations) with component characteristics delineated g) Publish results in future editions of SSV Booklet, technical journals and press articles | Full expansion of resilient interoperable GNSS supporting cislunar space and lunar surface operations | <ul style="list-style-type: none"> • WG-S • WG-B |
| GNSS space user Standards | Work with other organizations (e.g, CCSDS) on space user standards that will improve GNSS SSV interoperability and acceptance as an international standard | a) Collect suggestions for standards; b) Work requisite standards organizations to determine their interest in in proposed standards; c) Present proposed standards to SUSG for approval, rejection or modification; d) Socialize ideas with international providers | GNSS space user Standards | <ul style="list-style-type: none"> • WG-S • WG-B • WG-D |

Activity – Public availability of provider antenna data and requisite models

Objective:

- **Improving the use of GNSS in SSV(Space Service Volume)** by considering the publically available GNSS antenna pattern data(includes main lobe and side lobe) or equivalent representative modeling information.

Outcome:

- Provides accurate simulation data for GNSS satellite availability and signal received power levels to space users.
- Publication of simulation results in SSV booklet version 3.0.

Participation:

- Participation- China, Japan, Europe, USA and India.

Way forward:

- Assemble the list of available GNSS antenna patterns and equivalent antenna modelings.
- GNSS service providers are invited to share the GNSS antenna pattern of current operational civilian GNSS signals.
- WG-B SUSG shall discuss the antenna modelling for all GNSS constellations in order to improve the use of GNSS in SSV.

Activity – Public availability of provider antenna data and requisite models

Approach:

- A Sample of GNSS transmitting antenna pattern is shown in figure-1
- Similar information of transmit antenna data of all GNSS constellations will be considered for simulations or the requisite model of the antenna pattern shall be developed (figure-2).
- Considering antenna patterns, the off-boresight angle of the constellations will be analysed.
- Simulations will be done to generate variable transmit EIRP and the received C/N₀ for SSV user.
- This work plan approach increase the GNSS signal availability for SSV applications.

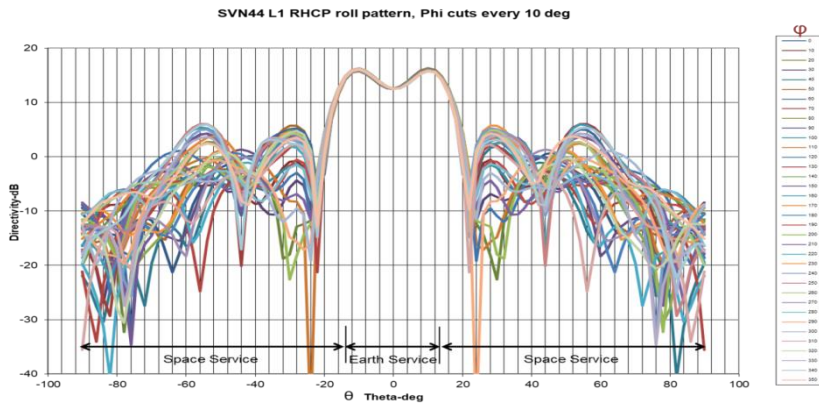


Figure-1: GNSS Transmit antenna pattern

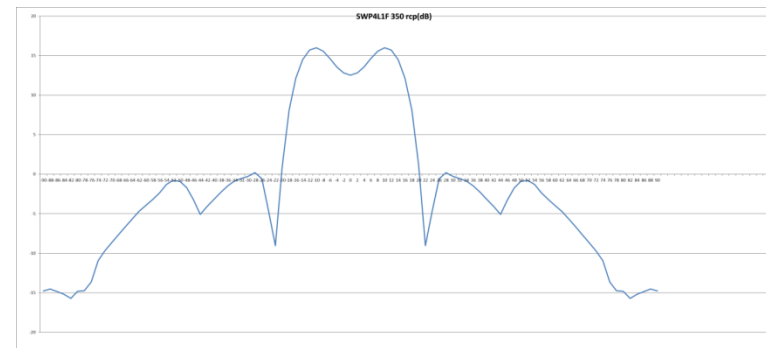


Figure-2: Modelled GNSS Transmit antenna pattern

The GPS antenna pattern shown fig-1 is GPS Block IIR/IIR-M antenna pattern (Lockheed Martin @2014).

Activity - GNSS Space Use Mission Data and Profile

Objectives

- identify and consolidate the existing and emerging GNSS space user community
- collect information and data of flight and planned space missions using GNSS and maintain a sustainable database

Benefits

- promote GNSS space application by solid mission and application data
- identify additional or potential requirements from user side and find current GNSS shortcomings on space services and performances
- recommend GNSS performance and service enhancements/ augmentation to system providers within ICG
- promote multi-GNSS space applications by cooperating with user communities.

Activity - GNSS Space Use Mission Data and Profile

Proposed Approach

- To collect public available information and data of flight and planned space missions using GNSS and form a common database
- To characterize and categorize the user profiles based on data collected
- To cooperate with the space user community and implement a survey on GNSS space use requirement

Expected Outcomes

Report/Presentation/Paper on

- GNSS space user catalogue and summary analysis on current capabilities
- GNSS space user requirements satisfaction analysis
- GNSS operation or enhancement recommendation

Activity – Expansion of GNSS SSV to Support Lunar Operations

Objective

- Expand interoperable GNSS SSV to support Lunar transit, surface, Earth-Moon Lagrange points and orbital operations (cis-lunar region); develop a formal definition of the expanded SSV

Implementation Objectives

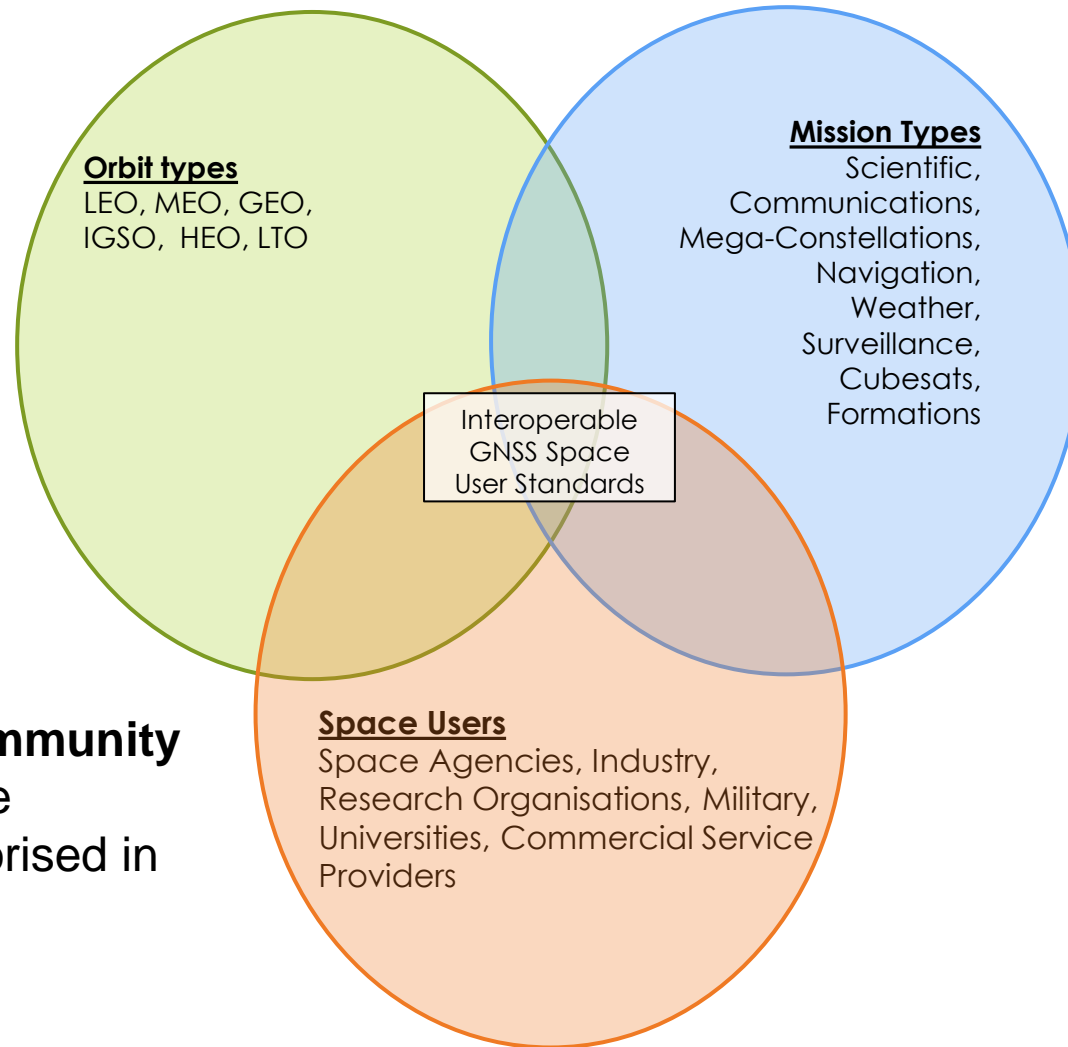
- Coordinate and socialize lunar GNSS capabilities amongst international teams and organizations (e.g. ICG, SFCG, ISECG, IOAG), particularly frequency and code coordination and role of GNSS in lunar PNT architecture.
- Establish a common set of lunar use cases, user-level requirements, and user needs.
- As needed, recommend provider requirement changes and architectural enhancements for robust signal reception and PNT resiliency. Enhancements might include strategically placed beacons and/or augmentations to supports near and far side lunar operations
- Work with service providers and/or international space agencies to implement needed changes and enhancements.

Activity – Expansion of GNSS SSV to Support Lunar Operations

Proposed Approach

- 1) **Frequency and code coordination; working in concert with the Space Frequency Coordination Group (SFCG) and ICG WG-S**
- 2) **Assess Cis-lunar user needs**
- 3) **Develop a draft Lunar SSV definition**
- 4) **Recommend and support lunar GNSS flight experiments commensurate with user needs; publish results and lessons learned**
- 5) **Leverage publicly available trade studies and performance analyses; if necessary, perform narrow analyses/trades via ICG region study team(s)**
- 6) **Recommend updated provider requirements and/or augmentations as needed**
 - Recommend roles for GNSS providers and space agencies to support lunar PNT
 - For each use case, list needed space user capabilities (GNSS receivers, antenna types, required augmentations) with component characteristics delineated
- 7) **Publish results in future editions of SSV Booklet, technical journals and press articles**

Activity - Interoperable GNSS Space User Standards



Space User Community

- Is very diverse
- can be categorised in different ways

Activity - Interoperable GNSS Space User Standards

Objectives

1. Identify commonalities of the user groups to evaluate if a common standard will be possible, or if different standards will be needed
2. Interoperability considerations: geodetic reference frame, time scale, center frequencies, coordinated signals.
3. NOT covering everything, but develop a standard that allows exchange and processing of GNSS data that is consistent, predictable and fit-for-purpose. Starting with:
 - Data formats and protocols for observations
 - Data formats and protocols for trajectory information and augmentation products
4. Other information that Users may need for their GNSS Space Application:
 - Information about GNSS receiver/antenna/cables
 - Spacecraft information: e.g. COM -> APC, surface properties, mass properties

Activity - GNSS Space User Timing Requirements

10. The Space User Subgroup (SUSG) informed WG-B on the progress since ICG-13 when the Subgroup has been established. The SUSG made major progress related to the updates for the next envisaged release of the GNSS Space Service Volume (SSV) booklet, in line with their work plan for 2019/2020. The finalization of a video, produced to explain the basic concept of the GNSS SSV to the general public, is expected during the 1st quarter 2020. In the same time frame the finalization of the name of this subgroup is envisaged. New activities have also been identified, including discussions on the need for user guidelines or standards for space usage of GNSS and the identification of space user needs related to timing aspects. The Subgroup also proposes a recommendation related to the release of the GNSS transmit antenna patterns or equivalent representative modelling information, including the side lobes, by all GNSS service providers, in order to fully exploit the potential of GNSS for space users, including Moon missions and beyond.

Currently no interoperable GNSS Time is existing. Different concepts has been proposed and discussed between 2016 and 2019. A dedicated AI has been given to the SUSG at the 14 ICG in Bangalore, India – see Joint Statement point 10.

Activity - GNSS Space User Timing Requirements

Activity Description

- GNSS space user timing requirement analysis and space user operations recommendations

Objectives

- Perform analysis to develop a GNSS space user timing requirement analysis and develop GNSS space user timing operational recommendations

Approach

- Collect space user requirements for timing interoperability for all Space user communities
- Socialize ideas with international providers (e.g. BIPM, national time labs, IGS,...)
- Develop joint demonstration projects for proposed interoperable GNSS timing concepts/solutions for Space Users
- Work with ICG WG-S and WG-D and coordinate proposed timing interoperability solutions;
 - Action: Include/coordinate with other ICG time-related WGs
- Present identified solutions to SUSG for approval, rejection or modification;

Outcome

- Development of space user timing capabilities and requirements; space user operations recommendation

Space Use Subgroup Meetings

Agreed schedule for meetings in 2021

- Monthly meetings via VC
- Every 3rd Thursday of each month
- Start at 12:00 UTC
- Meeting invitations will be send to POCs
- Face-to-Face meetings as mutually agreed within SUSG

Space Use Subgroup Meetings

