

esa

European Space Agency



ROSCOSMOS



Status Update on ICG WG-B Space Use Subgroup (SUSG) Activities

Werner Enderle (Europe/ESA)

Joel Parker (USA/NASA)

Xinuo Chang (China/CAST)

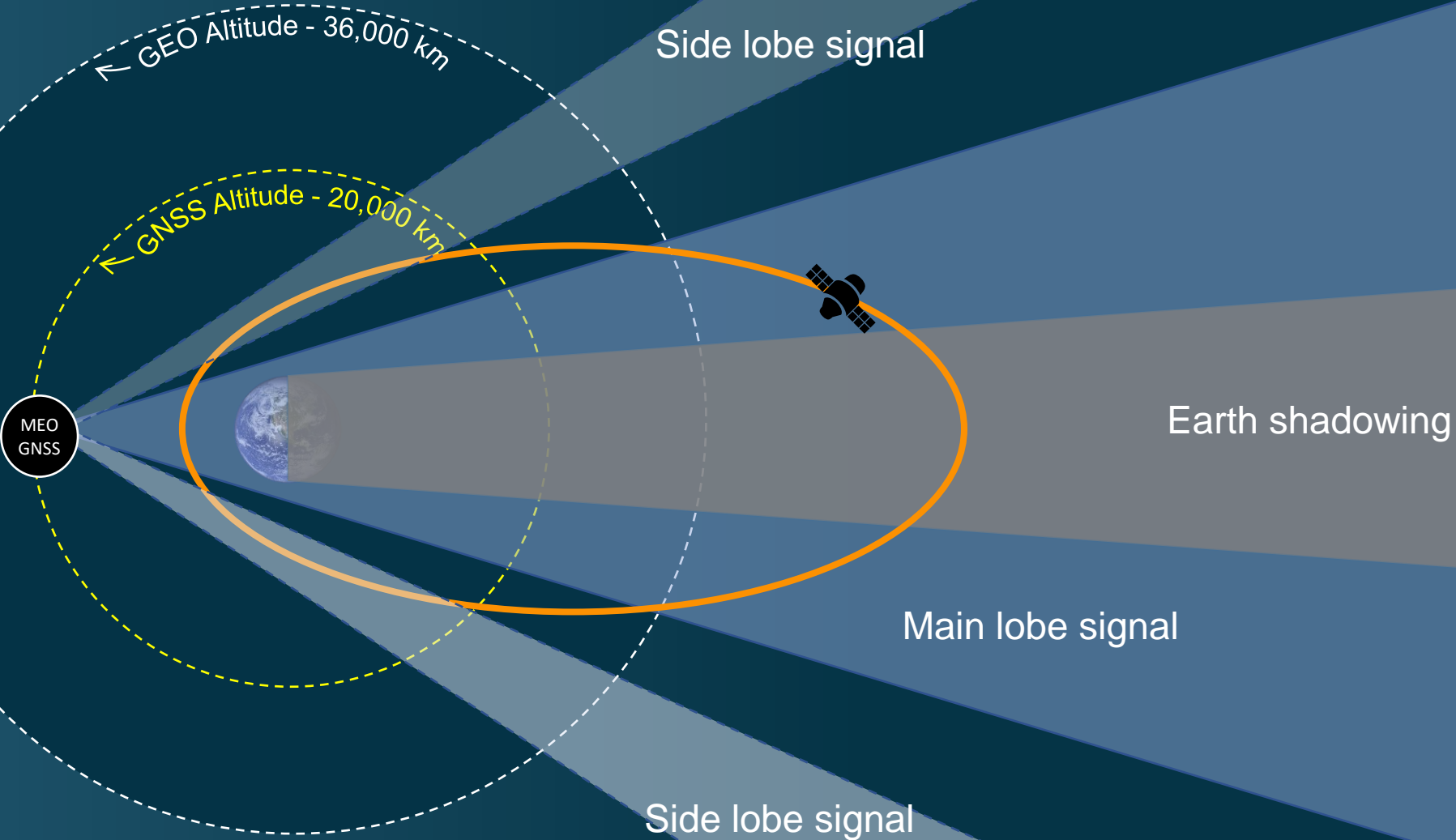
Co-Chair of ICG WG-B Space Use Subgroup

ICG-17 Mtg, WG-B, Madrid, Spain, 17 October 2023



International Committee on
Global Navigation Satellite Systems

Signal Reception in the GNSS Space Service Volume (SSV)



ICG WG-B Space Use Subgroup (SUSG)

Terms of Reference

- As adopted 15 Apr 2021

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.*
- The Space Use Subgroup operates within the scope of the overall ICG Terms of Reference.
 - https://www.unoosa.org/documents/pdf/icg/2021/ICG15/ICG_ToR2021amended.pdf
 - A review of the ToR was conducted during 2022/2023 and no need for ToR changes have been identified

Space Use Subgroup Work Plan

Work Plan, as adopted on 24 Sep 2021 at ICG-15, was reviewed and updated , if deemed necessary

WP#	Activity	Lead	Participation
1	Public availability of provider antenna/signal technical data and requisite models	India	China Japan Europe USA
2	GNSS Space User Mission Profiles and Needs	China	USA Europe Japan
3	GNSS space user timing requirement analysis and space user operations recommendations	Europe	USA China Japan India
4	Expansion of GNSS SSV to Support Lunar Operations	USA	Russia China Japan Europe
5	GNSS space user Standards	Europe	Russia USA China India

WP 1 - Public availability of provider antenna/signal technical data and requisite models

Activity objective:

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

Approach:

- a) Assemble the list of available GNSS antenna patterns and equivalent antenna modeling.
- 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.

Activity 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.

WP 2 - Space User Mission Profiles and Needs

Activity objective:

- Characterize the GNSS space user base and identify their needs based on broad GNSS space use mission data and an in-depth understanding of representative space application performance.

Approach:

- a) Collect publicly available data on space missions using GNSS and form a common database
- b) Develop a GNSS Space Application Term List to support SUSG activities and user profiles generation.
- c) Consolidate GNSS space use needs based on engagement with the international GNSS space user community

Activity outcome:

- a) GNSS space user mission database
- b) GNSS Space Application Term List
- c) GNSS space use needs analysis

WP 3 - GNSS Space User Timing Requirements

Activity objective:

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

Approach:

- 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

Activity outcome:

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

WP 4 - GNSS SSV and lunar PNT systems to support lunar operations

Activity objective:

- Work with GNSS providers and multilateral organizations, including the IOAG, and SFCG, to ensure **interoperability, compatibility, and availability** of GNSS and lunar PNT systems that can be **seamlessly employed together** from the Earth to the Moon

Approach:

- Establish necessary liaison roles with Space Frequency Coordination Group, ISECG, etc.
- Collect and document lunar use cases that require lunar GNSS or PNT
- Encourage and consolidate results of lunar flight experiments employing GNSS and lunar PNT systems
- Study and make recommendations to maximize compatibility, interoperability and availability of combined GNSS + lunar PNT “system of systems”, including:
 - Coordination of frequencies and codes
 - Service volume definitions
 - Combined GNSS-lunar PNT architectures
 - Signal interoperability, compatibility and availability
 - Reference frames and timing

Activity outcome:

- Full attainment of an **interoperable, compatible, and available** GNSS/lunar PNT **system of systems** that can support the world’s ever-expanding human and robotic space operations in transit, around and on the surface of the moon

WP 5 - GNSS Space Use Standards

Activity objective:

- Work with other organizations (e.g, IOAG/CCSDS) on space user standards that will improve GNSS SSV interoperability and acceptance as an international standard

Approach:

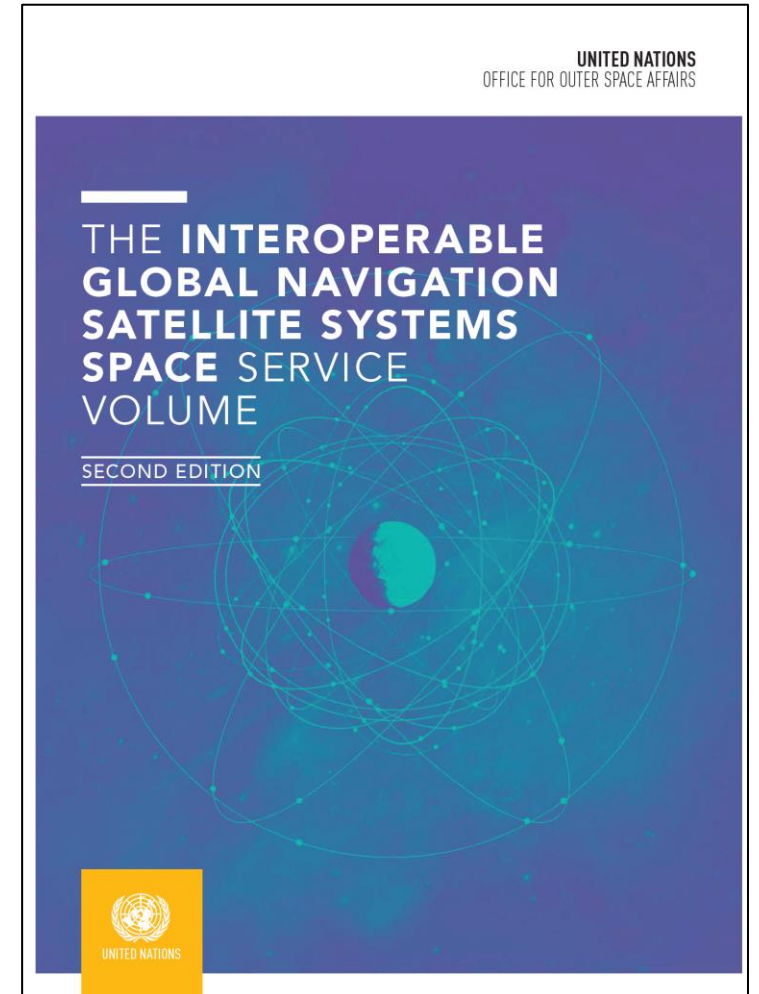
- Collect requirements from different space users communities
 - Space agencies, Scientific, Commercial, Institutional/Governmental (none military), Mega Constellations, Universities, Regulations for Space Debris
- Review of existing standards in different domains related to GNSS space usage
 - CCSDS (space agencies)
 - NMEA – maritime applications
 - IGS (Scientific, Institutions/Organizations/Government, Industry)
 - RINEX for off-line processing
 - State Space Representation (SSR) – Real Time processing (used for RT high accuracy positioning)
- Develop proposals for GNSS Space User Standards
- Socialize ideas with international providers
- Work requisite standards organizations to determine their interest in in proposed standards;
- Identify joint projects/opportunities in order to conduct tests/demonstrations in space (e.g. usage of Cubsats)
- Present proposed standards to SUSG for approval, rejection or modification;
- Submit formal proposal for GNSS Space User Standard to selected standardization body and support implementation of standard

Activity outcome:

Proposal for GNSS space user Standards

Committee on Short-Form SSV Booklet Publication

- SUSG created an ad-hoc Committee on Short-Form SSV Booklet Publication in Mar 2023 to respond to multiple requests for a condensed edition of the SSV Booklet published in 2018 and revised in 2021.
- **Objective:** Publish a short form of the 2nd edition SSV Booklet to fulfill need for a version that can be provided to non-technical audiences in multiple languages.
- **Requirements:**
 1. Adapted from existing 2nd edition Booklet
 2. Length <25 pages
 3. Focused on applications and benefits, with emphasis on graphical content
 4. Able to be translated into multiple languages by UNOOSA*
 5. Able to be redistributed by UNOOSA and ICG members*
- **Participants** include representatives from ICG membership participating in the SUSG, including: China, ESA, European Union, India, Japan, Russia, USA
- **Approach:**
 1. Publish update at ION GNSS+ 2023 conference
 2. Publish full short form as an article in Journal of Navigation – primary objective
 3. Summarize in trade publications/magazines, e.g., GPS World, Inside GNSS
- **Status:**
 - Committee membership established and two meetings held. Monthly meeting cadence agreed.
 - Presentation was given at ION GNSS+ 2023 conference in CGSIC forum
 - Next step is to begin outline and writing assignments for short-form article.



*Requirements currently under discussion within UNOOSA

Work Plan Team Updates

Activity	Lead	Participation	POC
<p>WP1: Public availability of provider antenna/signal technical data and requisite models</p> <ul style="list-style-type: none"> Meetings are held The main topics for discussion were <ul style="list-style-type: none"> advantage of including side lobes for SSV visibility Various options of antenna side lobe characterization were discussed. A White Paper was generated and disseminated to the working group for review, in order to explain the need for such information in a more detailed way 	<p>India Vishwanath Tirlapur/Shilpa</p> <p>Meeting schedule: 1st Tue of month, 11:00 UTC</p>	<p>China Japan Europe USA</p>	<p>Xinuo Chang Makoto Tomitaka Werner Enderle Joel Parker</p>
<p>WP2: GNSS Space User Mission Profiles and Needs</p> <ul style="list-style-type: none"> Meetings are held WP2 workplan was reviewed and updated WP2 name was changed from <ul style="list-style-type: none"> <i>GNSS space user mission data and profile</i> to <i>GNSS Space User Mission Profiles and Needs</i> Team is working on existing GNSS mission database (i.e IOAG table) and drafting GNSS Space User Mission Profiles 	<p>China Xinuo Chang</p> <p>Meeting schedule: Meetings: 1st Wed of month, 12:00 UTC</p>	<p>USA Europe Japan</p>	<p>Joel Parker Giovanni Lucchi Masaya Murata</p>
<p>WP3: GNSS space user timing requirement analysis and space user operations recommendations</p> <ul style="list-style-type: none"> Meetings are held Discussed and agreed way forward based on: <ul style="list-style-type: none"> orbit types (LEO, HEO Lunar) Applications (Time Ref, PVT, POD) Missions analyzed per each region In order to explain the need for such inform in a more detailed way, a White Paper, was generated and disseminated for review Comments were provided to the interoperable GNSS Time recommendation from WG D 	<p>Europe Erik Shoenemann</p> <p>Meetings: 1st Tue of month, 12:00 UTC</p>	<p>USA China Japan India</p>	<p>Frank Bauer Xinuo Chang Satoshi Kogure Ghanshyam</p>

Work Plan Team Updates

Activity	Lead	Participation	POC
<p>WP4: GNSS SSV and lunar PNT systems to support lunar operations</p> <ul style="list-style-type: none"> • Accomplishments: • Developed recommendation, approved at ICG-16, encouraging GNSS and lunar PNT teamwork to ensure the future attainment of an interoperable, compatible, and available PNT system of systems for lunar human and robotic operations • Reached consensus on several lunar PNT operations characteristics • Teams from ESA, JAXA, NASA & China provided in-depth descriptions of current lunar PNT planning • Documented comprehensive set of Lunar PNT Mission Profiles, Use Cases, and Architectures • Developed key lunar PNT definitions: cislunar space and shielded zone of the moon • Coordination started with IOAG and SFCG liaisons to ensure interoperability, compatibility and availability of PNT signals in and on the moon • Developed ICG-17 draft recommendation to conduct a Joint ICG-IOAG multilateral Workshop on Cislunar PNT 	<p>USA Frank Bauer</p> <p>Meetings: 1st Thu of month</p>	<p>Russia China Japan Europe</p>	<p>Nikolai Leonidov Xinuo Chang Masaya Murata Werner Enderle</p>

Work Plan Team Updates

Activity	Lead	Participation	POC
<p>WP5: GNSS space user Standards</p> <ul style="list-style-type: none"> • No meeting in 2023 so far • Intention is to re-start the activities in Nov 2023 • Discussed and agreed way forward based on: <ul style="list-style-type: none"> • Data Formats and protocols for observations • User trajectory information • Format and protocols for augmentation products • A document <i>called Overview - Space Standards for Navigation Draft V2</i> was generated and disseminated for review • Interactions took place with some standardization organizations, in order to understand latest status <ul style="list-style-type: none"> • CCSDS for orbit and attitude • IGS RINEX WG for GNSS observations 	<p>Europe Werner Enderle</p> <p>Meetings: 2nd Tue of month</p>	<p>Russia USA China Japan India</p>	<p>Nikolai Leonidov Nathan Esantsi Xinuo Chang Masaya Murata Braj Bhushan Gupta</p>

Conclusions

- The ICG, via its WG-B Space Use Subgroup (SUSG), is working for greater representation of space user PNT needs.
- SUSG has published the 2nd edition of the Interoperable Multi-GNSS SSV booklet, which updates constellation data, adds example missions, and expands technical analysis.
- SUSG has adopted a Work Plan that features significant efforts in areas that need coordination:
 - Constellation Technical Data
 - User Mission Profiles
 - GNSS Space User Requirements for Timing
 - GNSS Space User Standards
 - Expansion of GNSS SSV to Support Lunar Operations
- ICG is working toward robust multilateral coordination to enhance the overall lunar PNT architecture and all aspects of interoperability.