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

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ICG-16, Report to WG-B, Abu Dhabi, UAE, 11 October 2022



International Committee on  
Global Navigation Satellite Systems

# 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](https://www.unoosa.org/documents/pdf/icg/2021/ICG15/ICG_ToR2021amended.pdf)

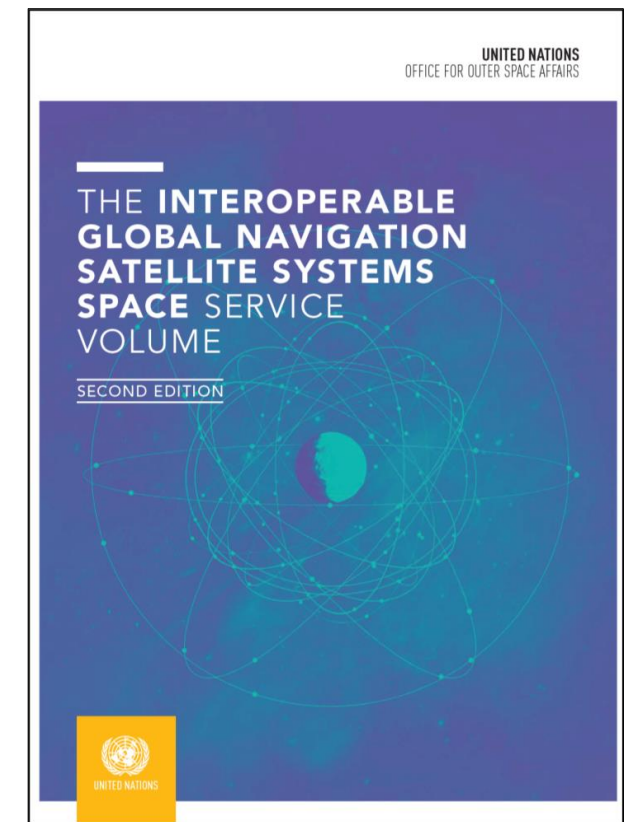
# Space Users Subgroup (SUSG) – Accomplishments

## • SSV Booklet 2<sup>nd</sup> Edition

- Full revision and update of all chapters
- New content:
  - GNSS constellation updates
  - new Flight Experiences chapter featuring five real-world missions
  - additional analysis of geometric aspects of SSV
- **Published at ICG-15**
- Available at: <https://undocs.org/ST/SPACE/75/REV.1>

## • 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
- **Published at ICG-15**
- Available at:  
<https://www.unoosa.org/oosa/en/ourwork/icg/documents/videos.html>



# Space Use Subgroup Work Plan 2021-2022

Adopted 24 Sep 2021 at ICG-15

| WP# | Activity  | Lead   | Participation                      |
|-----|---|--------|------------------------------------|
| 1   | Public availability of provider antenna/signal technical data and requisite models    | India  | China<br>Japan<br>Europe<br>USA    |
| 2   | GNSS space user mission data and profile  | China  | USA<br>Europe                      |
| 3   | GNSS space user timing requirement analysis and space user operations recommendations | Europe | USA<br>China<br>Japan<br>India     |
| 4   | Expansion of GNSS SSV to Support Lunar Operations                                     | USA    | Russia<br>China<br>Japan<br>Europe |
| 5   | GNSS space user Standards   | Europe | Russia<br>USA<br>China<br>India    |

# 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"> <li>Meetings started and held on a regular base</li> <li>Discussed and agreed way forward based on: <ul style="list-style-type: none"> <li>US intention to release Antenna pattern (measured on ground) for GPSIII</li> <li>Japan intention is to release the antenna pattern (measured on ground) for QZSS</li> <li>India intended to release the antenna pattern (measured on ground)</li> <li>EUROPE is assessing to release antenna pattern, but not decided whether and when</li> </ul> </li> <li>Actions taken for all relevant aspects</li> </ul> | <p>India<br/>Vishwanath Tirilapur/Shilpa</p> <p>Meeting schedule:</p> | <p>China<br/>Japan<br/>Europe<br/>USA</p> | <p>Xinuo Chang<br/>Makoto Tomitaka<br/>Werner Enderle<br/>Joel Parker</p> |
| <p>WP2: GNSS space user mission data and profile</p> <ul style="list-style-type: none"> <li>Regular Meetings not started yet.</li> </ul>   | <p>China<br/>Xinuo Chang</p> <p>Meeting schedule:</p>                 | <p>USA<br/>Europe<br/>Japan</p>           | <p>Joel Parker<br/>Giovanni Lucchi<br/>Masaya Murata</p>                  |

# Work Plan - Team Updates

| Activity   | Lead  | Participation                                       | POC   |
|--|---|---|---|
| <p>WP3: GNSS space user timing requirement analysis and space user operations recommendations</p> <ul style="list-style-type: none"> <li>Meetings are held on a regular base</li> <li>Discussed and agreed way forward based on: <ul style="list-style-type: none"> <li>orbit types (LEO, HEO Lunar)</li> <li>Applications (Time Ref, PVT, POD)</li> <li>Missions analyzed per each region</li> </ul> </li> <li>Actions taken for all relevant aspects</li> </ul>  | <p>Europe<br/>Erik Shoenemann</p> <p>Meetings: 1<sup>st</sup> Tue of month, 12:00 UTC</p> | <p>USA<br/>China<br/>Japan<br/>India</p>            | <p>Frank Bauer<br/>Xinuo Chang<br/>Satoshi Kogure<br/>Ghanshyam</p>                                 |
| <p>WP4: Expansion of GNSS SSV to Support Lunar Operations</p> <ul style="list-style-type: none"> <li>Meetings are held on a regular base</li> <li>Discussed: <ul style="list-style-type: none"> <li>Finalization of recommendations for ICG-16</li> <li>aspects of service volume definition</li> <li>WP4 re-naming from: <ul style="list-style-type: none"> <li><b>Old</b> : Expansion of GNSS SSV to Support Lunar Operations <b>to</b></li> <li><b>New: GNSS SSV and lunar PNT systems to support lunar operations</b></li> </ul> </li> </ul> </li> <li>Actions taken on all topic</li> </ul> | <p>USA<br/>Frank Bauer</p> <p>Meetings: 1<sup>st</sup> Thu of month</p>                   | <p>Russia<br/>China<br/>Japan<br/>Europe</p>        | <p>Nikolai Leonidov<br/>Xinuo Chang<br/>Masaya Murata<br/>Werner Enderle</p>                        |
| <p>WP5: GNSS space user Standards</p> <ul style="list-style-type: none"> <li>Last mtg was held on 12 April 2022</li> <li>Discussed and agreed way forward based on: <ul style="list-style-type: none"> <li>Data Formats and protocols for observations</li> <li>User trajectory information</li> <li>Format and protocols for augmentation products</li> </ul> </li> <li>Actions taken for all relevant aspects</li> </ul>   | <p>Europe<br/>Werner Enderle</p> <p>Meetings: 2nd Tue of month</p>                        | <p>Russia<br/>USA<br/>China<br/>Japan<br/>India</p> | <p>Nikolai Leonidov<br/>Nathan Esantsi<br/>Xinuo Chang<br/>Masaya Murata<br/>Braj Bhushan Gupta</p> |

# 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 - GNSS space user mission data and profile

## Activity objective:

- 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

## Approach:

- 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

## Activity outcome:

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



# 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



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# **Space Use Subgroup Work Package-3 (WP-3) 2022 Accomplishments**

11 October 2022

# WP-3 Working Elements

## Initial activities

1. Development, agreement for way forward
2. **Identify initial selection of space user groups to start with** [ESA proposal: Space Agencies, Academia, Commercial](#)
3. **Identify initial selection of orbit types to start with**
  - Europa: LEO, HEO and Lunar [confirmed](#)
  - USA: LEO, HEO and Lunar [confirmed](#)
  - China: [TBD](#)
  - Japan: LEO [confirmed](#) (HEO, Lunar TBC)
  - India: LEO, HEO, Lunar [confirmed](#)
4. **Identify initial selection of mission types to start with** [ESA proposal: Earth Observation mission, Science Mission](#)
  - Europa: GARISS, Proba 3, Sentinel 6A, Lunar Pathfinder
  - USA: MMS, GOES , LuGRE, Artemis
  - China: [TBD](#)
  - Japan: Alos, (LNSS TBC)
  - India: [TBD](#)

# WP-3 Working Elements

## Initial activities

### 5. Identify use cases

Europa: Interoperable PVT, POD, Time Reference [confirmed](#)

USA: Interoperable PVT, POD, Time Reference [confirmed](#)

China: [TBD](#)

Japan: Interoperable PVT, POD, Time Reference [confirmed](#)

India: Interoperable PVT, POD, Time Reference [confirmed](#)

### 6. Identify initial selection of national timing laboratories

Europa: BIPM, PTB, ESA [confirmed](#)

USA: USNO [confirmed](#)

China: [TBD](#)

Japan: NICT [confirmed](#)

India: NPLI [confirmed](#)

# WP 4 - Expansion of GNSS SSV to Support Lunar Operations

## Primary goals:

- Maximize interoperability, compatibility and availability of **all** internationally developed Positioning, Navigation and Timing (PNT) resources on and in the vicinity of the moon
- Leverage expertise of GNSS SSV space use team to research, analyze and recommend definitions, user base, capabilities and architectures for lunar operations
  - System of systems approach needed to optimally employ Earth-centric GNSS capabilities with an expanding, evolving lunar-centric PNT capability
  - Operational use of GNSS and Lunar PNT systems during transit operations for robust PNT continuity will require special attention

## ICG Terms of Reference:

- ICG provides recommendations; other organizations (e.g., IOAG, SFCG, space agencies) act on recommendations at their discretion.



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# **Space Use Subgroup Work Package-4 (WP-4) 2022 Accomplishments**

11 October 2022

# WP-4 Accomplishments (Slide 1)

- Developed ICG-16 recommendation encouraging GNSS providers and lunar PNT developers to work together to ensure the future attainment of an interoperable, compatible, and available PNT system of systems that can support the world's ever-expanding human and robotic space operations around and on the surface of the moon.
- Teams from ESA, JAXA and NASA provided in-depth descriptions of current lunar PNT planning; looking forward to hearing about China and Russia's plans in a future WP4 meeting
- ICG coordination with IOAG and SFCG will be important to ensure interoperability, compatibility and availability of PNT signals in and on the moon
  - Joel Parker and Werner Enderle serve as liaisons to the IOAG
  - WP4 team is working to understand regional coordinators in the Space Frequency Coordination Group; also need to communicate/coordinate with ICG WG-S
- Recommended WP-4 Name Change to SUSG
  - From: Expansion of GNSS SSV to Support Lunar Operations
  - To: **GNSS SSV and lunar PNT systems to support lunar operations**

# WP-4 Accomplishments (Slide 2)

## Lunar PNT Operations

### WP-4 Team Items of Agreement

- Lunar PNT operations will rely on two PNT services:
  - 1) Earth-centric SSV employing GNSS
  - 2) Lunar-centric PNT capability
- Need a way to connect GNSS SSV and Lunar PNT services with a common time-scale and make navigation seamless: interoperable, compatible & available
- Lunar PNT services will likely employ orbital and lunar-surface augmentations to be used in conjunction with weak signal GNSS
- Lunar PNT transmissions will not be lunar-circular, like the GNSS SSV around Earth
- Lunar PNT transmissions (e.g. a lunar SSV architecture) will:
  - Evolve over time
  - Be dependent upon lunar reference frame and time developments, and
  - Be driven by lunar use-cases and associated requirements



# 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



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# **Space Use Subgroup Work Package-5 (WP-5) 2022 Accomplishments**

11 October 2022

# WP 5 Working Elements

- Collect requirements from different space users communities – **So far identified list**
  - Space agencies, Scientific, Commercial, Institutional/Governmental (none military), Mega Constellations, Universities, Regulations for Space Debris, developers, operators, users of GNSS space user data, user equipment developers and commercial spacecraft developers
- Review of existing standards/white papers in different domains related to GNSS space usage – **So far identified standards**
  - IOAG/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)

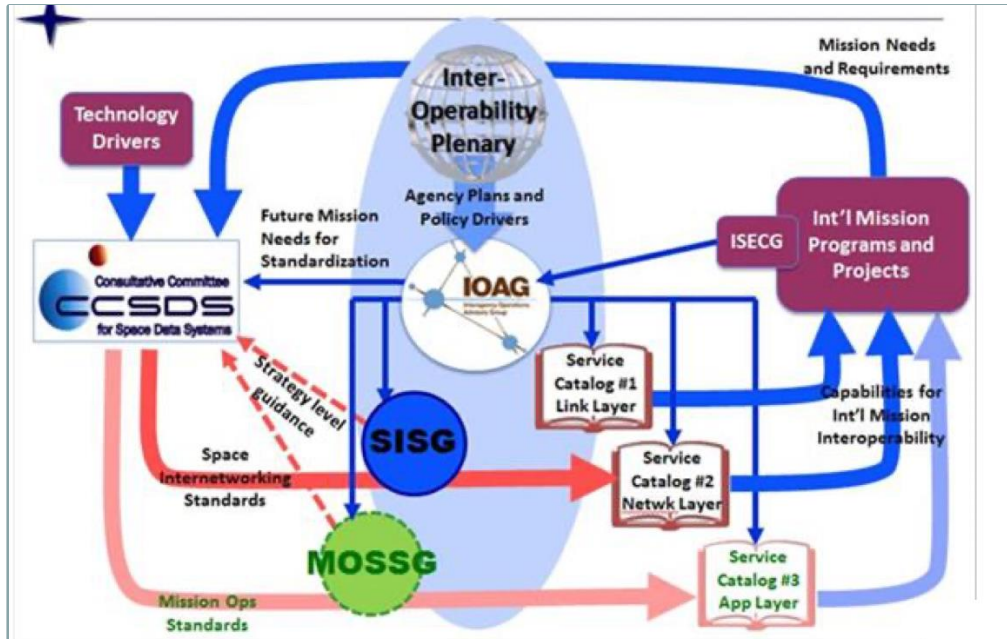
# WP-5 Approach for working elements - Agreed

- Identify commonalities of the user groups to evaluate if a common standard will be possible, or if different standards will be needed
- Work with other organizations (e.g, IOAG/CCSDS) on space user standards that will improve GNSS SSV interoperability and acceptance as an international standard
- Interoperability considerations: geodetic reference frame, time scale, centre frequencies, interoperable signals.
- NOT covering everything, but develop standards that allow exchange and processing of GNSS data that is consistent, predictable and fit-for-purpose. Starting with:
  - Data formats and protocols for observations
  - Formats and protocols for trajectory information (user and GNSS)
  - Formats and protocols for augmentation products
  - 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

# International Coordination – IOAG Background

- Different activities related to standards and definitions for GNSS usage for space applications are currently ongoing within various international groups which are partially overlapping
  - Within ICG WG-B Space Use Subgroup (SUSG):
    - WP3 – GNSS space user timing requirement analysis and space user operations recommendations
    - WP4 – Expansion of GNSS SSV to Support Lunar Operations
    - WP5 – GNSS Space User Standards
  - IOAG
  - Space Frequency Coordination Group
  - Lunar architecture definitions:
    - NASA LunaNet
    - ESA Moonlight
    - JAXA Lunar Navigation Satellite System
  - Others
- The objectives of this presentation are to:
  - To clarify the understanding of the roles of the ICG SUSG work packages and their contributions to international team coordination
  - To outline potential roles of ICG in coordination with other organizations (e.g. IOAG, SFCG)

# Need for Coordination between IOAG and ICG-Space Use Subgroup



- IOAG Organization : (15)
- 26 GHz Study Group
  - Coding and Modulation Working Group
  - Consultative Committee for Space Data Standards
  - International Committee on Global Navigation Satellite Systems
  - Lunar Communication Architecture Working Group
  - Lunar-Mars Working Group
  - Mars and Beyond Communications Architecture Working Group
  - Mission Operations Systems Coordination Group
  - Mission Operations Systems Strategy Group
  - Optical Link Study Group
  - Service Catalogs Working Group
  - Space Frequency Coordination Group
  - Space Internetworking Strategy Group
  - Space Operations Sustainability Working Group
  - Spacecraft Emergency Cross Support Working Group

**Coordination to ensure**

- Compatibility
- Interoperability
- Availability

