



Report from Interagency Operations Advisory Group (IOAG) to ICG

Joel Parker (NASA) – ICG-IOAG Liaison
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28th Meeting of the ICG Providers' Forum
15 October 2023



International Committee on
Global Navigation Satellite Systems

IOAG ROLE

The IOAG (Interagency Operations Advisory Group) provides a forum for **identifying common needs across multiple international agencies** for coordinating space communications policy, high-level procedures, technical interfaces, and other matters related to interoperability and space communications. Its goals are to:

- Enable safe, secure, and efficient interoperable mission operations;
- Enable higher rate throughput for space missions;
- Enable responsive networks around the Earth, Moon, and Mars to enable future exploration and science missions.

The IOAG was founded by the Interoperability Plenary (IOP) to:

- Understand issues related to interagency interoperability and other space communications matters;
- Identify common solutions complying with IOP guidance;
- Recommend resolutions to the IOP for specific actions created by the IOP and put to the IOAG.



Members



Observers



International Operations Advisory Group

Forum for identifying common needs across multiple international agencies for coordinating space communications policy, high-level procedures, technical interfaces, and other matters related to interoperability and space communications

It undertakes activities it deems appropriate related to multi-agency space communications

Goal to achieve full interoperability among member agencies

For more information: www.ioag.org

ICG-IOAG Collaboration: GNSS Space User Database

- IOAG has observer status in the ICG
- ICG recommendations encourage providers, agencies, and research organizations to publish details of GNSS space users and to contribute to IOAG database
- Database last updated on 50 May 2022 for IOAG-25
- Key changes since previous update (13 Nov 2020):
 - Includes **139** total missions from **9** agencies + affiliates
- We continue encouraging service providers, space agencies and research institutions to contribute to the GNSS space user database via their IOAG liaison or ICG WG-B



IOAG Missions & Programs Relying on GNSS

Agency*	Country	2021	2022
ASI	Italy	4	4
CNES	France	10	13
CSA	Canada	7	7
DLR	Germany	7	7
ESA	Europe	30	30
JAXA	Japan	13	13
KARI	Republic of Korea	8	8
NASA	USA	46	52
UKSA	UK	-	5

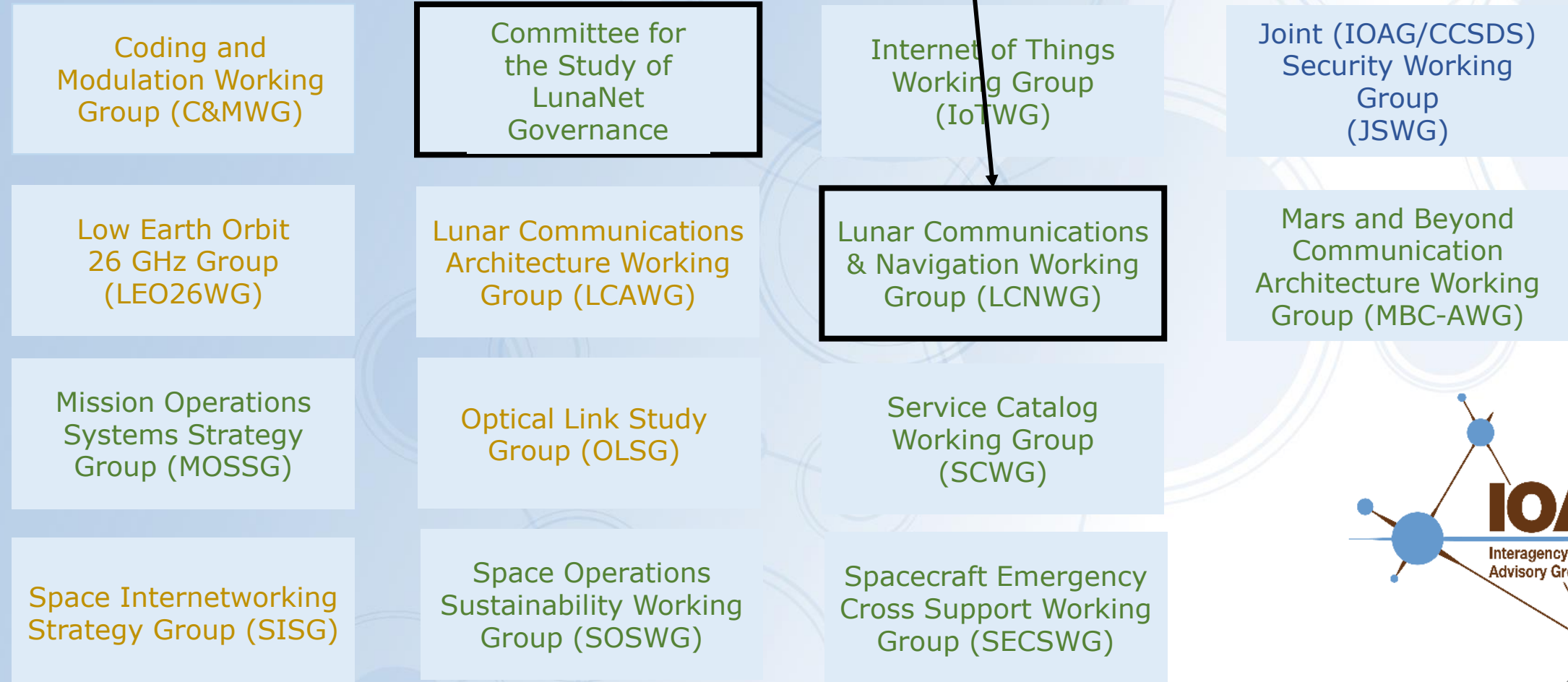
*Includes affiliated organizations

Active
Dormant
Future

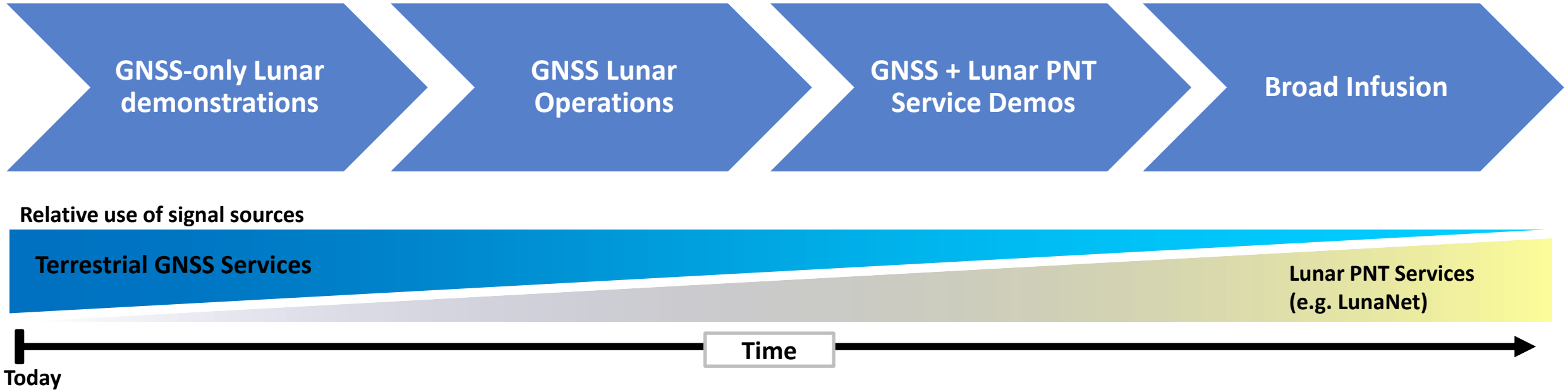
WORKING GROUPS

IOAG members are divided into working groups that meet independently and deliver reports and updates to all delegates at IOAG meetings.

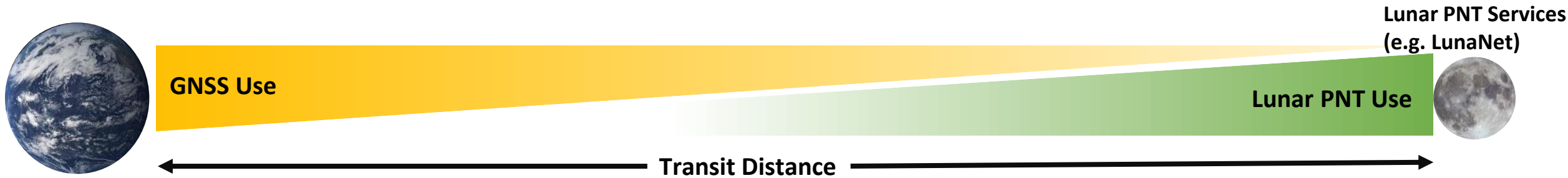
ICG liaison participation



Phased Expansion of Lunar PNT Services



Transit use of GNSS and Lunar PNT Services



Early Lunar Communications and Navigation Architecture Concept



Gateway

Additional relay capability

Orbital Relays

LINKING LUNAR USERS TO EARTH
& TO EACH OTHER

Diverse, evolving constellation
with multiple users and
providers



LunaNet

Framework of standards for
open, interoperable networks
- Data, PNT & other services

Earth Stations

Upgraded DSN and
other assets including
commercial stations



Orbiting
Spacecraft
Users

Far Side
missions

SOUTH
POLE

Artemis surface
missions

Other robotic
missions

Surface communications
and navigation assets

Communication and navigation infrastructure lowers the barriers to entry for new missions and capabilities and supports expanding robotic and human activities on the Moon.

Draft proposed LunaNet standards: <https://go.nasa.gov/3BQrCOk>

Recent Meetings

- **5th Interoperability Plenary (IOP-5)** held 20–22 Jun 2023
 - London, UK
 - ICG liaisons provided report on ICG-IOAG collaborations and activities
 - Final communique in progress
- **26th IOAG annual meeting** held 12 Sep 2023 (virtual)
 - Meeting Minutes in progress; will be available to members at <https://www.ioag.org>
- **Teleconferences:**
 - **IOAG-25f** – 22 May 2023
 - **IOAG-25h** – 23 Jun 2023
 - Presentations and meeting minutes available to members at <https://www.ioag.org>
- This report captures key content and outcomes relevant to ICG liaison activities.



IOAG-25, Chair: Pier Bargellini/ESA

IOAG Working Group Status

- **Lunar Communications and Navigation Working WG**

- Proposed at IOAG-25, May 2022 and subsequently chartered.
- Goals:
 - Define and recommend a lunar communications and position/navigation/timing (PNT) architecture to provide an interoperable framework for IOAG member agencies and other participants in lunar exploration.
 - Recommend, maintain, and align with international working groups interoperability requirements at the network, data link, and physical layers for lunar exploration and science.
- *Currently on hiatus due to ongoing procurements in participating agencies.*

- **Committee to Study LunaNet Governance**

- Established at IOAG-25 to “recommend an initial multi-stakeholder organizational governance structure, approach, and functions, with their respective interface organizations, to develop guidelines, policies, and practices to help fulfill LunaNet's operational responsibilities.”
- Terms of Reference adopted.
- Approach is to perform study over multiple phases.
 - Phase I will collect and describe governance structures from other organizations that can be used as references for eventual LunaNet governance structure.
 - Phase I led by Masaya Murata/JAXA. ICG is incorporated as one such reference organization.



Interoperability Plenary

- Interoperability Plenary (IOP) is highest level body focusing on space agency interoperability. IOP created and authorizes IOAG activities.
 - **Goal:** To reach multi-agency agreement on the need for interoperable space communications and navigation architectures.
 - **Objectives:**
 - As an intergovernmental and international activity, address joint space communications and navigation.
 - To broaden the cross support, compatibility, and interoperability agreement reached at IOP-1, particularly in regard to missions to the Moon and Mars.
- Previous meetings:
 - **IOP-1:** Jun 1999, Paris, France
 - **IOP-2:** Dec 2008, Geneva, Switzerland
 - **IOP-3:** Jun 2013, Toulouse, France
 - **IOP-4:** Dec 2018, Munich, Germany
- **IOP-5** was held Jun 20–22, 2023 in London, England, hosted by the UK Space Agency



IOP-5 Agenda

Date	Time (BST)	Location	Topics
Day 1 IOAG	am	British Standards Institute	IOAG Preparation Session
Day 1 IOP	1200 - 1730		Introduction Leadership Forum
Day 1 IOP	1900 - 2200	Royal Aeronautical Society	Dinner
Day 2 IOP	0830 - 1730		IOAG Report Liaison Reports WG Reports Discussions
Day 3 IOP	0800 - 1300		Completion of Communiqué Conclusion & Resolutions IOP Delegates Internal Discussion
Day 3	pm		<i>Internal discussions/bilaterals</i>
Day 4 IOAG	0900 - 15:00		IOAG Debriefing Session

Masaya Murata/JAXA moderating panel on "Cooperation and Commercialization" with ICG liaison participation

ICG Liaison Report by Joel Parker/USA and Werner Enderle/ESA

IOP-5 Recommendations and Communique

- Draft text for IOP-5 Communique:

In regard to its relationship with the International Committee on Global Navigation Satellite Systems (ICG):

- 1. The IOP recognizes that the success of many international space missions, from LEO into cislunar space, is dependent on Global Navigation Satellite Systems (GNSS) capabilities for positioning, navigation, and timing (PNT).*
- 2. The IOP recognizes the developing importance of GNSS as a contributor to robust PNT in the cislunar environment and the need for coordination between lunar PNT providers and GNSS providers to ensure interoperability, compatibility, and availability of PNT for cislunar users.*
- 3. The IOP acknowledges the benefits to the IOAG observer member status to the ICG and endorses its role as the provider of the database of IOAG missions utilizing GNSS.*
- 4. The IOP recommends the IOAG continue the liaison with the ICG and to build on the coordination it enables, including developing additional collaboration opportunities such as interoperability workshops.*

- Proposed recommendation (submitted by M. Murata/JAXA):

Authorize IOAG to jointly organize a multilateral forum with ICG to provide an international coordination venue for GNSS, Lunar Comm&Nav, and LunaNet Service providers.

- **ICG WG-B SUSG will propose a recommendation at ICG-17 in response, recommending ICG participation.**

IOAG 26a Meeting on 12 September 2023

- Deputy ICG-IOAG Liaison Werner Enderle (ESA) provided a status report of the SUSG activities
- Main points at the IOAG 26a Meeting related to interoperable Lunar PNT activities were
 - Release and Review of LunaNet documents
 - Approach for generation of standards for LunaNet
- Release and Review of documents
 - Release of the following documents on
 - LunaNet Interoperability Specification Draft Version 5
 - LunaNet Signal-In-Space Recommended Standard Augmented Forward Signal (AD1)
 - Link to the documents: [LunaNet Interoperability Specification - NASA](#)
 - IOAG asked for a review of the documents by SUSG and the comments should be provided to IOAG by 30 Nov 2023
- Approach for generation of standards for LunaNet
 - It was discussed that the proposed standards in the documents (*see above*) and the comments received by the review process of the documents will be used in order to formalize them via a CCSDS process
- Next Steps
 - LunaNet Developers Forum – Meeting in The Hague, Netherlands on 14 Nov 2023

IOAG 26a Meeting on 12 September 2023

Potential draft Agenda:

1. Short introduction (Sami Asmar CMC chair, Klaus-Juergen Schulz CESG chair)
2. IOAG Lunar Communication and Navigation Architecture (Stephen Lichten ?, Matt Cosby ?)
3. LunaNet Interoperability Specification v5 (David Israel ?)
4. Programmatic context
 - a) ESA Moonlight and Lunar Pathfinder (Carsten Tobehn, Moonlight Project Manager)
 - b) ESA Lunar Pathfinder (Brice Dellandrea, LPF Project Manager)
 - c) NASA LCNRS (LCNRS Project Manager)
 - d) JAXA LNSS (LNSS Project Manager)
 - e) NASA Artemis ?
5. CCSDS context (protocol stack upwards ?) - 6 presentations of what each area has available for LunaNet (BBs, MBs), and has in preparation in terms of CCSDS projects (BB updates, new BBs), and what is perceived as missing
 - a) SLS
 - b) SIS
 - c) SOIS
 - d) CSS
 - e) MOIMS
 - f) SEA
6. Communication System Developer's Presentations
 - a) ESA developers (by invitation)
 - b) NASA developers (by invitation)
 - c) JAXA developers (by invitation)
7. Way forward

Draft agenda for meeting in The Hague, Nov 2023 with focus on LunaNet Interoperability Standards.

Conclusions

- IOP-5 was held Jun 2023. Outcomes include recognition of ICG role in interaction between GNSS and lunar PNT services. Recommendation adopted to hold joint workshop on lunar PNT.
- IOAG held 26th annual meeting virtually, Sep 2023.
- ICG-IOAG liaisons continue to represent ICG within proposed areas of coordination, focused on space user timing, standards, and lunar PNT activities in the WG-B SUSG
- IOAG was requested to review LunaNet Interoperability Specification Draft v5 and Recommended Standard – Augmented Forward Signal (AD1).
- ICG sees coordination between GNSS and lunar PNT architecture as critical to ensure interoperability, compatibility, and availability of combined “system of systems” for space users. **A recommendation to host a workshop on this topic will be coordinated at ICG-17.**



BACKUP

IOAG RELATIONS WITH INTERNATIONAL BODIES

- **CCSDS (Consultative Committee for Space Data Systems)**
IOAG provides guidance, operational drivers, priorities, and requirements to CCSDS regarding the development of required standards.
- **ICG (International Committee on Global Navigation Satellite Systems)**
IOAG exchanges information and supports coordination of activities.
- **ISECG (International Space Exploration Coordination Group)**
IOAG provides guidance and support regarding the definition and implementation of the communications infrastructure.
- **SFCG (Space Frequency Coordination Group)**
IOAG exchanges information with the SFCG on the need for new spectrum allocations and priorities for defending existing allocations by maintaining mission model data.



ICG WG-B SUSG Potential Areas of Coordination

- Continue current activities:
 - Liaison role with IOAG
 - Contribute to GNSS mission tables to support understanding of Earth-based GNSS use cases and mission applications
- Establish necessary liaison roles with SFCG, ISECG, etc.
- Collect and document lunar use cases
 - Contribute to expanded GNSS mission tables to include proposed missions that require lunar GNSS or PNT
- Encourage and consolidate results of lunar flight experiments using 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 lunar PNT architectures
 - Signal compatibility and interoperability
 - Reference frames and timing