INTERAGENCY OPERATIONS ADVISORY GROUP

Committee to Study LunaNet Governance (CSLG) ～月測位のガバナンスについて～

Masaya Murata/JAXA and Brice Dellandrea/ESA (CSLG Co-Chairs)
@第11回月測位・LEO PNT研究会（2026/1/22）

IOAG
Interagency Operations
Advisory Group

What is LunaNet?

LunaNet is a set of cooperating networks providing interoperable communications and position, navigation, and timing (PNT) services for users in transit to, around, and on the Moon.

- **Based on a framework of mutually agreed-upon standards, protocols, frequency bands, and interface requirements that enable interoperability.**

- **Allows many lunar mission users to engage the services of diverse commercial and government service providers in an open and evolvable architecture.**

  - **Service-Oriented**
  - **Scalable**
  - **Open**
  - **Resilient**
  - **Secure**
  - **Extensible**

LunaNet consists of Earth Ground Stations (for Direct with Earth links), lunar orbital relays (lunar proximity and Earth trunk links), and surface assets.
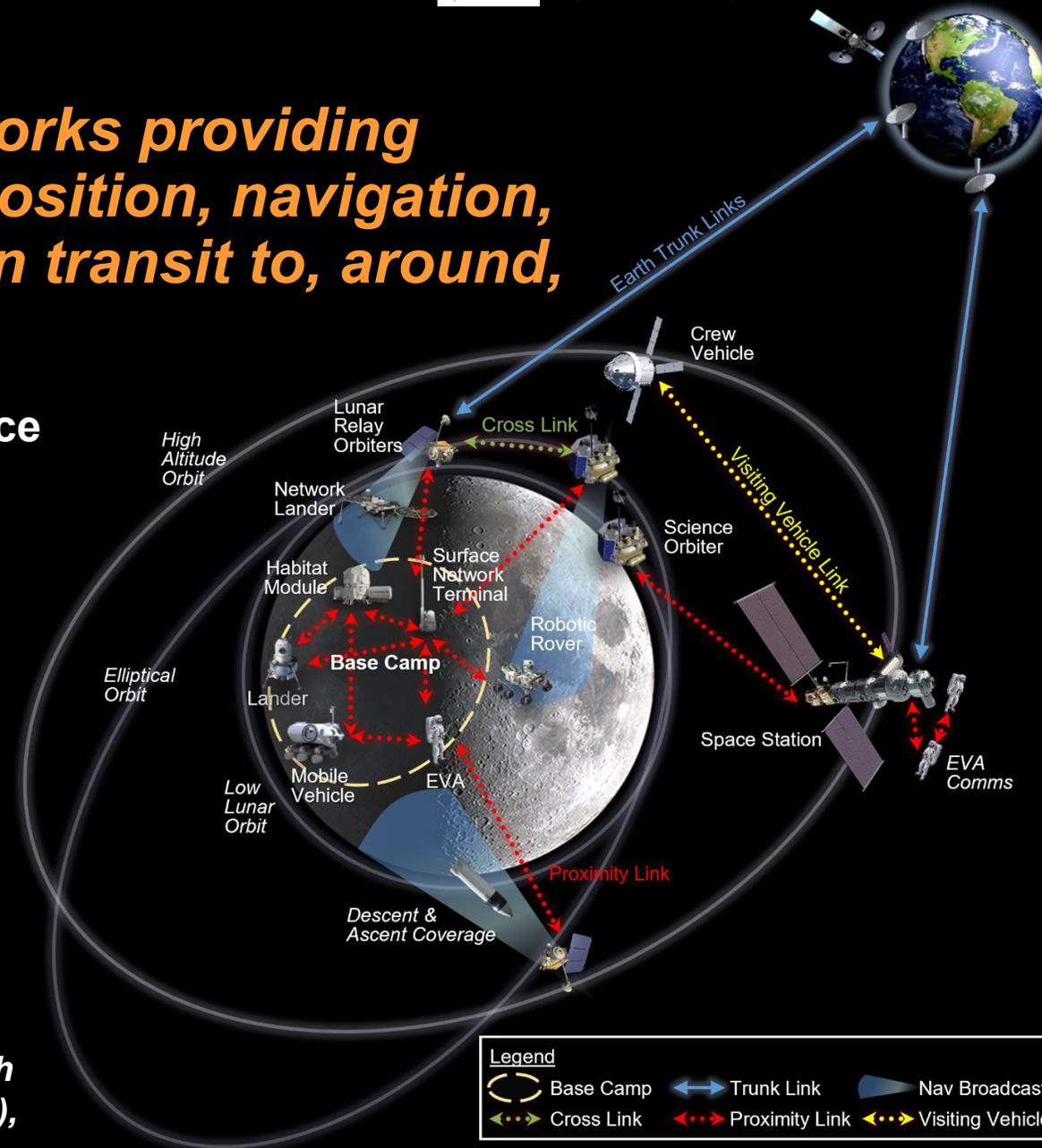
LunaNet Interoperability
Specification Document

Version 5

Published by NASA-ESA-JAXA
29 January 2025

LNIS V005

LunaNet Signal-In-Space Recommended
Standard - Augmented Forward Signal
(LSIS - AFS)
VOLUME A

Version 1

Noted as Applicable Document 1 [AD1 Vol-A] in LNIS V5

LSIS V1.0   29 January 2025   1

The LNIS and its *Applicable Document* includes:

· **Concept of the LANS, message format of the Augmented Forward Signal (AFS), signal frequency, power, signal modulation, etc.**

· **Signal-In-Space-Error (SISE) requirement for LunaNet Service Providers (LNSPs)**

· **Lunar Reference System and Lunar Time System Standard (forthcoming)**

JAXA/ESA/NASA comply with the LNIS to become interoperable LNSPs

JAXA, ESA, and NASA continue developing the LNIS documents and to ensure the success of the LANS

3

Lunar Comm & Nav (C&PNT) systems by US, Europe, Japan
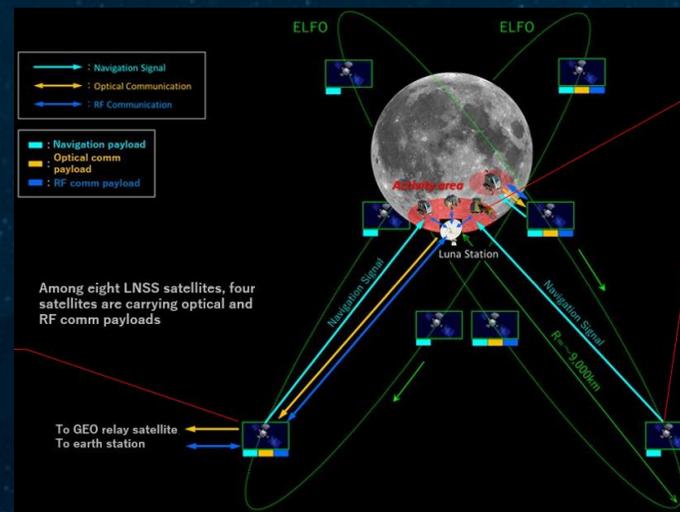

ESA Moonlight LCNS (2028～)

Contractor: Telespazio

NASA LCRNS (2026～)

Contractor: Intuitive Machines

Japan LNSS (2029～)

Contractor: ArkEdge Space

Among eight LNSS satellites, four satellites are carrying optical and RF comm payloads

LCNS:
Lunar Communications and Navigation System

LCRNS:
Lunar Communications Relay and Navigation Systems

LNSS:
Lunar Navigation Satellite System

IOAG AND WORKING GROUP (CSLG)

- ## What is IOAG?
  - The **Interagency Operations Advisory Group (IOAG)** is a collaborative organization that facilitates coordination between international space agencies to enhance interoperability and cooperation in space operations. It serves as a forum for space agencies to discuss and develop recommendations on issues related to cross-support, communication, and network interoperability for space missions

- ## What is CSLG?
  - Working group of IOAG called Committee to Study LunaNet Governance
  - As the name indicates, the CSLG studies and recommends governance items and structure for the LunaNet

IOAG PRELIMINARY REPORT ON LUNANET GOVERNANCE

- **Abstract**
  - This report is issued from the IOAG's CSLG and captures its recommendations for an initial multi-stakeholder organizational governance structure, approach, and functions to develop guidelines, policies, and practices to help achieve a publicly available (open) architecture to provide communications, networking, position, navigation, and timing (CPNT) services to cislunar Users (LunaNet)

- **Target publication schedule**
  - Publication at IOAG Webpage in April 2026

CONTRIBUTORS

- **Co-chairs**
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  - Masaya Murata – JAXA
  - Jim Schier (CSLG founder)
- **Members**
  - Benjamin Anderson – NASA
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  - Joel Parker – NASA
  - Corali Roura – NASA
  - Keith Scott – NASA
  - Catherine Sham – NASA

LUNANET GOVERNANCE REPORT: CHAPTERS AND STATUS

IOAG PRELIMINARY REPORT ON LUNANET GOVERNANCE

Coordination and Governance in the Initial Phase

Section	Title	Status
1	Executive Summary	Draft complete
2	Introduction	Draft complete
2.1	Problem Statement	Draft complete
2.2	Scope	Draft complete
2.3	Background	Draft complete
3	Methodology and Analysis Process	Draft complete
4	Analysis	Draft complete
4.1	Existing Governance Relevant to CPNT	Draft complete
4.2	Existing Governance Other than CPNT	Draft complete
4.3	LunaNet Characteristics that Need Governance	Draft complete
4.4	Gap Analysis: LunaNet Needs & Existing Governance	Draft complete
5	Preliminary Findings	Draft complete
5.1	Governance Options	Draft complete
5.2	Criteria for Assessing Options	Draft complete
5.3	Findings: Spectrum (Layer 1)	Draft complete
5.4	Findings: Communications (Layer 2)	Draft complete
5.5	Findings: Networking (Layer 3)	Draft complete
5.6	Findings: PNT	Draft complete
5.7	Findings: Orbits	Draft complete
6	Summary of Findings and Issues	Draft complete

EXECUTIVE SUMMARY (EXCERPT)

- **Toward a LunaNet governance structure**
    1. The LunaNet PNT WG team, should be recognized in the LunaNet Governance as the PNT Interface Design authority, constituted by engineers of each agency providing at least parts of LunaNet orbital infrastructure and related ground segment on Earth (currently NASA, ESA and JAXA) as a minimum
    2. The LunaNet C&PNT team would be advised by a High Level Committees gathering various institutions and/or national and/or space agencies representatives (IOAG, ITU, SFCG, ICG, CCSDS, feedbacks from industry, etc)
    3. The spectrum access will require coordination at agency level under, in particular, the SFCG supervision
    4. For IP networking, the current governance bodies such as IETF, ICANN, RIRs and NOGs should be used for LunaNet
    5. As part of its current duty, it is suggested to use SANA and IANA for any lunar DTN networking new policies and governance.

EXECUTIVE SUMMARY (EXCERPT)

- **Toward a LunaNet governance structure**

  6. Lunar PNT capabilities should enable compliance with "NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts", (July 20, 2011)

  7. Lunar PNT capabilities should enable safety of navigation for lunar missions from all countries and companies. A reinforcement of Space Situation Awareness in the Lunar vicinity will be required, as not covered within the current frameworks

  8. Use of common lunar reference frame and lunar time to avoid operational confusion

  9. There will also be a need for a certification process to check and verify the compliance to the LunaNet, either to be managed through the LNSPs or from a centralizing body
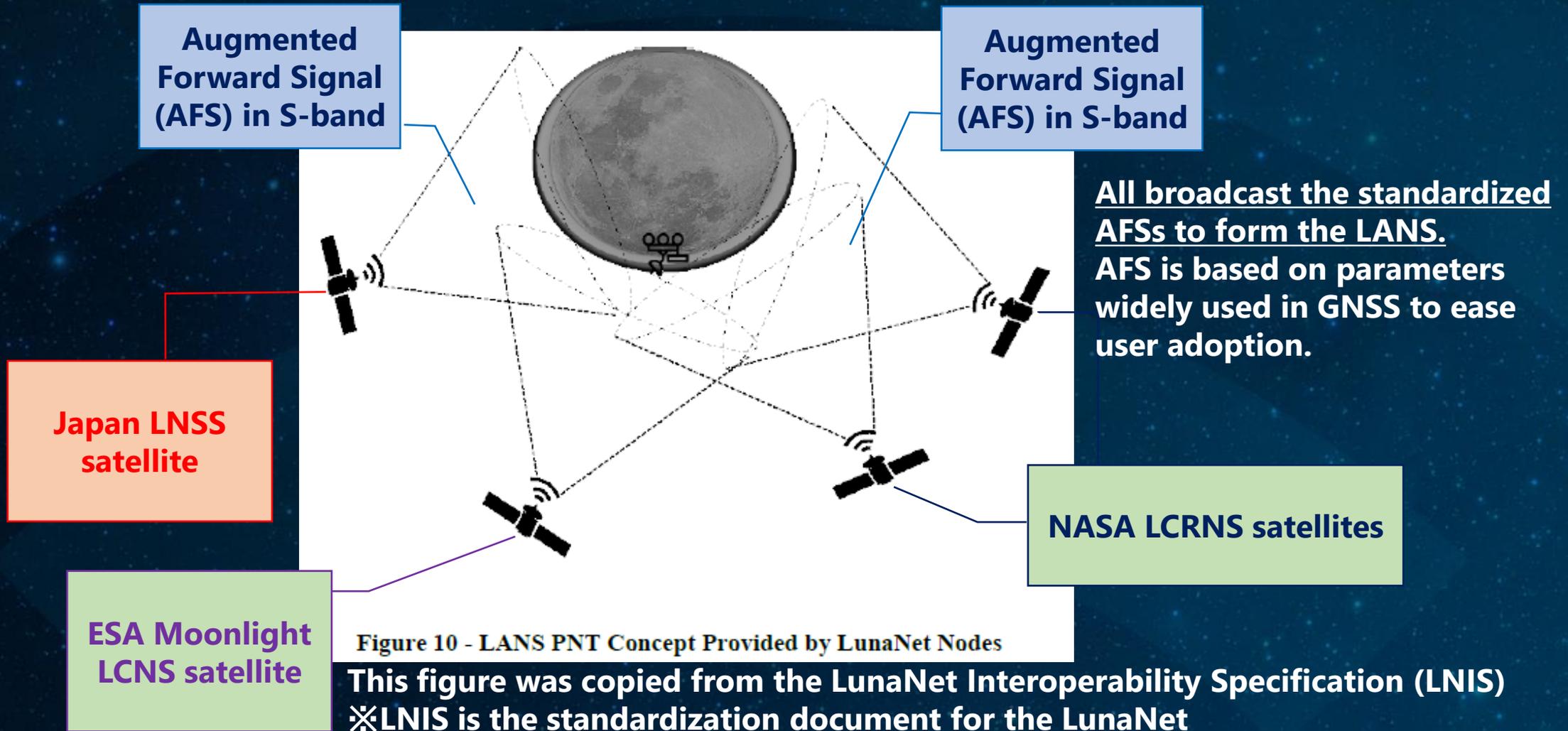
LunaNet LANS
Regional Lunar "GNSS"

The concept of interoperable lunar PNT system of systems (Lunar Augmented Navigation Service (LANS))
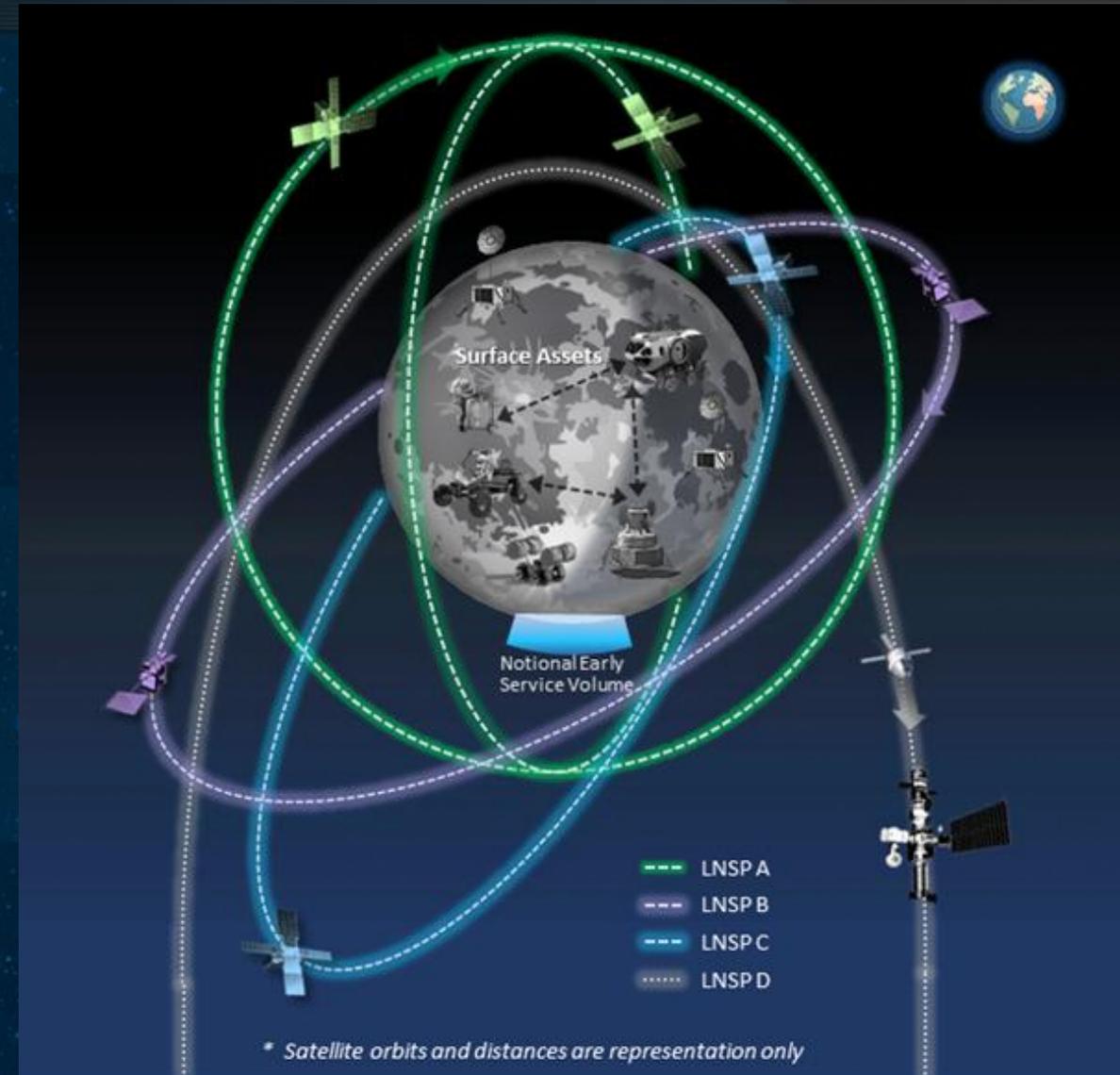
Augmented Forward Signal (AFS) in S-band

Augmented Forward Signal (AFS) in S-band

All broadcast the standardized AFSs to form the LANS. AFS is based on parameters widely used in GNSS to ease user adoption.

Japan LNSS satellite

ESA Moonlight LCNS satellite

NASA LCRNS satellites

Figure 10 - LANS PNT Concept Provided by LunaNet Nodes

This figure was copied from the LunaNet Interoperability Specification (LNIS) ※LNIS is the standardization document for the LunaNet

Current concept is to combine different LunaNet Service Provider (LNSP) space vehicles to create a constellation of AFS broadcasters for LANS. (Lunar Augmented Navigation Service)
➢ **Interoperability is critical to achieve this.**

LANS Interoperability[1]: each service provider that claims to be LunaNet compliant (becoming a LunaNet Service Provider, LNSP) for the LANS service, must:
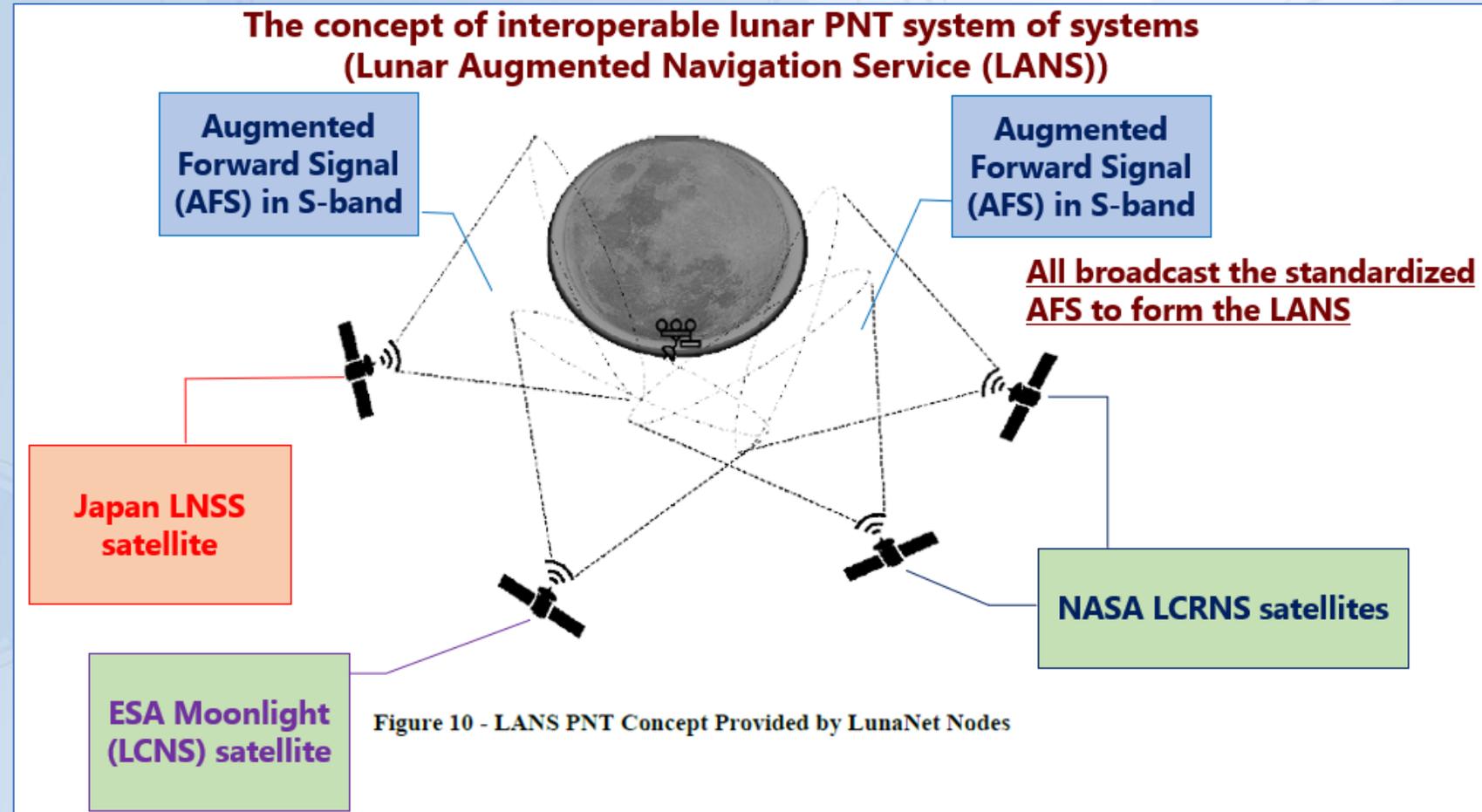➢ Comply with a common signal and message structure (Augmented Forward Signal, AFS).
➢ Comply with the Signal In Space Error requirements.
➢ Assure compliance with the Received Power at the Lunar Surface requirement.

[1] *ICG SSV booklet: "(interoperability is defined as) the ability of global and regional navigation satellite systems, and augmentations and the services they provide, to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system"*

Surface Assets

Notional Early Service Volume

- - - LNSP A
- - - LNSP B
- - - LNSP C
· · · · LNSP D

* Satellite orbits and distances are representation only

COORDINATION NEEDS FOR LANS

- Allocation and assignment of Pseudo Random Noise (PRN) Codes to LunaNet Service Provider (LNSP) nodes

- Allocation and assignment of AFS subFrame ID (in SB3, SB4) among LNSP nodes

- Necessary data sharing among LNSP

- Service and Signal-in-Space-Error (SISE) monitoring

- Reference orbits or orbital adjustment to maximize the LANS performance

- Provision of LNSP-specific ICDs for receiver manufacturers

The concept of interoperable lunar PNT system of systems (Lunar Augmented Navigation Service (LANS))

Augmented Forward Signal (AFS) in S-band

Augmented Forward Signal (AFS) in S-band

All broadcast the standardized AFS to form the LANS

Japan LNSS satellite

NASA LCRNS satellites

ESA Moonlight (LCNS) satellite

Figure 10 - LANS PNT Concept Provided by LunaNet Nodes

Who will manage and control these governance items?
How to certificate a LNSP that is compliant to the LunaNet?

INTERNATIONAL BODIES RELATED TO LUNAR PNT
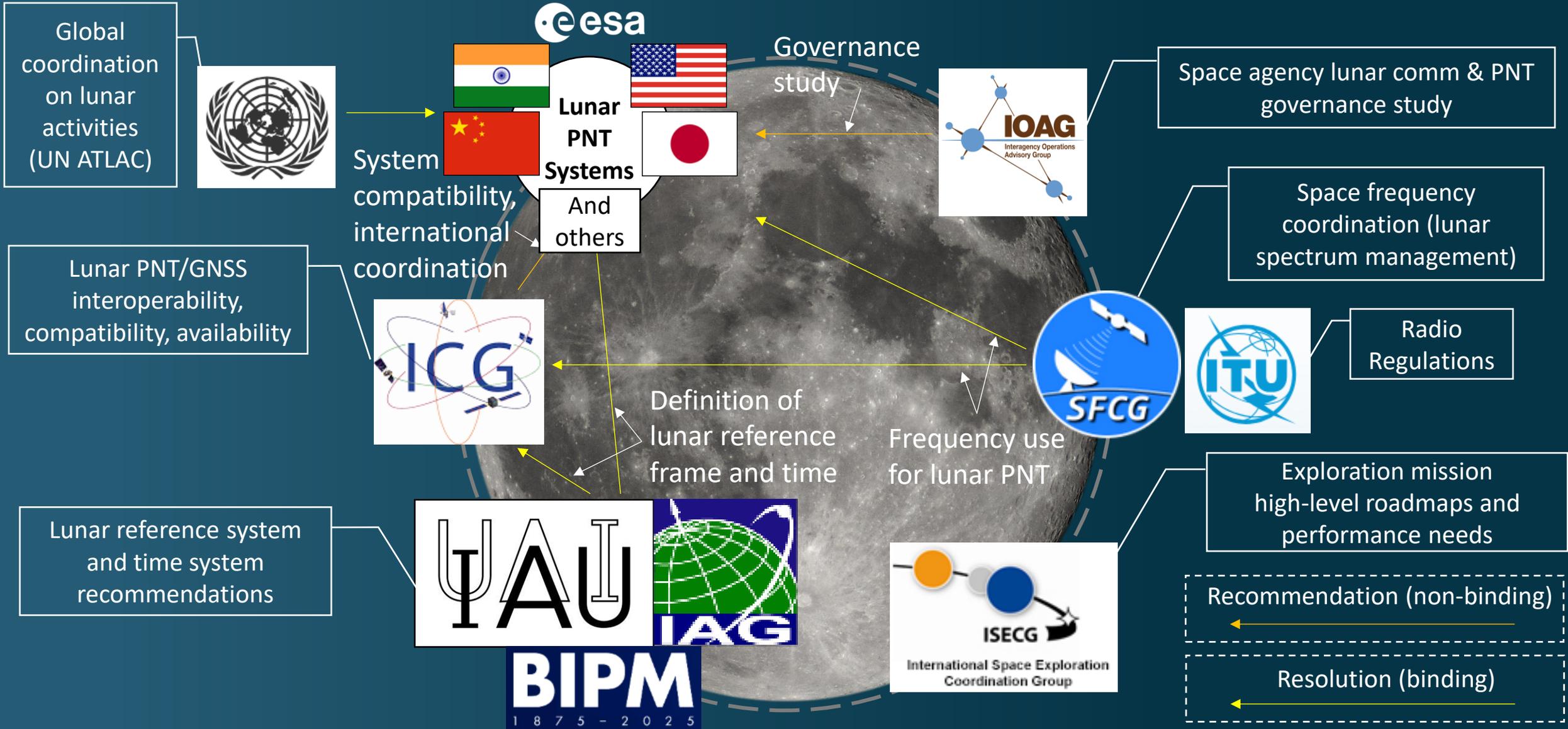
COLLABORATION WITH UN ICG, ATLAC

- International Committee on GNSS (ICG) WG-L (Lunar PNT) studies international cooperation beyond the scope of LunaNet
  - WG-L facilitates development of interoperable, compatible, and available lunar PNT systems
  - WG-L tasks include Lunar PNT international cooperation models: Work with appropriate international organizations to investigate and recommend international cooperation models that enable sustainable development and operations of lunar PNT systems.
  - The international coordination is such as PRN allocation, monitoring, provider joint activities, standardization

- ATLAC (Action Team on Lunar Activities Consultation) studies the global coordination on lunar activities such as policy development, international cooperation, identification of areas of collaboration to drive sustainable lunar exploration

NEXT STEPS AND PLANS (MAIN GAPS)

- Rationalize and monitor the compliance of LNSPs to the LunaNet framework through the monitoring of increments, statement of compliances and service deliveries including a process of certification with respect to the LunaNet framework.

- This can be done at different levels:
  - In relation with LunaNet or through specific cross-interoperability programs led by partner agencies (as for instance the LANS initiative for the navigation aspects)
  - LunaNet is not covering, as of today, the certification aspects of the LNSPs toward LunaNet standards but the LunaNet working groups could verify the compliance status of the LNSPs to LunaNet through the verification of test reports and statements of compliance/applicability from industry

Lunar Orbit

Asset deployment plan for the LANS demo in 2029

Elliptical Orbit
(Apogee=230000km)

④LNSS Satellite Separation

④' Polar orbit Insertion

⑤Power Descent
⑥Vertical Descent
⑦Landing

③Lunar Orbit Insertion

①H3 Launch

Japan first LNSS satellite

Japanese small lander carrying interoperability demonstration payload including LANS receivers

JAXA H3 rocket

②Trans Lunar Insertion(TLI)
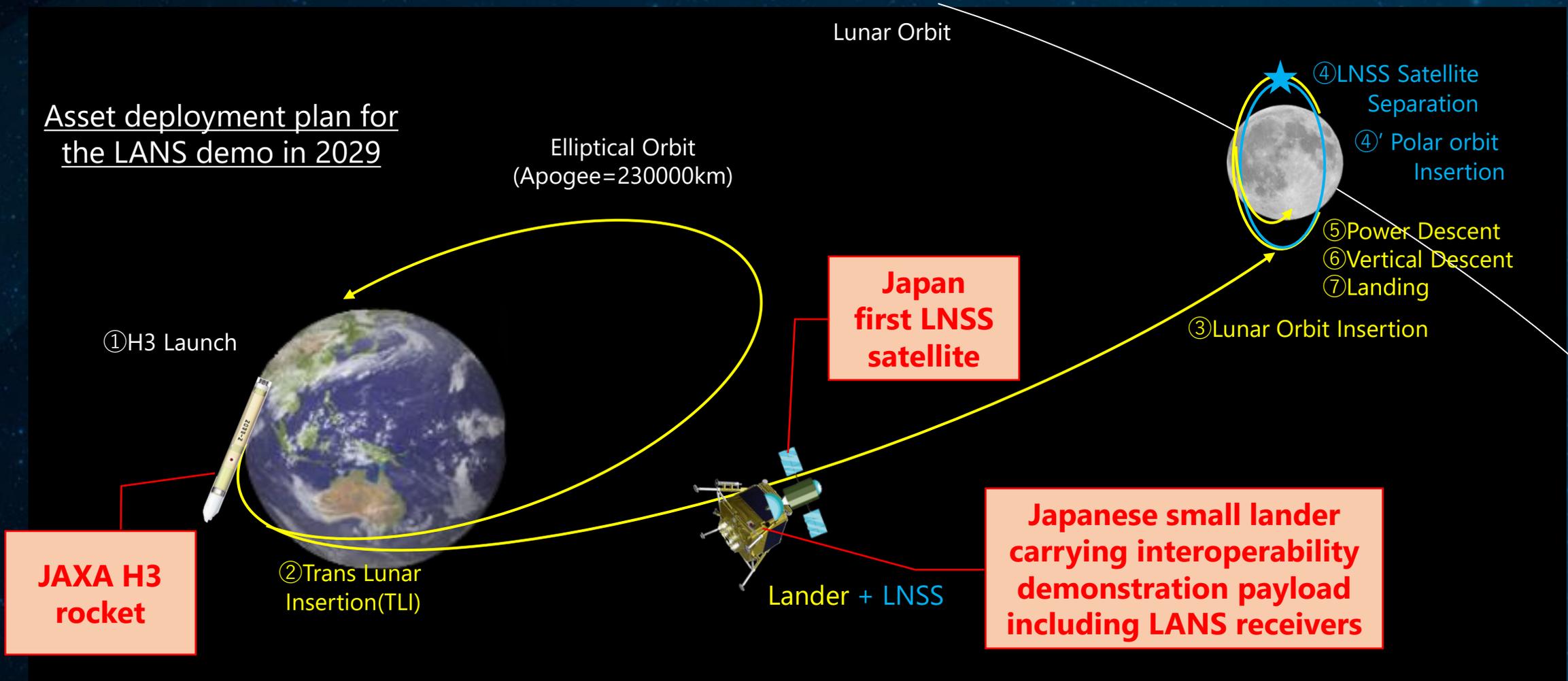
Lander + LNSS

Lunar position, navigation, and timing services jointly provided by international LNSPs (ESA's LCNS, NASA's LCRNS, and Japan's LNSS)
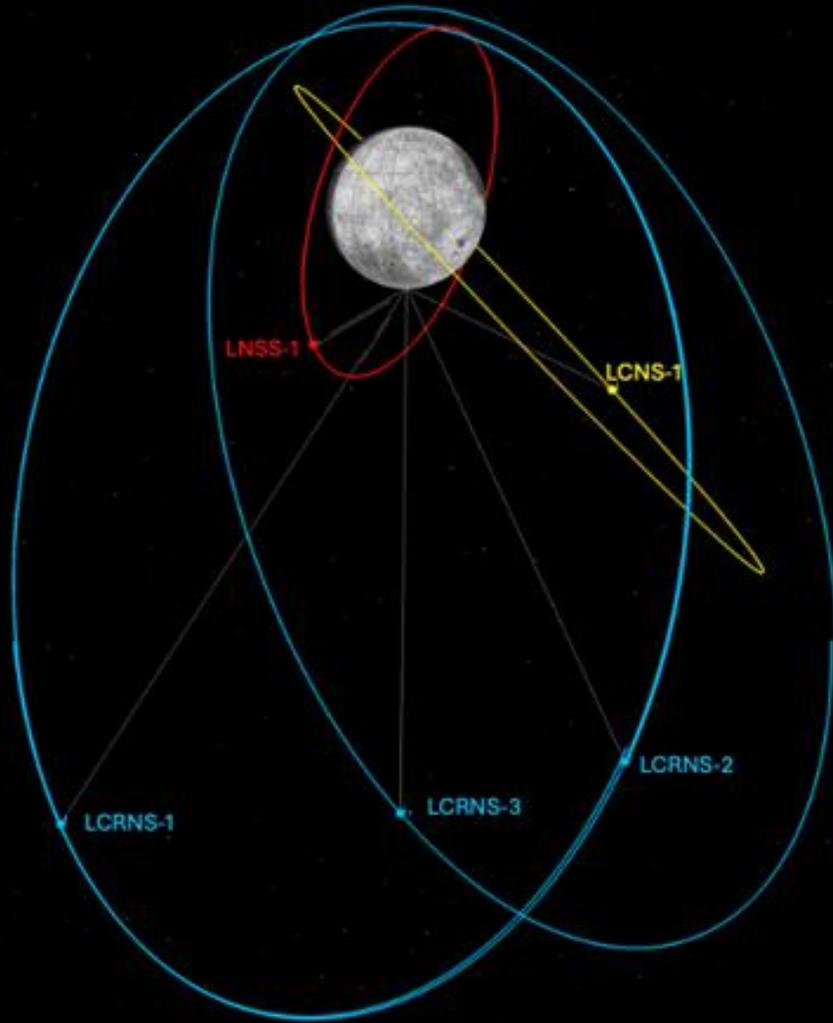
Analyzed orbital and SISE features:

	ESA LCNS	Japan LNSS	NASA LCRNS #1	NASA LCRNS #2	NASA LCRNS #3
Orbital Period	24 hrs (ELFO)	6 hrs (Circular)	32.8 hrs (ELFO)	32.8 hrs (ELFO)	32.8 hrs (ELFO)
Eccentricity	0.7	0	0.678	0.678	0.678
SISE-pos	20 m (2-sigma)	20 m (2-sigma)	13.43 m (3-sigma)	13.43 m (3-sigma)	13.43 m (3-sigma)

- Coordinate the allocation of the LunaNet specific resources among the LNSPs in the operational lifetime of the services. This includes the analysis of interference patterns and the frequency/polarization scheduling among LNSPs to their Users
  - This can be done in relation with SFCG in charge of coordinating the allocation of frequencies to specific missions yet currently not covering the operational coordination aspects

- Lunar trajectories coordination, registration and monitoring: the current orbit/debris management bodies are not covering beyond-Earth space, and would require specific framework extensions to cover cislunar space
  - This could be done through the extension of working groups already performing such activity for Earth orbits to include the cislunar missions or thought the creation of a specific entity

BEYOND LUNANET GOVERNANCE

Lunar PNT Systems

And others
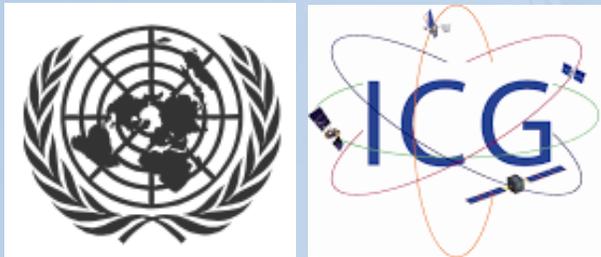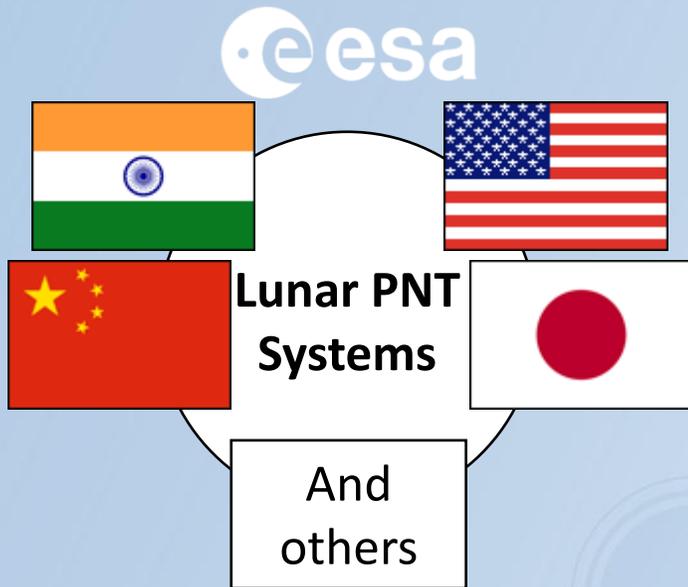
- The CSLG has been so far focusing on the governance for the LunaNet C&PNT capabilities, but there was also a discussion or suggestion to include lunar C&PNT systems that are not "LunaNet"

- For the frequency perspective, the SFCG and ITU have been providing international recommendations and radio regulations. However, the necessary coordination items are also including
  - in-orbit collision avoidance (space traffic management),
  - signal power coordination (interference prevention),
  - single-access bands coordination during the operational phases of the relay services

- Moreover, the interoperability is also important from user perspective, and even a basic-level technical coordination with non-LunaNet providers such as the alignment to a common lunar reference frame and time should significantly enhance overall lunar C&PNT user experience

まとめ

- 月測位を含む月のルール形成（国際調整）に向けてUNのATLACやICG（WG-L）、IOAG CSLGといった国際団体が活動を進めている
  - 周波数についてはSFCGやITU、月の座標系や時系についてはIAU、IAG、BIPMが定義活動を進めている

- 今回IOAG CSLGの活動（IOAG Preliminary Report on LunaNet Governance）について紹介した
  - 本ガバナンスレポート内で識別されているガバナンスアイテムや勧告についていくつか紹介
  - 2026年4月のレポート公開を目指し編集・レビュー作業中

- 今後の重要なイベントとして、来月2/10-13にウィーンで開催される2nd Joint ICG-IOAG Multilateral Cislunar PNT Workshopのgovernance sessionがある
  - 本セッション内でCSLGの他にATLACや中国からの発表がある（以降のスライドで紹介）

Workshop on Cislunar Positioning, Navigation, and Timing (PNT)

10 - 13 FEBRUARY 2026
VIENNA INTERNATIONAL CENTRE, AUSTRIA

Jointly organized by
**the International Committee on Global Navigation Satellite Systems (ICG) and
the Interagency Operations Advisory Group (IOAG)**

Time (CET)	Session
Day 1 (Tuesday, 10 February 2026)	
09:00 - 12:30	Welcome Keynotes Session 1: Lunar PNT Frameworks & Systems
12:30 - 14:00	Lunch
14:00 - 17:30	Session 2: Standardization and Governance
Day 2 (Wednesday, 11 February 2026)	
09:00 - 12:30	Session 3: Lunar Reference Frame and Time
12:30 - 14:00	Lunch
14:00 - 17:30	Session 3: Lunar Reference Frame and Time
18:00 - 20:00	Reception (TBC)
Day 3 (Thursday, 12 February 2026)	
09:00 - 12:30	Session 4: Lunar PNT Spectrum
12:30 - 14:00	Lunch
14:00 - 17:30	Session 5: Lunar PNT User/Test Equipment & Technology
Day 4 (Friday, 13 February 2026)	
09:00 - 12:30	Session 5: Lunar PNT User/Test Equipment & Technology Roundtable Discussion and Workshop Outcomes

16:00 - 17:30 **Sub-session: Governance**
Session Co-chairs: Masaya MURATA (JAXA), Guoyu Wang (Beijing Institute of Technology)

16:00 - 16:20 "ATLAC Framework: Principles, and Pathways for International Consultation on Lunar Activities", Ulpia Elena Botezatu (UN COPUOS ATLAC Co-Chair)

16:20 - 16:40 "IOAG Committee to Study LunaNet Governance (CSLG)", Masaya Murata (IOAG CSLG Co-Chair)

16:40 - 17:00 "The Envisaged Principles and Framework for Lunar Coordination Zone", Guoyu Wang (Beijing Institute of Technology)

17:00 - 17:20 "Principles and Practices of Lunar Information Sharing", Antonino Salmeri (Lunar Policy Platform)

17:20 - 17:30 Wrap-up by session co-chairs

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Organization of Governance Session

- Two talks on Governance
  - *Treaties & international space law implications for PNT*, Chris Johnson/Secure World Foundation
  - *The Road Ahead: From Cislunar PNT to the Solar System Internet*, Scott Pace/George Washington University
- Two talks on Technical Collaboration
  - *Considerations on Lunar PNT governance*, Yang Ruihong/CNSA LESEC
  - *IOAG LunaNet Coordination Study Preliminary Results*, James Schier/IOAG and Masaya Murata/JAXA
- Questions and (hopefully) Answers
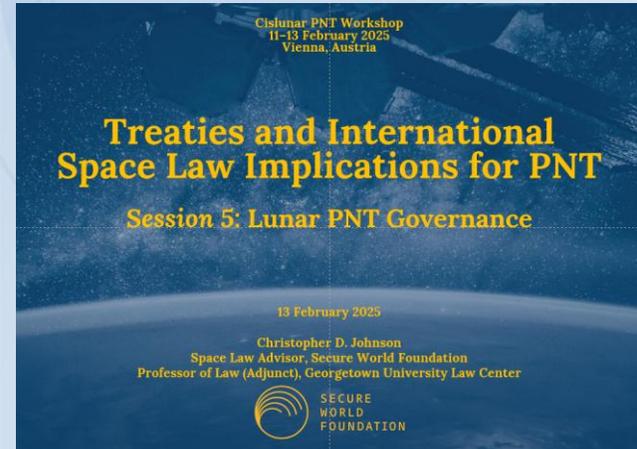
Cislunar PNT Workshop
11–13 February 2025
Vienna, Austria

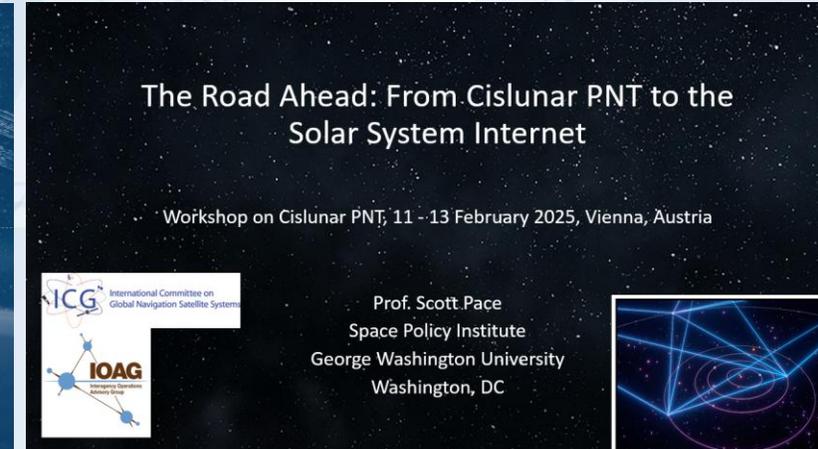**Treaties and International Space Law Implications for PNT**

Session 5: Lunar PNT Governance

13 February 2025
Christopher D. Johnson
Space Law Advisor, Secure World Foundation
Professor of Law (Adjunct), Georgetown University Law Center

SECURE WORLD FOUNDATION

The Road Ahead: From Cislunar PNT to the Solar System Internet

Workshop on Cislunar PNT, 11 - 13 February 2025, Vienna, Austria

Prof. Scott Pace
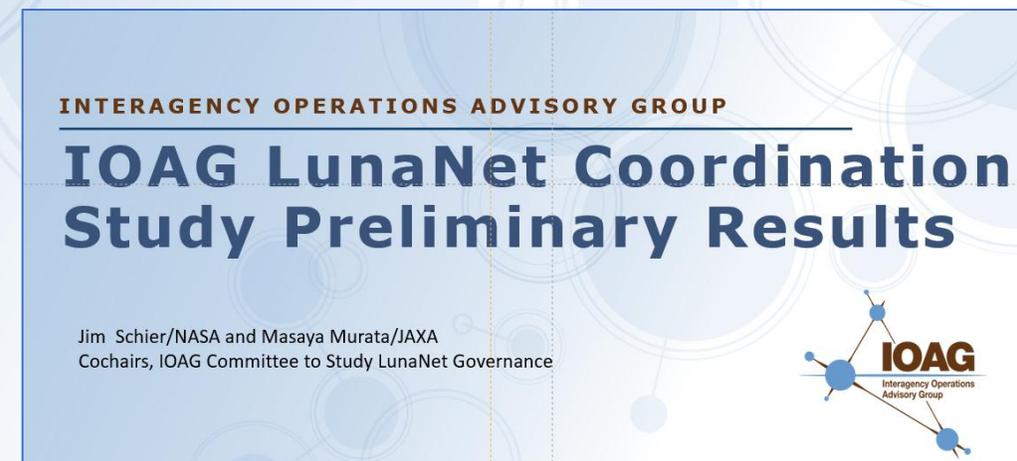Space Policy Institute
George Washington University
Washington, DC

Considerations on Lunar PNT Governance Principles

Ruihong YANG

Lunar Exploraiton and Space Engineering Center

INTERAGENCY OPERATIONS ADVISORY GROUP

IOAG LunaNet Coordination Study Preliminary Results

Jim Schier/NASA and Masaya Murata/JAXA
Cochairs, IOAG Committee to Study LunaNet Governance

Proceedings and Recommendations

- 2025 1st Cislunar PNT Workshop proceedings are available:

  https://ioag.org/meetings/cislunar/

- Includes all presentations and summaries from each session, assembled by session co-chairs.

- Summaries record 32 recommendations from session co-chairs.

- Recommendations can be optionally taken up by international organizations, including ICG WG-L.
  - To be discussed in WG-L and ICG-20 in 2026