Lunar Standards Update

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CCSDS Spring 2025 Meetings Plenary

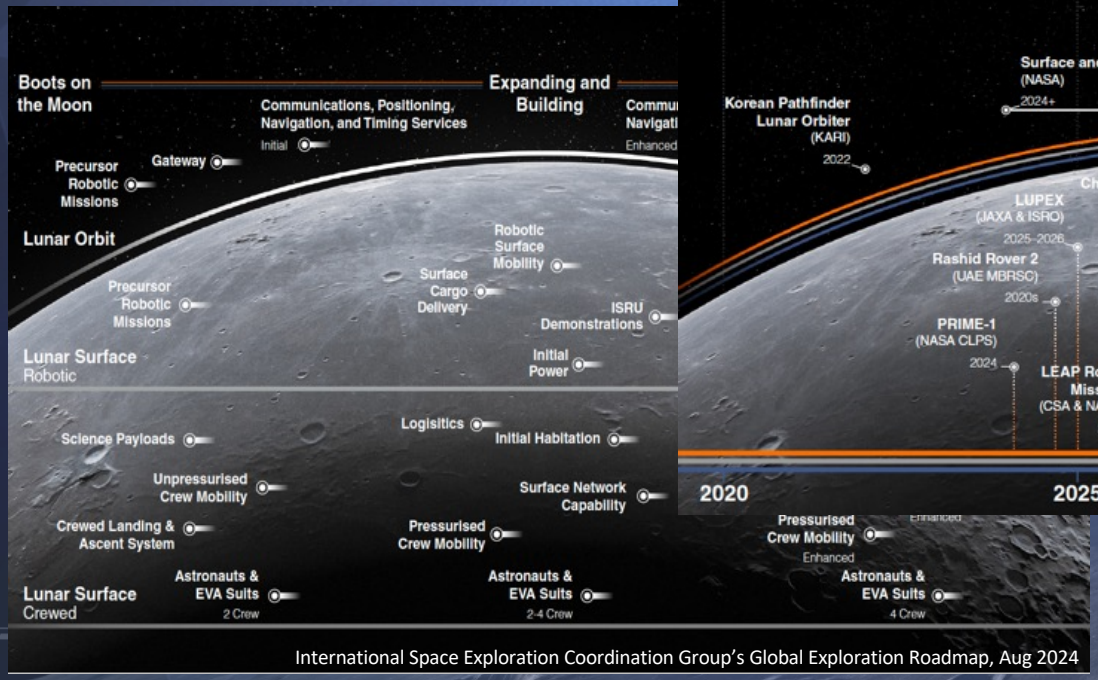
Laurel, MD

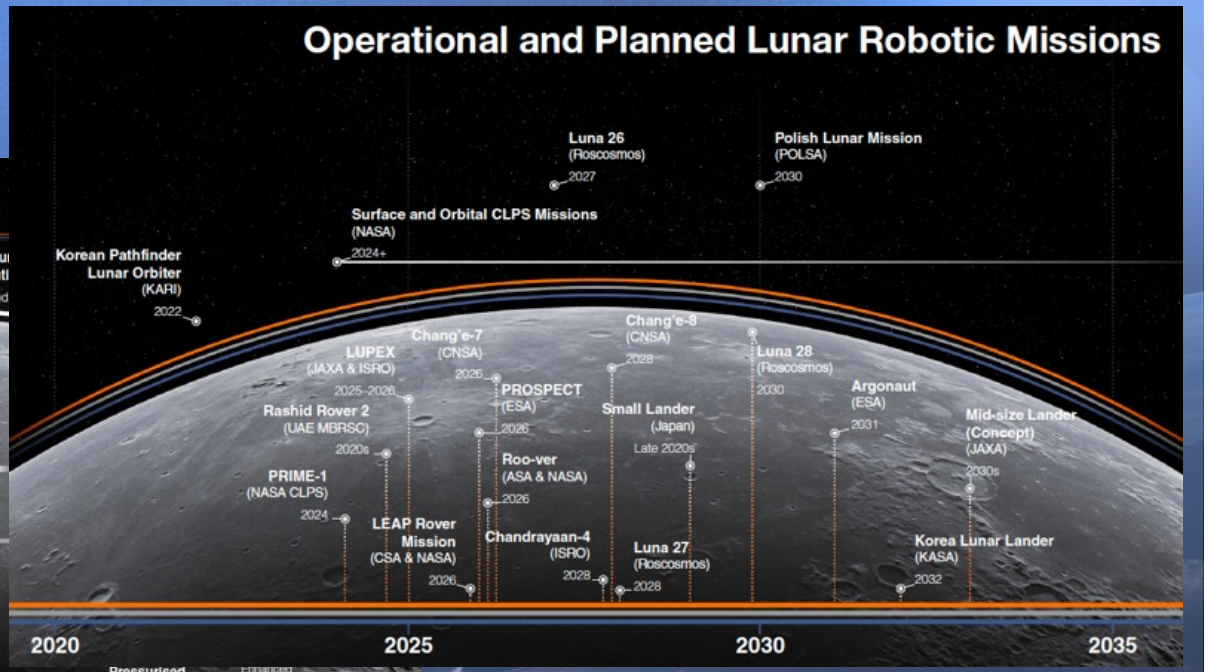
Topics

- Drivers for Cislunar Standards
- Other Standards Organizations
- ICG-IOAG Cislunar PNT Workshop
- LunaNet and the LunaNet Interoperability Specification (LNIS)
- LunaNet ←→ CCSDS

Mission Set

As identified in ISECG Report and openly available media, there are many nations with existing and/or planned missions to the Moon or cislunar space (e.g. E-M Lagrange).



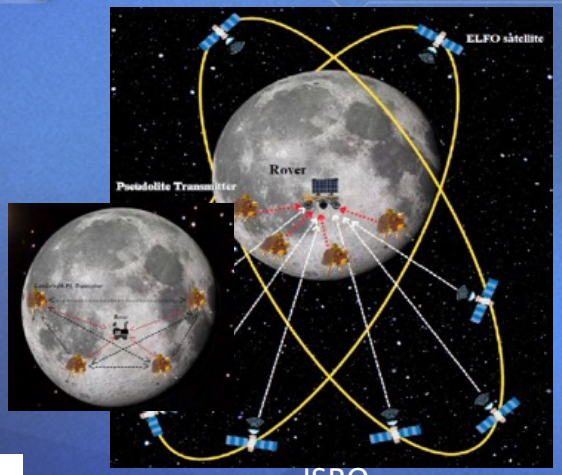


International Space Exploration Coordination Group's Global Exploration Roadmap, Aug 2024

Lunar C&PNT Systems

In addition, many nations are deploying infrastructure for comm and PNT systems and services.

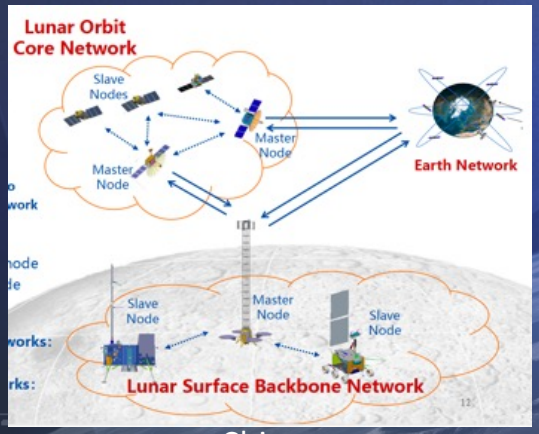
Other nations are considering plans.



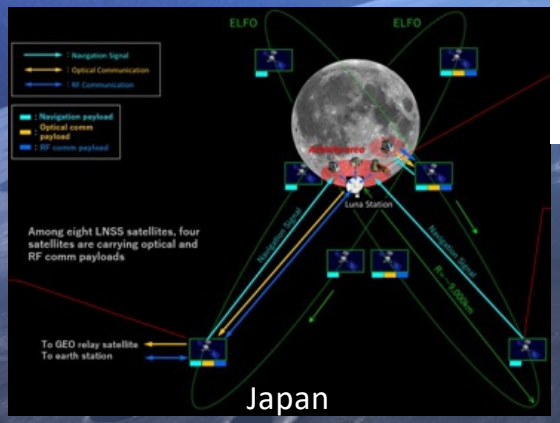
ISRO

ESA

NASA



China



Japan

Organizations Beyond Space Agencies

Several [non-space agency] organizations involved to assure interoperability, compatibility among the different systems.

Space Agency Based

Other/Future Lunar C&PNT

SFCG

Consultative Committee CCSDS for Space Data Systems

IOAG

IAU
- Commission A3, Fundamental Standards
- WGCCRE
- Time & Frequency

Body-specific Celestial System, Coordinate Time, Lexicon

IAG

Body-fixed Reference System (frame, gravity model, equipotential surface, shape; transforms)

BIPM

Time Scales: Coordinate and equipotential surface

ITU

Spectrum; Time

ICG International Committee on Global Navigation Satellite Systems

PNT systems Interoperability ***(Recommendations)***

IEEE SA STANDARDS ASSOCIATION

Telecomm

Joint ICG-IOAG Multilateral Cislunar PNT Workshop

11–13 February 2025 | Vienna, Austria and broadcast

- Held at UN Vienna International Centre (VIC), 11–13 Feb 2025
- Approx. 100 in-person + 100 online attendees
- Approx. 20 countries & international organizations represented, including industry
- Approx. 45 speakers & presentations
- Final agenda and artifacts: https://www.ioag.org/SitePages/Cis-Lunar-Workshop.aspx

Workshop Summary

From survey to workshop participants:

- Overal positive apprecitation (96%) of the workshop and organization (99%*) which met (57%) or exceeded (36%) expectations
- Recommend to organize workshop in the future (97%) with a yearly cadence (64%) and similar duration (76%)
- Remote participation could be improved (10%**) including better monitoring of the chat (7%**)
- Length of the sessions (97%*) and the techincal content (99%*) were perceived well

*Includes neutral

**Includes only remote partcipants

LunaNet

- LunaNet is a framework for standards- based interoperable communications/network, PNT, and Alert services.
  - Scalable in the environment (expand service volume, capacity/capability)
  - Extensible to other regimes
  - Incorporates cyber security
- LunaNet Interoperability Specification (**LNIS**) document set establishes the standards, protocols, interfaces for a network of interoperable networks. Complemented by a Concept of Operations
- Developed by the international partners in the LNIS Working Group.
- Use existing standards, when applicable;

Develop standards where needed.
Direct With Earth (Earth Ground Stations to lunar region user)
Proximity links (via systems in the lunar region to lunar region user)

- Point-to-Point (relay to user)
- Broadcast (relay(s) to user(s))
- Future: Surface

Currently adopts several CCSDS Standards;
Ongoing work with CCSDS to update specific existing Standards.

>>Not limited to CCSDS Standards (e.g. RFC 9172, 3GPP) <<

LNIS

- Publication Jan 2025: LNIS main v5 and AD1 Vol A v1
- Future LNIS update to complete LunaNet 1.0 specification to cover near term needs.
- LNIS Document Set:
  - Main Document
  - AD1 Volume A LunaNet Signal-In-Space Recommended Standard (LSIS) Augmented Forward Signal (AFS)
  - AD1 Volume B LunaNet Signal-In-Space Recommended Standard (LSIS) Point-to-Point Signals
  - AD2 LunaNet Measurement Schema and Parameters
  - AD3 LunaNet Detailed Message Definition Document
  - AD4 LunaNet Location Services for Users (not LunaNet 1.0)
  - AD5 Lunar Reference System and LunaNet Reference Time System Standard
  - AD6 LunaNet Data Services Document
  - AD7 LunaNet LunaSAR Definition Document (not LunaNet 1.0)
  - AD8 LunaNet Interoperability Security Specifications

LNIS version 5 and AD1VolA LSIS-AFS version 1 available online.

https://www.nasa.gov/directorates/somd/space-communications-navigation-program/lunanet-interoperability-specification/#_blank

LunaNet and CCSDS

The following efforts are underway to apply or align CCSDS standards with LNIS:

DTN:

- BPv7 Blue Book
- Custody Transfer and Compressed Reporting (CT/CRS) OB and BB
- BPSec OB and BB

Work related to space-to-space links:

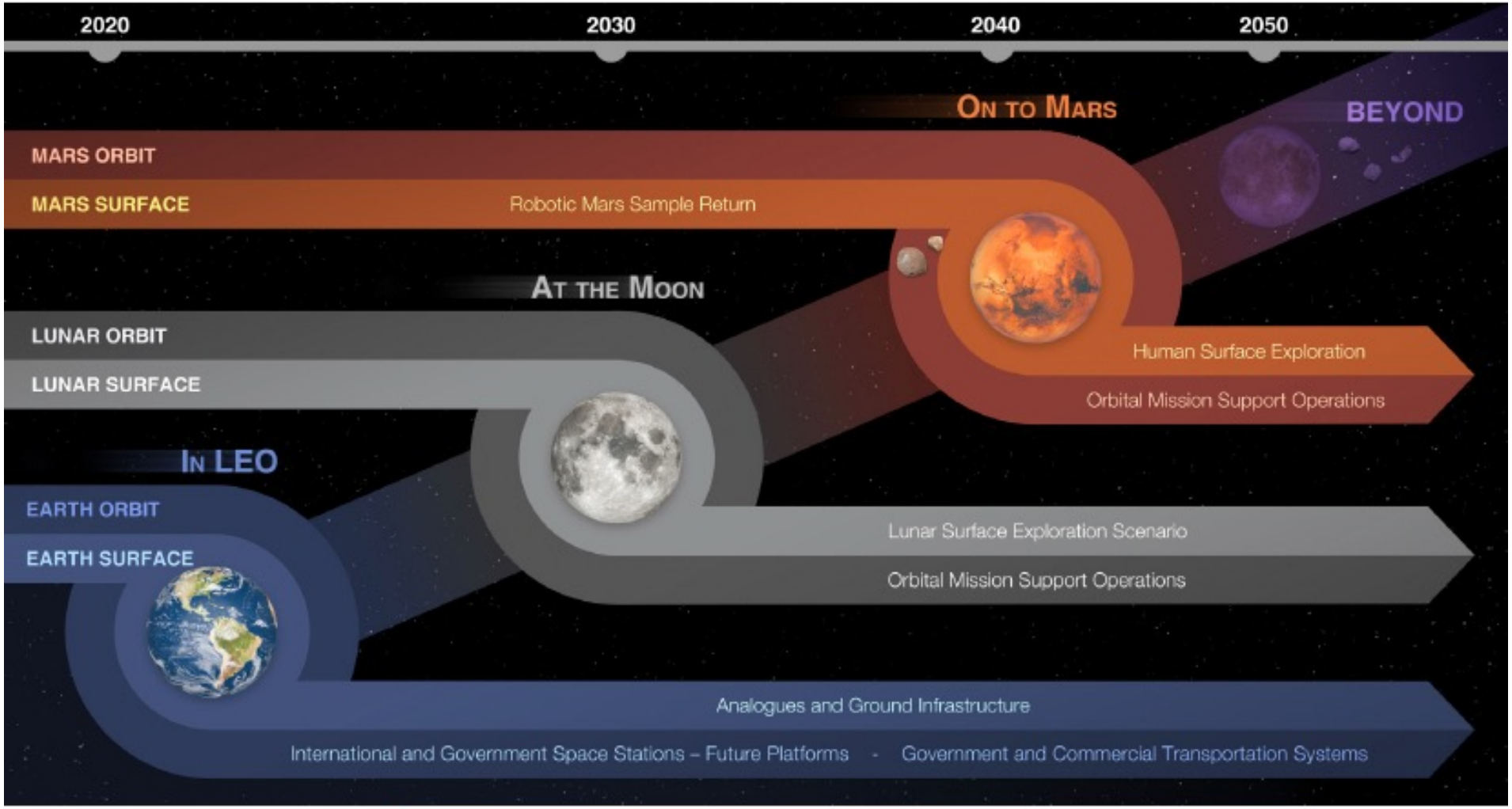
- Prox-1 Standard extension to S-band and Ka-band (211.2 Coding & Sync BB, 211.0 Data Link Layer BB, 211.1 Physical Layer BB), including the addition of ranging
  - S-band extensions: books' drafts creation is currently on-going
  - Ka-band conversations starting in the Spring 2025 CCSDS meeting
- 235.1 Generic Session Control BB for proximity links
- 401.0 RF Modulation Volume B for space to space links
- Update to 414 and 415 to incorporate support for lunar proximity (e.g. local) links (including ability to transfer time)

NOTE: It is not incumbent on every LunaNet Service Provider to provide *every* service defined within the LNIS.

Other Topics in CCSDS wrt LNIS

These topics are in discussion for potential coordination between LNIS and CCSDS:

1. Possible Green Book for recommended operating parameters and/or data rate/PN ranging combinations, with rationale.
2. Message products that would be suitable for LNIS services, such as:
   a. Contact Schedule and updates for space-to-space link exchange
   b. Version of Nav WG CDM suitable for space-to-space link exchange
3. Updating standards to designate the upper portion of the VCID number range as “Reserved”.
   a. LNIS AD6 has identified application for a few high-numbered VCIDs specifically for provider-to-user use, rather than the normal solely mission-determined use of VCIDs.
4. Discussions on possible approach wrt CCSDS and LNIS that meets Agency objectives.
   a. Request CCSDS feedback in writing on AD1 Vol A differences wrt a CCSDS Blue Book Standard format.
   b. Potential process for CCSDS to endorse select LunaNet specifications (as Blue Book, or other) when LNIS Working Group identifies them as sufficiently mature.
5. Future need: Lunar Surface communications with PNT protocol.



The ISECG Global Exploration Roadmap.