



# LunaNet: Interoperability for Lunar PNT

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# Topics



- LunaNet
- LunaNet Interoperability Specification
- LunaNet PNT Services

# LunaNet Overview



- A flexible **scalable** architecture for providing communications and navigation services to all lunar missions
- Disaggregated approach allows for phased implementation of infrastructure as driven by user needs and technology developments
- Architecture implementation comprised of International and Commercial **interoperable** lunar surface, lunar orbiting, and earth-based elements
- Incorporates in-situ capabilities to detect events and distribute situational alerts
- Is fully compatible with and promotes future deployments at Mars or any other destination

***Just as the Internet and GNSS have transformed our lives on Earth, LunaNet will transform lunar science and exploration.***

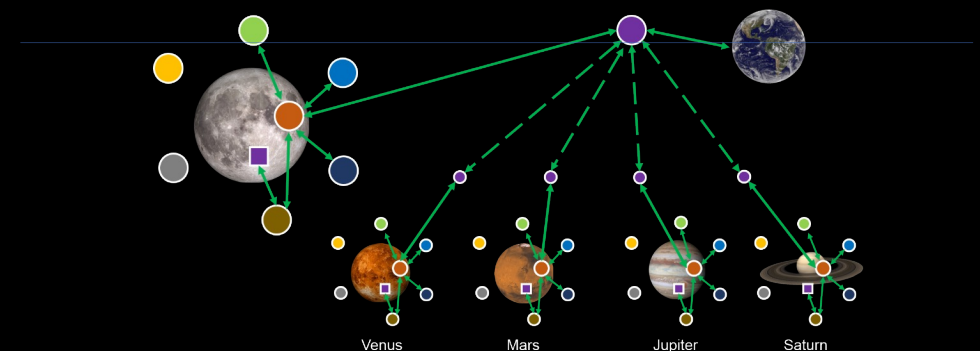
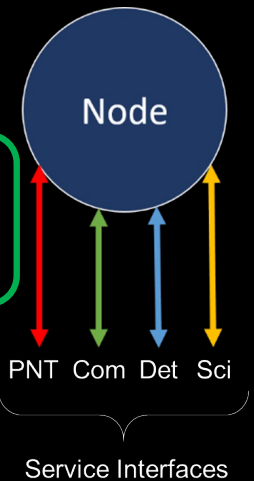
## LunaNet Service Types

1. **Communications Services (Com):** Data transfer services capable of moving addressable and routable data units between nodes in a single link or over a multi-node, end-to-end path via communications or networking services.

2. **Position, Navigation, and Timing Services (PNT):** Services for position and velocity determination, and time synchronization and dissemination. This includes search and rescue location services.

3. **Detection and Information Services (Det):** Services providing detection of events in order to generate timely alerts for human and asset safety and protection. These services publish other beneficial information to users as well.

4. **Science (Sci):** Services that use the RF and/or optical capabilities of the node as a science instrument or part of an instrument.





# Lunar Systems Relationships



## LunaNet

Framework for Standardized Interoperable Services,  
umbrella under which many providers collectively work.  
*Architecture* originally documented by IOAG Lunar  
Communications Architecture WG.  
Interoperability defined in a *specification*.

### Lunar Comm. Relay and Navigation System (LCRNS)

NASA's instantiation of LunaNet  
Services— a LunaNet Service  
Provider (LNSP)

Currently scoped for Initial  
Operating Capability

### Moonlight

ESA's instantiation of  
LunaNet Services

### Lunar Navigation Satellite System (LNSS)

Japan's  
instantiation  
of LunaNet  
Services

### Others

e.g. other orbiting  
systems, 3GPP (surface  
cell towers), users

## Lunar Reference System (LRS) Components (includes Time)

A canonically  
defined set of  
components for  
consistent, accurate,  
and safe navigation.  
Interoperability  
defined in Applicable  
Document 5 (AD5).



# LunaNet Interoperability Specification



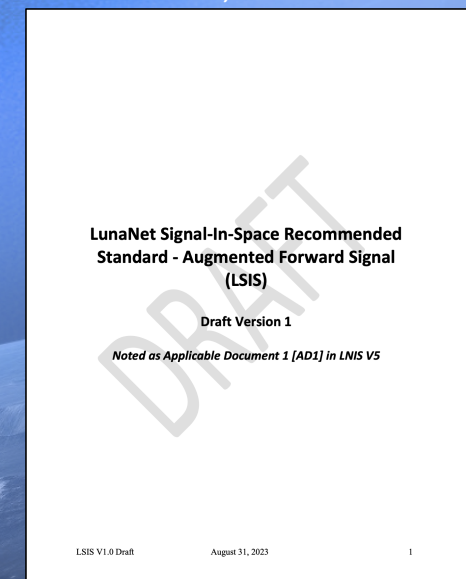
## LunaNet Interoperability Specification (LNIS)

- LNIS is a set of mutually agreed-upon specifications of standards, protocols, and interface requirements that enable interoperability.
- LNIS provides a basis for operation of a network capable of interoperating with other LNIS-compliant networks.
- LNIS is being developed cooperatively with international partners through the LNIS Working Group.
- **Includes a set of Applicable Documents:**
  - AD1 LunaNet Signal-In-Space Recommended Standard (LSIS)
  - AD2 LunaNet Measurement Schema and Parameters
  - AD3 LunaNet Detailed Message Definition Document
  - AD4 LunaNet Location Services for Users
  - AD5 Lunar Reference System and Lunar Time System Standard
  - AD8 LunaNet Interoperability Security Specifications

LNIS v5



AD1, LSIS v1





# LunaNet Interoperability Specification Status



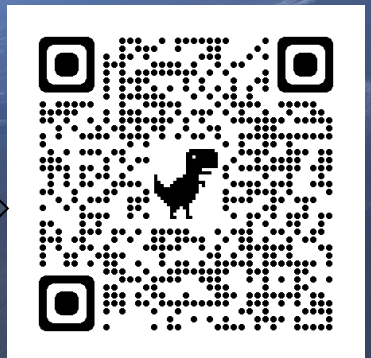
- LNIS Draft Version 5 *and* associated document LunaNet Signal-In-Space Recommended Standard - Augmented Forward Signal (AD1)\* provided for public comment 1 September, 2023.
  - Comments received 1 December, 2023.
  - LNIS Working Groups dispositioned comments collectively among the three agencies.
  - Document updates currently underway, focusing on near-term needs for required services
    - Address comments
    - Confirm parameters based on analysis
- Future LNIS updates to complete LunaNet 1.0 specification that covers near term needs.



South Pole Region  
Service Volume

**LNIS version 5 and LSIS version 1 are available in Draft form.**

[https://www.nasa.gov/directorates/heo/scan/engineering/lunanet\\_interoperability](https://www.nasa.gov/directorates/heo/scan/engineering/lunanet_interoperability)

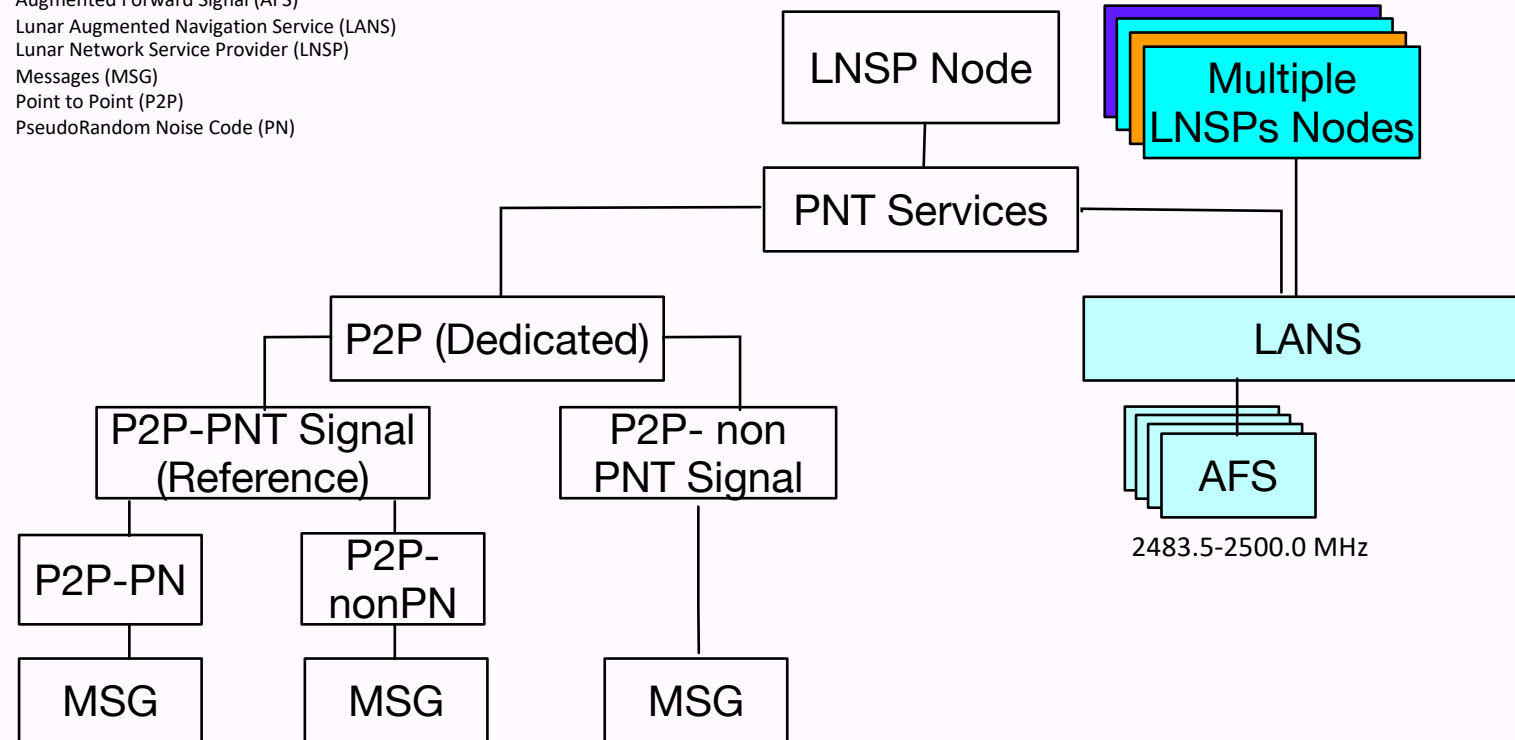


\* Technical paper and presentation available in ION GNSS+ 2023 proceedings:  
<https://www.ion.org/gnss/abstracts.cfm?paperID=12341>

# LunaNet Framework PNT Services



Augmented Forward Signal (AFS)  
Lunar Augmented Navigation Service (LANS)  
Lunar Network Service Provider (LNSP)  
Messages (MSG)  
Point to Point (P2P)  
PseudoRandom Noise Code (PN)



PNT Services rely on definition, adoption, and maintenance of common lunar geodetic and time systems.



# LunaNet PNT Services



## LunaNet PNT services:

1. Proximity:
  - a. Point-to-Point navigation services (direct link between the user and the provider); PNT-over-Comm
  - b. Lunar Augmented Navigation Service (LANS)
2. Direct With Earth
3. LunaNet Interoperability Spec responsible for defining signal designs, Signal in Space Error, messages for interoperable services.
4. Reliant on definition and maintenance of lunar reference geodetic and time systems.

## LANS characteristics:

- A lunar analog to terrestrial GPS/GNSS with associated benefits from broadcast signals and messages.
- The concept is to achieve maximum reuse of GNSS techniques and technologies.
- Defines a Lunar Service Volume (LSV) that extends beyond the local lunar region.
- This proximity service is provided from multiple providers nodes to multiple users at the same time.

**LANS Interoperability<sup>1</sup>:** 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 Power at the Surface requirement.

<sup>1</sup> 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"





Questions?