LANS Interoperability Demonstration Mission Under Planning

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

- **ESA Moonlight LCNS** (2027～)
- **JAXA LNSS** (2028～)
- **NASA LCRNS** (2025～)

**LCNS:** Lunar Communications Navigation Services

**LCRNS:** Lunar Communications Relay and Navigation Systems

**LNSS:** Lunar Navigation Satellite System
Towards the establishment of the Moon GNSS (LANS)

The concept of the Moon GNSS called the Lunar Augmented Navigation Service (LANS)

Augmented Forward Signal (AFS)

JAXA LNSS satellite

ESA Moonlight (LCNS) satellite

NASA LCRNS satellites

All broadcast the standardized AFS to form LANS

This figure was copied from the LunaNet Interoperability Specification (LNIS)
※LNIS is the standardization document for the LunaNet
STEP 1: LUNAR PATHFINDER
Low-rate satellite communications service + Moon GNSS Receiver

Development → Pathfinder Service ⇒ Q4 2025

STEP 2: MOONLIGHT CONSTELLATION
High-data rate satellite communications and navigation service

Design → Development → IOC → FOC

2020 2021 2022 2023 2024 2025 2026 2027 2028 2030
Mid term - Moonlight IOC

- IOC phase will start by end of 2027 with at least one satellite transmitting the one-way (AFS) navigation signal
- Signal will be compliant with LunaNet requirements ensuring interoperability (same user terminal can work with multiple LNSP with minor SW modifications)
- Orbits will be defined by the service provider, however ELFO orbits are expected (e.g.: 24h orbit period)

From LNIS:

*The SISE is defined as the instantaneous difference between the position, velocity and time of a LunaNet satellite as broadcast by the LunaNet node navigation message and the true satellite position, velocity and time, respectively expressed in the lunar reference frame [AD5] and the lunar system time reference [AD6].*

<table>
<thead>
<tr>
<th>LCNS NAV service main targets (IOC)</th>
<th>Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SISE</td>
<td>&lt; 20m 95%</td>
<td></td>
</tr>
<tr>
<td>OWR availability</td>
<td>&gt; 80%</td>
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Initial Capability for LCRNS

- IOC phase will begin late 2025 with IOC-Alpha with a minimum of one Augmented Forward Signal (AFS) broadcast over the South Pole region.
- IOC-Bravo is expected by 2027 with a minimum of two AFS over the same South Pole region.
- Service continues over an expanded South Pole volume with IOC-Charlie broadcasting a minimum of four AFS, also meeting a requirement for GDOP for a limited portion of an Earth day.

- The LCRNS AFS will comply with the LunaNet Interoperability Specification.
- LCRNS orbit(s) will be defined by the service provider and are expected to meet the Signal-in-Space-Error.
- It is expected that LCRNS will be capable of providing two-way measurements from Peer-to-Peer signals.
- Service delivery is reliant on defined lunar geodetic system and lunar time.
LNSS is GPS-like satellite constellation for the Moon designed by JAXA

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

To GEO relay satellite
To earth station

Target: South Pole region

LNSS satellite broadcasting one-way navigation signal

LNSS satellite also functioning as a data relay satellite to the earth

JAXA’s plan
JAXA’s plan

GNSS navigation (real-time OD) for LNSS satellites, making the lunar PNT autonomous

SISE of about 20m (RMS) after filter convergence
We constitute the Moon GNSS called Lunar Augmented Navigation Service (LANS)
The LNIS includes:

- Concept of the LANS, message format of the AFS, signal frequency, power, etc.
- LANS Initial Operations Capability (IOC) and Enhanced Operations Capability (EOC)
- Signal-In-Space-Error (SISE) definition for the LunaNet Service Providers (LNSPs)
- Lunar Reference System and Lunar Time System Standard

The JAXA LNSS complies with the LNIS and will be designed to become interoperable and comparable with the other LNSPs such as ESA and NASA.
Both SISEs are based on lunar reference frame and time, which will be defined in the LNIS applicable documents called Lunar Reference System and Lunar Time System Standard.
Plan of LANS interoperability demonstration mission targeting in 2028
Launching and deploying our first LNSS satellite and LANS receivers to the moon

JAXA H3 rocket

JAXA small lander called LEAD carrying LANS receivers

JAXA first LNSS satellite
Proposing the first-ever ESA-JAXA-NASA LANS interoperability and PNT demonstration

All broadcast the standardized AFS to form LANS

LANS receivers and laser retroreflector placed at South Pole region
Proposing the first-ever ESA-JAXA-NASA LANS interoperability and PNT demonstration

- GNSS satellite
- JAXA LNSS satellite
- LANS receivers and laser retroreflector placed at South Pole region
- And PNT evaluation based on precise position and clock information of the LANS receivers
- NASA LCRNS satellites

Weak signal

ESA Moonlight (LCNS) satellite
Takeaways

- The JAXA LNSS, ESA Moonlight LCNS, NASA LCRNS will comply with the LNIS and join the LANS that becomes the Moon GNSS

- ESA, JAXA, and NASA encourage the LANS interoperability demonstration mission in 2028 and are currently assessing their respective participation. The receivers to be located at the South Pole region will receive all LNSPs AFSs and send them back to the Earth for the in-depth analysis

- In this demonstration mission, a laser retroreflector will be placed on the Moon surface for the precise position estimation of the LANS receiver. The laser ranging data will be also utilized for the refinement of the Lunar Reference System (LRS)