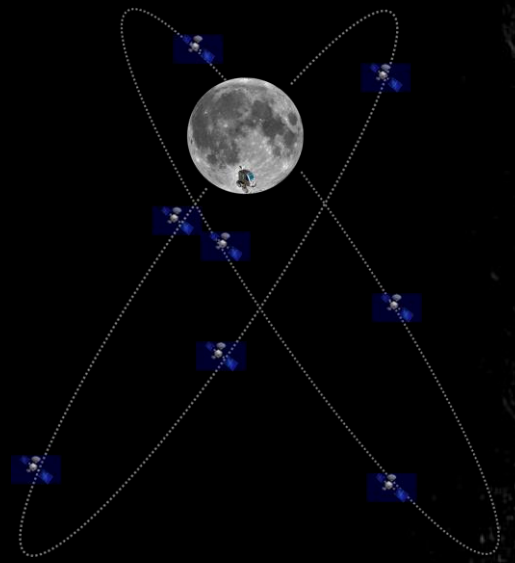
Japan Aerospace Exploration Agency

Lunar Navigation Satellite System

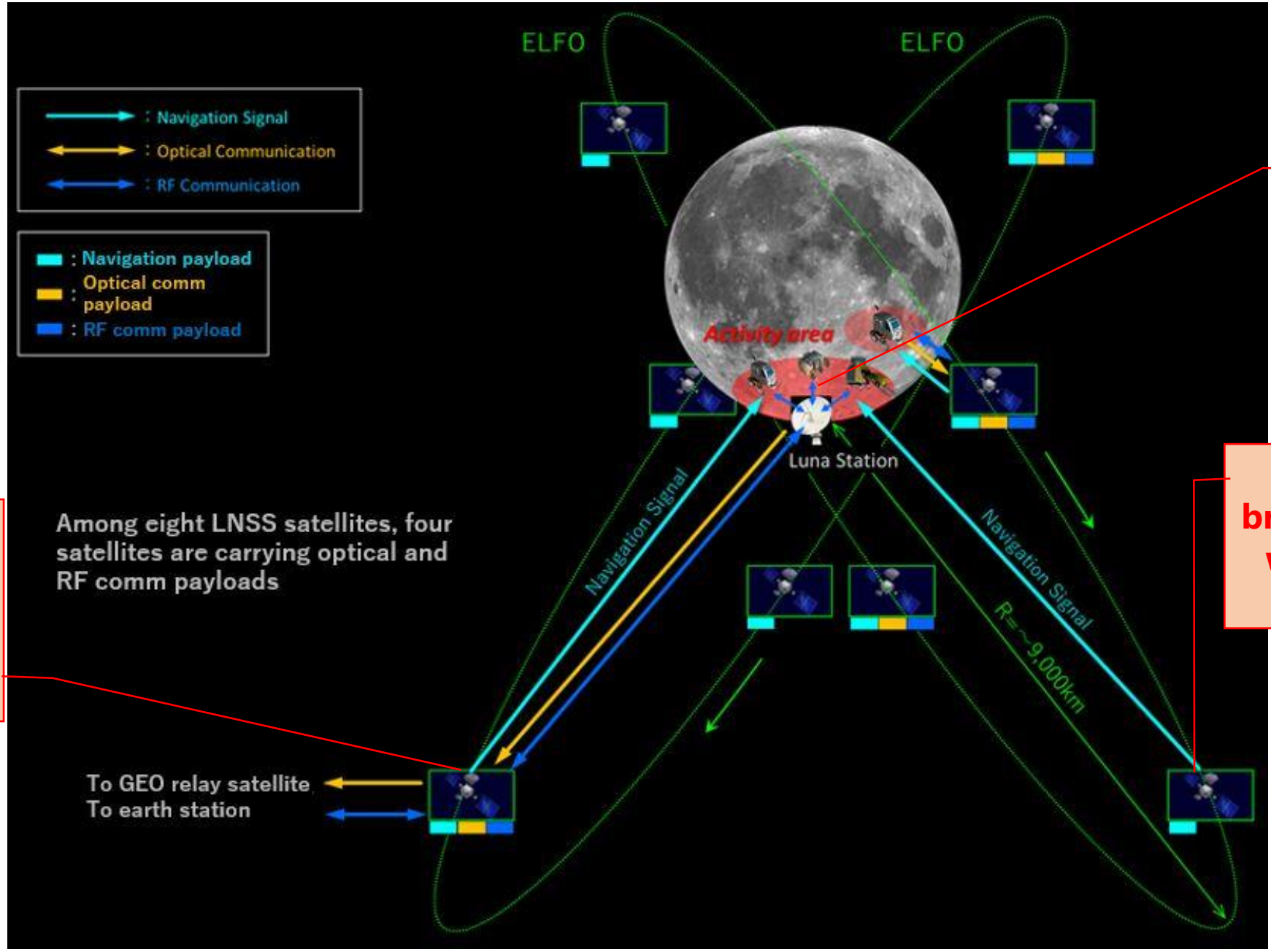


Japan Lunar Navigation Satellite System (LNSS) and Its Contribution Towards Lunar Augmented Navigation Service

Masaya Murata (JAXA)

JAXA's plan

LNSS is GPS-like satellite constellation for the Moon designed by JAXA



Target: South Pole region

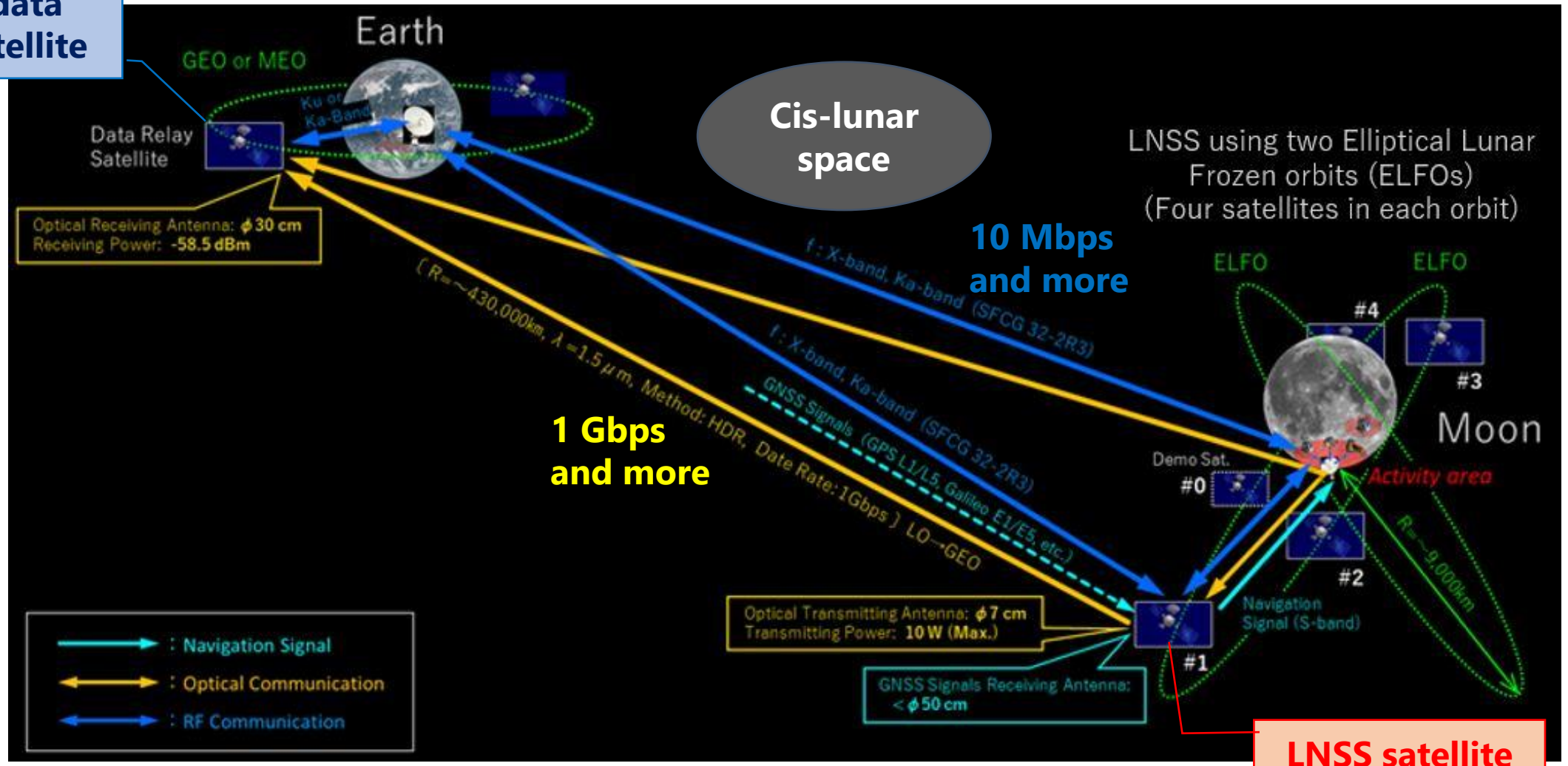
LNSS satellite broadcasting one-way navigation signal

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

JAXA's plan

LNSS also provides the communications service between Moon and Earth (X-band, Ka-band, and optical links)

Earth data relay satellite



LNSS satellite functioning as data relay satellite

JAXA's plan

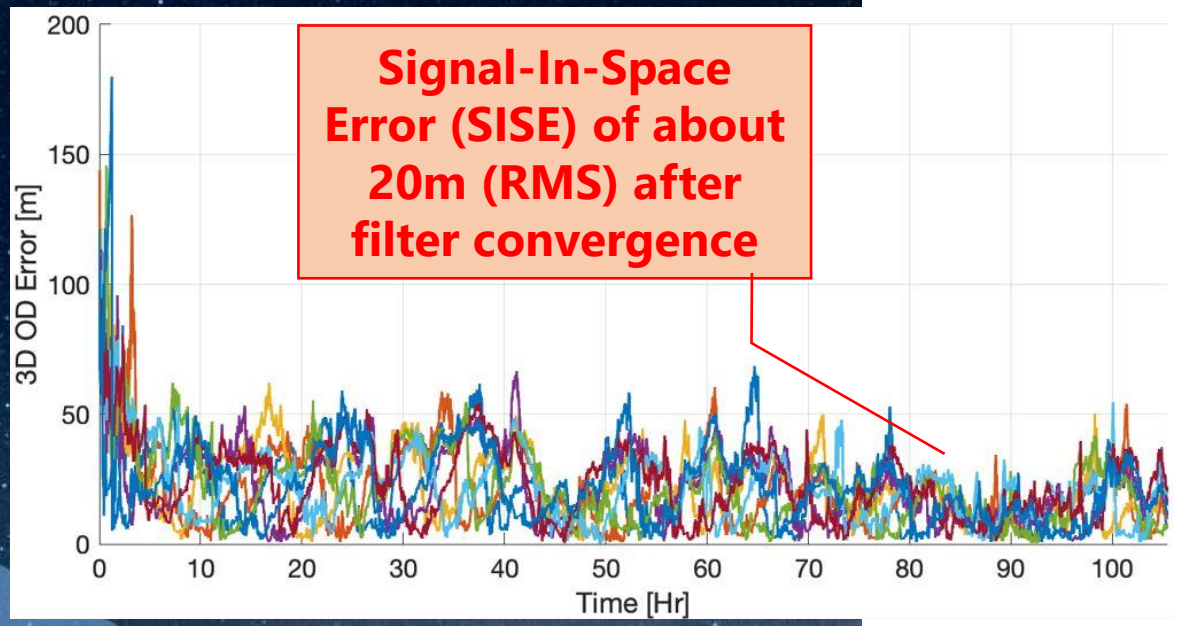
GNSS weak signal navigation for LNSS satellites, making the lunar PNT autonomous

GNSS satellites

Cis-lunar space

weak signal

JAXA LNSS satellite

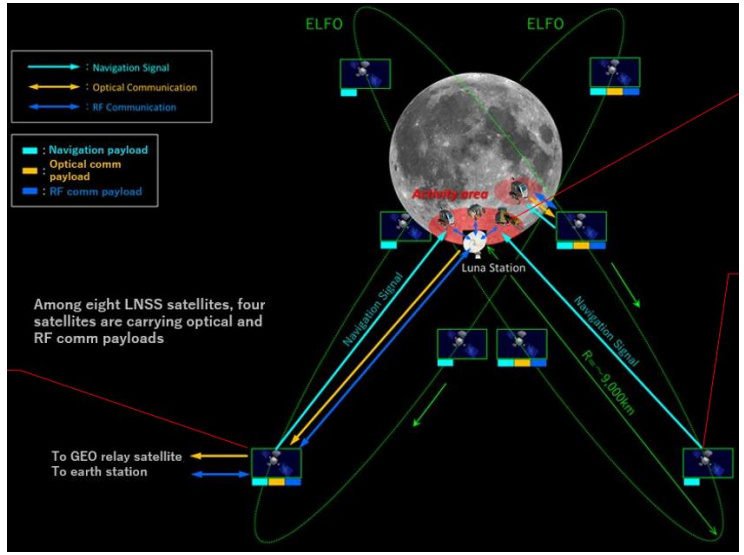


Lunar Comm & Nav (CPNT) systems by US, Europe, Japan

ESA Moonlight LCNS (2027～)

NASA LCRNS (2026～)

Japan LNSS (2028～)



LCNS:
Lunar Communications and Navigation Services

LCRNS:
Lunar Communications Relay and Navigation Systems

LNSS:
Lunar Navigation Satellite System

Towards the establishment of 'Moon GNSS' called LANS

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

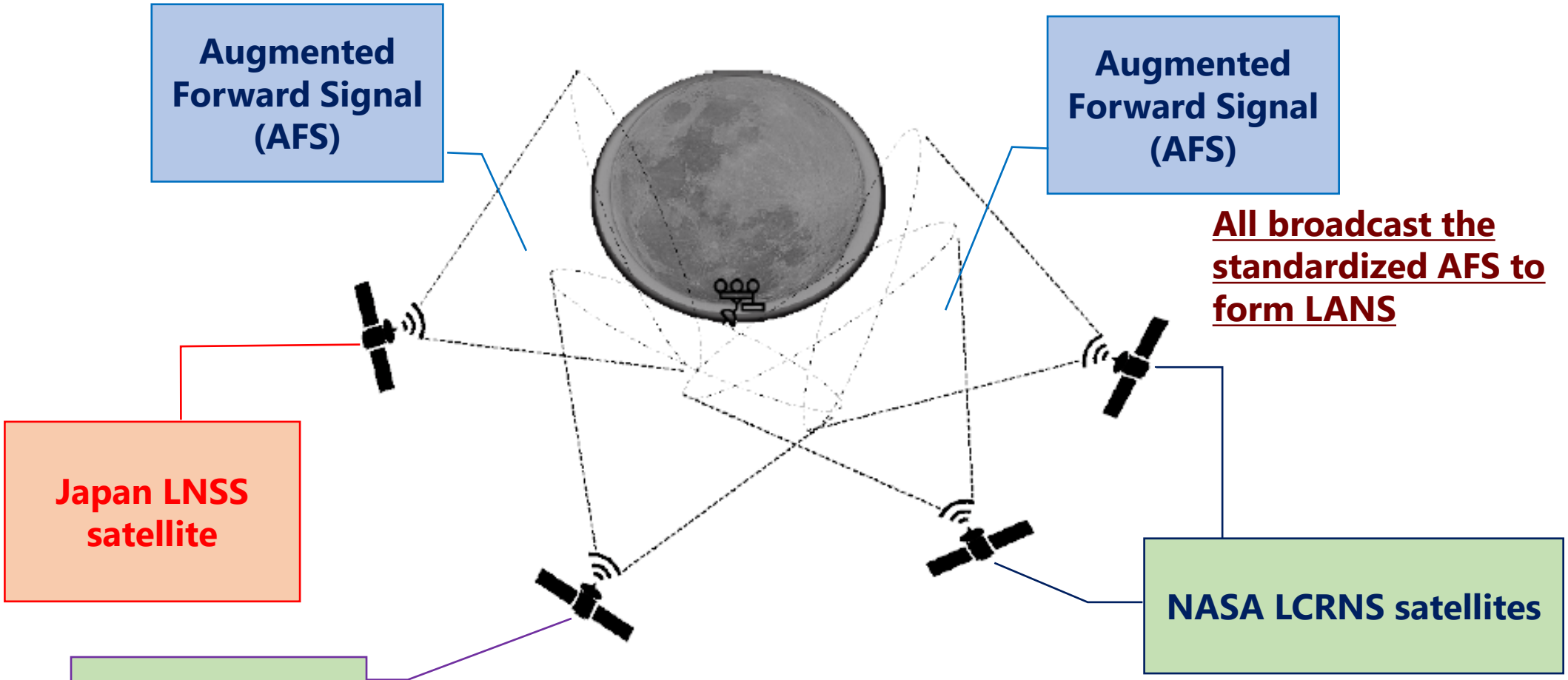


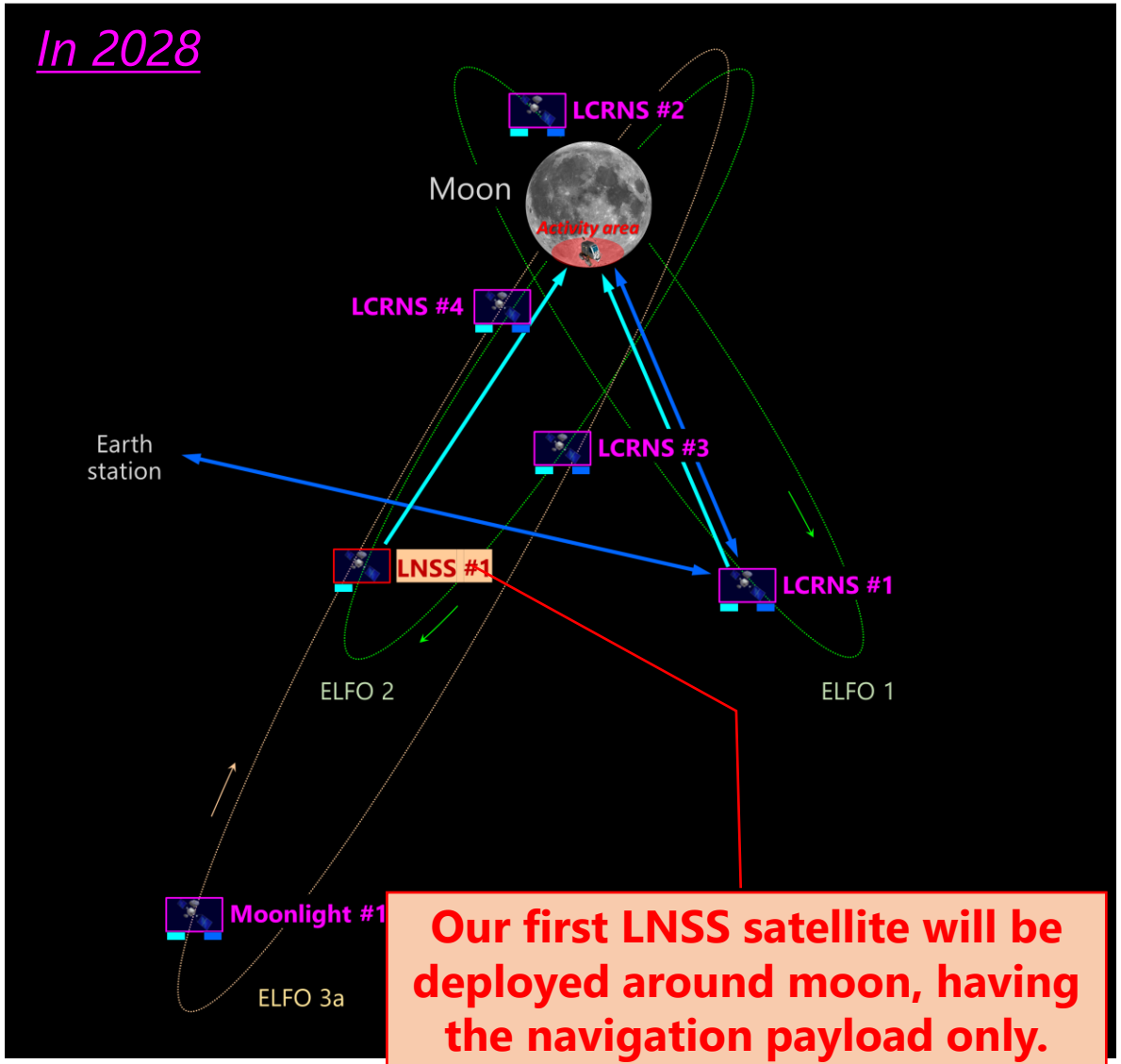
Figure 10 - LANS PNT Concept Provided by LunaNet Nodes

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

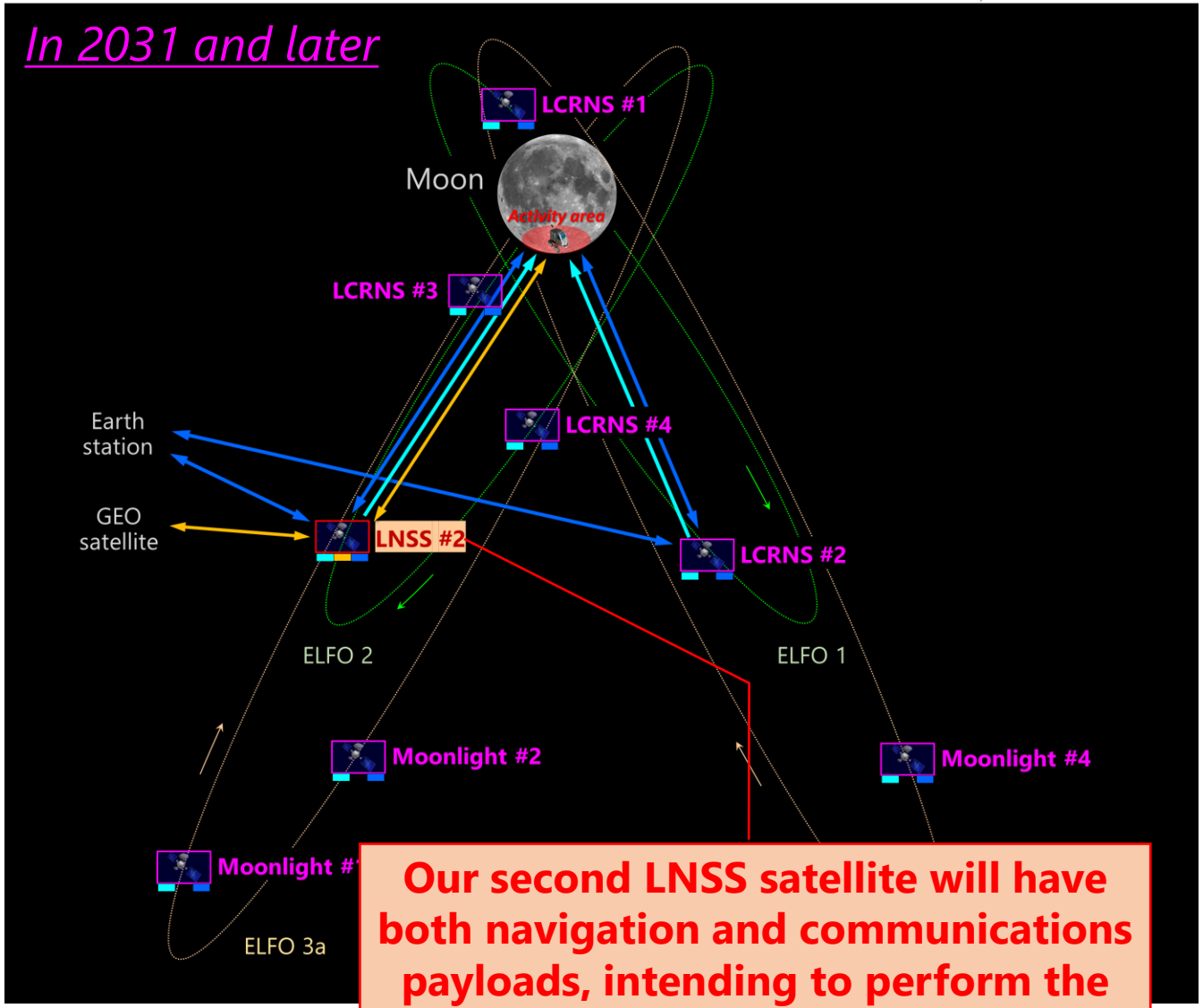
JAXA's plan

LNSS contribution towards the establishment of the LANS

※ LNSS, ESA LCNS, and NASA LCRNS orbits are notional in figures below



Our first LNSS satellite will be deployed around moon, having the navigation payload only. The LANS interoperability and PNT accuracy will be evaluated



Our second LNSS satellite will have both navigation and communications payloads, intending to perform the optical communications experiment between Moon and Earth

Collaboration with ESA and NASA and LunaNet Interoperability Specification (LNIS)

Lunar Systems Relationships

LunaNet

Framework for Standardized Interoperable Services, umbrella under which many providers collectively work.
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

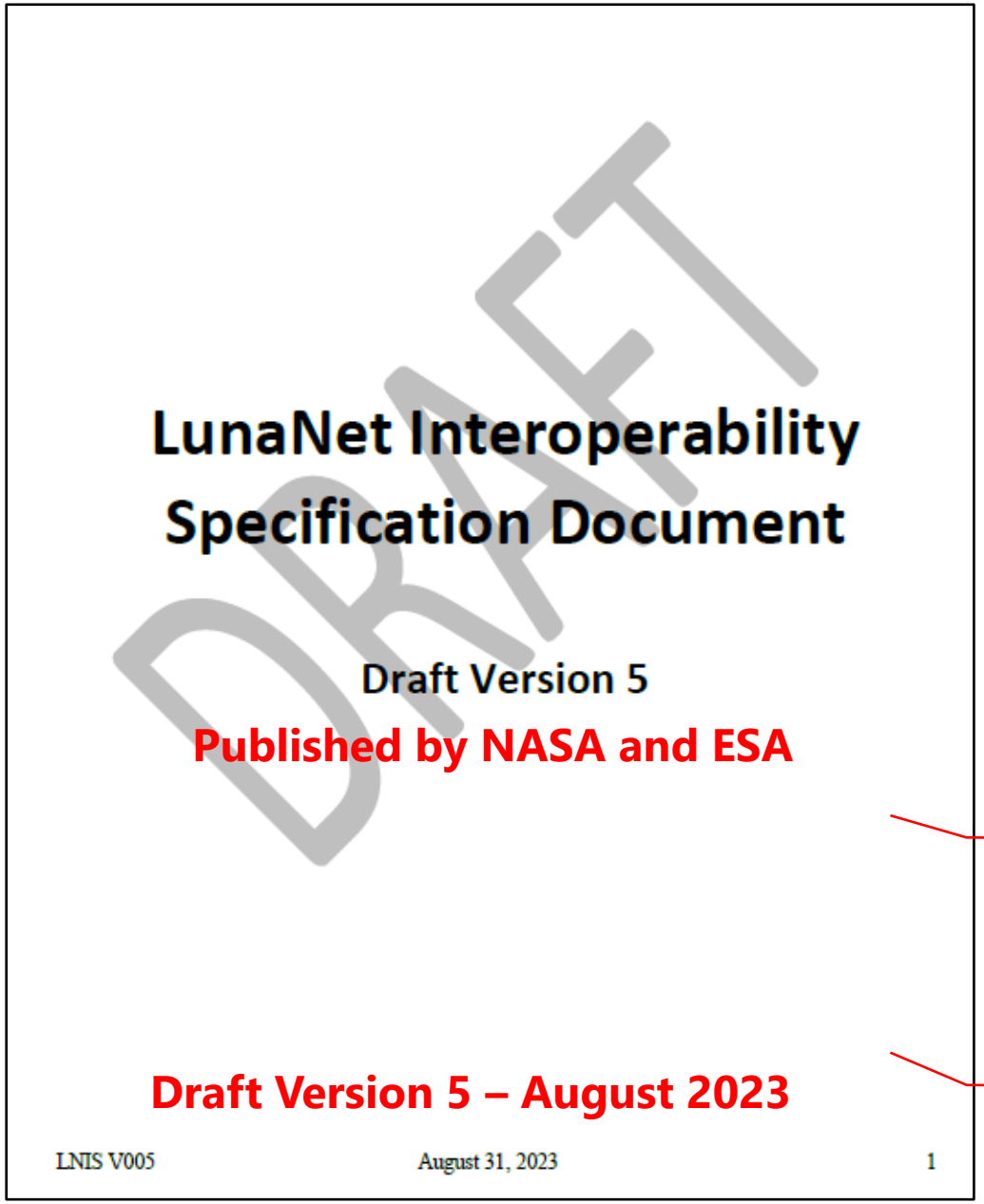
Others

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

For interoperable and safe navigation, LunaNet systems shall use the Lunar Reference System (LRS). LunaNet Interoperability Spec defines an Applicable Document 5 (AD5) to define an interoperable LRS & Lunar Time System set with associated criteria (e.g. tolerances).

A canonically defined set of components for consistent and accurate navigation.

LunaNet Interoperability Specification (LNIS) Draft Version 5 now available on the internet



The LNIS and its applicable document includes:

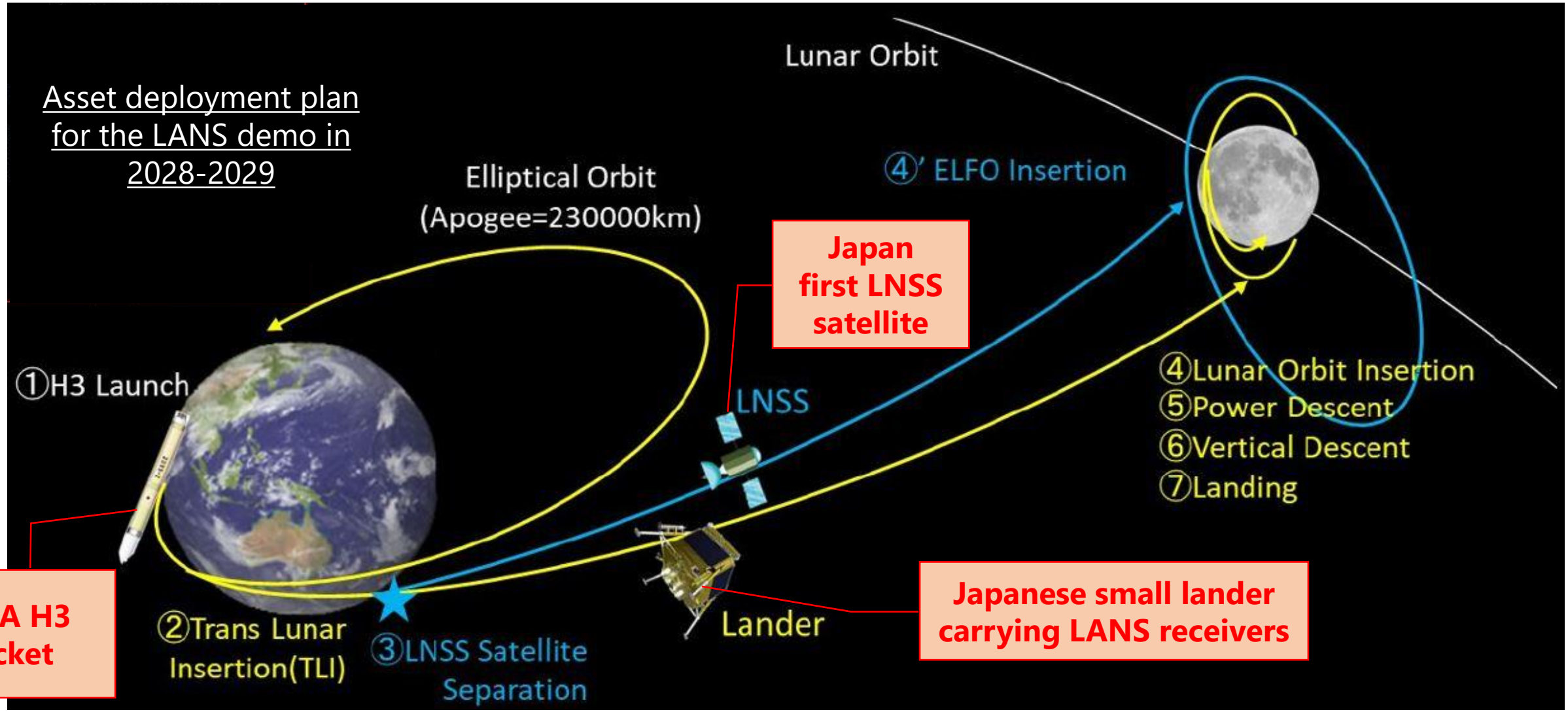
- **Concept of the LANS, message format of the Augmented Forward Signal (AFS), signal frequency, power, etc.**
- **Signal-In-Space-Error (SISE) requirement for LunaNet Service Providers (LNSPs)**
- **Lunar Reference System and Lunar Time System Standard**

The Japan LNSS complies with the LNIS to become interoperable and comparable with the other LNSPs

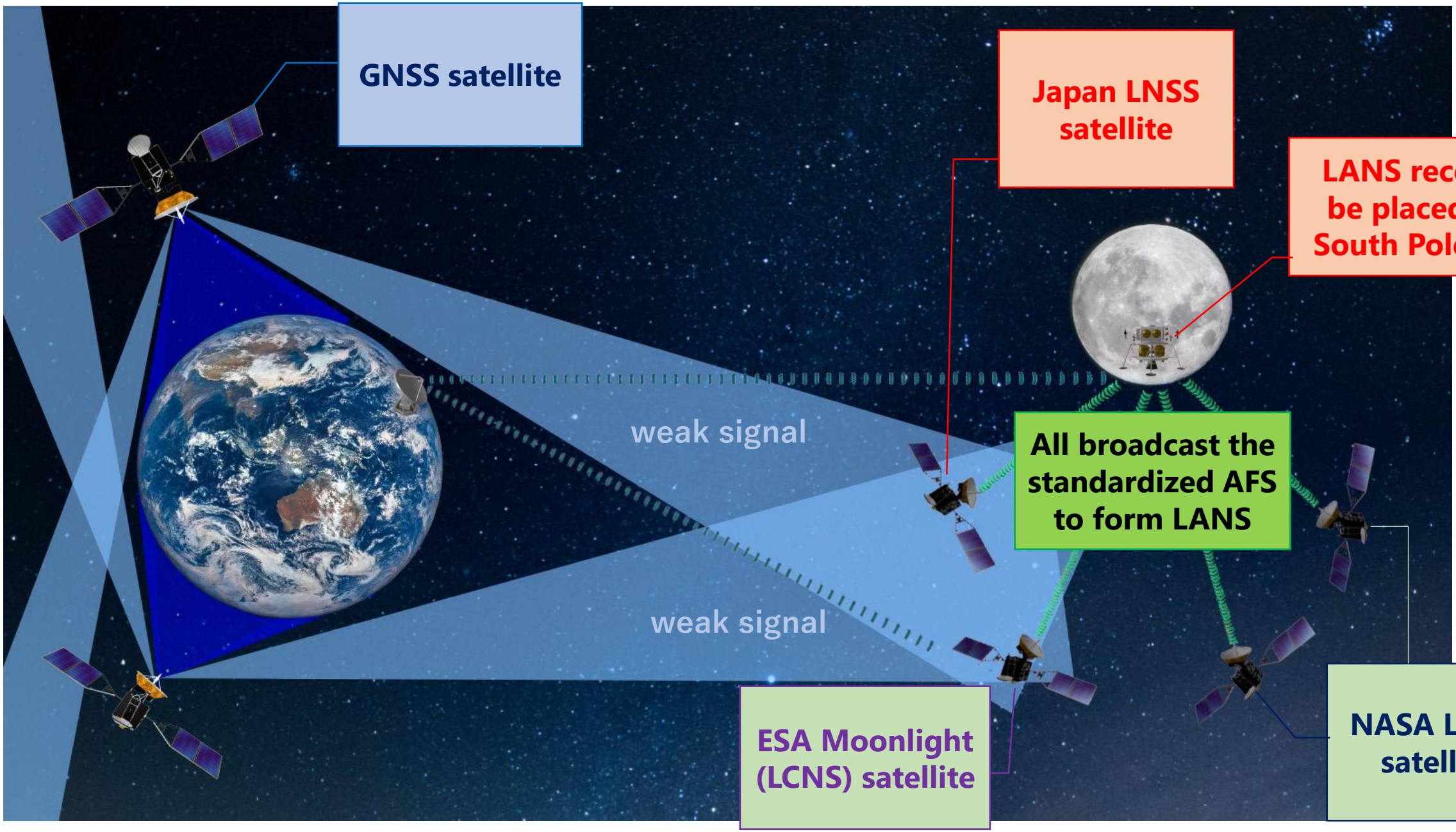
Thanks to NASA and ESA, JAXA has joined the LNIS working groups and is now working with NASA and ESA for the publication of the LNIS Version 5 (publication effort ongoing)

Plan of LANS interoperability and PNT demonstration mission targeting in 2028-2029

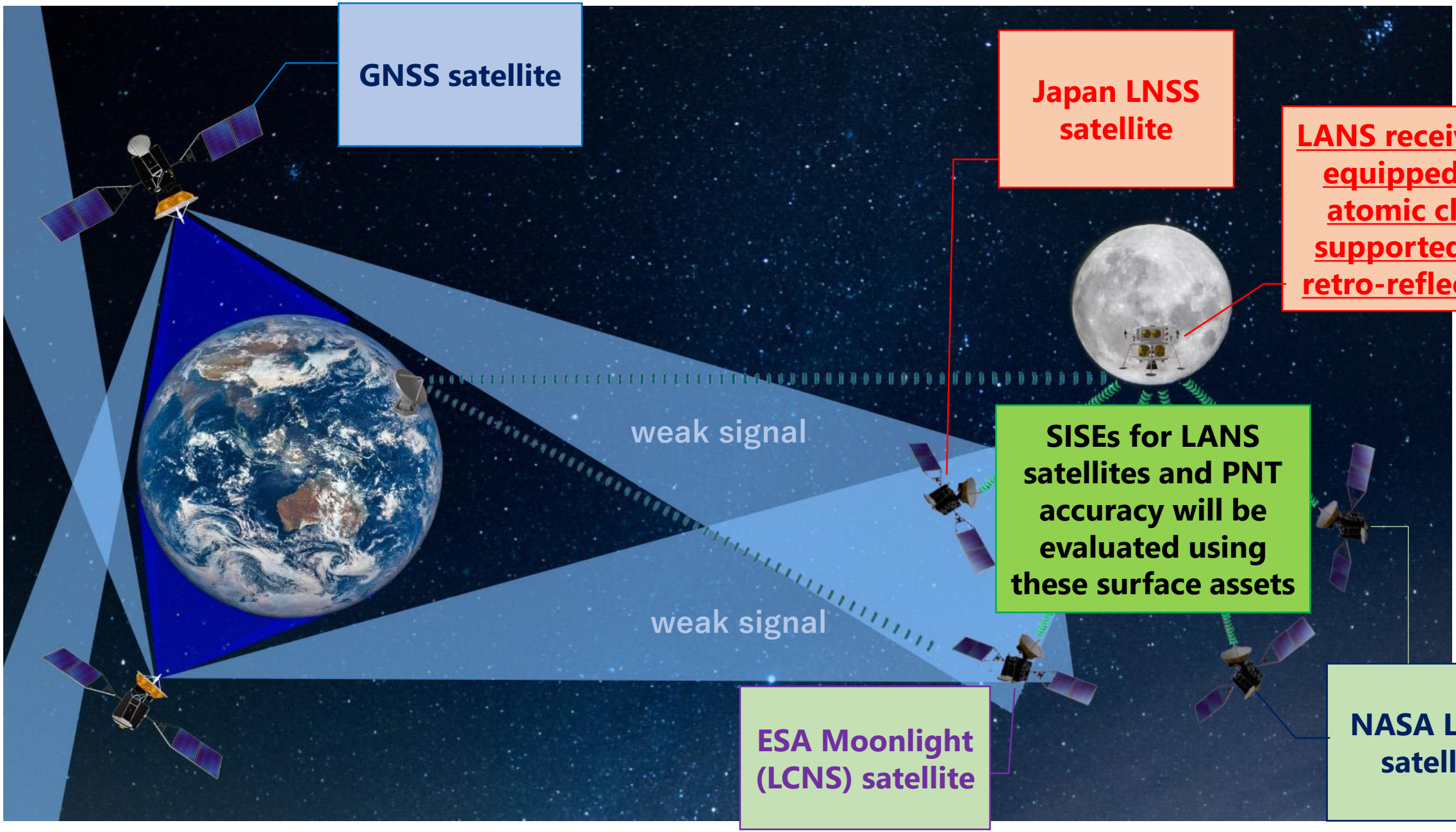
JAXA is proposing the first-ever ESA-NASA-JAXA LANS interoperability demonstration
LANS = Lunar Augmented Navigation Service



# LANS receiver to be placed at the South Pole region will receive all broadcasted AFSs
AFS = Augmented Forward Signal

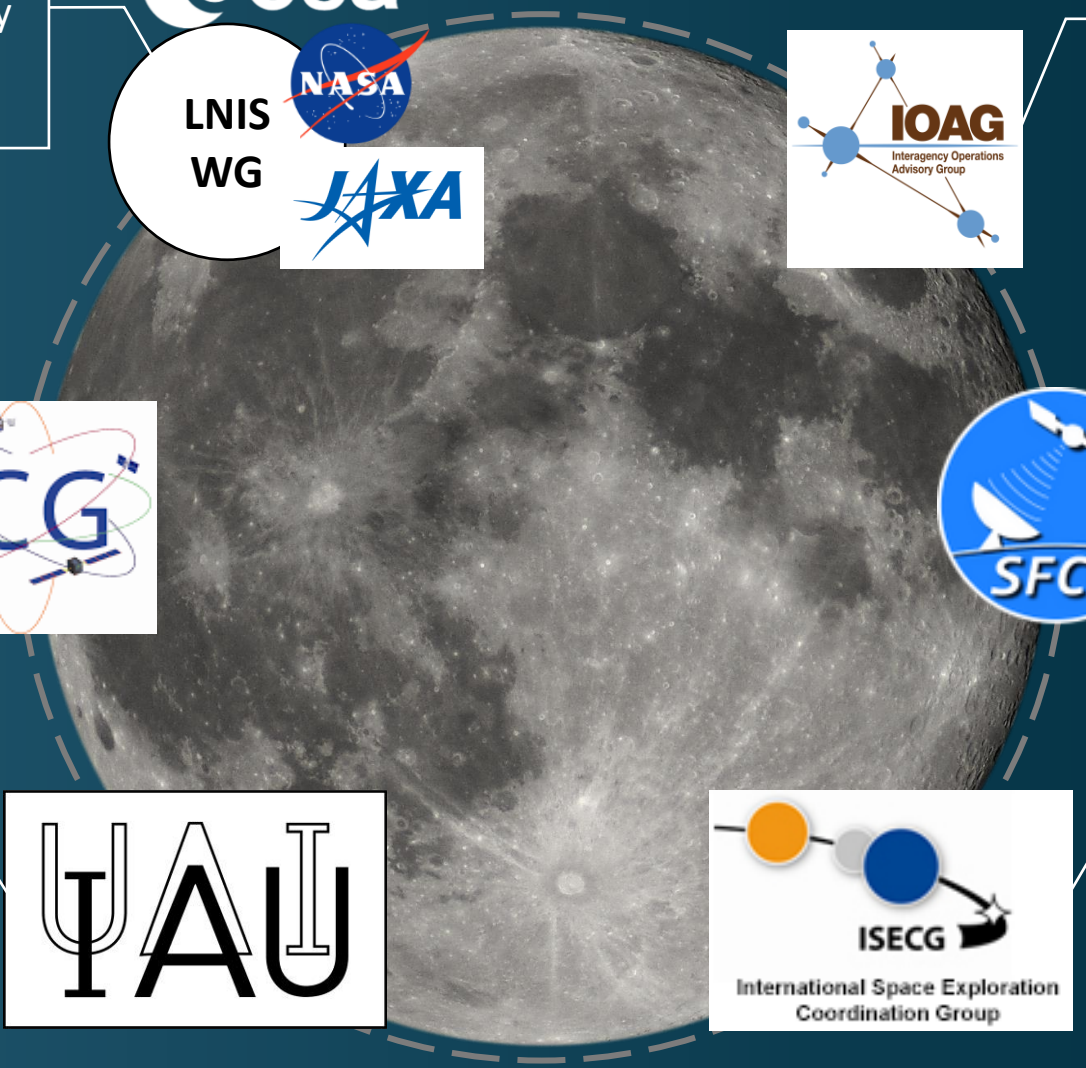


# This mission is also expected to contribute to the lunar reference frame and the LTC
LTC = Coordinated Lunar Time



International lunar PNT activities

International Organizations Currently Involved in Lunar PNT



LunaNet Interoperability Specification (LNIS) development

LNIS WG

Space agency lunar PNT (LunaNet) governance coordination

IOAG
Interagency Operations Advisory Group

Lunar PNT/GNSS interoperability, compatibility, availability

ICG

Space frequency coordination (lunar spectrum management)

SFCG

Lunar reference system and time system recommendations

IAU

Exploration mission high-level roadmaps and performance needs

ISECG
International Space Exploration Coordination Group

Outcomes of ICG-17 (International Committee on GNSS) last year

- Lunar PNT presentations were made from NASA, ESA, JAXA, China, and India

- Joint statement on encouraging interoperability and compatibility among the respective lunar PNT systems was adopted

- Recommendation on holding joint ICG-IOAG multilateral workshop on cislunar PNT was adopted

Takeaways

・The international collaboration between JAXA, ESA, and NASA is ongoing on the LunaNet Interoperability Specification (LNIS). The Lunar Augmented Navigation Service (LANS) becomes the “Moon GNSS” and lunar users will enjoy the interoperable lunar PNT system of systems from the get-go

・JAXA is proposing the joint LANS interoperability demonstration mission in 2028-2029 and ESA and NASA are currently assessing their respective participation through the collaborative discussion

・Several countries are planning their lunar PNT systems around/on the moon and the international coordination becomes much more important from this year onwards. The interoperability and compatibility among the respective systems become a key issue for the successful, international lunar PNT system of systems

Joint ICG-IOAG Multilateral Cislunar PNT Workshop

At VIC in February 2025

Organization Committee

ICG:

China/CAST: Xinuo Chang

Europe/ESA: Javier Ventura-Traveset

India/ISRO: Ashish Shukla

Japan/JAXA: Masaya Murata

USA/NASA: Joel Parker

SFCG Liaison: Catherine Sham (NASA)

LNIS WG Liaison: Cheryl Gramling (NASA)

IOAG:

Jim Schier (NASA, IOAG Chair)

Stephen M. Lichten (NASA JPL)

Matthew Cosby (UK Space Agency)

Corali Roura (NASA, IOAG CSLG)

Angela D. Peura (NASA, IOAG Secretariat)

Jidesh Jidesh（ISRO）

Shri Madhav Nakhani（ISRO）