ArkEdgeSpace

Lunar PNT Spectrum Sharing Considerations: A Japanese Industry Perspective

2nd Joint ICG-IOAG Multilateral Cislunar PNT Workshop
Vienna, Austria

Feb. 12th, 2026

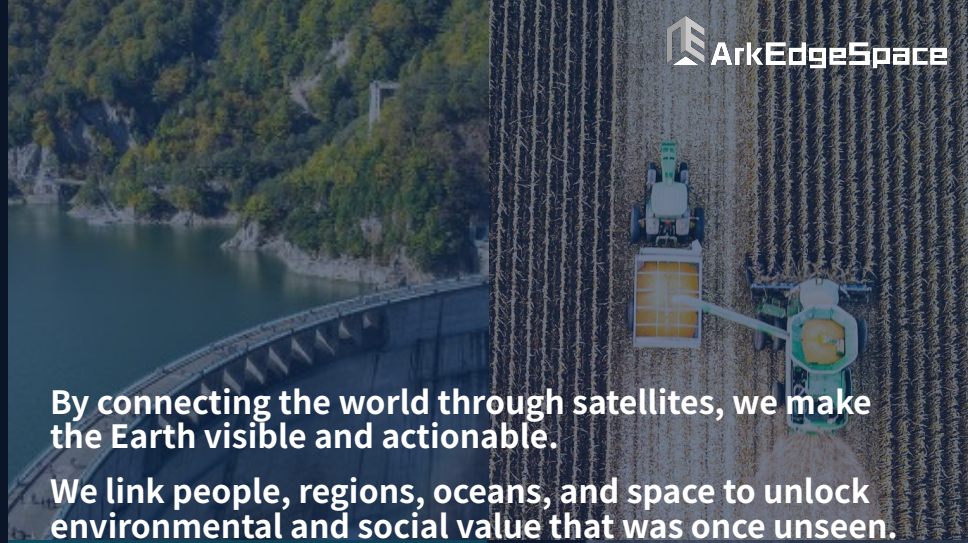
Toshihiro SHIBUKAWA

01

Introduction

Our Mission

Empowering people with satellites for a prosperous future.



By connecting the world through satellites, we make the Earth visible and actionable.

We link people, regions, oceans, and space to unlock environmental and social value that was once unseen.

Placing people at the center, we build space systems as critical infrastructure, extending new economic spheres from land to sea, and onward to space.

As a comprehensive micro-satellite system integrator, we deliver end-to-end solutions from planning and design to mass production and operations, driving real-world development and societal impact.

ArkEdgeSpace

Empowering people with satellites for a prosperous future.

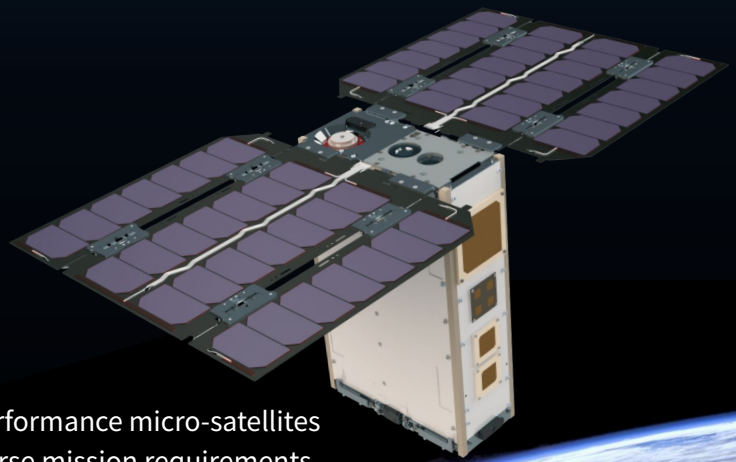
A General Integrator for Micro-Satellite Systems

Delivering end-to-end solutions for microsatellite constellations,
from design and development to mass production and operations.

Company Profile

(as of Jan. 2026)

Founded：July 2018
Headquarters：Tokyo, Japan
Total Funds Raised：$74.2M+
Total Orders & Selections：$195M+
Number of Employees：approx. 190
Launched & Operated：17 satellies



High-performance micro-satellites
for diverse mission requirements

Completion of Series B Funding (January 2025)

ArkEdgeSpace

Empowering people with satellites for a prosperous future

Series B

JPY **8** billion

(USD 51 million)

INCUBATEFUND
VENTURE GROWTH INVESTMENTS
WiL WORLD INNOVATION LAB
MUFG 三菱UFJ銀行
SMBC SMBCベンチャーキャピタル
MIZUHO みずほキャピタル
静岡キャピタル株式会社
SMBC日興証券
未来創造キャピタル Future Creation Capital
SPARX
MS&AD 三井住友海上キャピタル
HULIC
清水建設
スカパーJSAT
for Startups Capital

Key Business Growth since Series A

2022.3 (as of Series A)	2025.1 (as of Series B)

Satellite Launch and Operation

10+

In-house developed satellite 1 → 6
Third-party satellite operation 0 → 5

Accumulation of Orders & Contracts

30+billion

JPY 2.23 B → JPY 32.19 B

Number of Team Members

4.5 x

28 → 126

Total Funds Raised

3.2 x

JPY 2.7 B → JPY 10.7 B

Satellite Bus Design and Development Capabilities

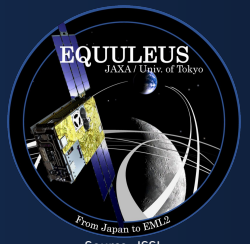
From deep space to LEO constellations, we pursue excellence in design, development and solutions.

Cutting-Edge Technologies for Lunar & Deep Space

- **Complex & High-Level Orbit Control**
- **Lightweight & Compact**
- **Adaptation to Harsh Environments** (Heat, Radiation and Power)

Deep-space 6U spacecraft EQUULEUS

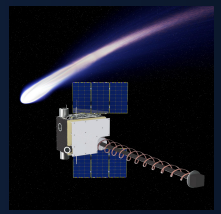
- ○ A spacecraft jointly developed by JAXA and the University of Tokyo to demonstrate Earth-Moon orbit control.
- ○ AE participated in the spacecraft's operation.
- ○ The 6th Space Development and Utilization Grand Prize Selection Committee Special Award



Source : ISSL

Long-period Comet Spacecraft Comet Interceptor

- ○ A joint mission between ESA and JAXA, where ArkEdge Space will contribute a single spacecraft.
- ○ Advanced mission to be placed in the orbit of the Sun-Earth Lagrange Point, in readiness to intercept a passing comet.

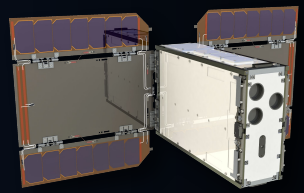


Cross-apply mission outcomes

Applications to Life back on Earth

- **Compact & High Performance**
- **Support Variety of Missions**
- **Cost-Effective & Mass Production**

Multi-Purpose Satellite Bus Series



Future Development into

- ○ 16U-Class CubeSat
- ○ 50kg-Class Micro-Satellite
- ○ 100kg-Class Micro-Satellite

Satellite Series (Including Development and Operational Track Record)

- From development to mass production of micro-satellites, we now enter the phase of full-scale launch and utilization.
- We develop diverse micro-satellites for earth observation and positioning, while expanding into new markets.

3U Satellite

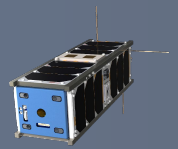
Operation

Launched in 2019

RWASAT-1

Operation

Launched in 2023



OPTIMAL-1

6U Satellite

Operational Support

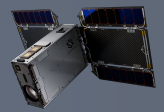
Launched in 2022

EQUULEUS

©The University of Tokyo

Operational Support

Launched in 2023

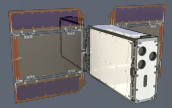


SPHERE-1 EYE

Support operation of 6U-class earth observation

Utilization Phase

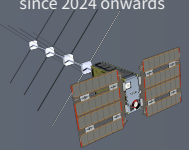
Scheduled for 7 launches since 2024 onwards, with 5 already deployed



6U Multi-Purpose Satellite Bus Series

In-Orbit Demonstration in Progress

Gen-0 was launched in Jan 2025. Scheduled for several launches since 2024 onwards

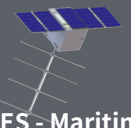


VDES Demonstration Satellite

30 to 100kg class Satellite

Under Development

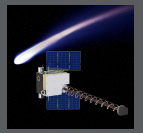
Multiple satellites scheduled for launch around 2026



VDES - Maritime Observation Satellite

Under Development

Scheduled for launch around 2029

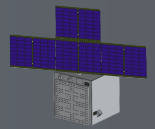


Comet Interceptor

100+ kg class Satellite

Under Development

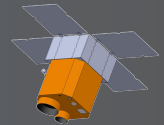
Scheduled for launch around 2028



Lunar Positioning Satellite

Under Development

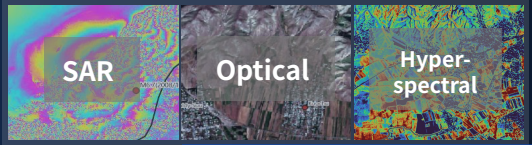
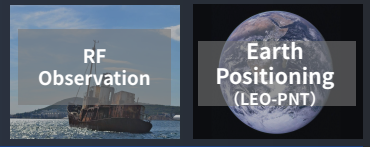
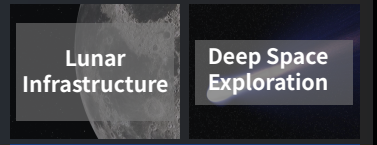
Scheduled for launch around 2027



Hyper-Spectral Remote Sensing Satellite

Capable of Supporting Diverse Missions

- Capable of developing satellites for remote sensing, IoT/VDES, radio frequency (RF) observation, positioning, as well as lunar infrastructure & deep space exploration.
- We will deliver **comprehensive solutions across fields** by utilizing satellites.

	Remote Sensing	Communication	Locations	Deep Space
				
Satellite Development	ArkEdgeSpace			ArkEdgeSpace
Service	Future Business Area			

Our Lunar PNT Activities

3 Years of Feasibility Study Work with JAXA

Have been awarded multiple contracts by JAXA for work on lunar PNT

- Conceptual studies on architecture design of lunar navigation / communication infrastructure (2022 - 2023)[*1]
- Conceptual studies on Lunar Navigation Satellite System technology demonstration mission (2022 - 2024) [*1]
- Prototype development of onboard navigation payload of lunar navigation system (2023 - 2024)

Awarded Space Strategy Fund for Lunar Navigation System Demonstration Satellite Development

Awarded contract for JAXA Space Strategy Fund Technology Development Theme "Lunar Positioning System Technology" on November 22, 2024 [*2]

- Progressing to actual development of Lunar PNT Payload and Demonstration Satellite

Further Feasibility Studies for LANS Receivers and FOC Level Systems

Awarded 3 additional contracts from JAXA for FOC level feasibility studies[*3] and LANS receivers

- Working on not only satellite development, but also future service providing and receiver manufacturing

*1: https://arkedgespace.com/en/news/2022-01-11_jaxa_moon
*2: https://arkedgespace.com/en/news/2024-11-29_jaxaspacestrategyfund_lnss
*3: https://arkedgespace.com/en/news/2024-12-11_jaxafeasibilitystudy_lnss

02

Lunar PNT Frequency Considerations

LunaNet and Lunar PNT Interoperability

- Under the LunaNet framework, mainly driven by NASA/ESA/JAXA, documents such as the LunaNet Interoperability Specification (LNIS) and LunaNet Signal-In-Space Recommended Standard (LSIS) are published to realize interoperability between systems
  - Frequency coordination plans are based on SFCG recommendations
  - Therefore, following LNIS/LSIS will lead to proper frequency occupation assumed by SFCG

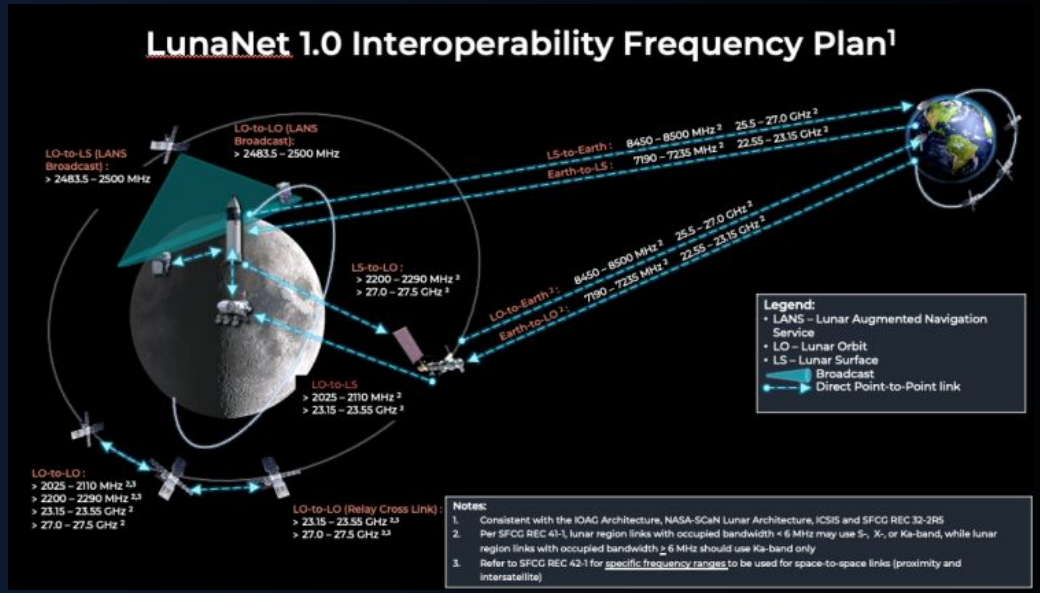
LunaNet Interoperability Specification Document

Version 5

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



LunaNet Interoperability Specification - Version 5, NASA

Items Introduced Inside LNIS/LSIS

- SISE Performance (Position / Velocity)
- **Signal Frequency Band, Carrier Frequency (and maximum offset)**
- Signal Polarization, Axial Ratio
- Phase Noise, **Spurious Transmissions (In-band, Out-Of-Band)**, Correlation Losses
- **Lunar Surface Received Power Levels (Maximum / Minimum)**
- Modulation, Spreading Codes
- Message Structure and Content

All of these are to be defined in a SIS-ICD for each lunar PNT provider.

2.3.1.1. FREQUENCY PLAN

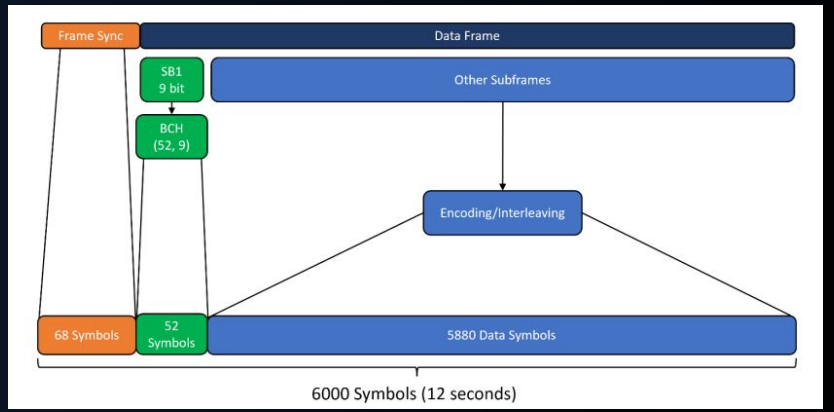
LSIS-010: Frequency Band
The frequency band allocated to the AFS signal shall be in S-band between 2483.5 MHz and 2500 MHz.

Note: This is in line with Space Frequency Coordination Group (SFCG) recommendation 32-2, that identifies the band between 2483.5 MHz and 2500 MHz for "In-situ Lunar based RNSS to Lunar Orbit and Lunar Surface."

LSIS-020: Carrier Frequency
The Augmented Forward Signal carrier frequency shall be 2492.028 MHz.

Table 4 - Received Minimum and Maximum Power

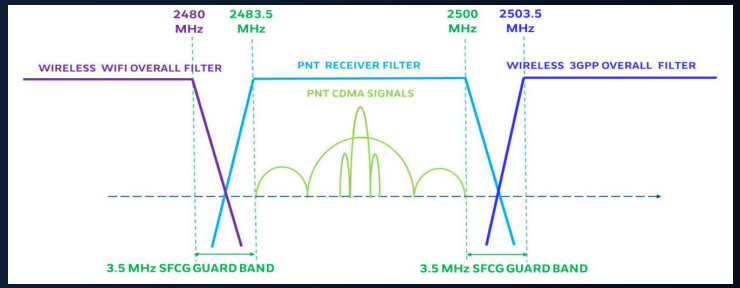
Received minimum power [dBW]	Received maximum power [dBW]
-160 {LSIS-TBC-2012}	-147 {LSIS-TBC-2013}



AD-1 Volume A – LunaNet Signal-In-Space Recommended Standard – Augmented Forward Signal, NASA

Frequency Coordination and Filtering

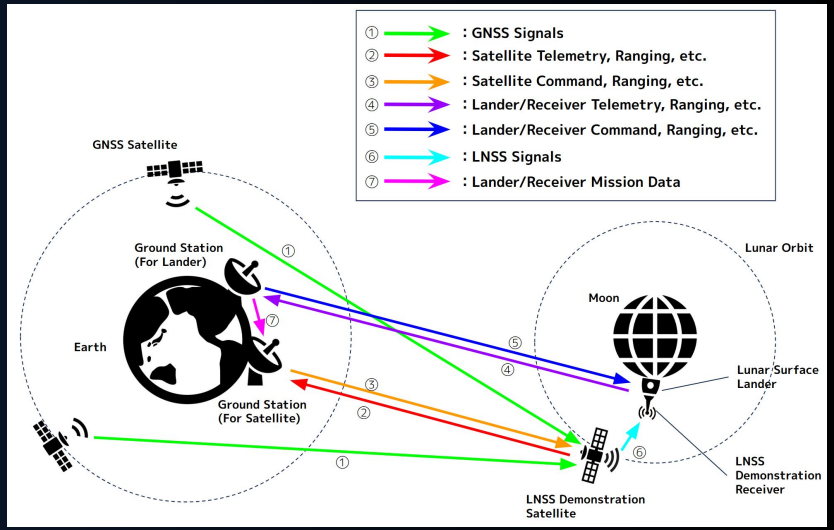
- For lunar PNT, 2483.5 – 2500.0 MHz is assumed to be used in SFCG and LNIS, however there still is no status in the ITU radio regulations
  - As a Japanese lunar PNT provider, under cooperation with JAXA and MIC, ArkEdge Space will prepare ITU filing as soon as this signal is included in the radio regulations (expected in WRC-27)
- In ArkEdge Space, we are designing the LNSS signal to be compatible with LNIS/LSIS
  - The signal ICD, required in LSIS, is still under work and will be prepared before ITU filing
- Lunar surface communication is expected in adjacent bands, and mutual interference is a concern when lunar surface development accelerates
  - Affects both receiver and transmitter design



Issler, J. L., et al. (2025). Ensuring Lunar and Martian in situ PNT Coexistence with Surface Wireless by Respecting SFCG Recommendations. *In Proceedings of the 38th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2025)* (pp. 834-848).

Filtering Consideration in Demonstration Mission

- In the initial demonstration mission of LNSS (scheduled in 2029), we plan to have one satellite and one receiver on a lander to demonstrate LNSS signal transmission and reception
- SFCG REC 43-1 recommends a maximum aggregated PFD limit of -121 dBW/m^2/MHz at the PNT receiver antenna end
  - For the demonstration mission, we assume no other vehicles near the lander using wi-fi and 3GPP, therefore will only consider interference from the lander itself
- On the other hand, we will consider use of filters for future practical receivers, which will be utilized under environment with background emissions related to wi-fi and 3GPP



LNSS Demonstration Mission

LANS Signal Transmission and RA Interference

- One reason for Lunar PNT to be in S-band is to avoid interference with Radio Astronomy (RA)
  - CNES has pointed out the interest of C-band (4800 - 5000 MHz, especially 4990 - 5000 MHz) for RA in the Shielded Zone of the Moon (SZM)

Interest of C-band for RA in the SZM for the Radio Astronomers (1)

cnes

C-band (4800-5000 MHz) and **its neighbourhoud** is very important for RA on Earth and in the SZM. This band contains a spectrum line (H_2CO) used for studies of interstellar clouds and of the dynamic formation of the universe (central frequency with Doppler shift **above** and below). It is also used for VLBI observations.

These 2 bands 4.8-4.99 GHz and 4.99-5.0 GHz (primary status on Earth) are observed by radiotelescopes notably in Germany, Italy, Netherlands, UK, Sweden ...

Interests of RA observations of C bands from the SMZ include the issue of their radio-pollution on Earth, as well as the interferences in their neighbourhood, and VLBI observations in 4990-5000 MHz considering Moon-Satellites-Earth baselines for instance. **RA Observations in 5000-5030 MHz (a RA band in the SZM) and above are also important for RA in SZM**.

The ASTRON russian Radio Astronomy satellite made observations notably below and **above** 5000 MHz. It has an apogee at 390000 km (a « lunar » distance), and a 10 meters deployable parabolic RAS antenna ➔ ➔ ➔ ➔ ➔

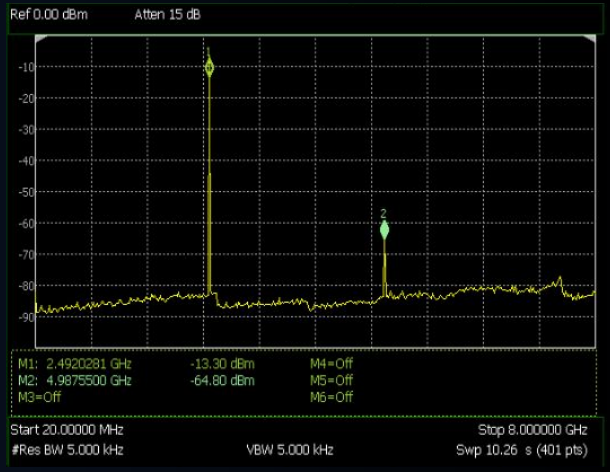
Independantly of ITU REC and ITU RR, there is an interest for RA continuum and VLBI observations in C-band. ➔ This is a sufficient reason to not accept an in-situ lunar PNT C-band

5 © cnes

CNES, "Lunar and Martian in-situ PNT frequency bands, and guard bands". https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17.02.09.rev1.pdf . ICG-17, Madrid, Spain.

LANS Signal Transmission and RA Interference

- The 2nd harmonic spurious emissions of the LANS signal directly overlaps with the C-band RA protected bands
  - Fundamental (S-band): 2483.5 - 2500.0 MHz
  - 2nd Harmonic Range: 4967.0 - 5000.0 MHz
  - Target Protected Bands: 4800.0 - 4990.0 MHz, 4990.0 - 5000.0 MHz
- The amplifier we are developing for LANS signal transmission demonstrates this spurious
  - -50 dB compared to fundamental signal
  - Will work for improvement to comply with LSIS maximum out-of-band emission requirements (TBW in future revisions)
- In initial stages of lunar PNT system operation, time-division management may be adopted, considering the small number of users



CW Spectrum of Amplifier

03

Conclusions

Conclusions

- By following LunaNet Interoperability Specification (LNIS) and LunaNet Signal-In-Space Recommended Standard (LSIS), lunar PNT service providers can transmit signals with proper frequency occupation assumed by SFCG
- However, the following interferences are concerned for S-band lunar PNT signals
  - 3GPP and wi-fi in adjacent bands for the receiver side
  - Radio astronomy bands for the transmitter side
- As ArkEdge Space, we will consider these interferences to a certain extent to balance with fast development to meet our schedule in the demonstration mission, but at the same time, will start to work on studies for future practical utilization of lunar PNT systems

Acknowledgement

- Development of the navigation payload of the LNSS demonstration satellite is supported by the Space Strategy Fund under the project titled: Development of Lunar Positioning System Technology (Project No. JPJXSSF24ME13001). We would like to express our gratitude to JAXA for all of their support.