Lunar Communications for Artemis Program

IPNSIG Academy Keynote

Oct 30th, 2024

KDDI Corporation

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Tomorrow, Together
KDDI

Shuichi Ichimura

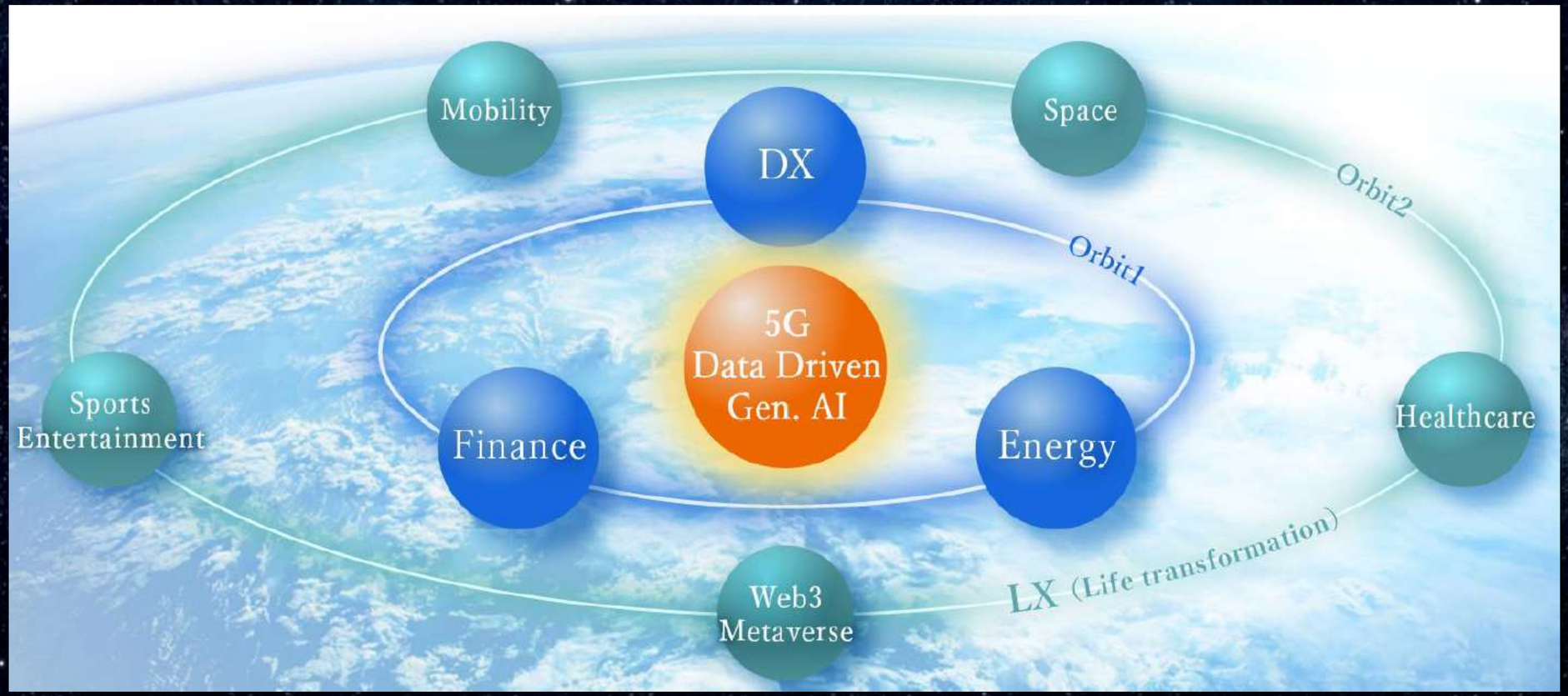
Strategy Lead of Space Business and Technology

Who we are

Tomorrow, Together
KDDI

Japanese Telecommunications Company

- ✓ Number of Employees: 61,288 (as of March 2024)
- ✓ Connects 190 countries with fiber-optic subsea cables
- ✓ 40+ Data centers in 13 countries

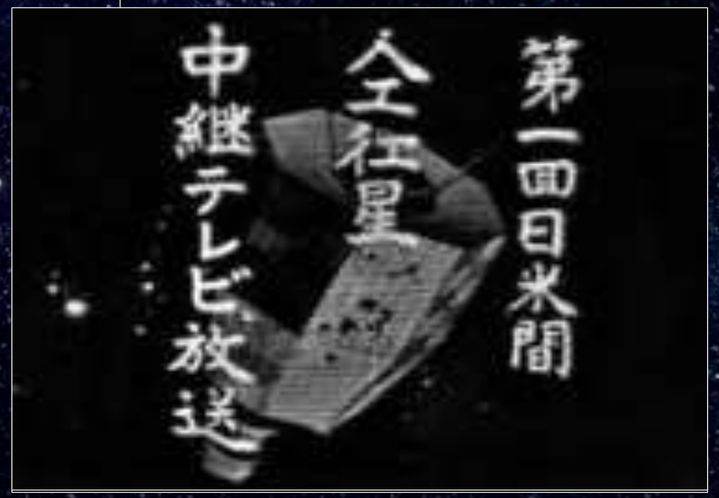


History of KDDI's SATCOM Services

We have 60+ years of connecting the world with SATCOM

1960-70s | 1980s | 1990s | 2000s | 2010s

- *60* First communication satellite (US)
- *63* Ibaraki Earth Station
- *69* Yamaguchi Earth Station
- *71* Video transmission for Munich Olympics
- *77* Inmarsat service (maritime)
- *79* Video transmission from Antarctica
- *90* Inmarsat service (aeronautical)
- *98* Video transmission for Nagano Olympics
- *05* Iridium Service launched
- *09* BGAN Service launched
- *11* the Great East Japan Earthquake
- *13* VSAT for Vessels
- *22* Starlink Service launched



'63 the world's first trans-Pacific television relay

'98 Nagano Olympics

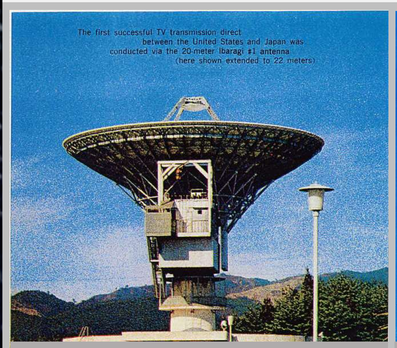
'11 disaster-relief activity of the Great East Japan Earthquake

Source: "KDDI corporate history"

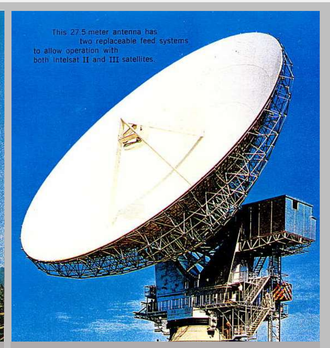
KDDI's contribution to satellite communication technologies

1. Development of earth station's antenna

Large-scale antennas with novel technologies



World's first Cassegrain antenna for satellite communications

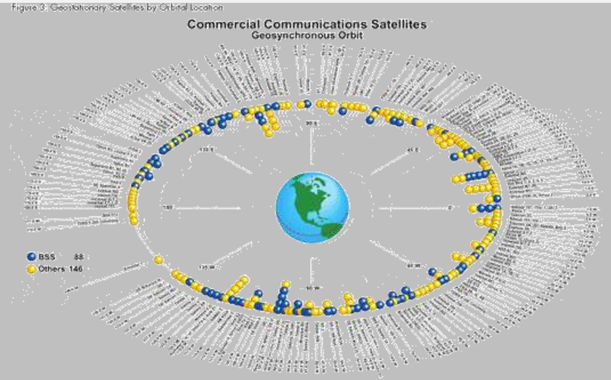


World's first Intelsat standard-A antenna

Intelsat standard-A antenna with 4 times beam feeding method

2. Optimization of satellite locations in GSO

Contribution to equitable access of GSO orbit



Development of "Orbit-2" software for the use of FSS plan design

3. R&D in digital mobile satellite communications

Development of various Inmarsat standards

4. Video coding with compression

Video transmissions for international events

KDDI’s Yamaguchi Satellite Communication Center

Our Teleport in Yamaguchi has been the gateway since 1969

Since 1969, 20 Antennas

Space X’s Starlink

We have been partnering with Space X since 2020 To provide Starlink services in Japan

Falcon 9

Credits: SpaceX

Starlink Business has already been used in various cases

Construction site

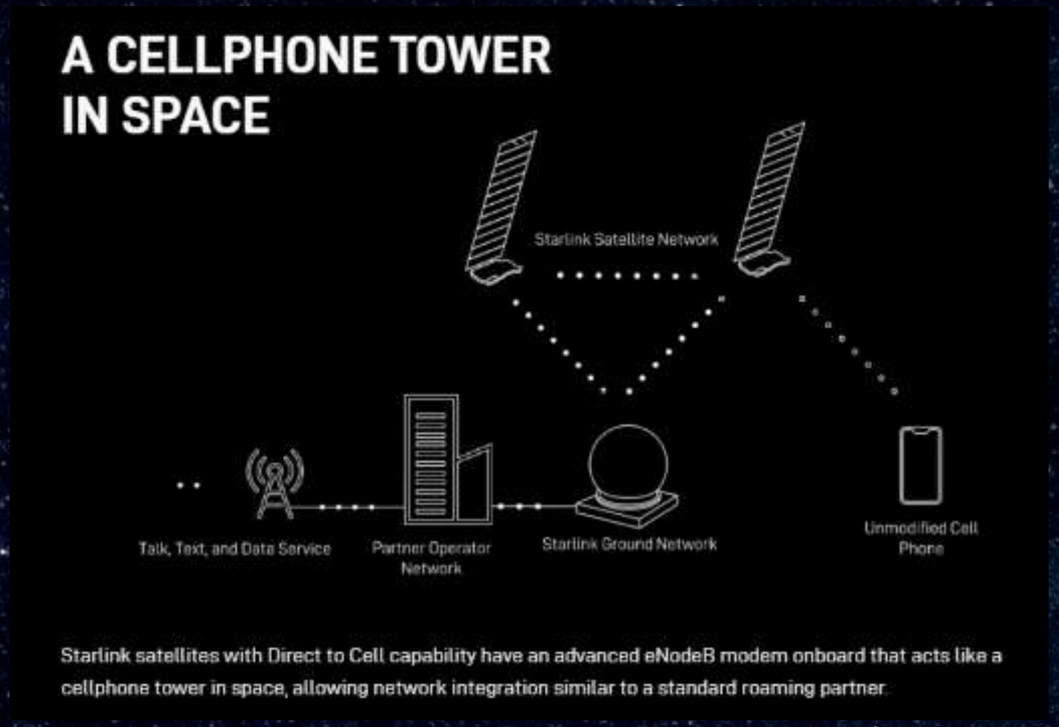
Remote monitoring

Disaster

Maritime

Direct to Cell Service with Starlink

KDDI signed with SpaceX to provide D2C service to Japan



Credits:SpaceX

- KDDI and SpaceX will provide Direct-to-Cell service leveraging Starlink satellites and KDDI’s national wireless spectrum nationwide.
- We plan to start with SMS text services no earlier than Dec 2024 and will eventually provide voice and data services.

*SpaceX successfully launched and deployed into orbit the first 6 Starlink satellites with Direct to Cell capabilities on January 3, 2024.

KDDI's Space Communications

1963～
SatCOM between US-Japan

2024/E～
Starlink Direct To Cell@Japan

2028～
Moon-Earth Direct Comm

2030～
5G on the Moon

Big picture of the Lunar Comm services

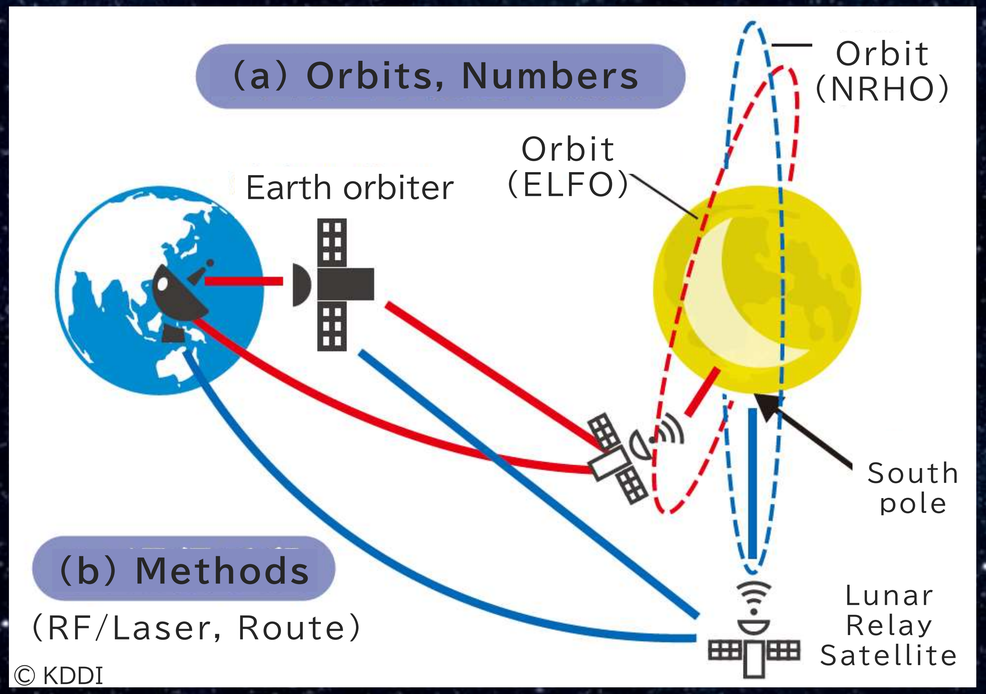
KDDI is looking for an opportunity to provide Lunar communications and navigation services

R&D for Lunar Comm (1/2)

We've been engaged in couple of R&D projects to study about E-to-E Comm Architecture

E2E Comm Architecture

Trade-off studies to meet mission requirements



JAXA Feasibility Study regarding Lunar Navigation and Communication Technologies

Lunar Surface Network

Initial study of establishing mobile network

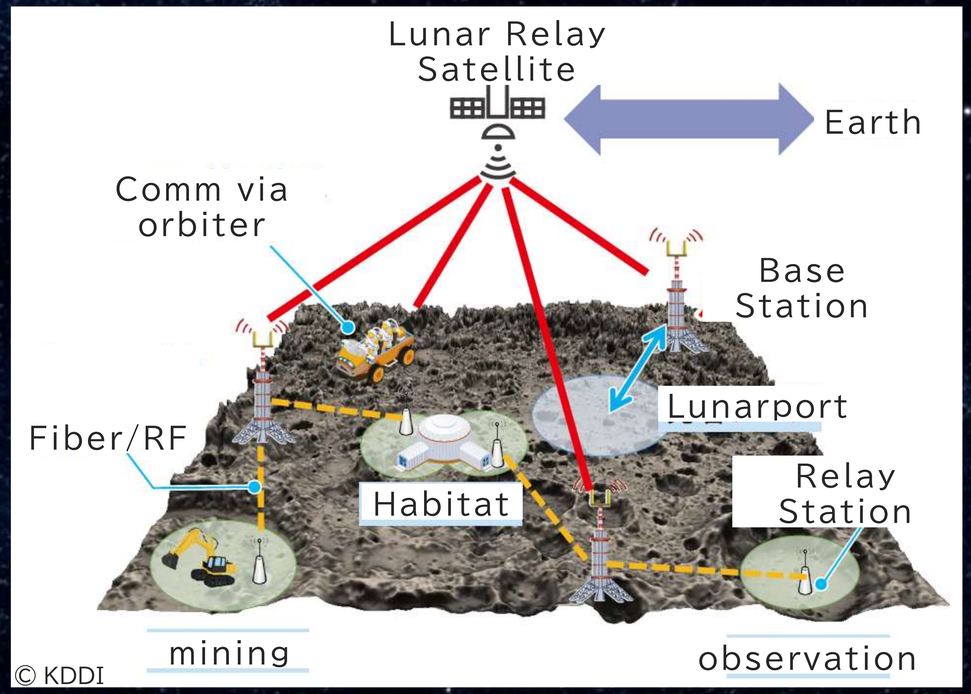
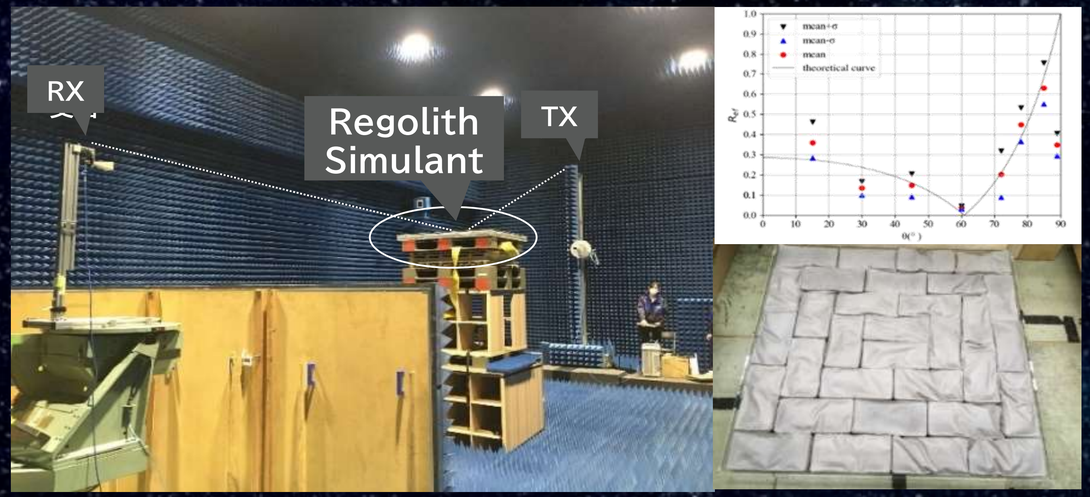


Image: Aitken valley, topographic maps of the moon in Geospatial Information Authority of Japan, https://www.gsi.go.jp/chirijoho/chirijoho41003.html

Lunar radio propagation were studied with JAXA as well

Study on Radio Propagation

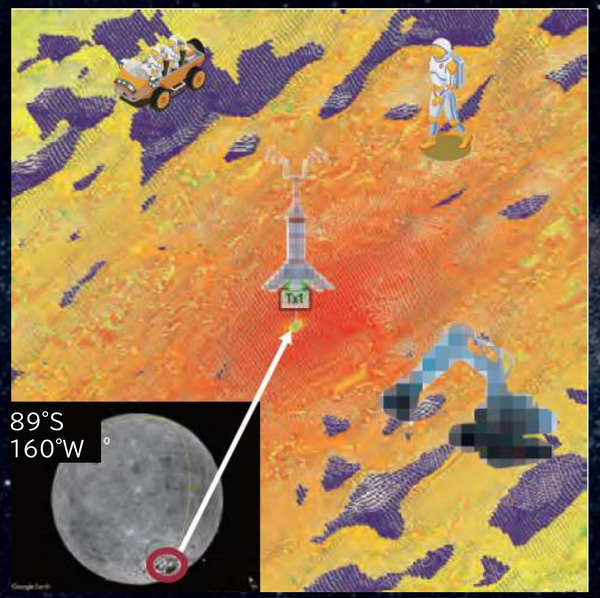
A JAXA-KDDI joint project to study
the radio propagation on lunar surface



JAXA-KDDI Research at JAXA's open innovation hub "Tansa-X."

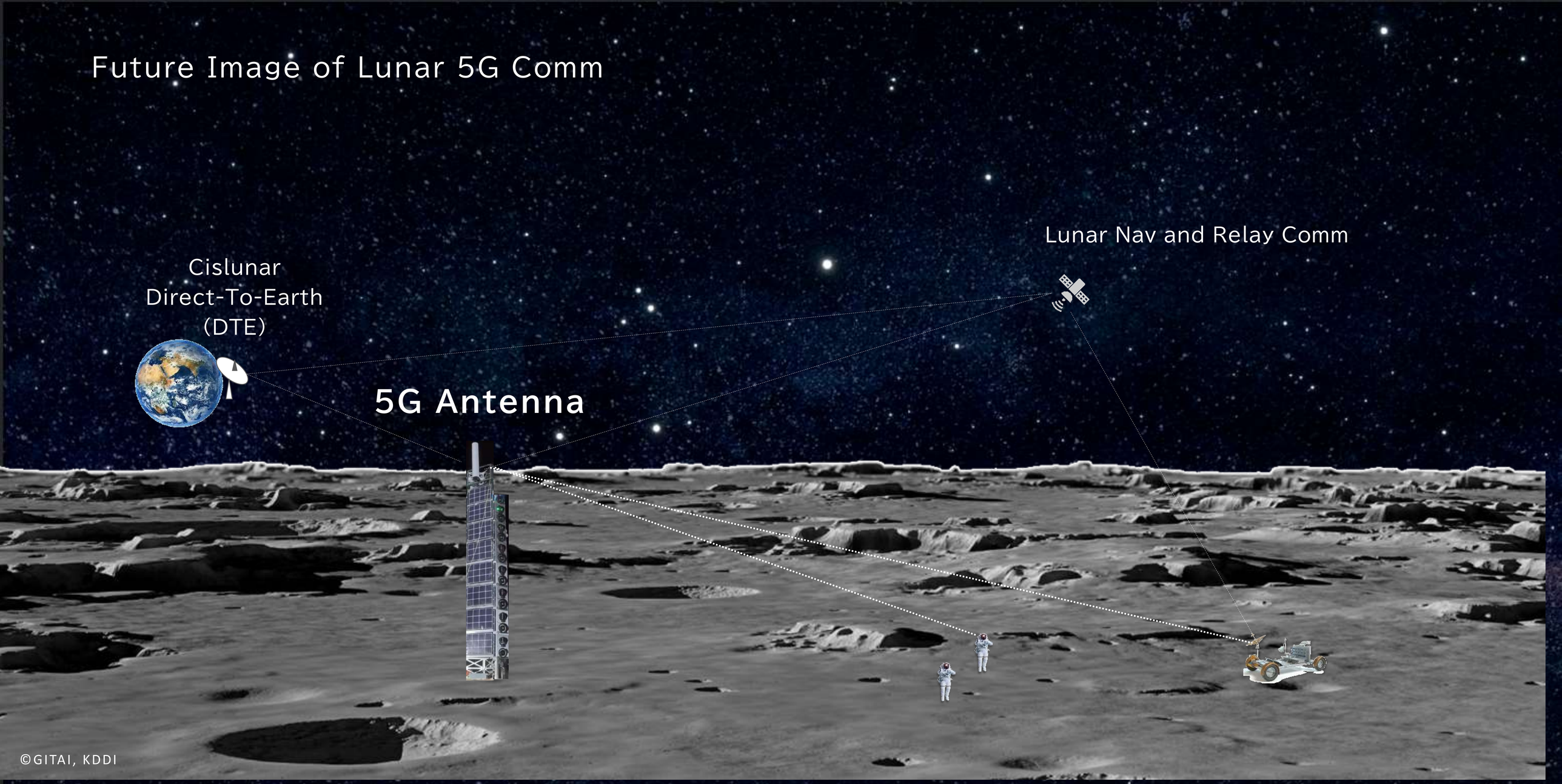
Developing Simulation Model

Studying on cellular coverage area by
simulating lunar surface and propagation

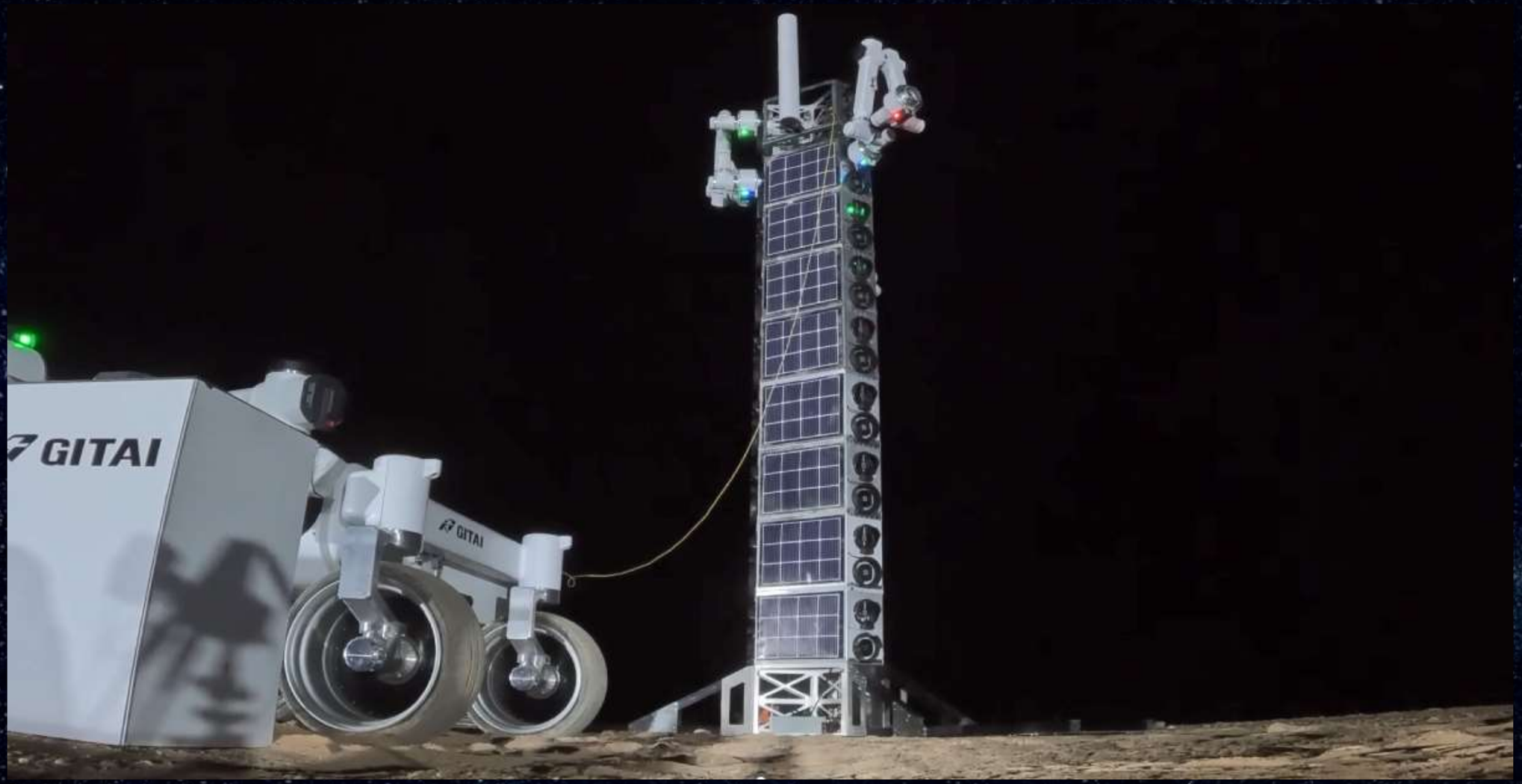


Lunar images by Google Earth and NASA Lunar Reconnaissance Orbiter

Future Image of Lunar 5G Comm



Lunar Cell Tower Construction Demo | KDDI & GITAI

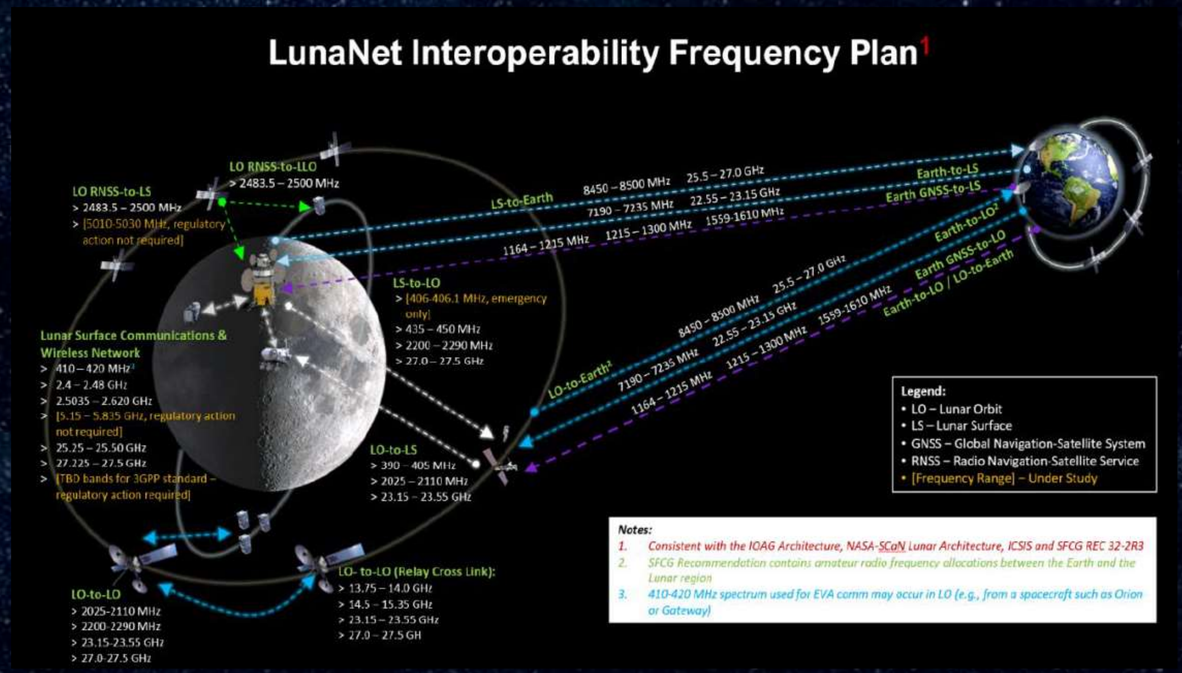


©GITAI, KDDI

Source: KDDI News Release “GITAI and KDDI Successfully Demonstrates Robotics Construction Capabilities for Lunar Communications Towers”

Spectrums for Lunar Comm are coordinated at the Space Frequency Coordination Group

Link	Frequency	
Earth to Lunar Orbit	2025-2110	MHz (Note 1), (Note 2)
	7190-7235	MHz
	22.55-23.15	GHz (Note 2)
	40.0-40.5	GHz
Lunar Orbit to Earth	2200-2290	MHz (Note 2)
	8450-8500	MHz
	25.5-27.0	GHz
	37-38	GHz (Note 3)
Earth to Lunar Surface	2025-2110	MHz (Note 1), (Note 2)
	7190-7235	MHz
	22.55-23.15	GHz
Lunar Surface to Earth	2200-2290	MHz (Note 2)
	8450-8500	MHz
	25.5-27.0	GHz
Lunar Orbit to Lunar Surface	390-405	MHz (Note 4)
	2025-2110	MHz (Note 2)
	23.15-23.55	GHz
Lunar Surface to Lunar Orbit	435-450	MHz (Note 4)
	2200-2290	MHz (Note 2)
	27.0-27.5	GHz
Lunar Orbit to Lunar Orbit	2025-2110	MHz (Note 2)
	2200-2290	MHz (Note 2)
	23.15-23.55	GHz
	27.0-27.5	GHz
Lunar Surface Wireless Network	390-405	MHz (Note 4)
	410-420	MHz (Note 8)
	435-450	MHz (Note 4)
	2.400-2.480	GHz (Note 7)
	2.5035 – 2.655	GHz (Note 9)
	3.5-3.8	GHz
	5.15-5.835	GHz (Note 6)
	5.855-5.925	GHz
	25.25-25.5	GHz
	27.225-27.5	GHz
	27.5-28.35	GHz



Source: LunaNet, Space Frequency Coordination Group

WRC-27 Agenda Item

And it is currently one of the WRC-27 agenda items to discuss about 3GPP bands on lunar surfaces

SGT5 - GENERAL REGULATORY, FUTURE WORK & OTHER
AGENDA ITEM 10

OAS CITEL

Interamerican Proposal (IAP)

Lunar: To consider frequency allocations and/or identifications for lunar surface communications in accordance with Resolution [USA-B2027AI-10-LUNAR].

Initial survey of available technologies has indicated that a network based on commercial standards such as those developed by 3GPP can be capable of servicing reference mission concept of operation involving many user groups over a widespread surface area with high data throughput requirements. This future conference agenda item proposes to study the spectrum needs of communications systems on the moon, system
f a potential new
Hz, 3 500 - 3 800

quency allocations

ITU

Radiocommunication Bureau (BR)

Administrative Circular
CA/270

26 January 2024

To Administrations of Member States of the ITU, and Radiocommunication Sector Members

Subject: **Results of the first session of the Conference Preparatory Meeting for WRC-27 (CPM27-1)**

Introduction

The World Radiocommunication Conference (Dubai, 2023) decided in its Resolutions **813 (WRC-23)** and **814 (WRC-23)** to recommend to Council the agenda for the World Radiocommunication Conference 2027 (WRC-27) and the preliminary agenda for the World Radiocommunication Conference 2031 (WRC-31). These agendas are contained in Annex 1 and Annex 2 to this Administrative Circular. The list of the provisional numbers for new Resolutions from WRC-23 is provided in Annex 3.

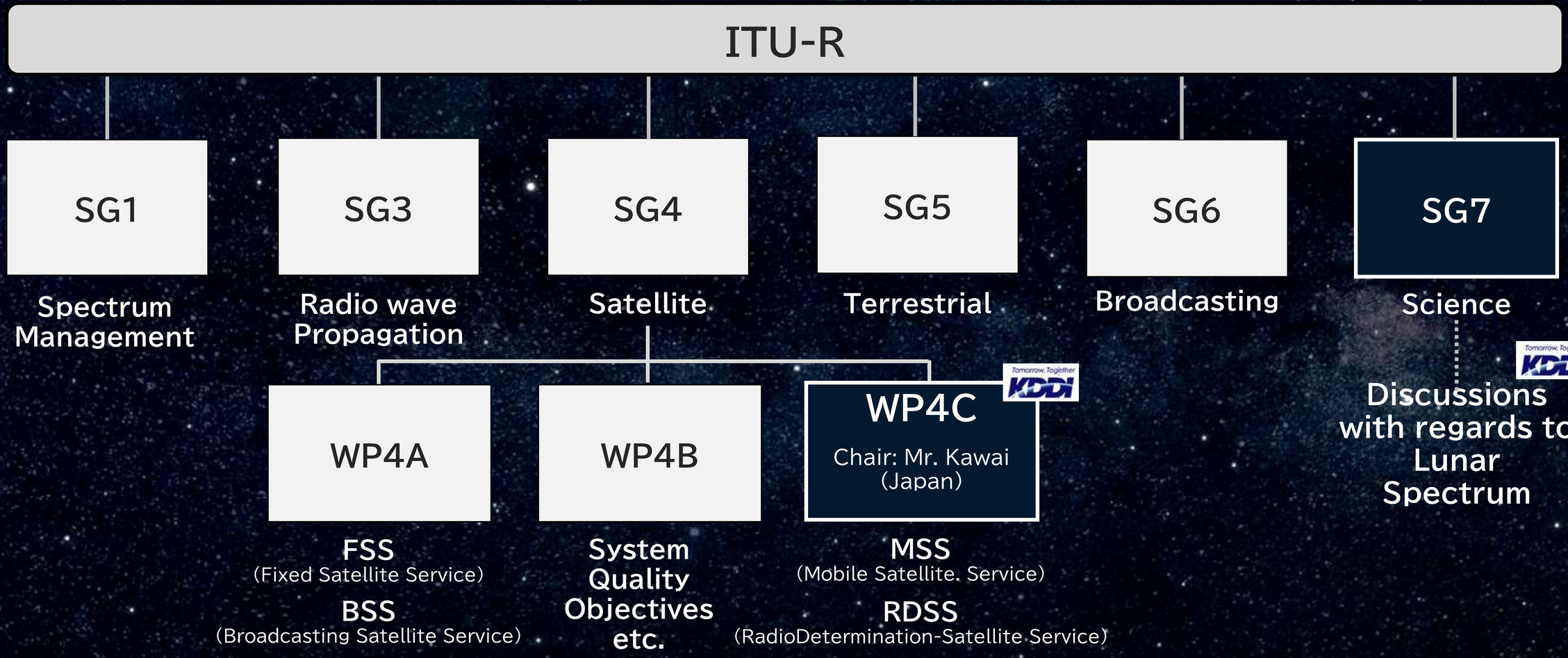
The Radiocommunication Assembly 2023 (RA-23), by its Resolution ITU-R 2-9 (https://www.itu.int/pub/R-RES-R.2-9-2023), reconfirmed the Conference Preparatory Meeting (CPM) and updated its working methods. Also, WRC-23 agreed that preparatory studies for WRC-27 are to be carried out by the CPM process.

- WRC: World Radiocommunication Conference
- Studies on spectrum needs, the technical and operational characteristics, as well as protection criteria, and propagation for sharing and compatibility related to systems in the SRS which may operate on the lunar surface or systems in lunar orbit communicating with systems on the lunar surface.
- Frequency bands to be studied contain 2.4GHz, 3.7GHz, 5GHz, 7/8GHz and 26GHz. Sharing and compatibility studies with various services including RA, SRS, FSS, MSS, BSS, RLS and FS/MS are needed, in particular, to protect passive services in SZM (Shieled Zone of the Moon).

Source: Status of CITEL preparation for WRC

KDDI on ITU-R Contribution

KDDI is serving as a chairman of ITU-R SG4 WP4C, And is also supporting SG7 for lunar spectrum discussion



Couple of discussions need to be done when applying Internet protocol to Moon-to-Earth Communications

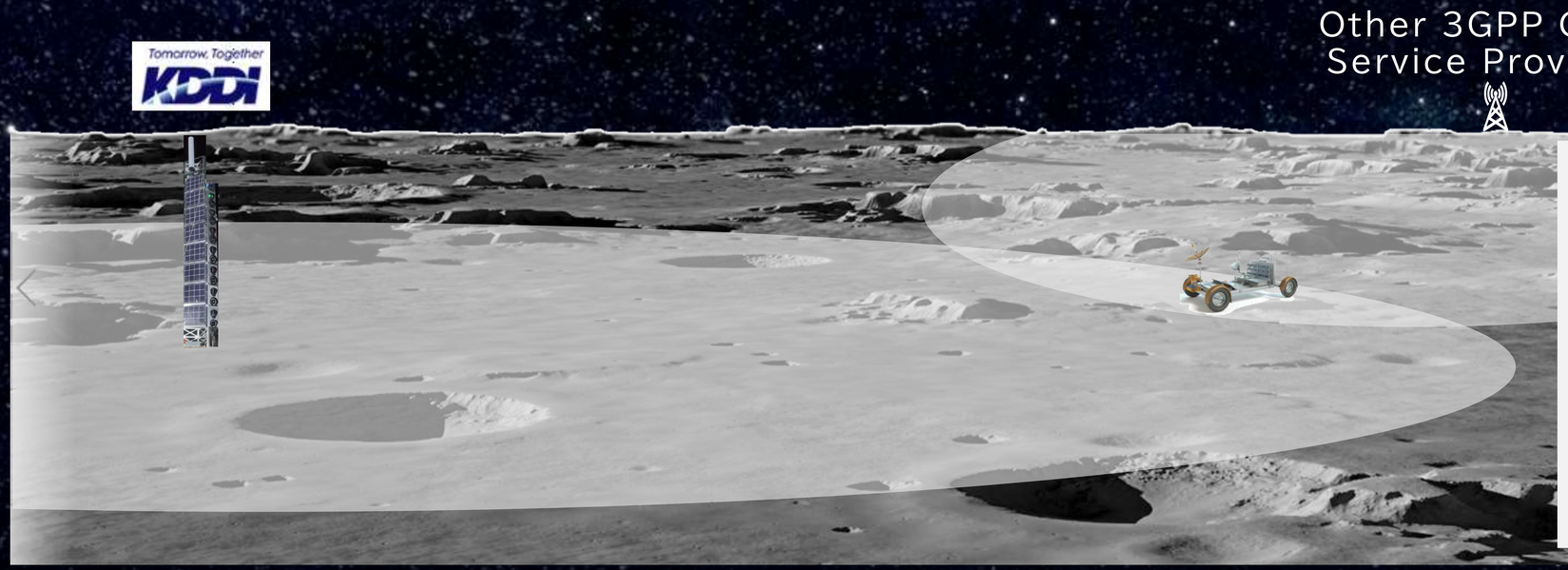
Ex. Discussions when applying Internet protocol to lunar communications

- **Routing and Addressing schemes**
  - Routing protocol
  - Multi domain networks : lunar surface, between the Moon and Earth, and on Earth
- **Transport protocol**
  - Timeout timer, congestion control, flow control
  - How would the end terminal know the predictable disconnections between satellites?
- **Application protocol**
- **Clock synchronization**

Future goals

Interoperability would be important as lunar mobile network will likely be developed with partners

- Planning to contribute not just for Japanese missions but also and other countries by developing a mobile communication area on the lunar surface.
- Japanese telecommunications providers could contribute to establish high quality, stable, and reliable 3GPP services (hopefully).



【Benefits】

- ✓ Contribute to LunaNet, rovers and EVAs on the moon
- ✓ Provide wider coverage, and redundancy
- ✓ Higher throughput by carrier aggregation
- ✓ More precise PNT (Pointing, Navigation, Timing)

Tomorrow, Together
KDDI
おもしろいほうの未来へ。
au

「つなぐチカラ」を進化させ、
誰もが思いを実現できる社会をつくる。

KDDI VISION 2030