

新しい深宇宙探査用54mアンテナプロジェクトの現状 Status of JAXA's new 54m deep space station

24th December, 2017

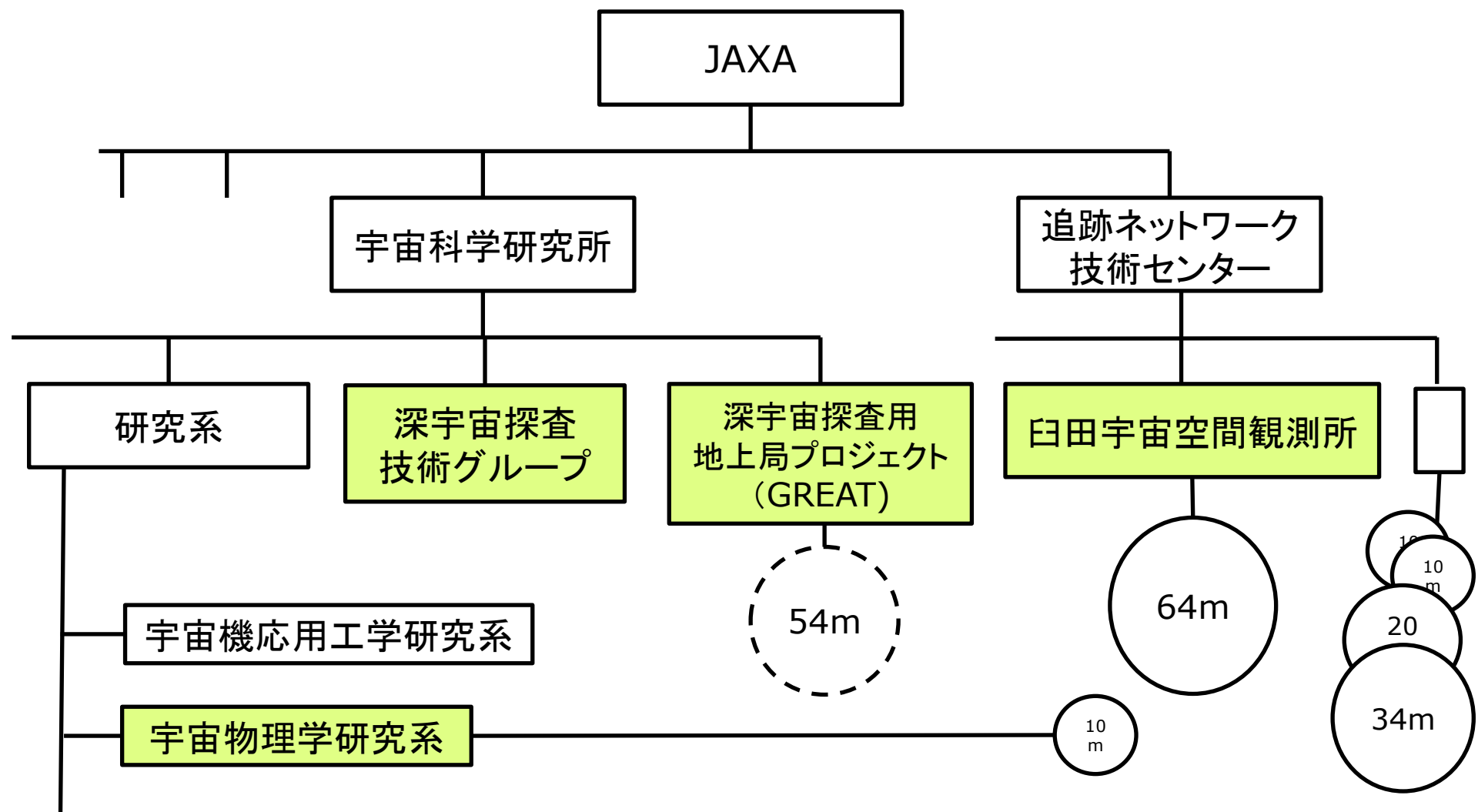
GREAT Project Team

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<http://www.isas.jaxa.jp/home/great>

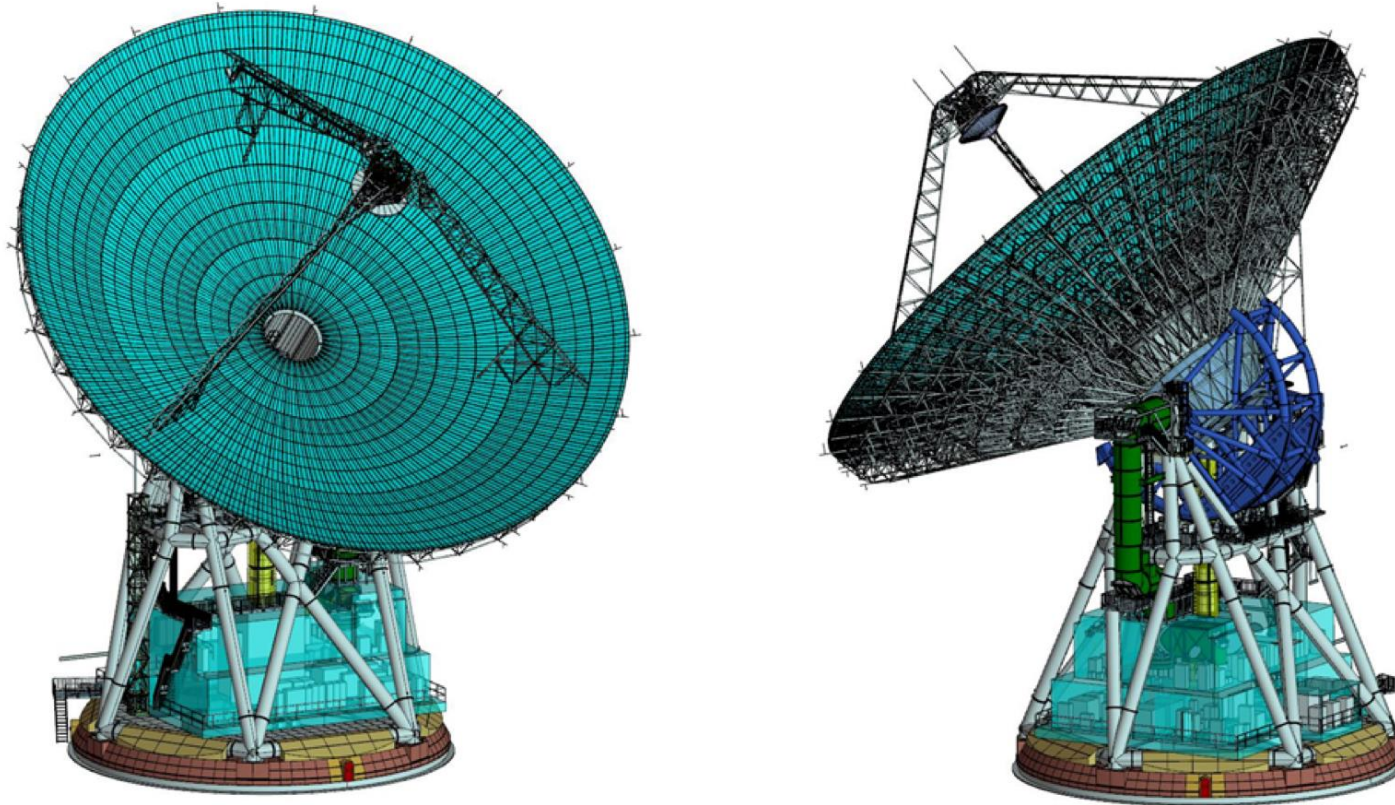
Structure



Purpose of new Deep space antenna

- ❑ 64 m deep space antenna is too old to support reliable deep space missions, though it works well now.
- ❑ Capability to support **HAYABUSA-2** and **MMO** (Mercury Mission, BepiColombo) which are designed to use 64m antenna.
- ❑ Newer deep space mission can be designed based on new antenna specification.
- ❑ Most of mission requirements come from HAYABUSA-2 and MMO
- ❑ Other missions (future missions, near earth missions, radio astronomy etc) have secondary priority.)
- ❑ Capability to support X(8.4GHz)- and Ka(32GHz) - deep space downlink bands.
- ❑ Support X(7.2 GHz) deep space uplink
- ❑ Antenna diameter 54m is designed to support current 64m capability (Gain, G/T etc) with minimum cost.

The view of the 54m antenna (1/2)



- X/Ka-band BWG antenna based on homologous structure.
- Coverage for backing structure is removed for visibility.
- Frontends and backends are inside of the antenna.

The view of the 54m antenna (2/2)



- Sun-shields cover backing structure.

Purpose

□ The purpose of the new station:

Succeeding the function of more than 30 year old Usuda 64 meter antenna.

Add function to receive at Ka band (32 GHz).

Table 1 Comparison between old UDSC and new 54m station

	UDSC	New (TBD)
Main reflecting mirror (diameter)	64 m	54 m
Mass	1900 ton	2100 ton
Frequency band	S band (2 GHz) X band (8 GHz)	X band (8 GHz) <u>Ka band (32 GHz)</u>

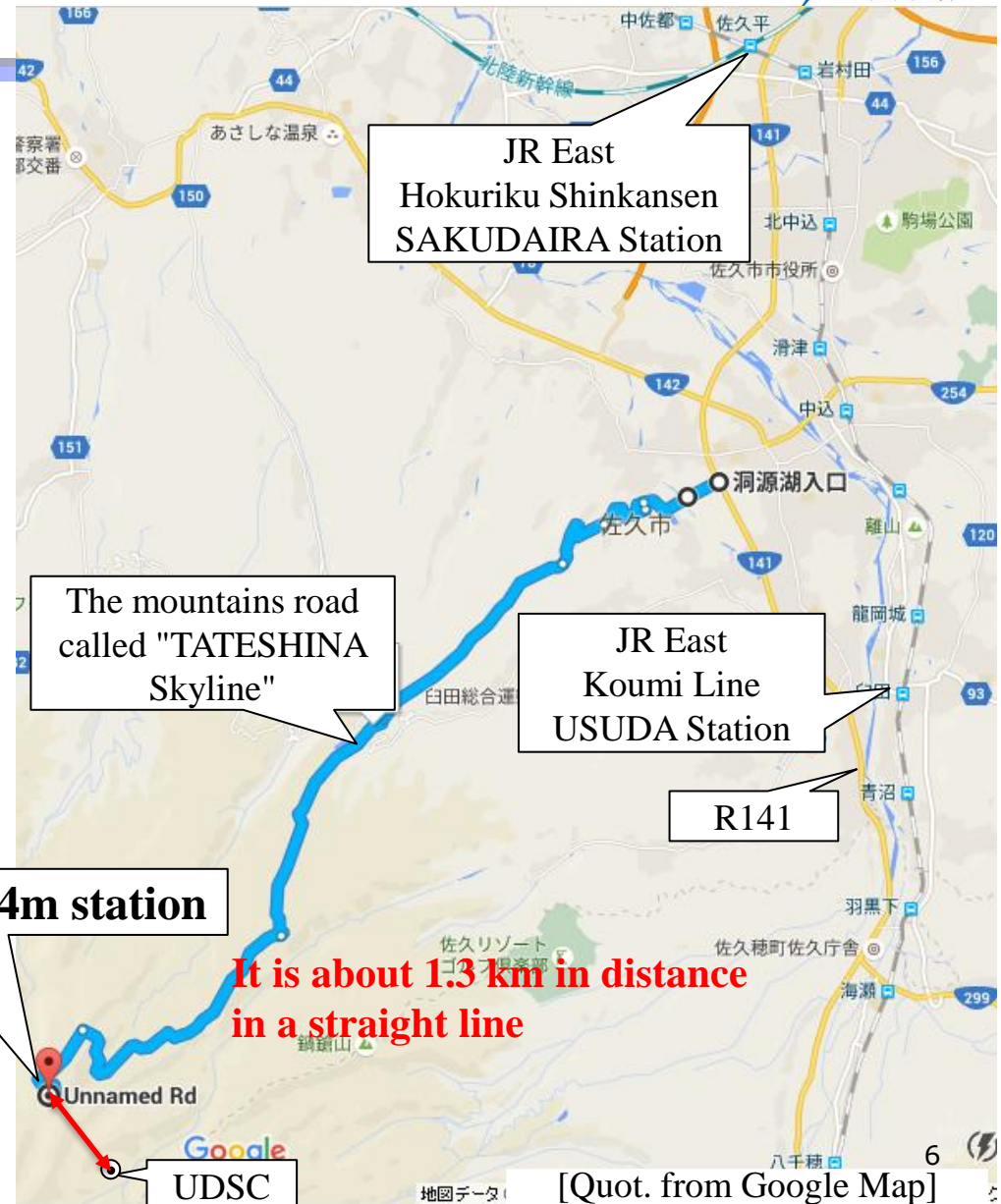
Table 2 New 54m station G/T and Tx Gain specification

	Design	Specification
X-band Effective G/T	53.37dB/K (SEFD 125 Jy)	$\geq 53.35\text{dB/K @ } 80^\circ < \text{EL} > 15^\circ$
Ka-band Effective G/T	59.61dB/K (SEFD 431 Jy)	$\geq 59.33\text{dB/K @ } 80^\circ < \text{EL} > 15^\circ$
X-band Tx Gain	70.98dBi	$\geq 69.62\text{dBi}$

Location (1)

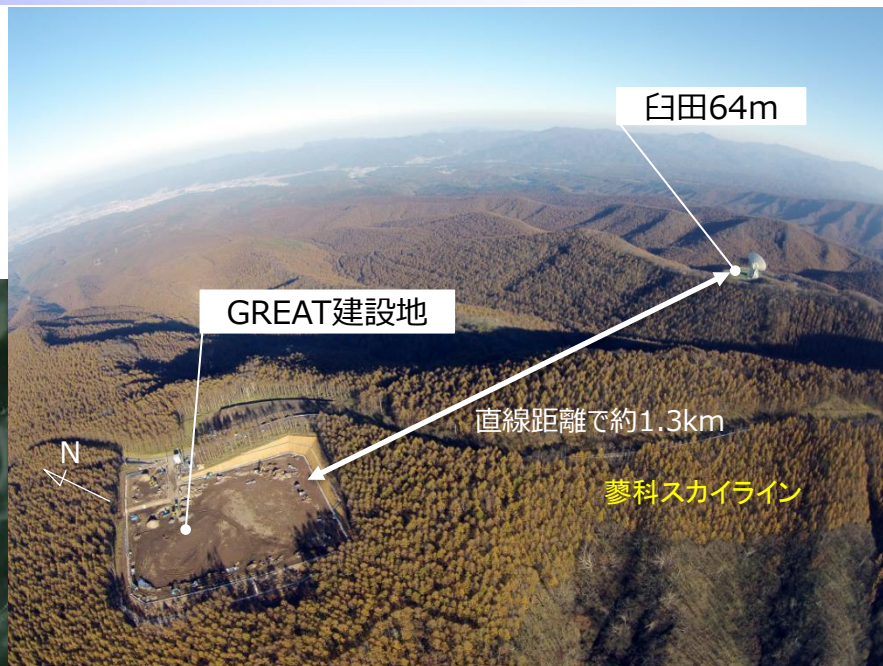
□ The conditions of the station-installed site:

- Less noise
- Less rain/snow fall
- Flatness
- Accessibility
- Secured infrastructure
- Understanding of local residents
- No private land, it is the national forest



Location (2)

- The new station will be in the vicinity of the UDSC64. Its major specifications are shown as following table.



Major Specification (1)

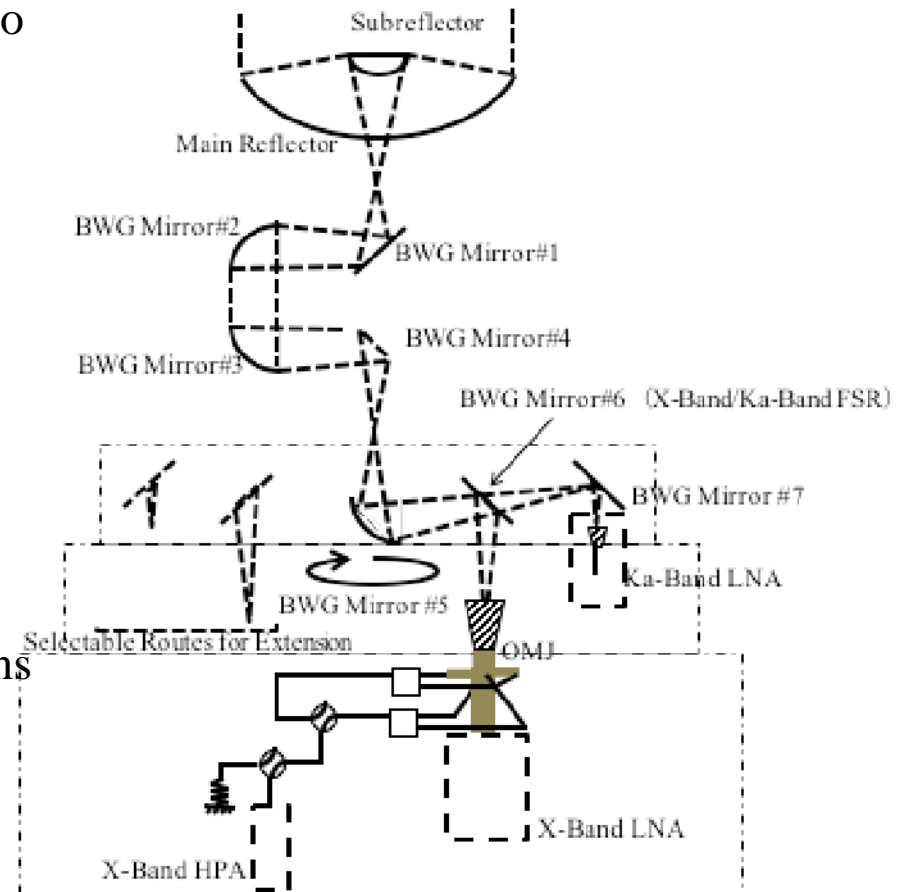
Reflector Design	It is compatible with X- and Ka-band based on homologous structure design	Ring Focus Cassegrain Code
Mount	Altazimuth mount	The anti-backlash mechanism
Feeding Scheme	Beam waveguide scheme	
Driving performance	Maximum driving speed: 1 deg/sec	
Rx Gain	X-band(Rx) : 72.37 dBi Ka-band(Rx) : 78.96 dBi	Other space research allocated bands less than 45GHz are to be covered if need be.
EIRP	X-band : More than 142.6 dBm	When equipped with 20kW power amplifier. The update to 40kW is foreseen in the future.

Major Specification (2)

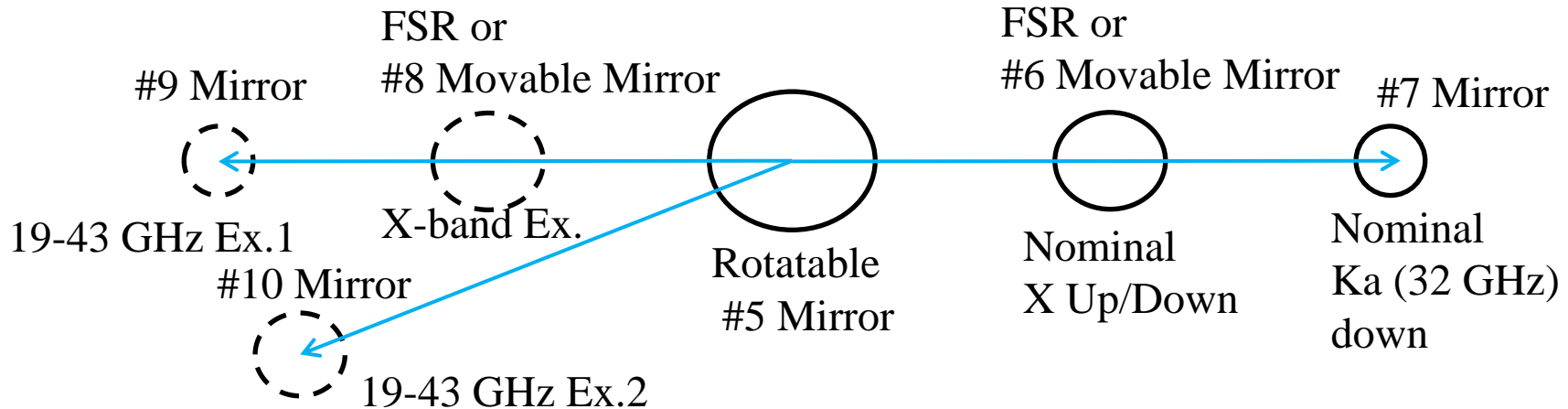
Up link frequency band	7145 MHz-7235 MHz	X-band
Down link frequency band	8400 MHz-8500 MHz 31800 MHz-32300 MHz 8200 MHz – 8700 MHz	X-band Ka-band Limited for the open loop receiving function
Pointing Accuracy	Less than 4,8 mdeg (0-p) @ 10m/s maximum wind speed.	Fine control fed back from master collimator
Tracking Function	Program mode	To add auto tracking mode in the future.
Receiver Noise	X-band: Less than 21 K Ka-band: Less than 35 K	Ka-band receiver is developed as a JAXA in-house product.
Demodulation/decoding performance	X-band carrier acquisition threshold : C/No=6 dBHz Ka-band carrier acquisition threshold: C/No=15 dBHz X-band Demodulation loss: <=1.5 dB Ka-band Demodulation loss: <=1.5 dB	
Ranging measurement accuracy	<=1.15 m	
TT&C Capability	Compatible with CCSDS	To cover most of deep space services defined in the standards such as turbo coding, SLE interface, and DDOR function.

BWG Configuration

- ❑ X/Ka-band received signals are transferred to each receiver located in the building.
- ❑ X/Ka-band signals are separated by FSR.
- ❑ X-band transmit and receive signals are separated by OMJ combined with filters.
- ❑ RHCP and LHCP transmit signals are synthesized in OMJ.
- ❑ RHCP and LHCP transmit signals are transferred to a LNA.
- ❑ Rotatable mirror #5 for extension ports.
- ❑ Implementing 26 - 27GHz for Cat.A missions will be done by using these optional routes.



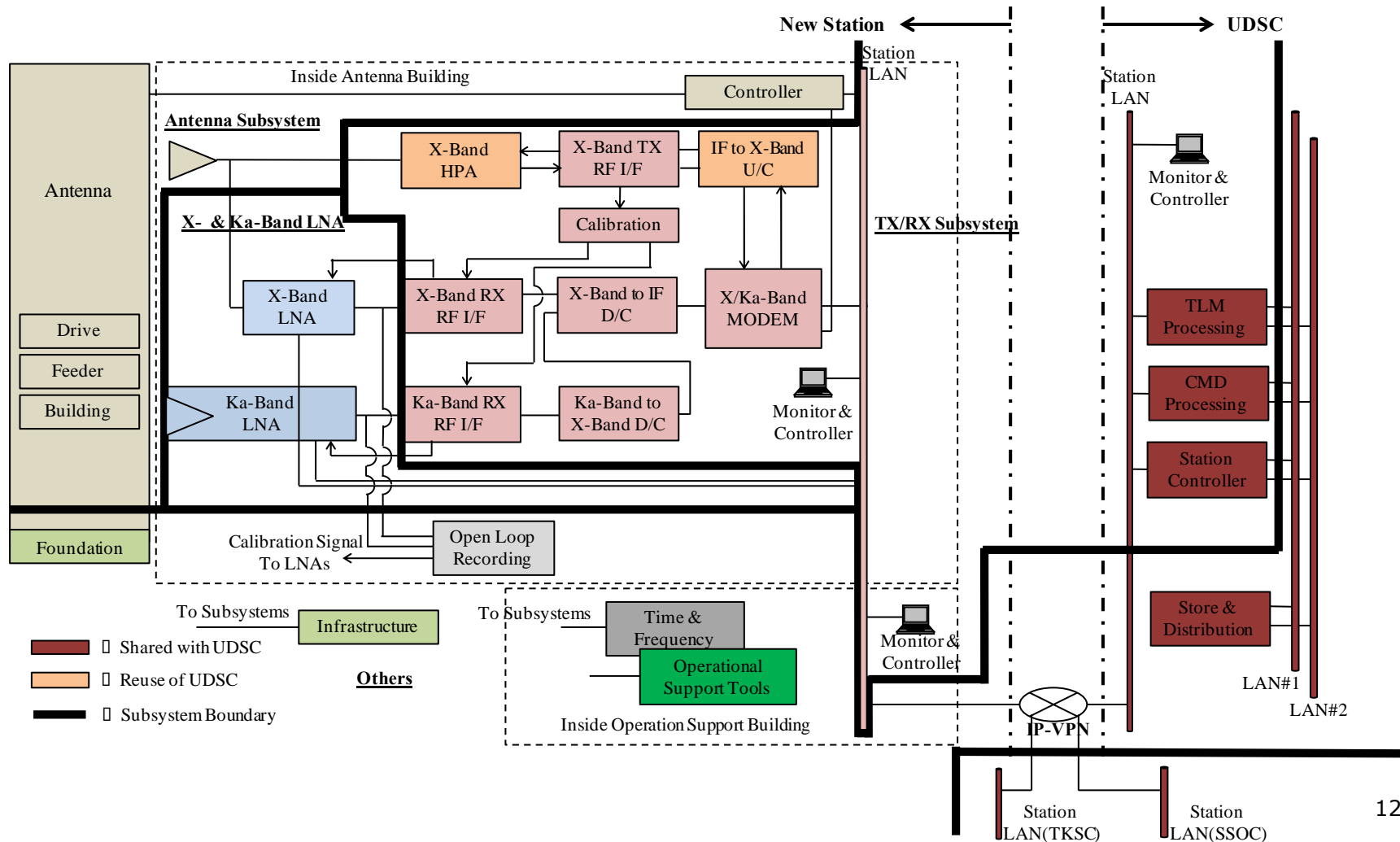
Extension Ports



- ❑ 54m antenna will install extension ports for future new usages
- ❑ 22 GHz receiving system is under consideration for integration test (Pointing observation and holography measurement.)
- ❑ Candidates of extension port usage
 - Ka near earth band 25.5 – 27 GHz, for L2, Lunar missions
 - Radio Astronomy (including VLBI)
 - Development of X/Ka horn (no FSR)
 - Other useful for space science.

Block Diagram of The Station System

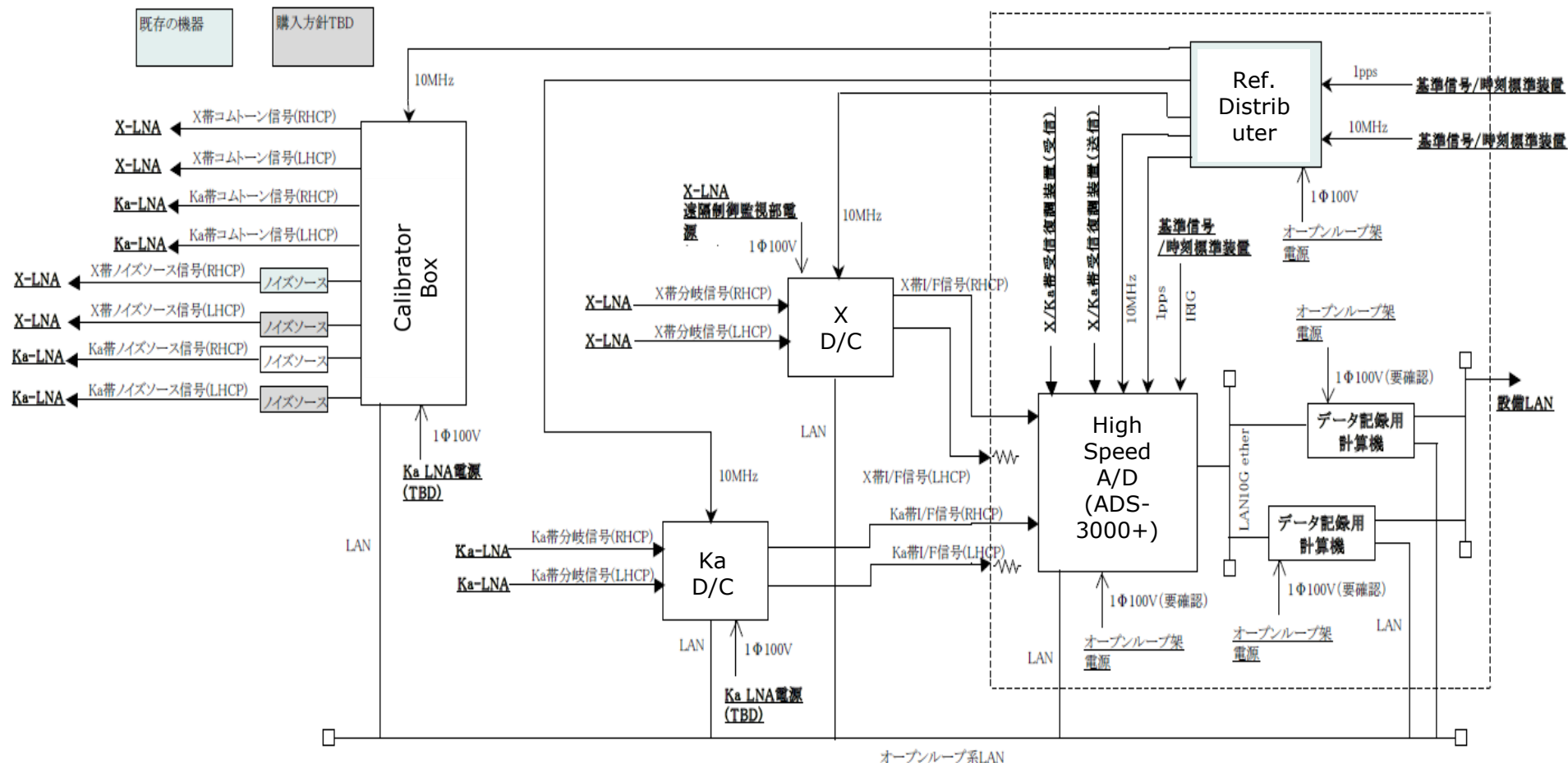
- The new station should be available to use the existing station function.



Open-loop system (オープンループ記録装置)



~ VLBI backend and calibration system



54m station needs VLBI observation for the decision of the location of the station and DDOR observation (Delta Differential One-way Ranging), and Openloop system will be installed.

54m VLBI observation

- ❑ X-band: J-Net frequency is available: 8.2-8.7 GHz
- ❑ Ka-band is also possible but no counterpart except for DSN station in NASA and ESA
- ❑ Extension ports: It depends on the design in future at 19 – 43 GHz?

- ❑ Geodesy
 - ❑ Geodesy observation of Usuda 64m
 - S/X observation with GSI Ishioka stations
 - Accuracy is $\sim \pm 1\text{cm rms}$

 - ❑ Geodesy observation of 54m
 - Requirement : $\pm 3\text{cm rms}$
 - No S-band, No VGOS receiver
 - X/Ka Geodesy with NASA and ESA stations
Only deep space stations have receivers for X/Ka simultaneous observation.

 - Back up plan: Co-observation with Usuda 64m and other S/X geodesy stations, and use 64m ionosphere data for 54m

On-site status (beginning of 2016)



↑15th Dec., 2015 (Before felling of trees)



↑28th Dec., 2015 (During felling of trees)



↑4th Feb., 2016 (After felling of trees)

(Note) Already installed "the weather observation equipment"

On-site status (April - June 2017)



↑26th Apr., 2017



↑16th May, 2017



↑27th May, 2017



↑7th Jun., 2017

On-site status (October 2017)



Site View and 64m antenna



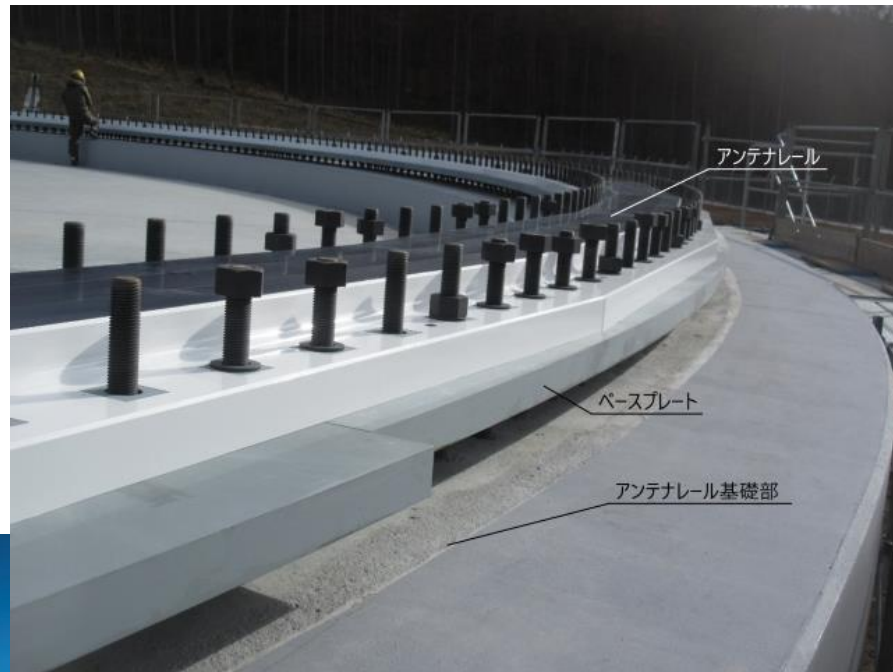
↑ Antenna Foundation (No Az rail)



Foundation of
Master Collimator

On-site status (November – December 6, 2017)

Installation of Az Rail by MELCO



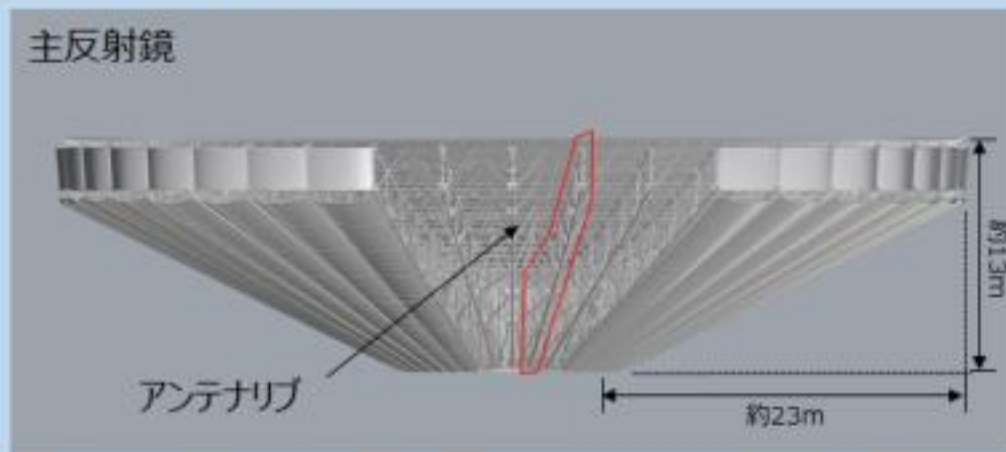
Ceremony for building antenna



Production of Antenna parts (Dec. 2016-June 2018)

November, 2017

①アンテナリブは、主反射鏡のパネルを支える骨格のことを言います。普段はアンテナカバーにより見えませんが、下図に背面パネルを外した時のリブ構造を示します。



②アンテナリブはトラックで輸送可能なように幾つかに分割して組み立てられます。以下はその一部です。



③リブ全体の結合風景（左図の赤枠部分）です。その大きさに圧倒されます。

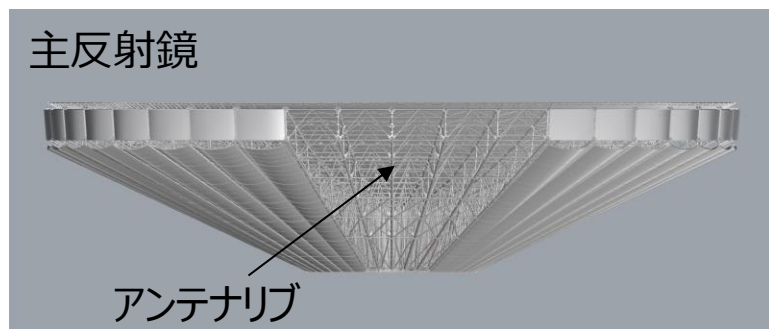


無断利用・転載を禁じます

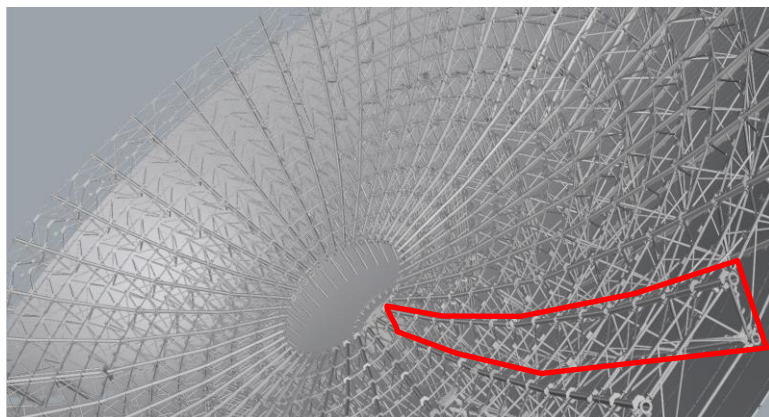
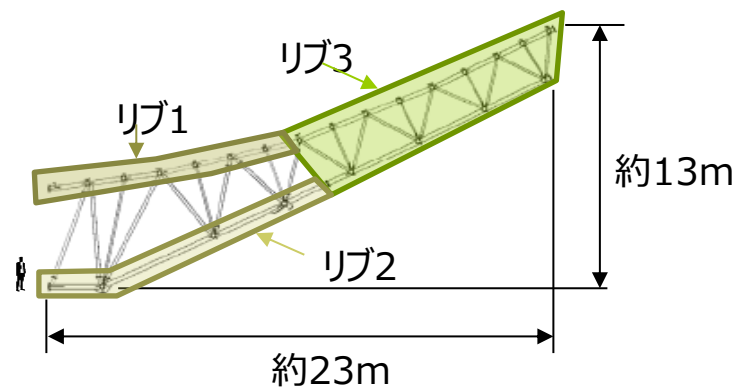
Production of Antenna parts (Dec. 2016-June 2018)

写真②リブ説明

①アンテナリブは、主反射鏡のパネルを支える骨格のことを言います。普段はアンテナカバーにより見えませんが、下図に背面パネルを外した時のリブ構造を示します。



②①の赤枠を横から見ると以下のような構造になっています。



③リブの製造現場にて



Production of Antenna parts (Dec. 2016-June 2018)

November, 2017

加工が終了したリブが置かれている三栄建設さんの工場です。敷地の一角にリブが置かれていました。ここで試験と塗装を実施し建設地へ運ばれます。



@Himejima Kinzoku



Summary

- JAXA new 54m antenna project is on going.
 - Construction
 - Manufacture
 - Developments
 - VLBI backend will be installed.

- VLBI technology is the key for:
 - DDOR observation for accurate navigation in deep space missions
 - Geodesy observation to get accurate position of antenna
 - Other scientific outputs.

64m アンテナについて

- 54mアンテナが完成したら、維持費は54mへ
- 64mは十分な信頼性が必要な探査機運用につかうのはリスクがある。
- 維持費を別の予算で確保しなければならない。

- 信頼性が必要でない目的に転用する。=> 実験・開発・研究への利用
 - 新しい装置開発・研究のためのテストベンチ
 - 64m/54m Arraying
 - New low cost/reliable receiver (Full Digital)
 - 次世代地上局のための開発検討 (アンテナ計測技術・環境の影響計測)
 - ソフトウェア開発 (自動運用)
 - 低コスト維持の研究

- 人材育成 失敗できる設備
- 広報
 - パルサーやスペクトル線など宇宙からくる電波を見せる。
- Astronomy and VLBI experiments
 - どのくらい使えるか？ 空き時間をFULL稼働できれば… 1000-2000 時間/年？ (今：100 時間/年くらい？)
 - 共同利用が必要 (装置を貸す？) どのような形態がのぞましいか？

64m アンテナについて(お願い)

- コミュニティからの要望書
 - コミュニティからのプレッシャーは大事
 - タイムリーに出すことが重要
- Userグループの拡張・形成
 - 成果を出すことが重要
 - 成果を出すシステムになってない！
 - 計画・予算獲得・高性能化
 - 維持費＋運用費に見合う成果が出ること
 - 臼田に来なければならないか？
 - 今は実験室状態：観測ごとに結線を変える
 - リモート運用可能なシステムに
 - 時間はとれるのか？
 - 物理的時間よりMan Powerリミット
 - My Telescopeとってくれる人の拡大