

# China Deep Space TT&C and International Cooperation





# China Deep Space TT&C and CLEP

- Deep space TT&C (Tracking, Telemetry and Command) capability is an inevitable requirement for the implementation of lunar and deep space exploration.
- China's deep space TT&C system is gradually built and developed along with the three Phase of "Orbiting, Landing and Sample Returning" of China lunar exploration Program (CLEP).





# China Deep Space TT&C and CLEP -1



## CLEP Phase I: Chang'E-1 Mission

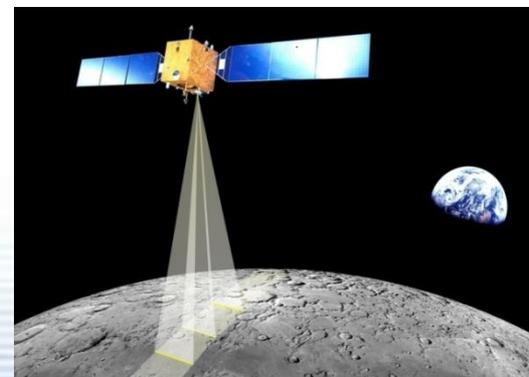
- No deep-space TT&C facilities to support Chang'E-1 mission.
- So we used existing earth orbit satellites TT&C equipment to implement the TT&C capability of 400,000 km.



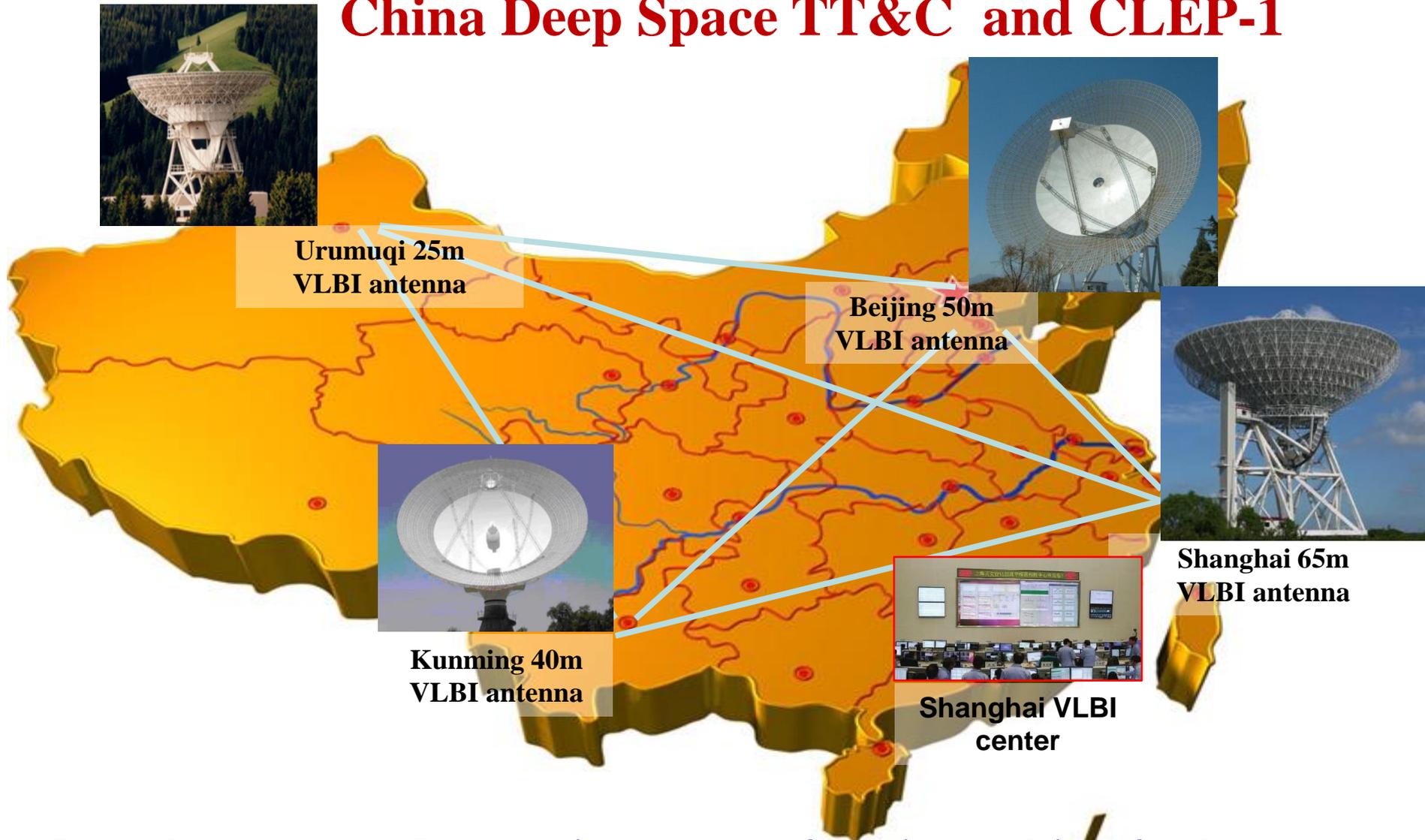
Kashi 12m +18m



Qingdao 10m +18m



# China Deep Space TT&C and CLEP-1



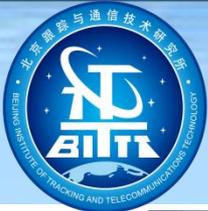
- In order to meet the requirements of orbit tracking for lunar exploration missions, China VLBI Network (CVN) took part in CLEP mission from Chang'E-1 mission (2004).



# Chang'E-1 TT&C International Cooperation

- Tracking “Smart-1” spacecraft of ESA was used to test and verify the long-distance tracking capability of China TT&C System in 2006.
- This is the beginning of China TT&C System cooperation with ESA.





# Chang'E-1 TT&C International Cooperation



ESA Kourou 15m station



ESA Maspalomas 15m station



ESOC

CCSDS SLE



ESA NNO 35m station



BACC

- Three ESA stations supported China Chang'E-1(2007) mission
- CCSDS SLE protocol be used to connect with ESA TT&C Network.



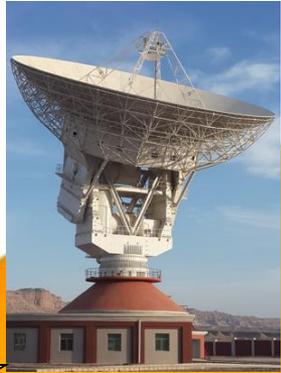
# China Deep Space TT&C and CLEP -2



## CLEP Phase II:

## Chang'E-2 and Chang'E-3 Mission

**During the Phase II of CLEP, China began to build Deep Space TT&C Network for tracking and telecommunication support (2008--2013).**



**Kashi 35m Station**



**Kashi18m**



**Beijing Aerospace Control Center (BACC)**



**Jia Musi 66m station**

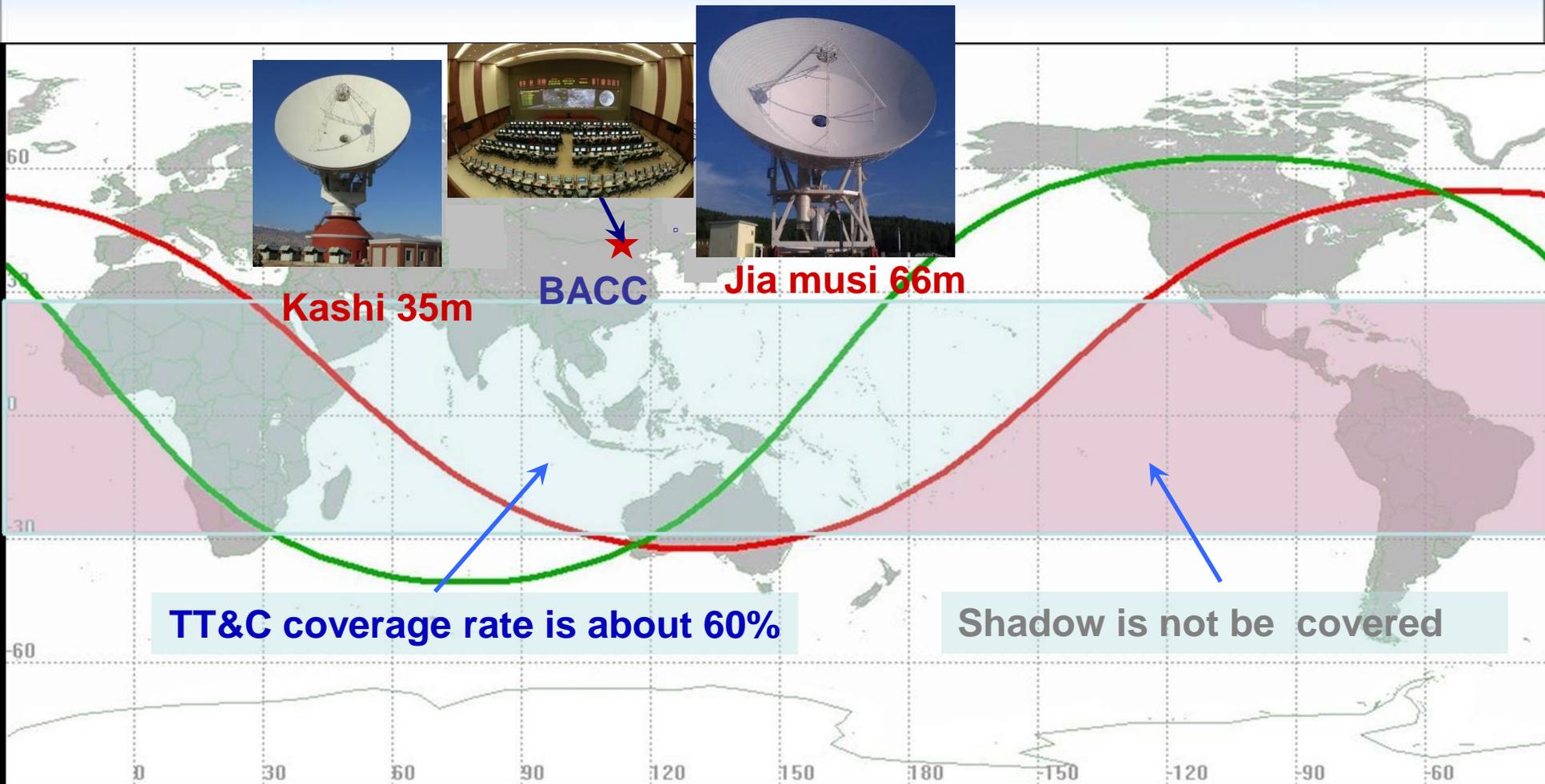


**Qingdao18m**

- **During Phase II of CLEP , China Deep Space TT&C Network includes :**
  - ✓ **Kashi 35m S/X/Ka band station ( Northwest of China ) , 2012.**
  - ✓ **Jia Musi 66m S/X band station ( Northeast of China ) , 2012.**
  - ✓ **Deep Space Mission operation center is Beijing Aerospace Control Center.**
  - ✓ **Kashi 18m and Qingdao 18m S-band received only antennas were upgraded to 18m S/X band full function TT&C equipment.**



# China Deep Space TT&C and CLEP -2



**TT&C coverage rate with two Deep Space Stations in China (2013)**

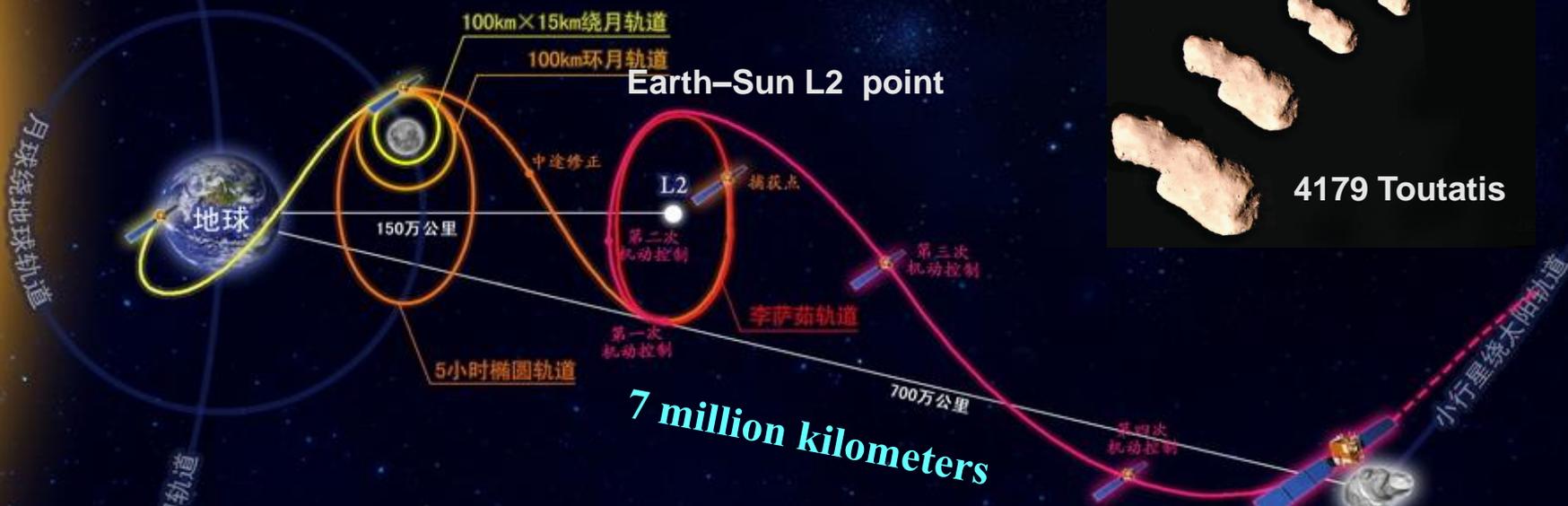


# China Deep Space TT&C and CLEP -2

## ➤ 1. Chang'E-2 mission, Oct.01, 2010—

For the first time, China Deep Space TT&C Network supported deep space mission in 2012.

(Extended mission)



4179 Toutatis

It departed the Moon on June 8, 2011 and arrived in the Sun-Earth L2 point on August 25.

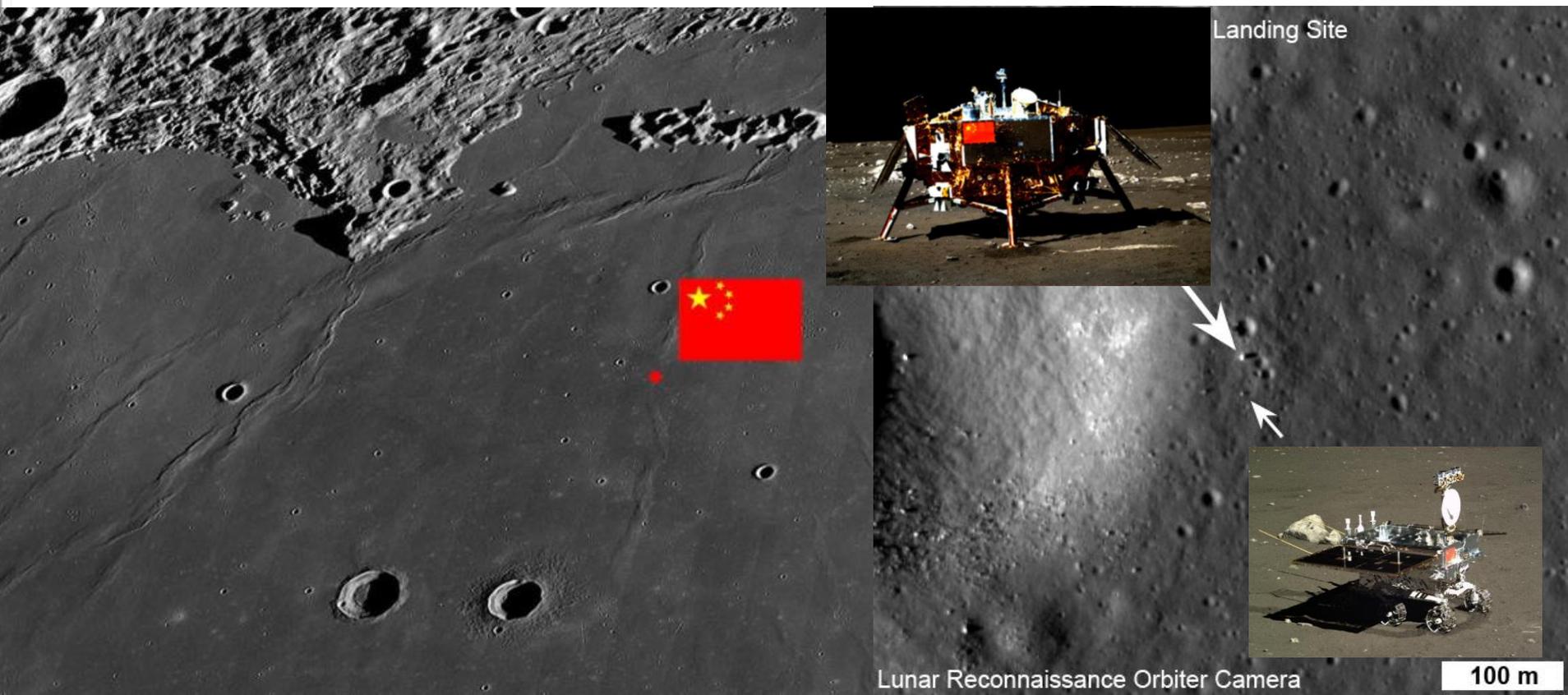
It completed a flyby of asteroid 4179 Toutatis on 13 December 2012



# China Deep Space TT&C and CLEP -2

## ➤ 2. *Chang'E-3 lunar lander and rover, Dec.2,2013—*

**This is the first formal mission for China Deep Space TT&C Network.**

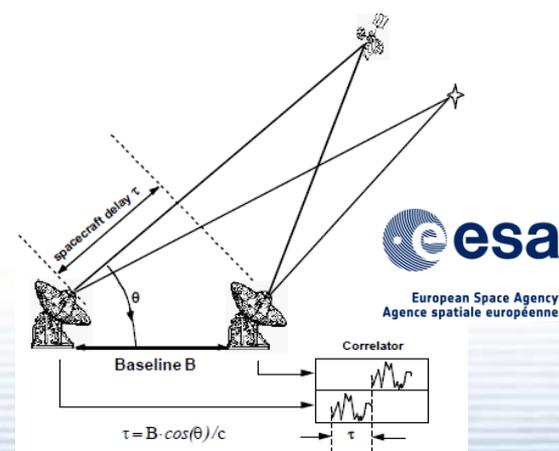




# Chang'E-2/3 TT&C International Cooperation

## *Cooperation with ESA during phase II of CLEP*

- Delta-DOR tracking of Chang'E -2 (Sun-Earth L2 point) and Chang'E-3 by ESA DSA and supply raw data(2011,2013)
- Joint Delta-DOR tracking of VEX by deep space Antennas of both sides(2012)





# China Deep Space TT&C and CLEP -3



## CLEP Phase III:

## Chang'E-4 and Chang'E-5 mission

**In order to meet the mission requirements of the third phase of CLEP:**

- **built a 35m deep space TT&C station, in Argentina**
- **built a new 18m S/X band TT&C equipment(with interferometry function), in Namibia.**

Chile



Argentina



35m深空站站址

80km

拉斯拉哈斯市

萨帕拉市

The site is 80km north of Zapala , Neuquen Province, Argentina

(38° 11'28.90"S, 70° 8'58.20"W)



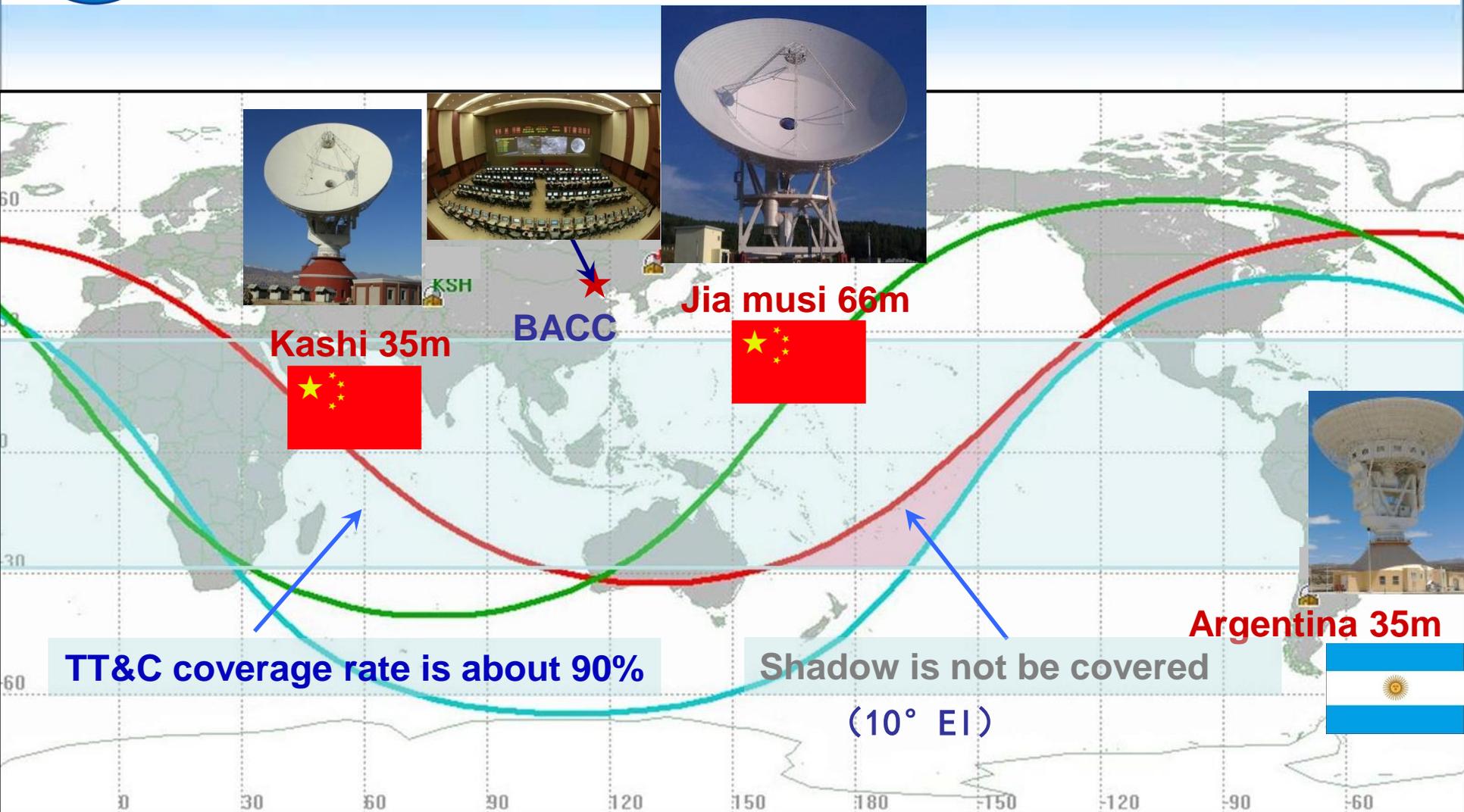
# China Deep Space TT&C and CLEP -3



**Control room and antennas of Argentina station, 2017**



# China Deep Space TT&C and CLEP -3



China deep space TT&C network formed in the third phase of CLEP



# China Deep Space TT&C and CLEP -3



Jia Musi 66m S/X band antenna



Kashi 35m S/X/Ka band antenna



Argentina 35m S/X/Ka band antenna

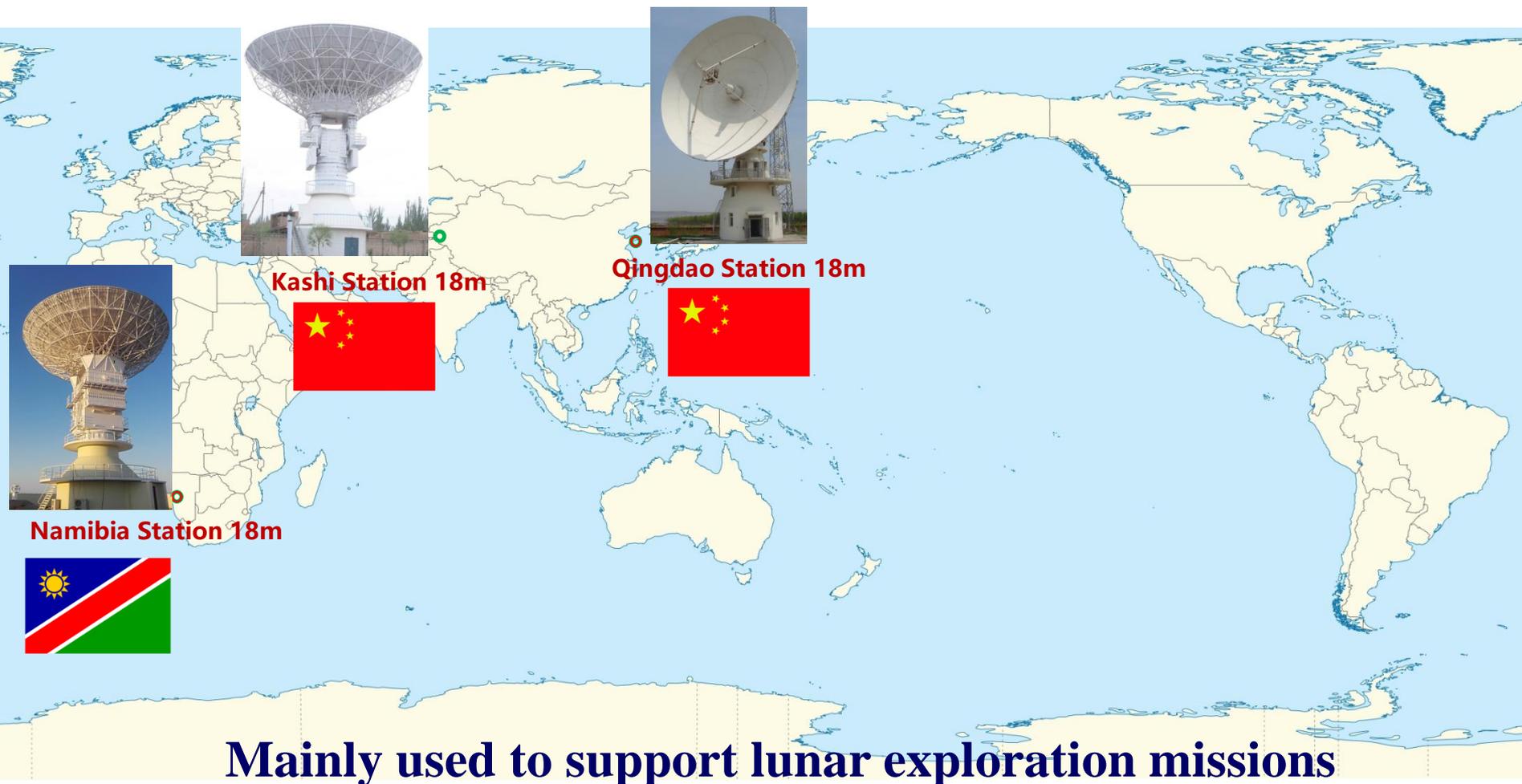
Frequency	Uplink (MHz)	Downlink(MHz)
S-band	2025~2120	2200~2300
X-band	7145~7235	8400~8500
Ka-band		31800~32300

- These are international common frequency bands, compatible with the CCSDS.
- We can do cross-support with other countries or agencies for deep space mission.



# China Deep Space TT&C and CLEP -3

## ■ China's 18m S/X band TT&C subnet



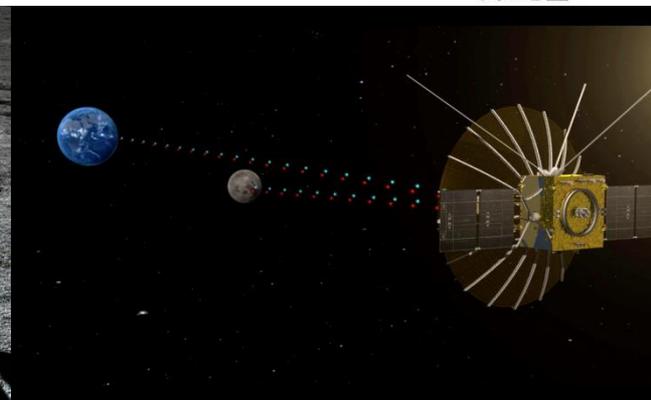
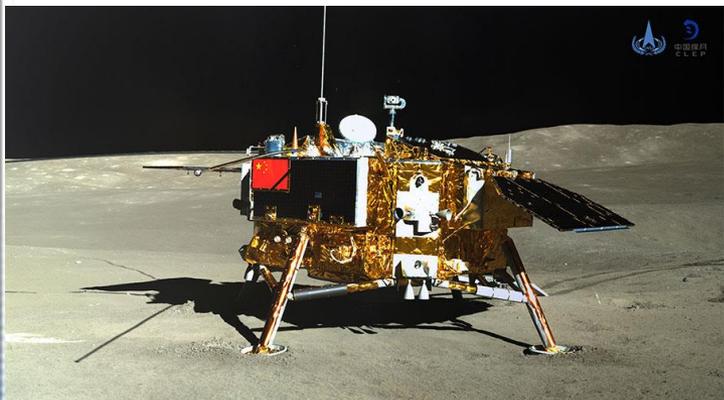


# Chang'E-4/5 TT&C International Cooperation

## Mission support for Chang'E-4 Mission

The Chang'E-4 mission has implemented to realize the first soft landing and roving on the lunar far-side, to realize the TT&C and science data relay at earth-moon L2 point.(2018-2019)

- Both Deep Space TT&C Network and 18m Subnet supported this mission.
- Argentina 35m station for the first time supported CLEP mission.
- The construction and operation of this station took friendly cooperation with CONAE (Comisión Nacional de Actividades Espaciales) .



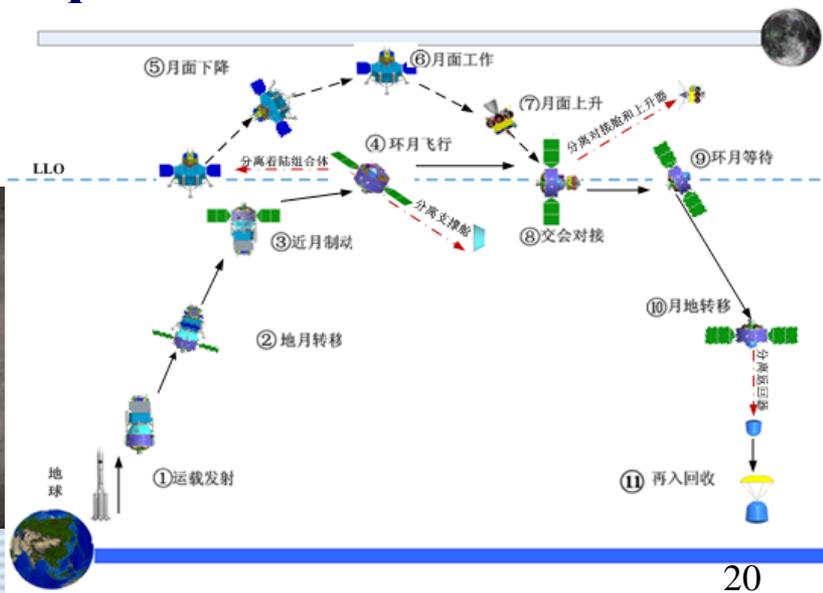
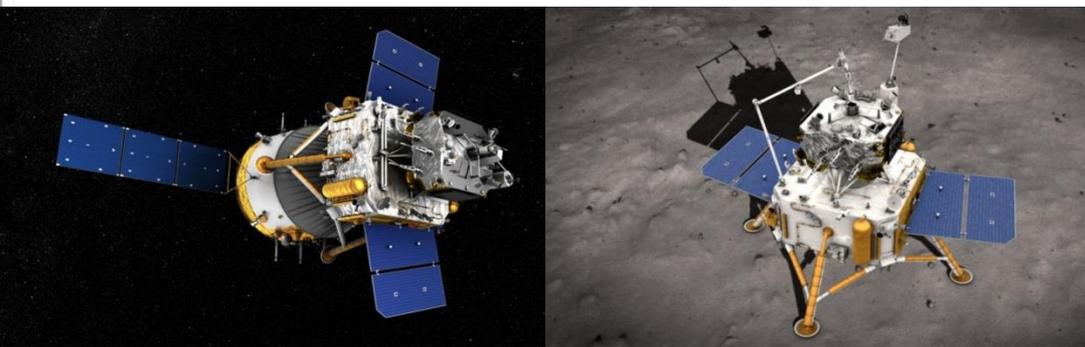


# Chang'E-4/5 TT&C International Cooperation

## Mission support for Chang'E-5 Mission

Launched before 2020. Realize automatic lunar sample ,return sampling of the moon, carry out comprehensive analysis of lunar samples.

- Both Deep Space TT&C Network and 18m Subnet will support this mission.
- ESA Kourou Station and Maspalomas Station will provide TT&C Support.

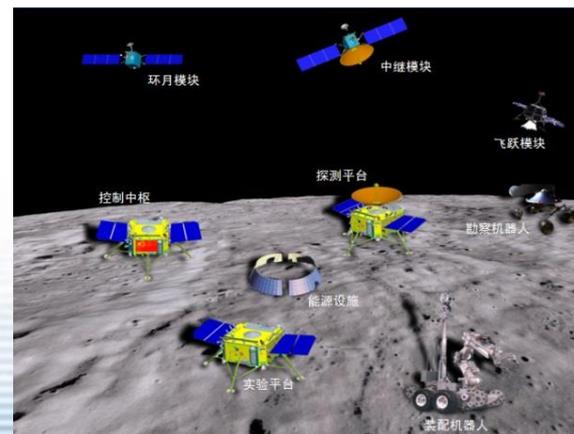
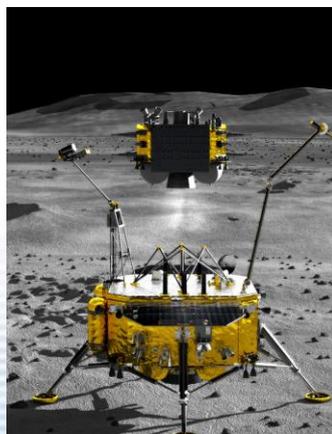
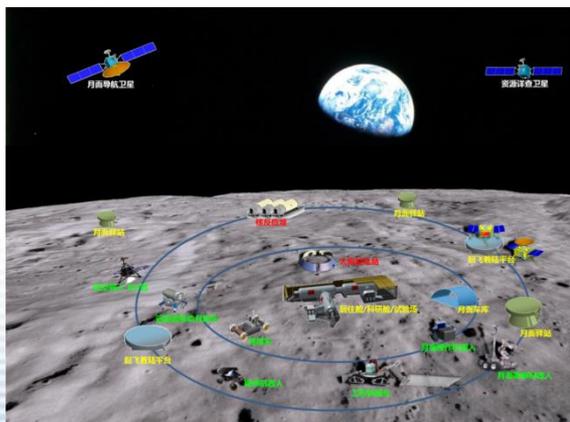


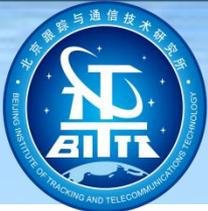


# China Deep Space TT&C and Future Missions

## Follow-up China lunar exploration program

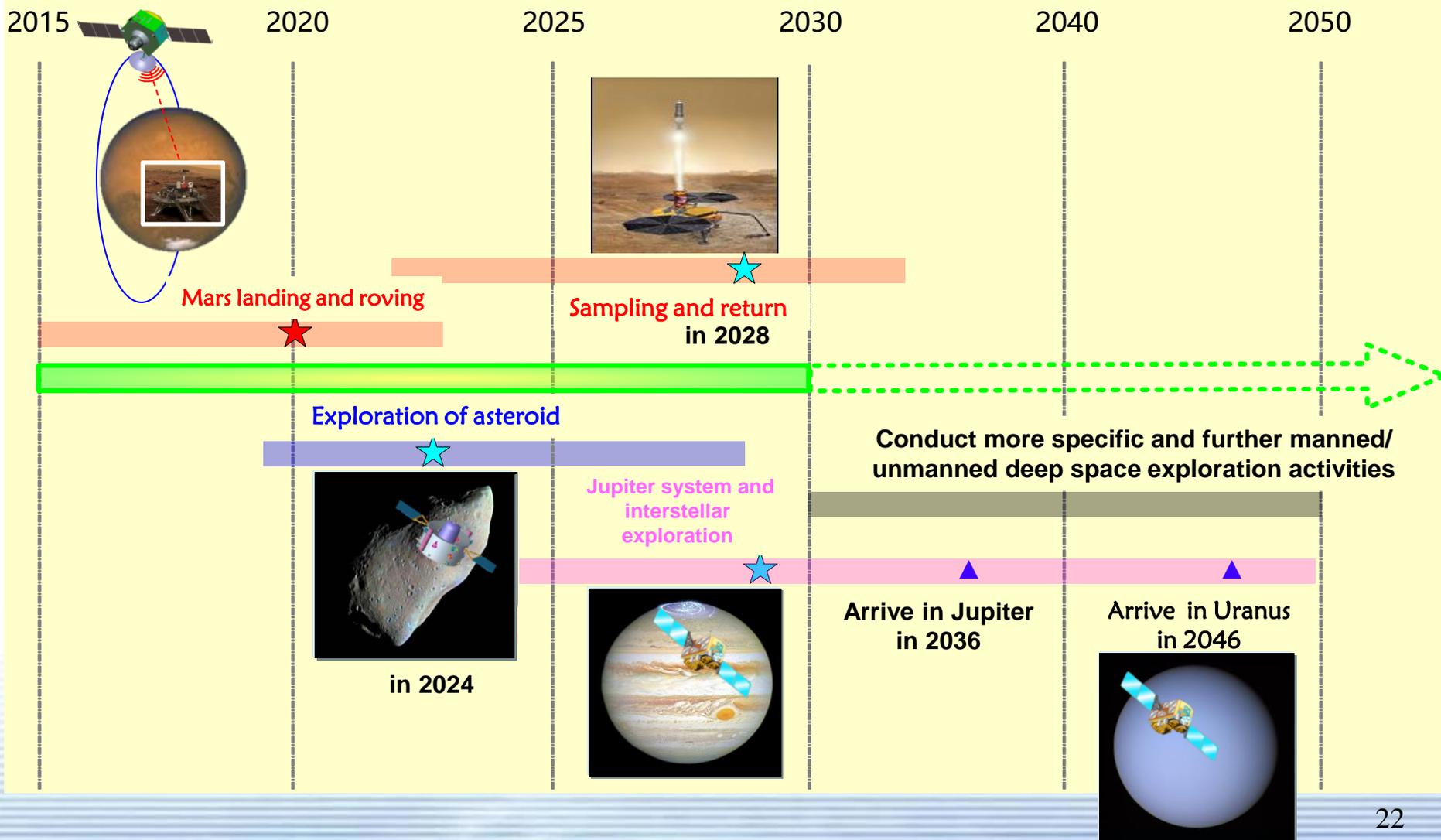
- Chang'E-6: sample on the south pole of the Moon;
- Chang'E-7 : conduct a comprehensive exploration on the south pole of the Moon, including topography、 material composition 、 spatial environment;
- Chang'E-8 : carry out further scientific exploration experiments and test some key technologies on the moon .





# China Deep Space TT&C and Future Missions

## Future China Deep Space program:

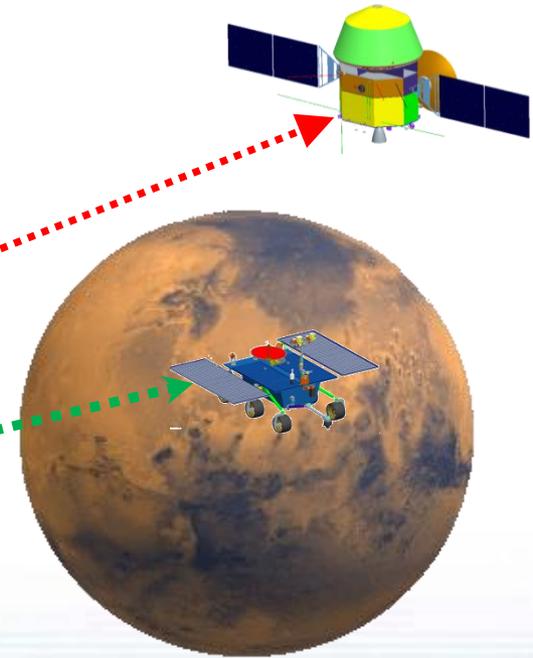
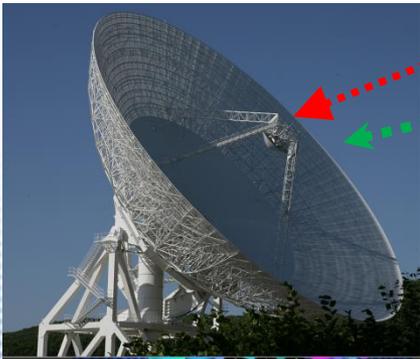




# China Deep Space TT&C and Future Missions

## Future Requirements for Deep Space TT&C capability

- 1、 To Improve downlink capability
- 2、 To Improve uplink capability
- 3、 Multiobjective TT&C capability





# China Deep Space TT&C and Future Missions

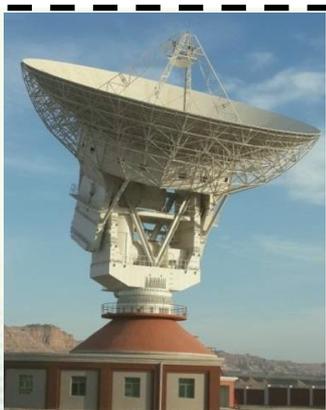
## 1、 To Improve downlink capability



New 3 × 35m



Kashi 35m



Jia Musi 66m

Kashi Deep Space Antenna Array (4 × 35m, 2020) for China First Mars Mission



# China Deep Space TT&C and Future Missions

## 2、 To Improve uplink capability

### High power transmitter

X band 10kW transmitter



X频段 10kW

50kW

2012

2025

Ka频段

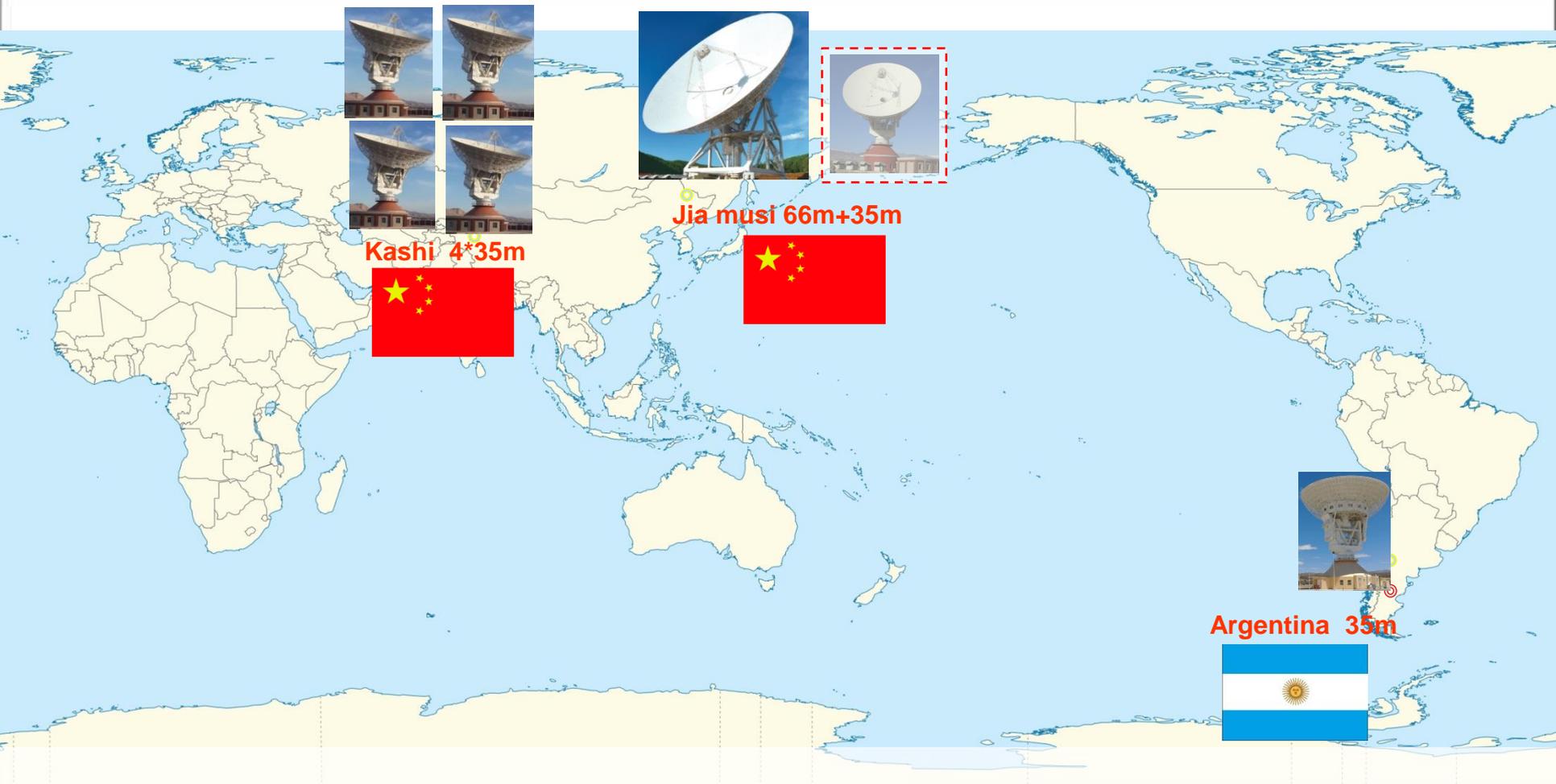
2kW





# China Deep Space TT&C and Future Missions

## 3、 Multiobjective TT&C capability



For China future deep space program ,before 2025



# **Future Deep Space TT&C International Cooperation Proposals**

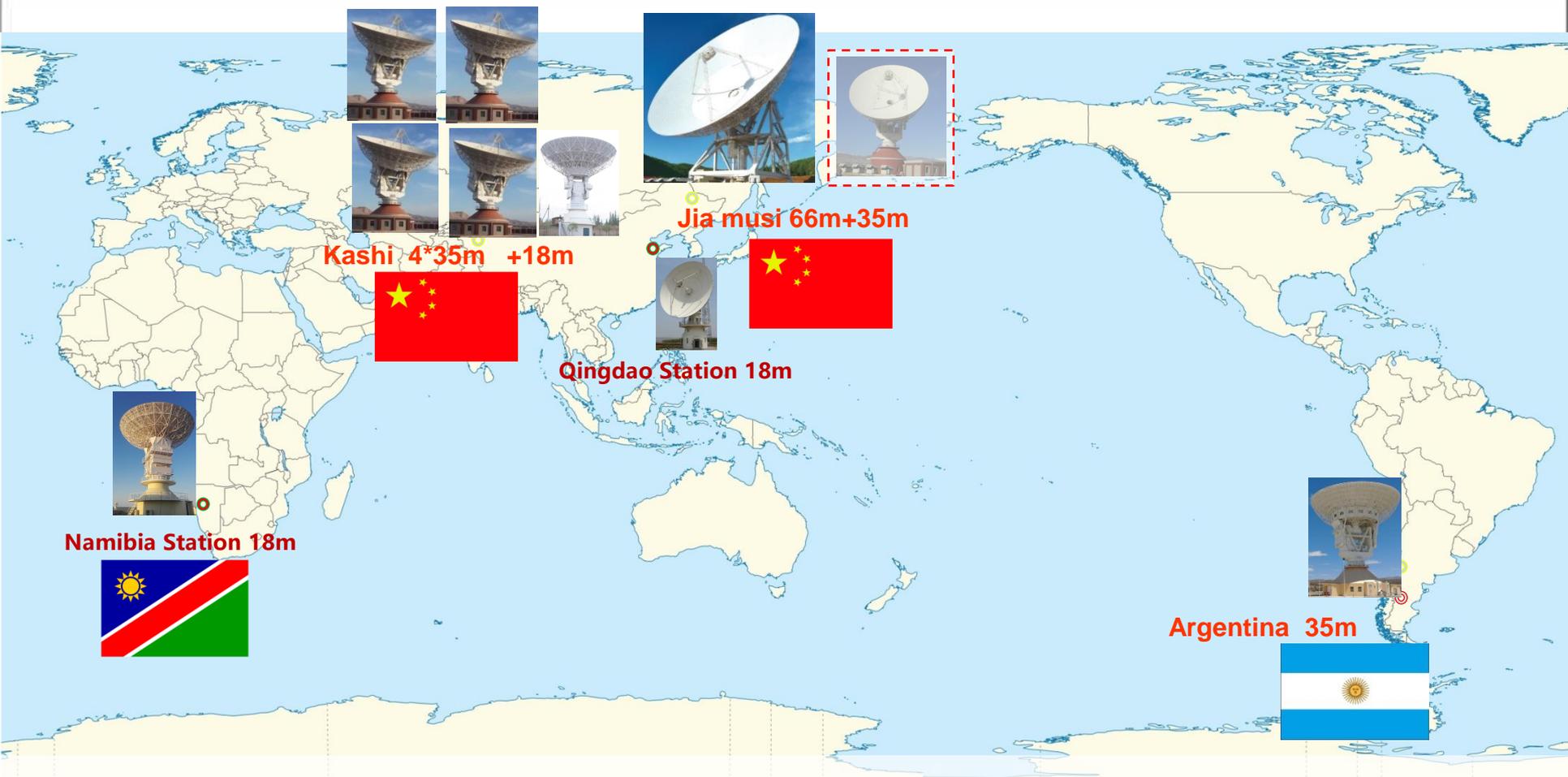
**China Deep Space TT&C Network is open , Possible areas of future international cooperation as follow:**

- 1. Mission Cross-support with deep space TT&C system.**
- 2. Long baseline  $\Delta$ DOR with other Deep Space Antennas for improving navigation accuracy.**
- 3. Antenna arraying with other Deep Space Antennas for higher data rate received from deep space probe.**

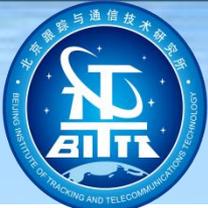


# Future Deep Space TT&C International Cooperation Proposals

1. 18m,35m and 66m TT&C systems can provide cross-support.



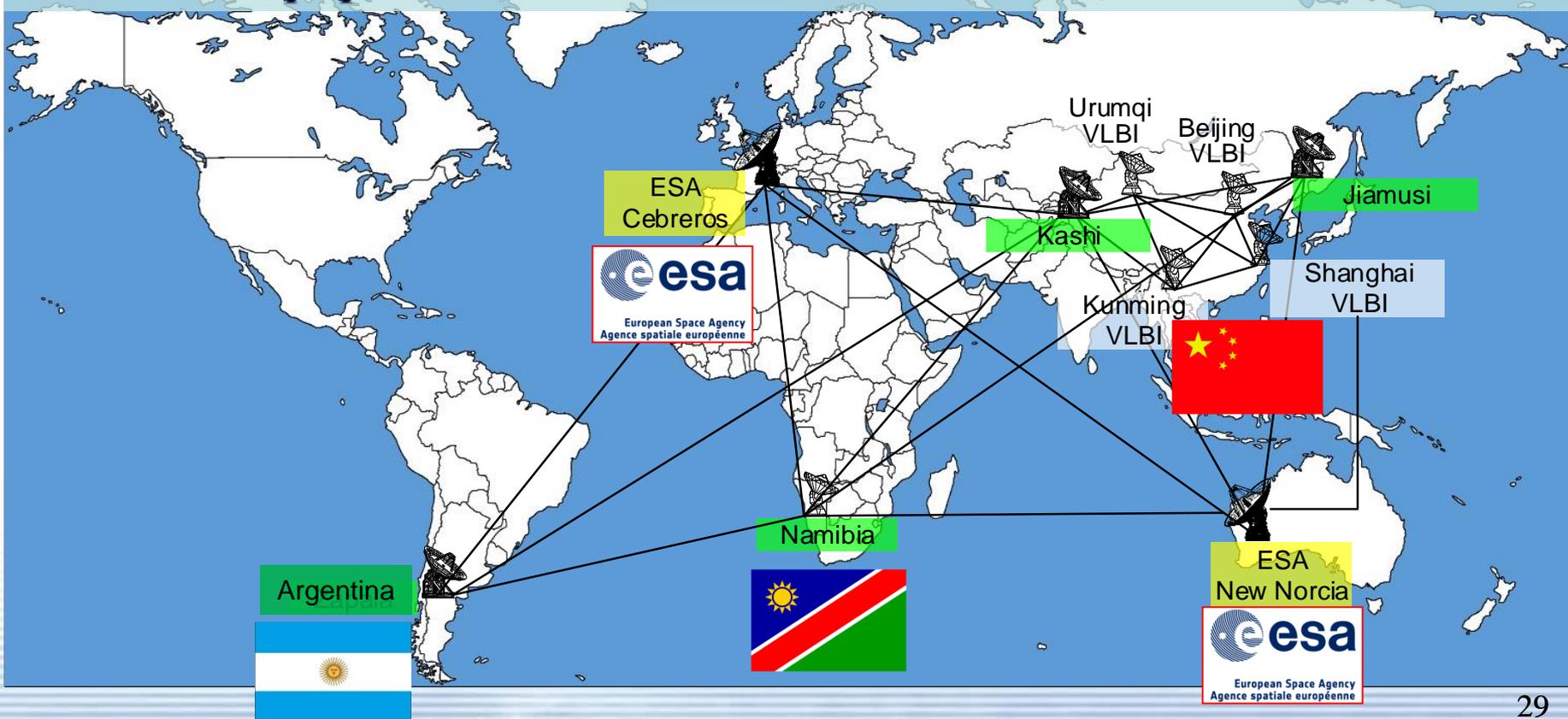
China's Deep Space TT&C system ,before 2025



# Future Deep Space TT&C International Cooperation Proposals

2. 35m,66m and 18m(in Namibia) antennas can provide Long baseline  $\Delta$ DOR support.

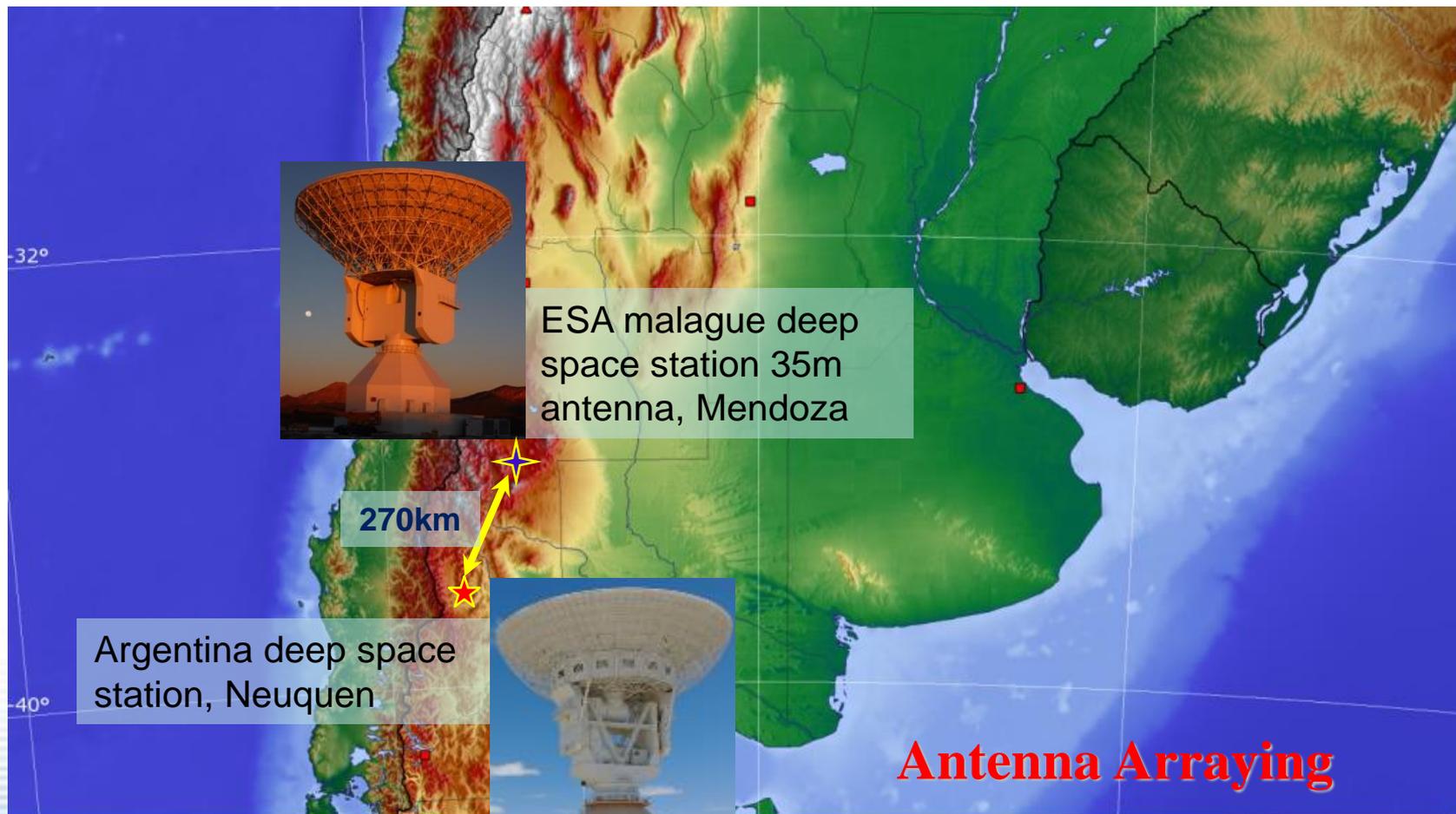
Interferometry baselines of China's deep space TT&C Network cooperation with ESA deep space stations





# Future Deep Space TT&C International Cooperation Proposals

**3. 35m and 66m antennas can provide antenna arraying support with other deep space antennas.**



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# Thanks !

An aerial photograph of a radio telescope facility at sunset. The central focus is a large, white, parabolic radio telescope dish mounted on a complex metal lattice structure. The dish is pointed towards the sky. The facility is situated on a hillside, with several smaller buildings and structures nearby, including a building with a red roof and a blue roof. The surrounding landscape is a mix of fields, forests, and distant mountains under a dramatic sky with orange and pink hues from the setting sun. The overall scene is peaceful and scenic.