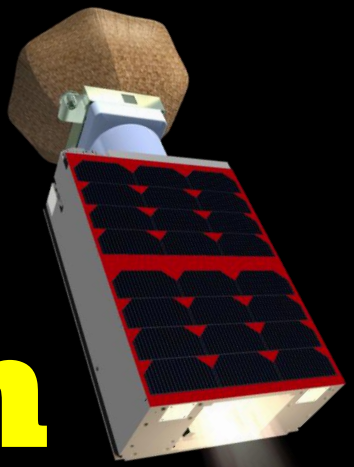
44th Virtual UNISEC-GLOBAL meeting
Opening Remarks



# Go to the Moon using CubeSats

Tatsuaki HASHIMOTO (JAXA)

The Moon is

very far from the Earth compared with LEO.

1000 times farther

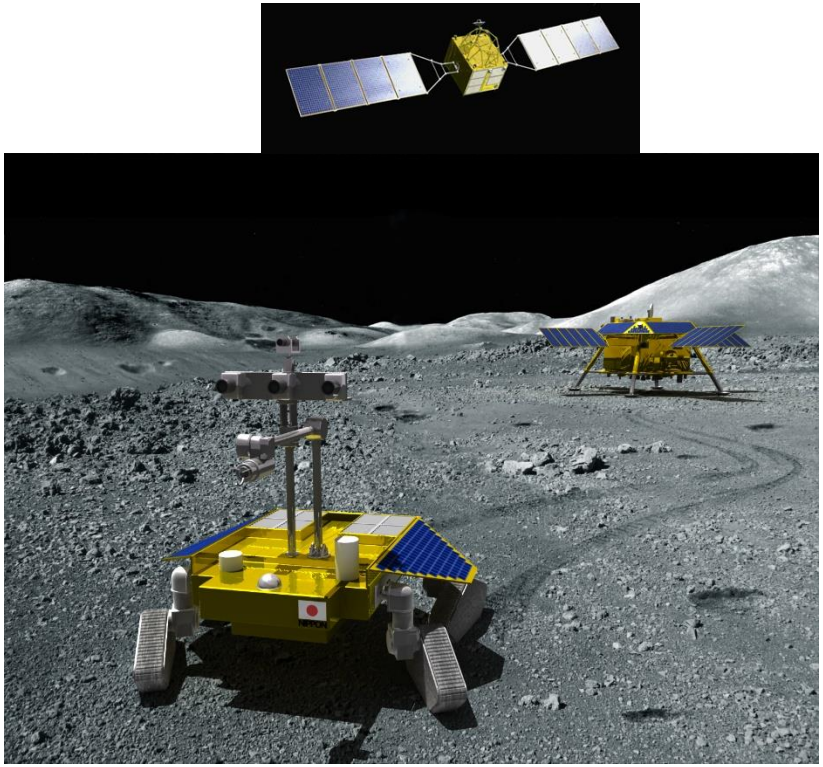
very close compared with Mars or asteroids.

145 – 1000 times closer

Opportunities to go to the Moon will likely increase in the future.

# My history

- 2000s
  - I had been in charge of a large lunar exploration mission.
  - However, we could not receive the budget.



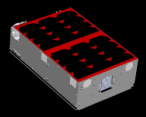
# My history

- 2015
  - NASA offered opportunities for rideshare CubeSats on Artemis-I.
  - I proposed a moon landing mission OMOTENASHI (Outstanding MOon exploration TEchnologies demonstrated by NAno Semi-Hard Impactor)

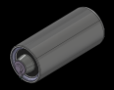
# Conditions for a secondary payload

1. Its mission should include science and technical goals that advance human exploration
2. Its size should be within 6U (113 x 239 x 366 mm) and its mass should be less than 14 kg
3. The launch date was 2018 at the time of the invitation, necessitating very rapid development
4. It was to be put into lunar flyby orbit, but no detailed trajectory information was provided at the invitation. Later, initial trajectories for all possible launch dates and times were provided, but we didn't know which was the real launch trajectory in a-few-thousands cases.
5. The safety regulations were those for crewed vehicles because it would be co-launched with Orion spaceship

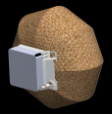
# Mission Sequence of OMOTENASHI



Orbiting Module (OM) 7.6 kg



Rocket Motor (RM) 4.3 kg



Surface Probe (SP) 0.7 kg

＜Launch day＞
Deployment
from SLS
Attitude control
for pointing sun

＜day 2＞
Orbit control to
lunar impact orbit
(DV1: 15m/s)

＜day 5-6：just before landing＞

Air bag deployment

Attitude maneuver for DV2
Spin-up

SP is separated from OM.

Total mass 12.6kg

OM hits to the moon surface
with 2500 m/s

Measuring the radiation environment
during this sequence

Deceleration by solid motor
(DV2: 2500m/s)

Landing!!
(50m/s)

Smallest moon lander in the world,
launched by the most powerful rocket in the world

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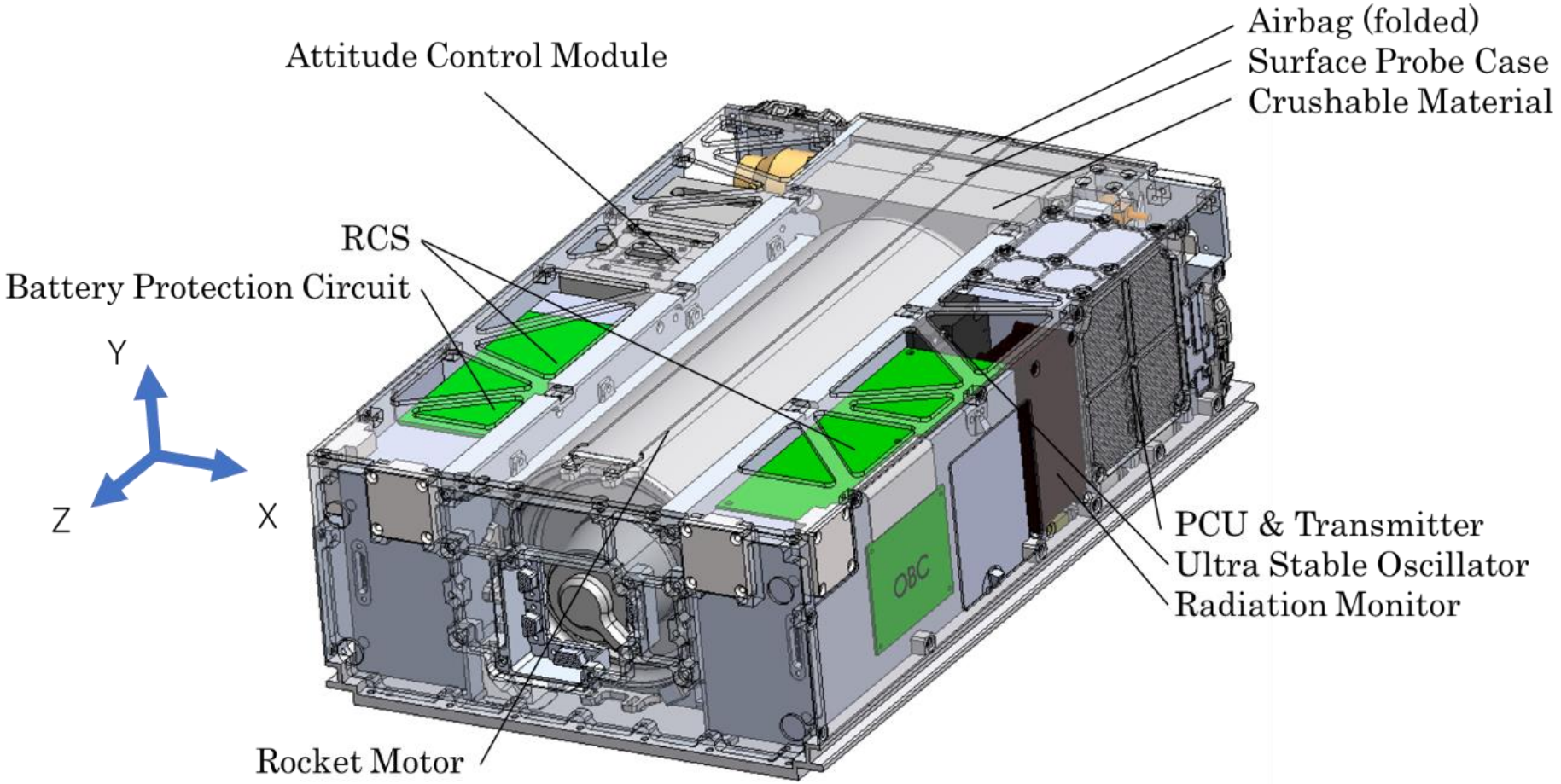
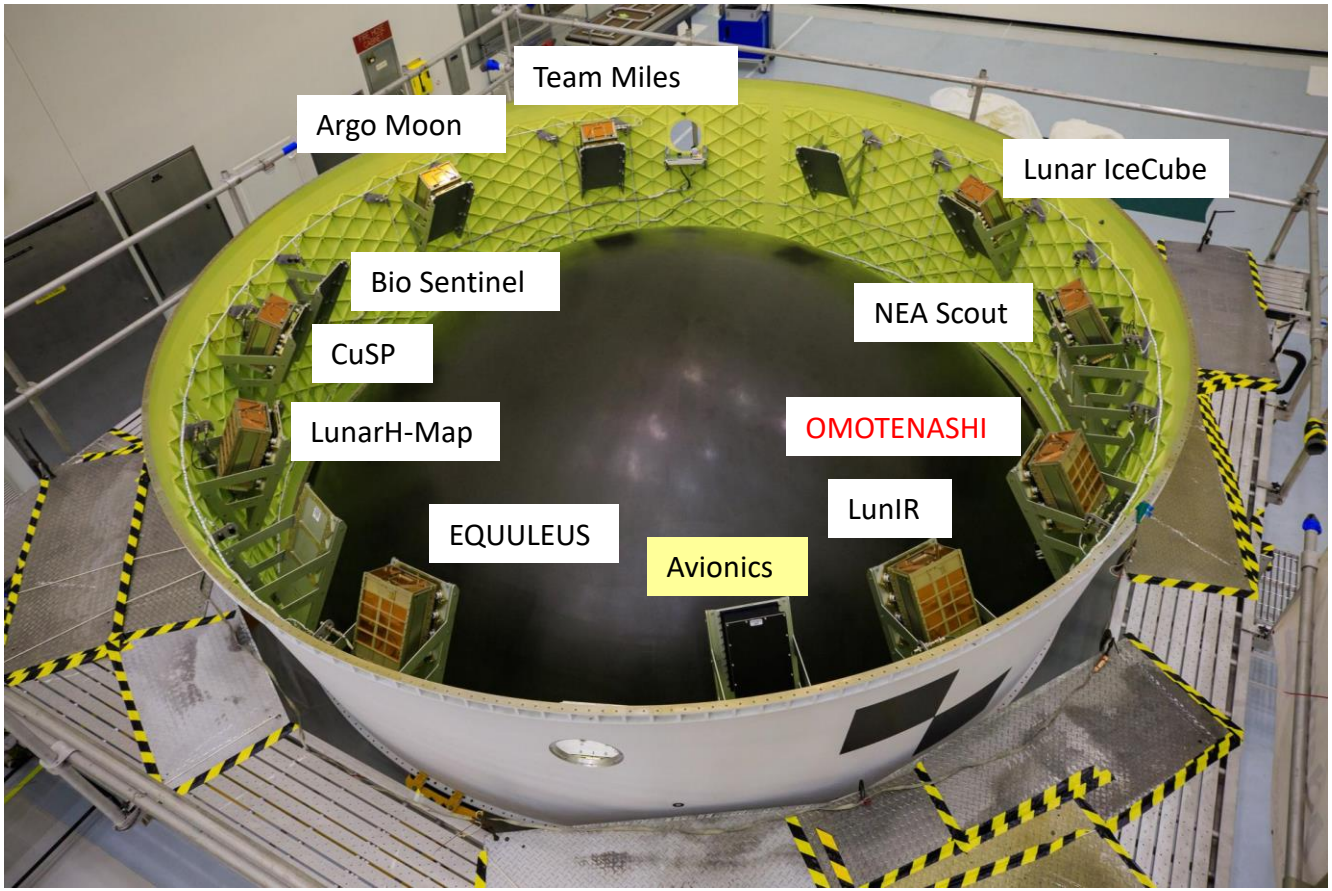
- 2016
  - It was selected, and we had started the development.
- 2021
  - The CubeSat was completed and handed over to NASA.

# Perspective view of the spacecraft



# Hand over to NASA at Kennedy Space Center

# Photo of Orion Stage Adapter Aug. 12, 2021 ©NASA



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- 2021
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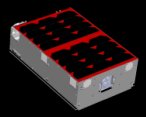
- 2022
  - After several delays, the CubeSat was launched.

# SLS Artemis-I launch (2022/11/16 6:47 UTC)

About 40 minutes delayed from the start time of the window

(c)NASA

# Mission Sequence of OMOTENASHI



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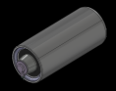

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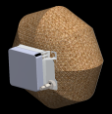

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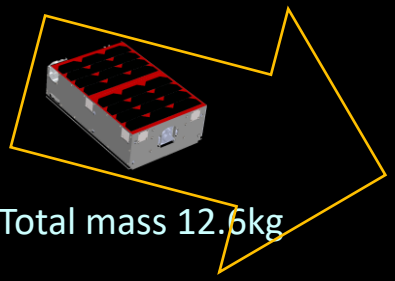


Total mass 12.6kg

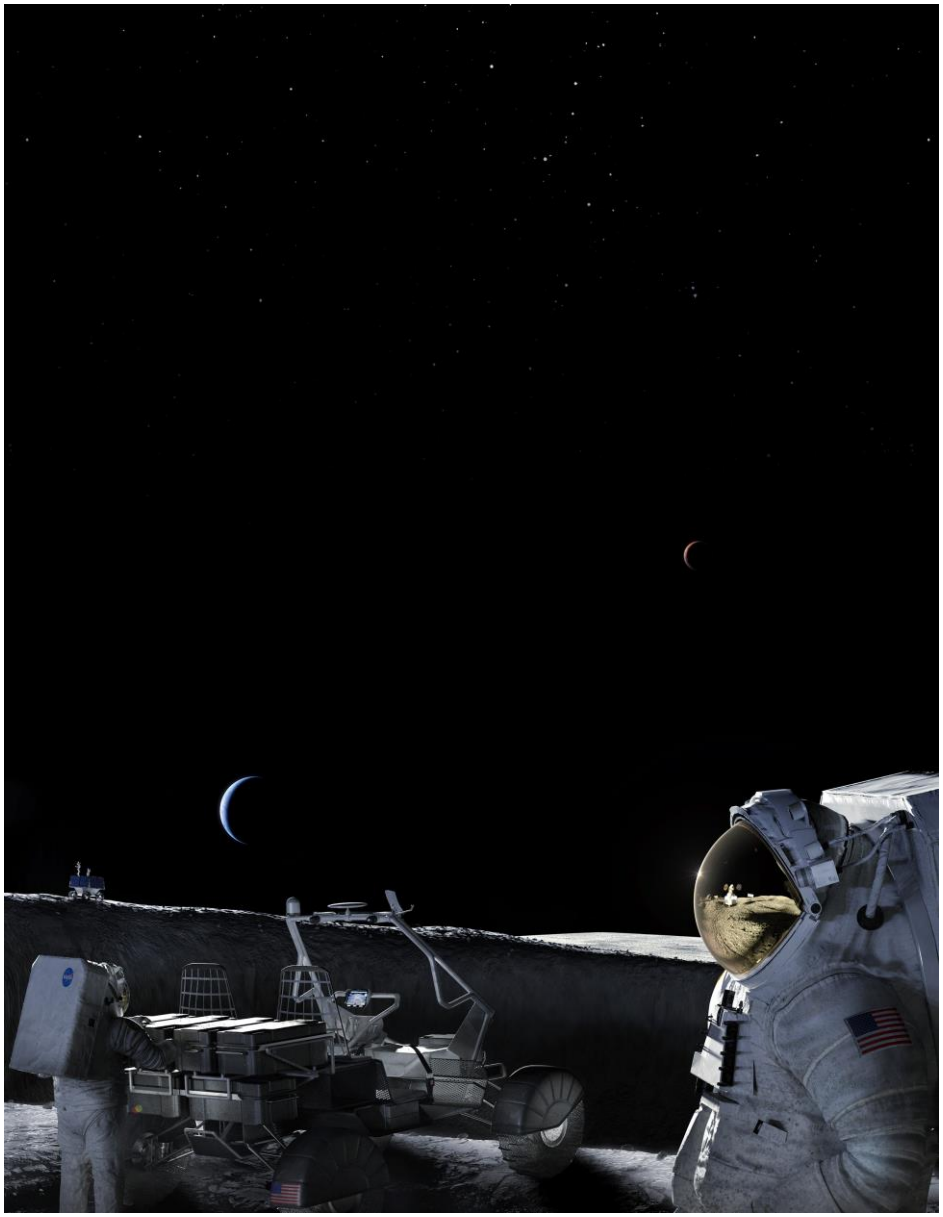
The CubeSats failed the initial sun acquisition control, and finally its battery was depleted. Since then, we have not been able to communicate with the CubeSat.

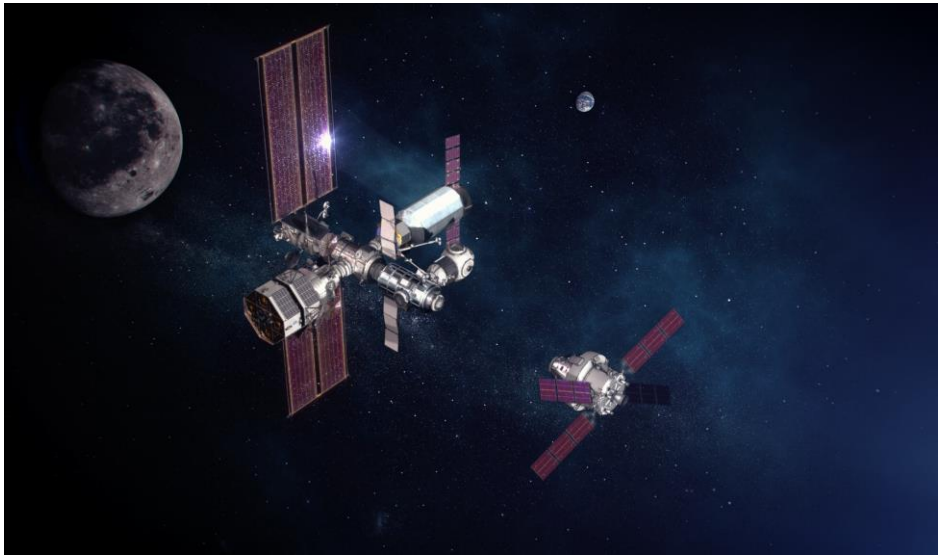
Measuring the radiation environment was successful for 30 minutes.

# Summary

- Unfortunately, OMOTENASHI had to give up the moon landing experiment. However, we could develop some technologies for semi-hard landing scheme.
- OMOTENASHI successfully measured the radiation environment outside Earth's magnetosphere by an ultra-small sensor.
- Currently, the success rate of the spacecraft is not high. It will be hard job. But the opportunities are extremely valuable.
- Onboard opportunities of not only CubeSats but also small observation instruments are expected to increase from now.

# Artemis program





(c) NASA

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Let's take on the challenge of "go to the moon"!