Space Debris Research at JAXA

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2019.2.18
JAXA

- Observation
- Modeling
- In-Situ Measurement of Small Debris
- Active Debris Removal (ADR)
- Ground Testing
- Related Topics

Observation Technology Development

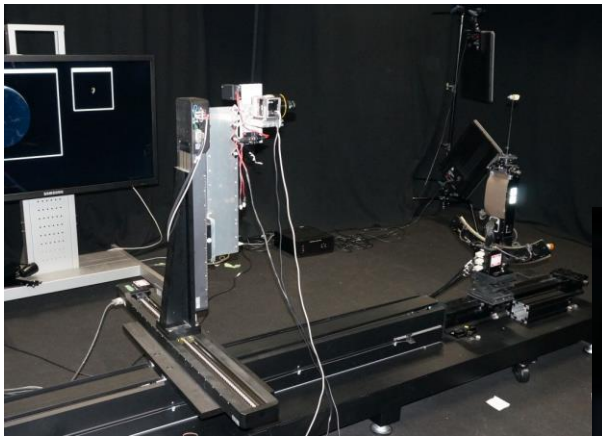
(1) **Remote observation** site in Australia

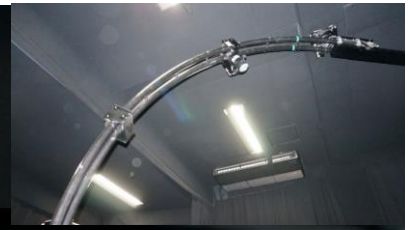
3 20-cm class telescopes were installed at Siding Spring Observatory in **Australia.** GEO and LEO observations are possible. **Collaborative observation with CNES was carried out.**

Remote observation site in Australia

(2) **Light curve simulation for ADR**

Optical simulator of JAXA was modified to **simulate light curve of ADR targets**. Technologies of motion and attitude estimation will be developed using scale model of the targets.

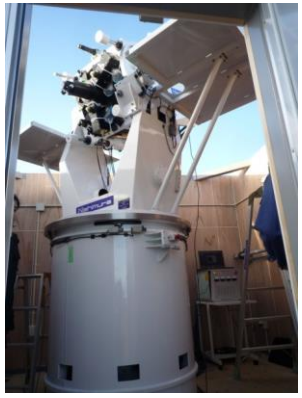




Optical simulator set for artificial light curve

(3) **Direct imaging of ADR targets**

The 60cm telescope at Mt.Nyukasa Observatory was modified for **direct imaging of ADR targets**. Shack-Hartmann sensor was installed to monitor the atmospheric condition of the site, which will be used to develop the optimum **adaptive optics system**.

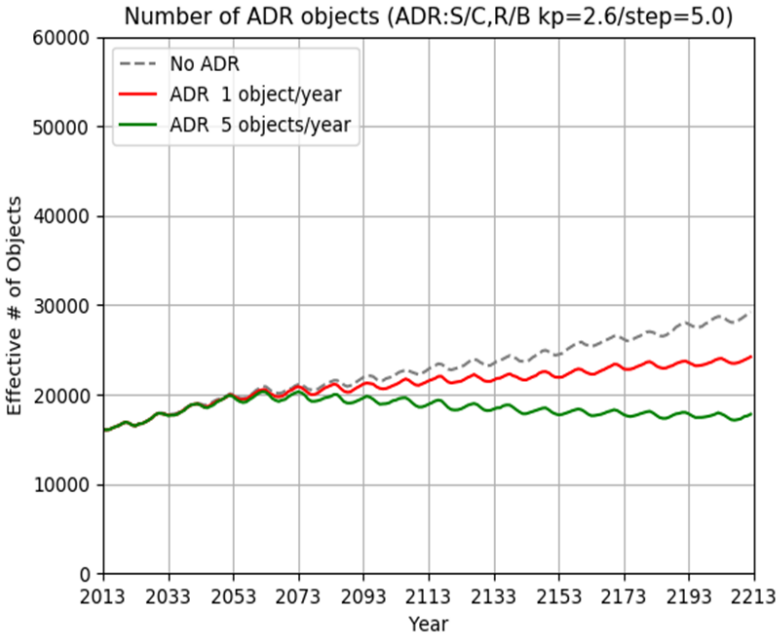


60cm telescope for direct imaging of ADR targets

Space Debris Modelling

(1) Debris evolutionary model

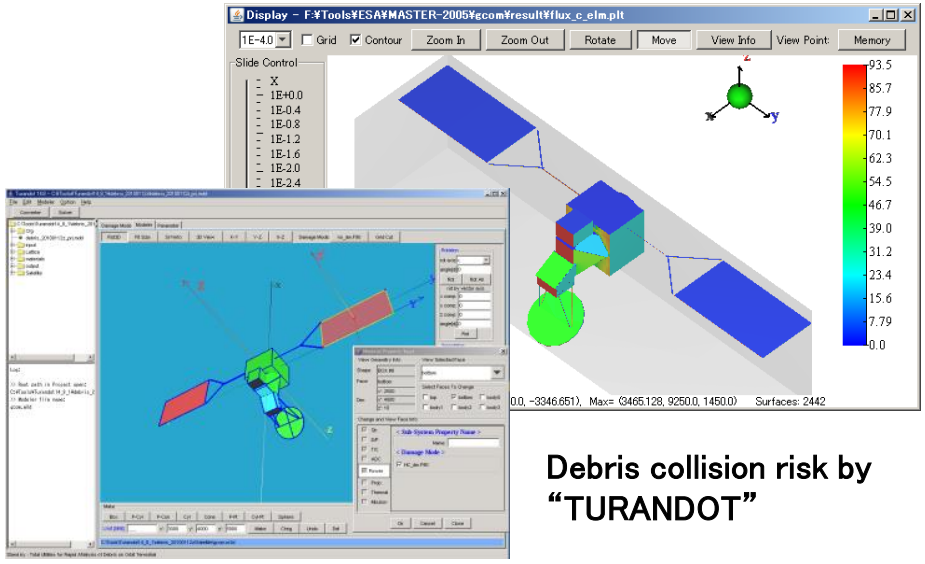
- **NEODEEM** (Near-Earth Orbital Debris Environment Evolutionary Model) developed in collaboration with Kyushu University
- **To evaluate effective mitigation measures**
- **To select active debris removal targets**



Debris population prediction by "NEODEEM"

(2) Debris collision risk assessment tool

- **Turandot** (Tactical Utilities for Rapid ANalysis of Debris on Orbit Terrestrial)
- **To predict spacecraft damage probability by collisional debris** including shielding effect of the spacecraft itself
- Users can choose MASTER-2009 or ORDEM 3.0 as database of debris flux

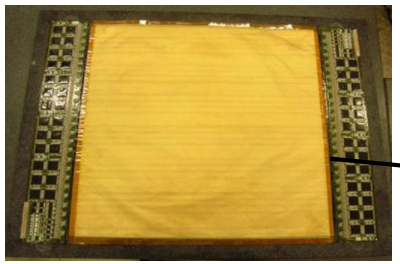


Debris collision risk by "TURANDOT"

In-situ Measurements of Small Debris

In-situ measurement

- **SDM**（Film-perforation type debris sensor）was developed for in-situ measurement of MMOD.
- Flight demonstration of SDM was conducted on **HTV-5/ISS**.
- In-flight SDM detected a debris of 100μm in size.

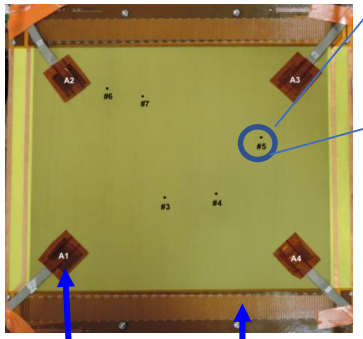


SDM

HTV-5

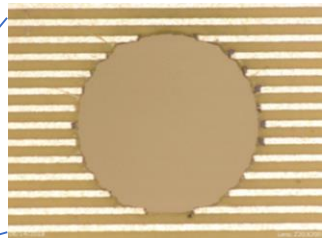
International Collaboration

- **By combining JAXA's sensor and NASA's sensor, it was confirmed it can be a system to measure collision frequency, size, direction, speed, mass, etc. of debris**



NASA Sensor (Acoustic sensor)

JAXA Sensor



Perforation hole.
（projectile: Al, 1060μm）

Active Debris Removal Technology Development

(1) **Rendezvous technology** to non-cooperative space debris

- ➢Onboard real-time image navigation

Robust onboard real-time navigation using deep learning based pose estimation.

High fidelity ground test environment for onboard image navigation.

(2) **Capture technology** for non-cooperative large intact space debris

- ➢Dedicated capture mechanism

Mechanism to capture slowly **rotating rocket upper stage.**

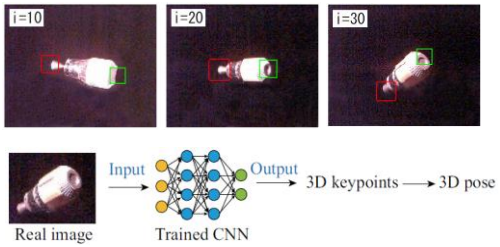
High fidelity ground test facility.

(3) **Efficient propulsion system** to remove large intact space debris

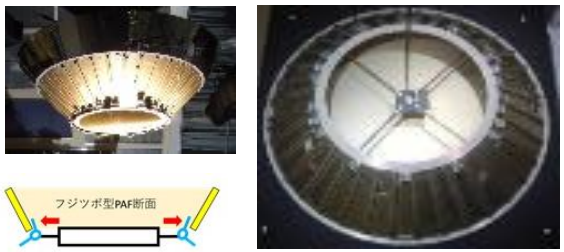
- ➢Efficient electric propulsion

Novel efficient electric propulsion to transfer large intact space debris into graveyard or reentry orbits.

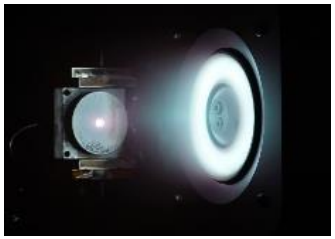
Deep learning based pose estimation



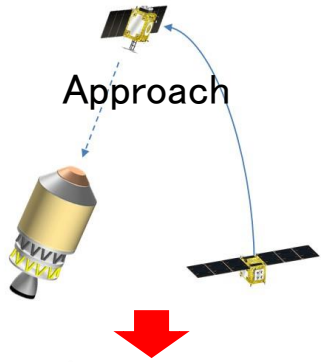
Mechanism to capture payload attachment Fitting (PAF) of upper stages

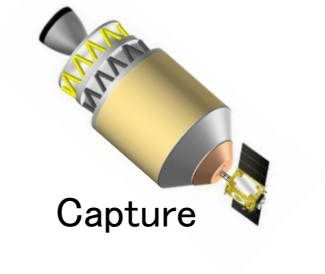


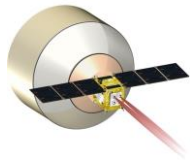
Efficient electric propulsion system such as hall effect thruster



Mission concept







Rendezvous Technology

- Fault Tolerant System Design
- Safe Trajectory Design
- Operational Consideration

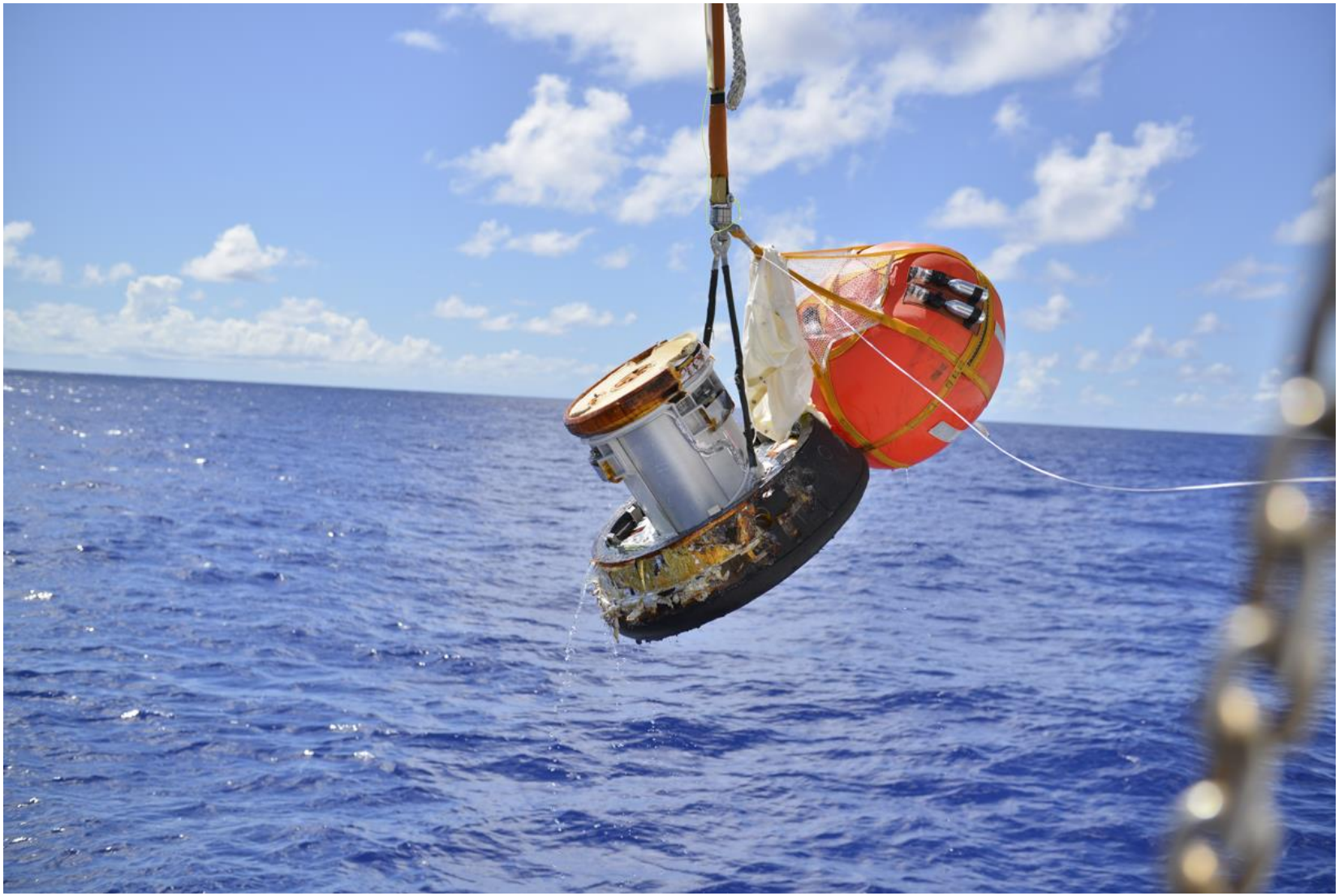
HTV-7 Rendezvous 2018.9.27

ADR Technical Background of JAXA (cont'd)

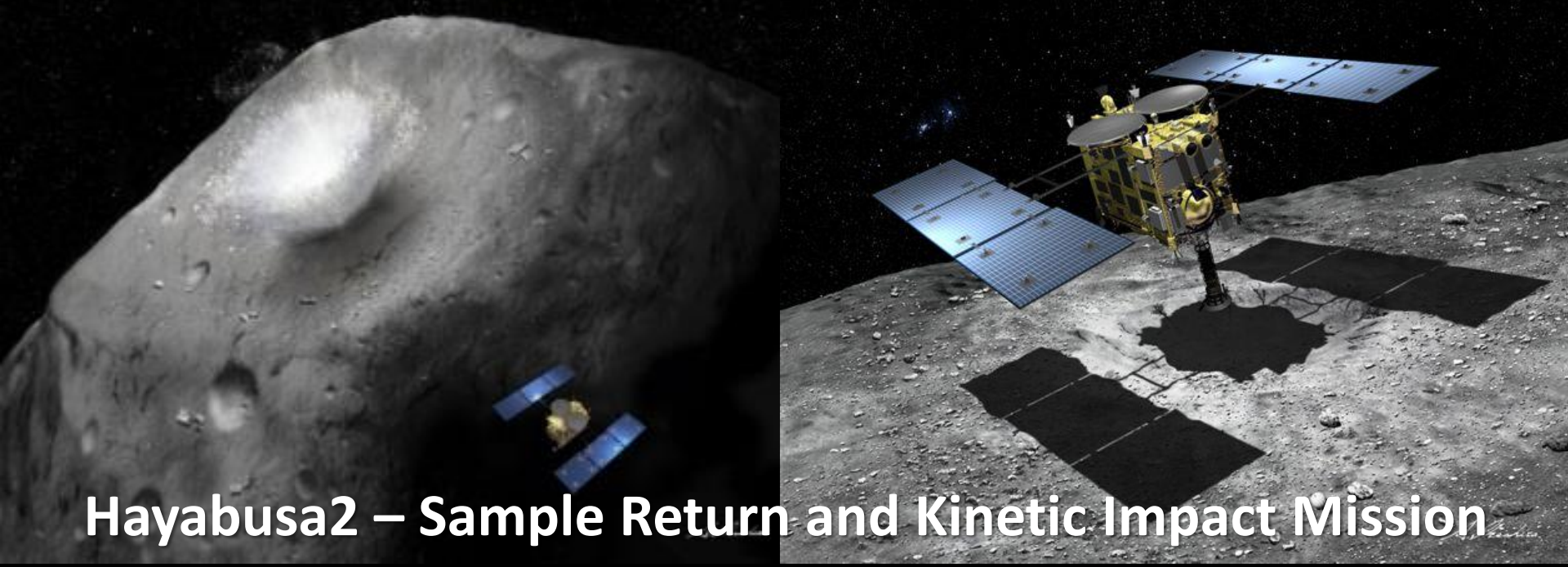
Safe Departure and Reentry Technology

- Separation
- Departure
- Deorbit
- Reentry

HTV-7
Departure and
Reentry
2018.11.11

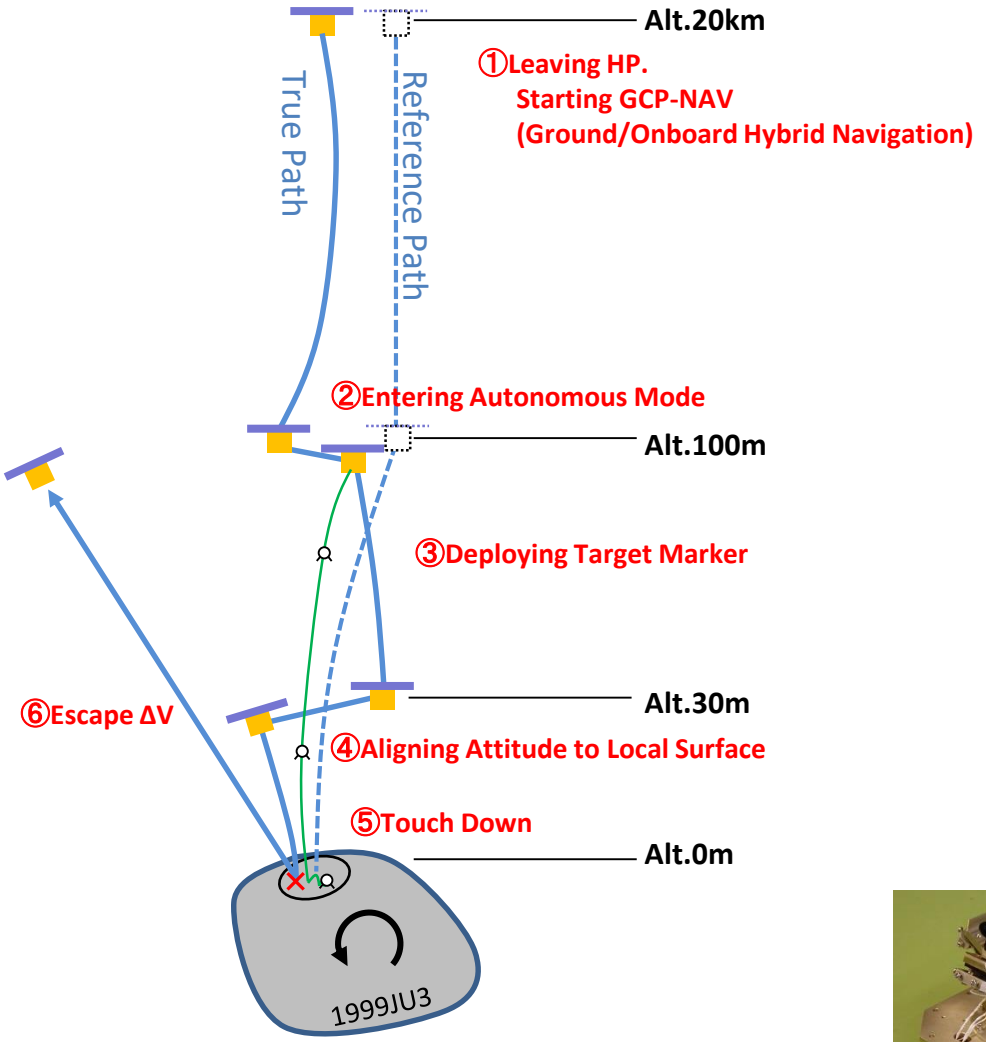


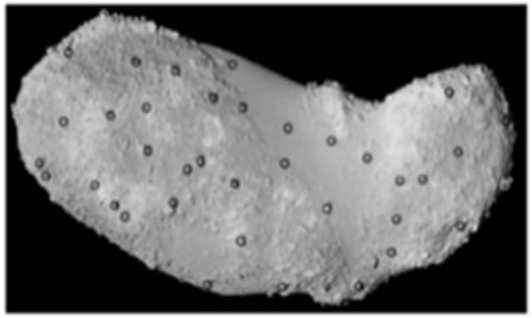
HTV7 Reentry Capsule, 2018.11.11



Hayabusa2 – Sample Return and Kinetic Impact Mission to Near-Earth Asteroid Ryugu

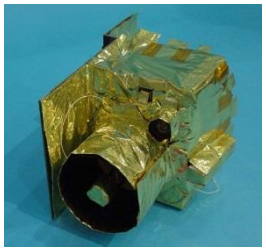
Hayabusa-2 Proximity Operation





"GCP" Landmark based navigation

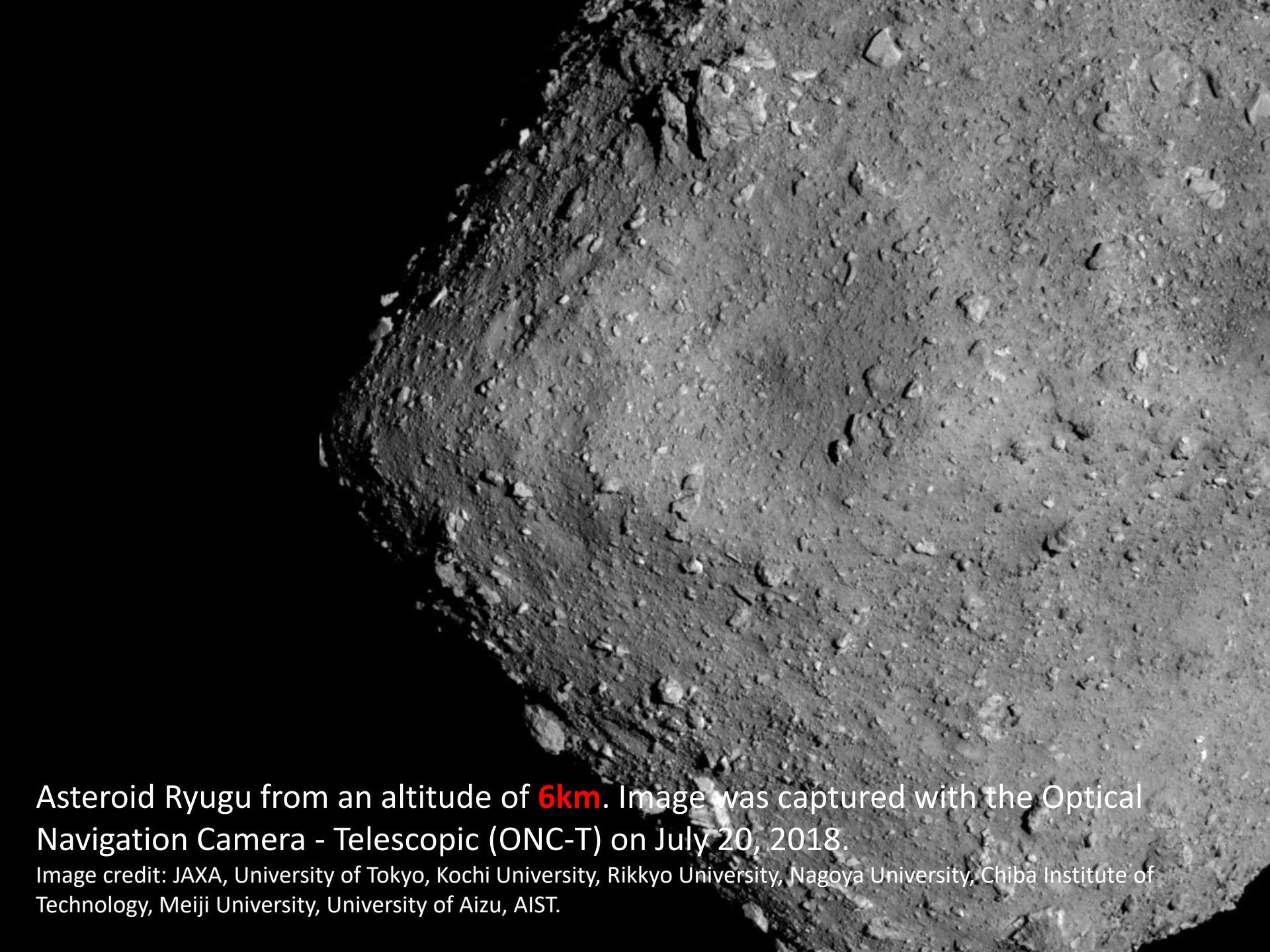
ONC



LIDAR

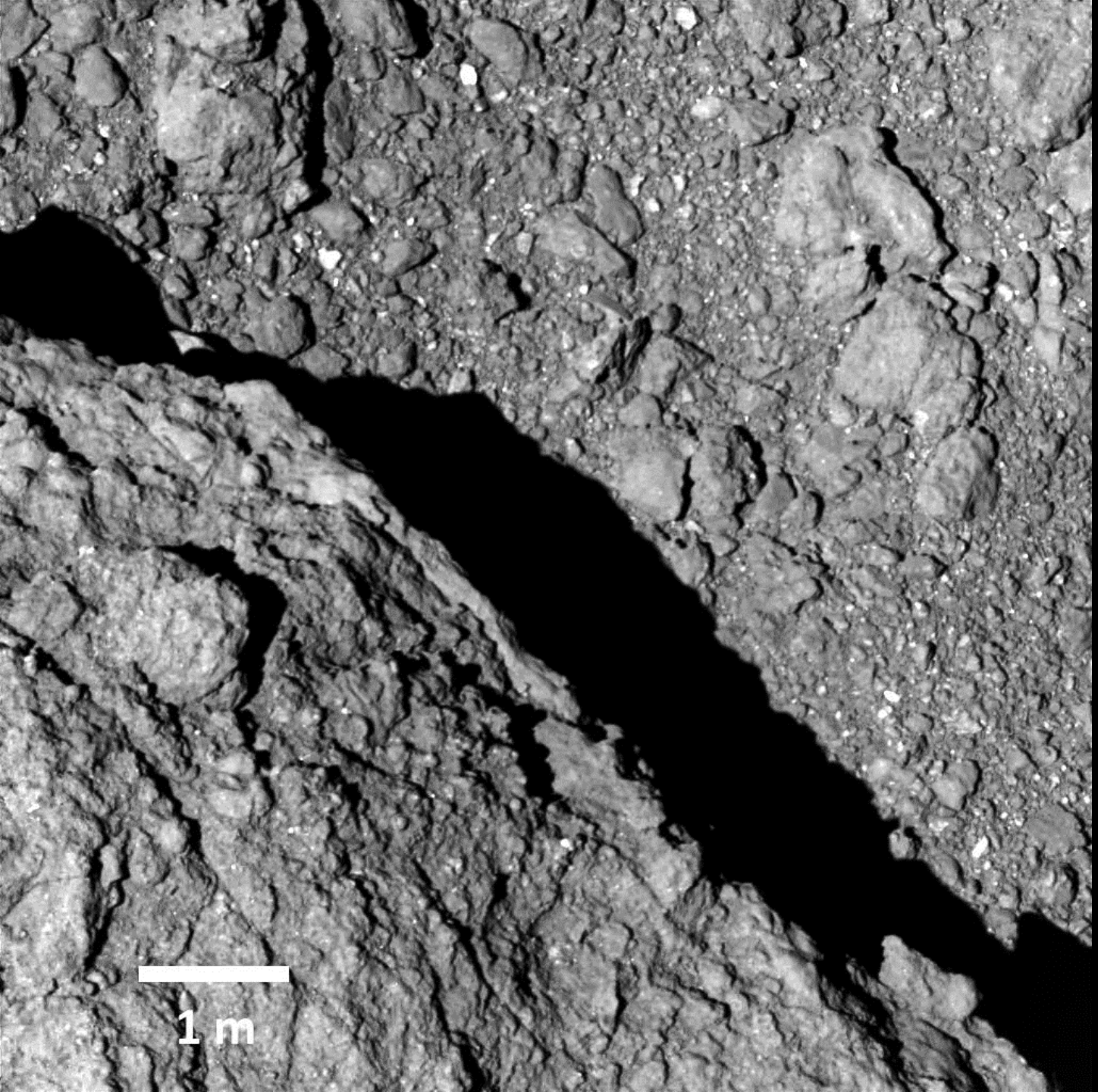
Target Markers & FLASH

LRF



Asteroid Ryugu from an altitude of **6km**. Image was captured with the Optical Navigation Camera - Telescopic (ONC-T) on July 20, 2018.

Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST.



Altitude about **210 feet (64 meters**)
Sept. 21, 2018
Credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST

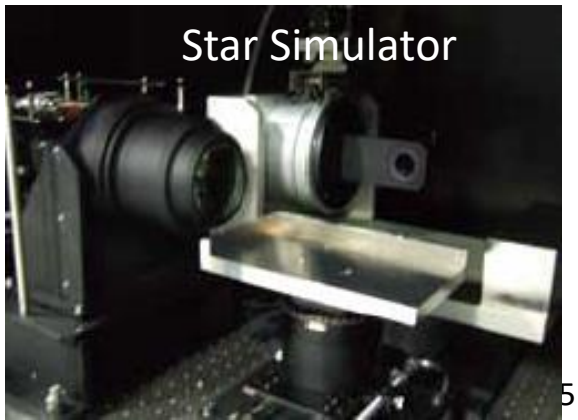
Ground Test Facility

Ground Test Facilities (Cont'd)

Three Axis Motion Simulators


Earth Simulator


Sun Simulator


Star Simulator

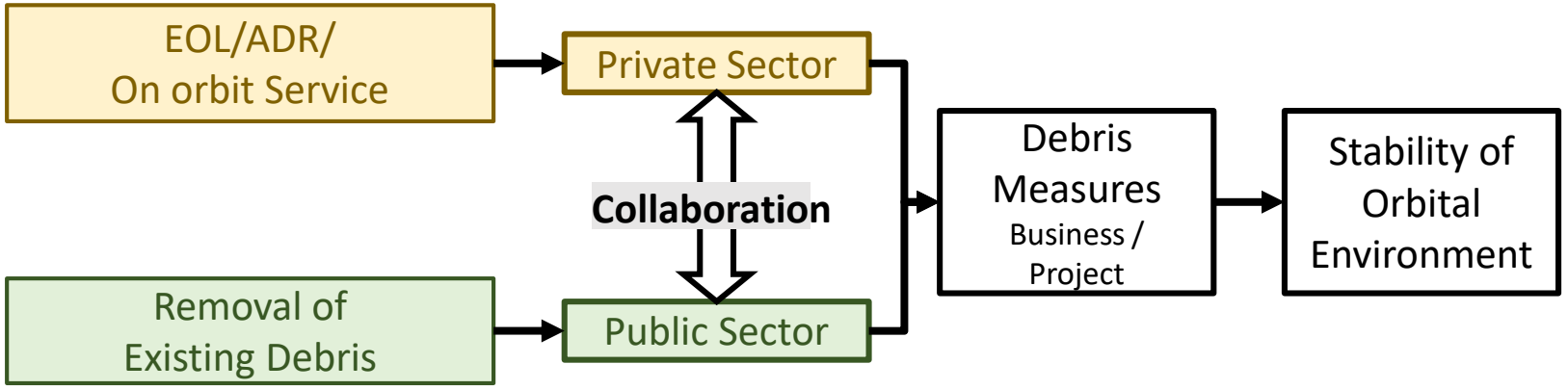
“Space Proven” Ground Testbed

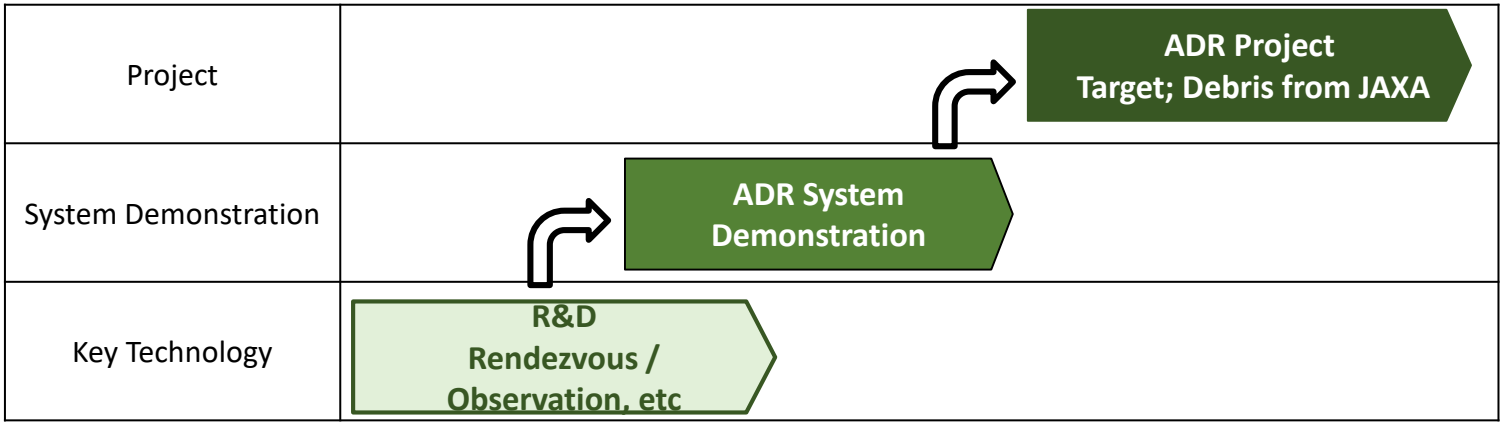
Orbit

Ground

JAXA's Contributions for ADR

- **Continue researches for removing large space debris.**
- **Partner with private sectors; by joint programs including research, ground testing, demonstration in orbit and so on.**

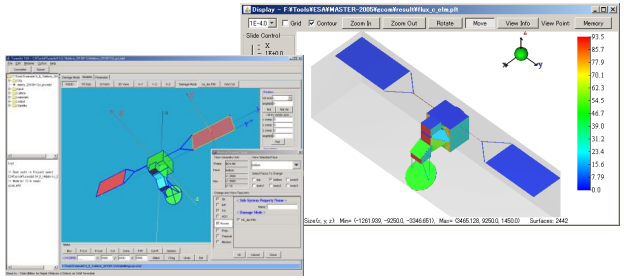




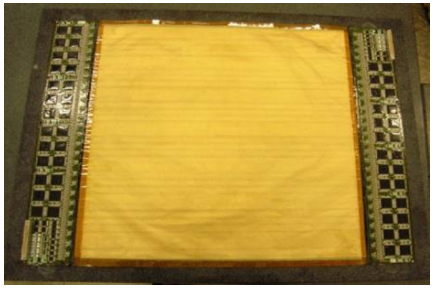
Research Subjects

Observation

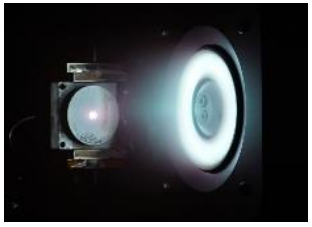
Modeling



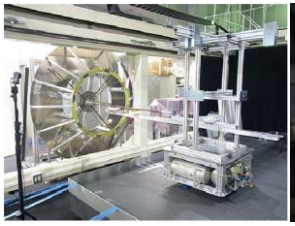
In-Situ Measurement



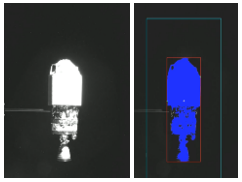
Propulsion



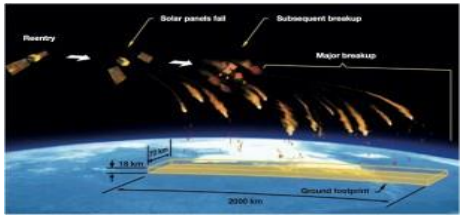
Capture



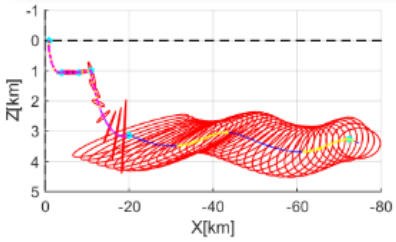
Rendezvous



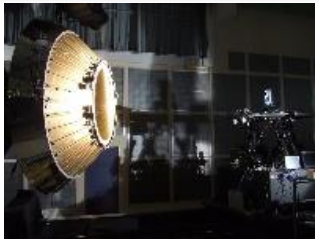
Deorbit & Safe Reentry



Numerical Simulation



Ground Testing



Summary

- JAXA continues researches on both technical and non-technical aspects.
- JAXA contributes continuously to the cooperation with international partners.
- JAXA will partner with private sectors in joint programs including research, ground testing, demonstration in orbit etc. utilizing JAXA's experience and lessons learned.