A01

Space Debris Research at JAXA

Koji Yamanaka (JAXA)

JAXA's vision of space debris measures is to improve the orbital environment for sustainable development of space activities and to find the opportunity of a novel market as space debris measures. JAXA's contribution is to support private sectors such by joint research program, provide opportunity of demonstration on orbit, ground testing and so on. JAXA's possible contribution also is to promote projects aiming at debris removal including industrial stimulation and promotion. JAXA Research and Development Directorate has set up R&Ds according with these vision and contribution objectives. Status of these research are overviewed in this presentation.

Biography

Koji YAMANAKA
Director, Research Unit I,
Aerospace Research and Development Directorate

Mr. Koji Yamanaka received a Master of Engineering from Nagoya University in 1992. He has been with JAXA for more than 25 years. He has developed rendezvous system of Japanese H-II transfer vehicle (HTV). He has been the Flight Director of HTV and Lead Flight Director of HTV-1. He received NASA Superior Achievement Award, Prizes for Science and Technology from the Minister of Education, Culture, Sports, Science and Technology of Japan, NASA Group Achievement Awards and many other awards. He is now director of research and development section of JAXA.

Space Debris Workshop 2018

Space Debris Research at JAXA

Koji Yamanaka
2018.12.3
JAXA

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

Observation Technology Development

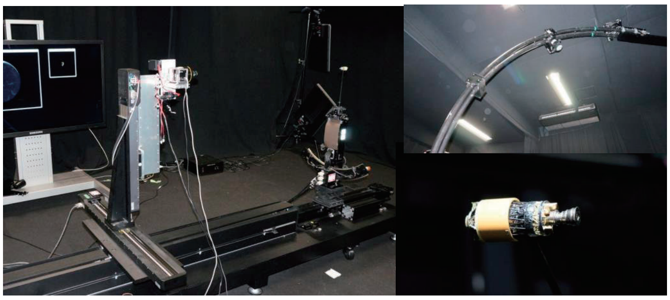
(1) **Remote observation** site in Australia

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**

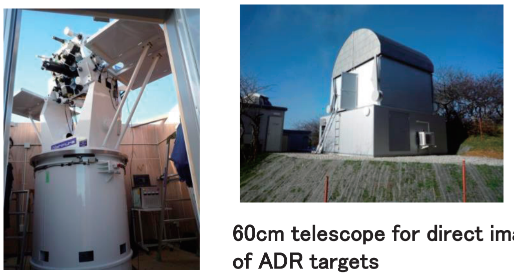
Optical simulator of JAXA was modified to **simulate light curve of ADR targets**. Technologies of motion and attitude estimation will be developed using scale model of the targets.



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**.

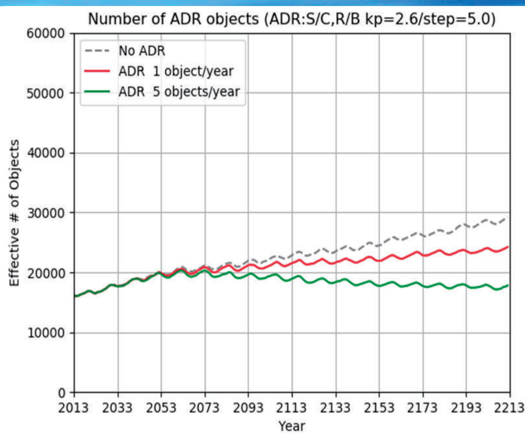


60cm telescope for direct imaging of ADR targets

Space Debris Modelling

(1) Debris evolutionary model

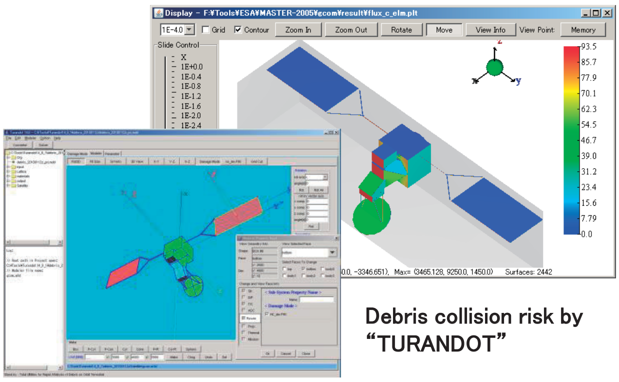
- **NEODEEM** (Near-Earth Orbital Debris Environment Evolutionary Model) developed in collaboration with Kyushu University
- **To evaluate effective mitigation measures**
- **To select active debris removal targets**



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

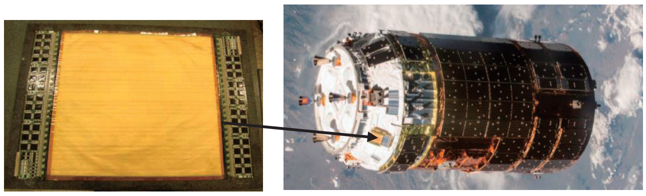


Debris collision risk by "TURANDOT"

In-situ Measurements of Small Debris

In-situ measurement

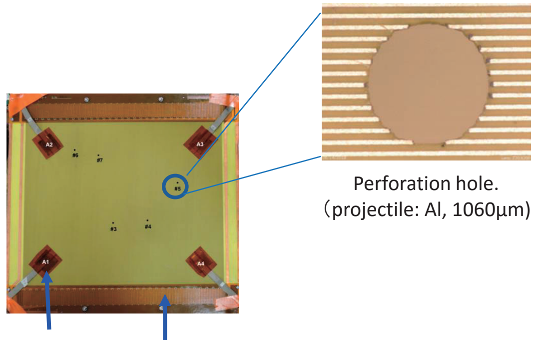
- **SDM** (Film-perforation type debris sensor) was developed for in-situ measurement of MMOD.
- Flight demonstration of SDM was conducted on **HTV-5/ISS**.
- In-flight SDM detected a debris of 100μm in size.



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**



Perforation hole.
(projectile: Al, 1060μm)

NASA Sensor (Acoustic sensor) **JAXA Sensor**

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.**

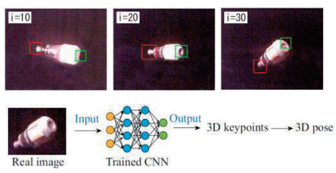
  High fidelity ground test facility.

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

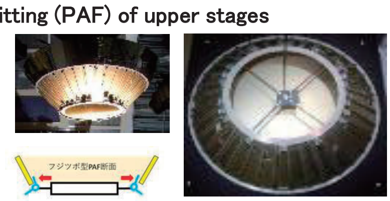
- Efficient electric propulsion

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

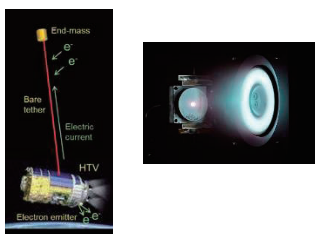
Deep learning based pose estimation



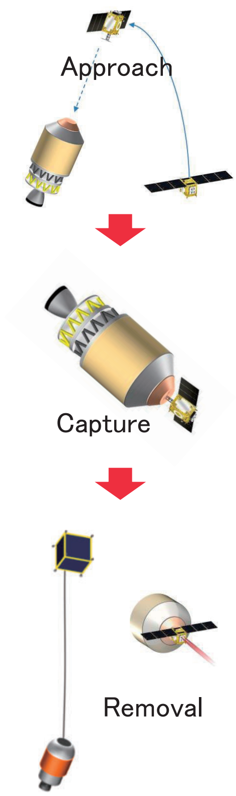
Mechanism to capture payload attachment Fitting (PAF) of upper stages



Electrodynamic tether and hall effect thruster



Mission concept



ADR Technical Background of JAXA

Rendezvous Technology

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

HTV-7 Rendezvous 2018.9.27

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ADR Technical Background of JAXA (cont'd)

Safe Departure and Reentry Technology

- Separation
- Departure
- Deorbit
- Reentry

HTV-7 Departure and Reentry 2018.11.11

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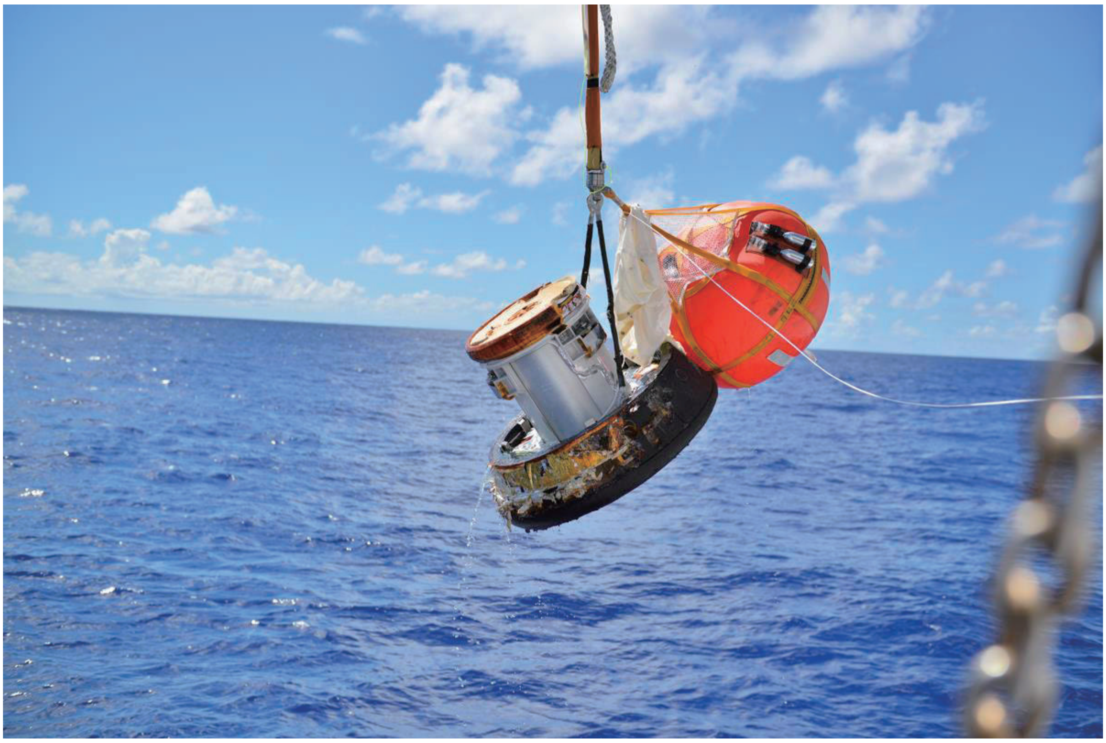

HTV7 Reentry Capsule, 2018.11.11

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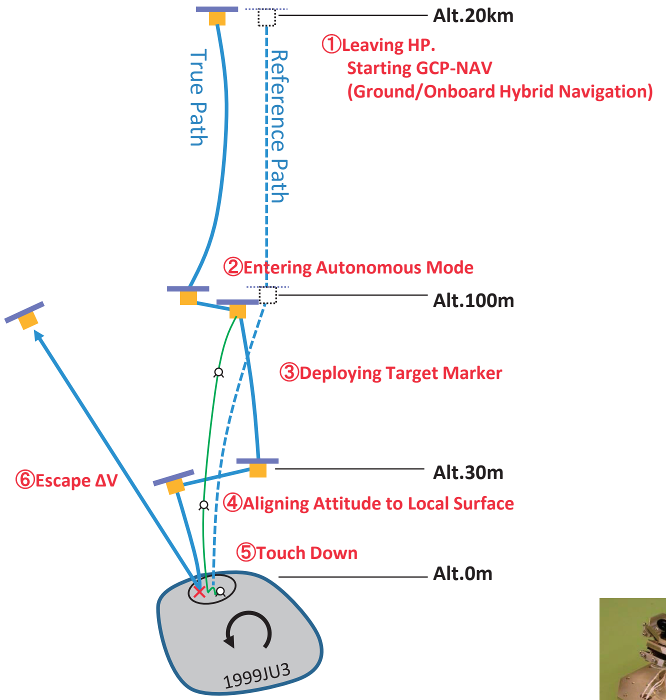
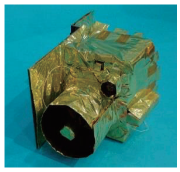
Hayabusa-2 Proximity Operation




"GCP" Landmark based navigation


ONC


LIDAR


Target Markers & FLASH


LRF

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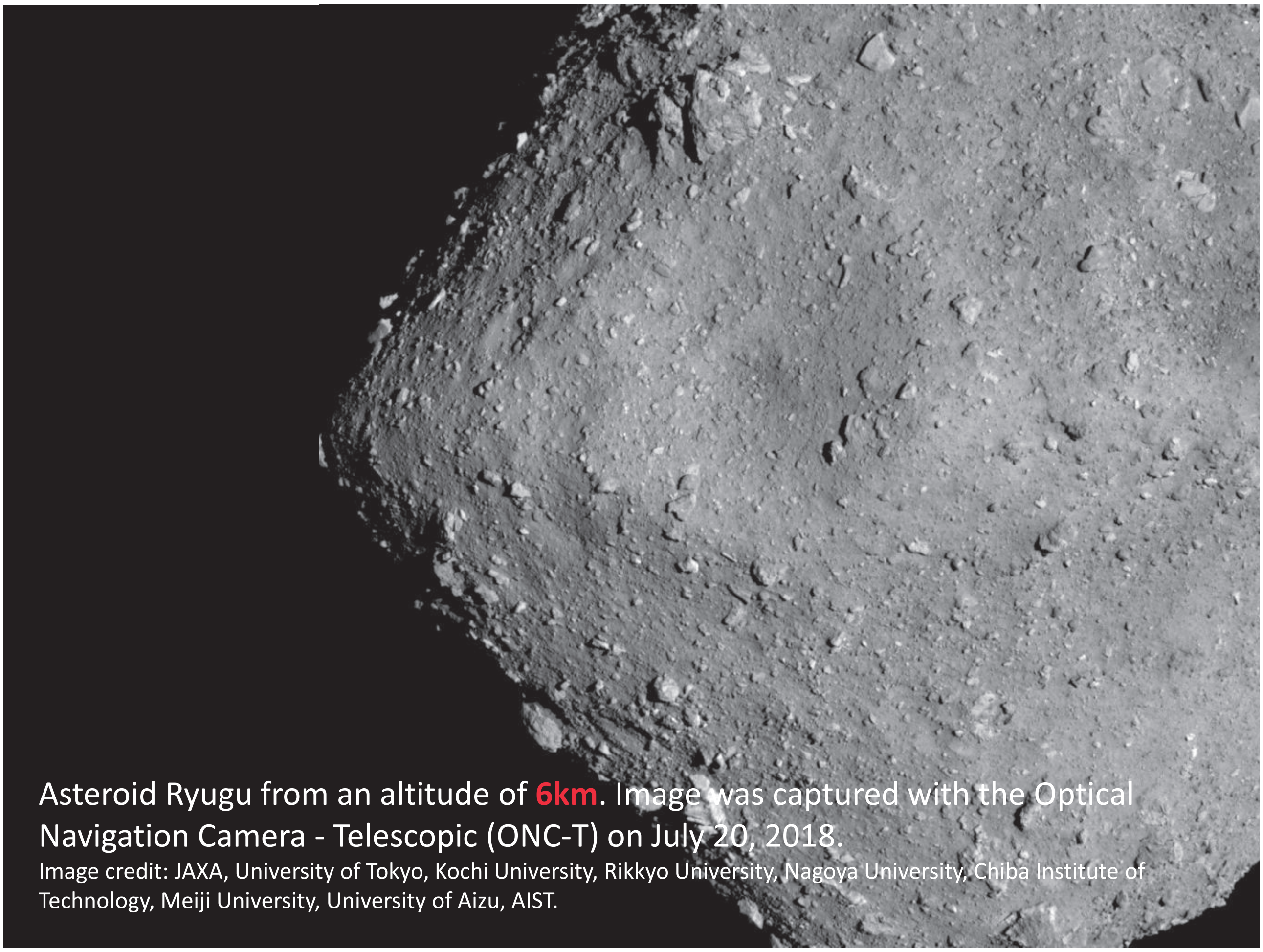
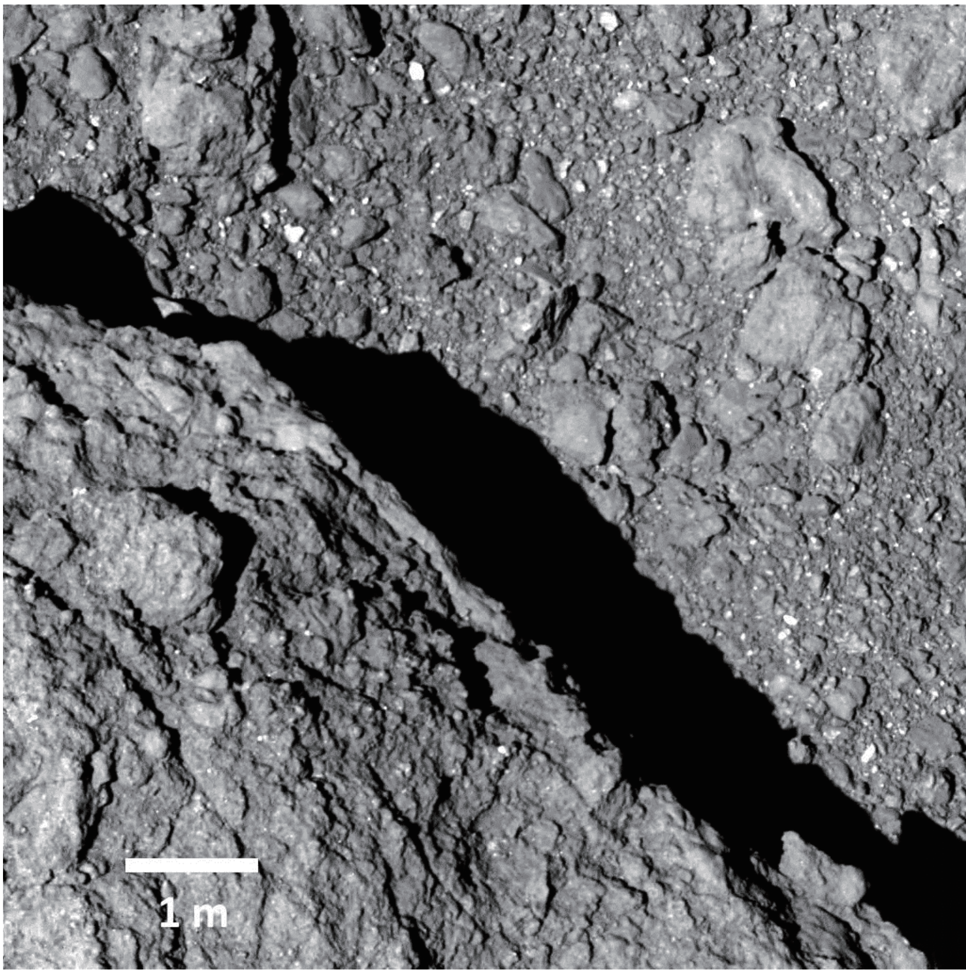

Asteroid Ryugu from an altitude of 6km. Image was captured with the Optical Navigation Camera - Telescopic (ONC-T) on July 20, 2018.
Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST.



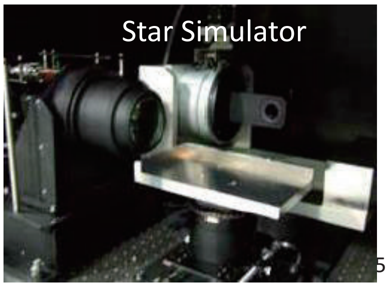
Altitude about **210 feet (64 meters)**
Sept. 21, 2018
Credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST

Ground Test Facilities (Cont’d)


Three Axis Motion Simulators


Earth Simulator


Sun Simulator


Star Simulator

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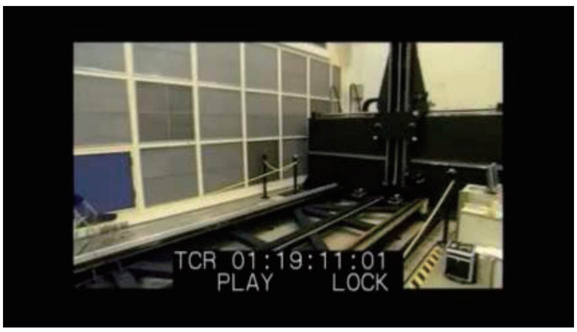
“Space Proven” Ground Testbed

Orbit



Ground

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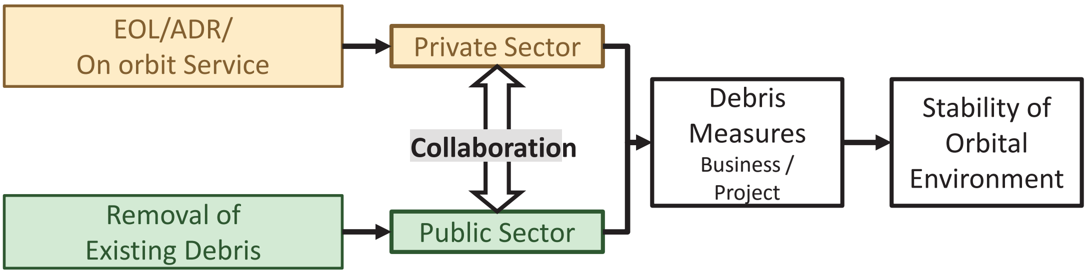
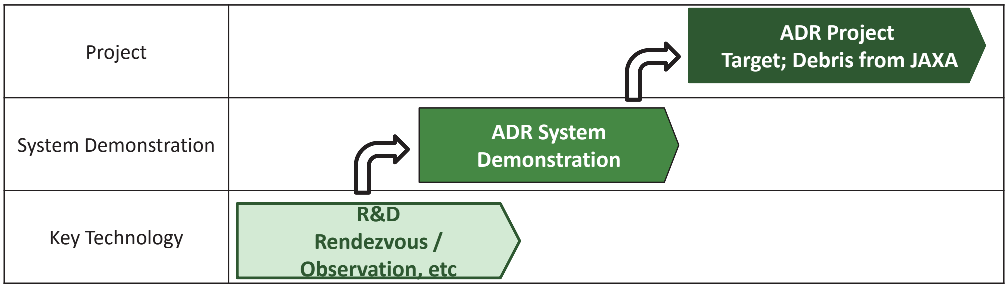
JAXA's Contributions for ADR

- Continue researches for removing large space debris.
- Support private sectors; by joint research program, provide opportunity of demonstration in orbit, ground testing and so on.





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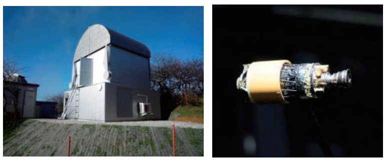
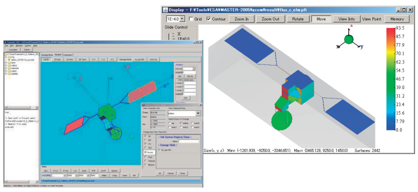
Research Subjects

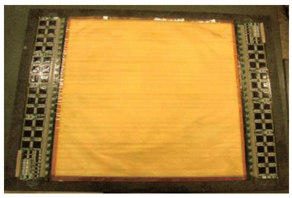
Observation



Modeling



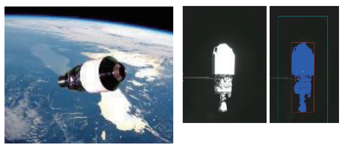
In-Situ Measurement



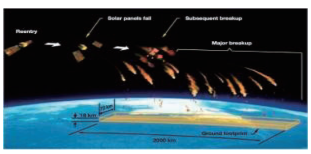
Propulsion

Capture

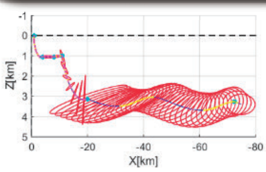
Rendezvous



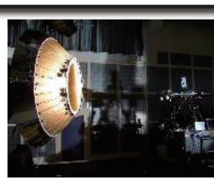
Deorbit & Safe Reentry



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 support private sectors by joint research programs, projects including industrial promotion, ground testing, and by JAXA's experiences and lessons learned.