Space Debris Mitigation Related Research and Development of JAXA

Japan Aerospace Exploration Agency
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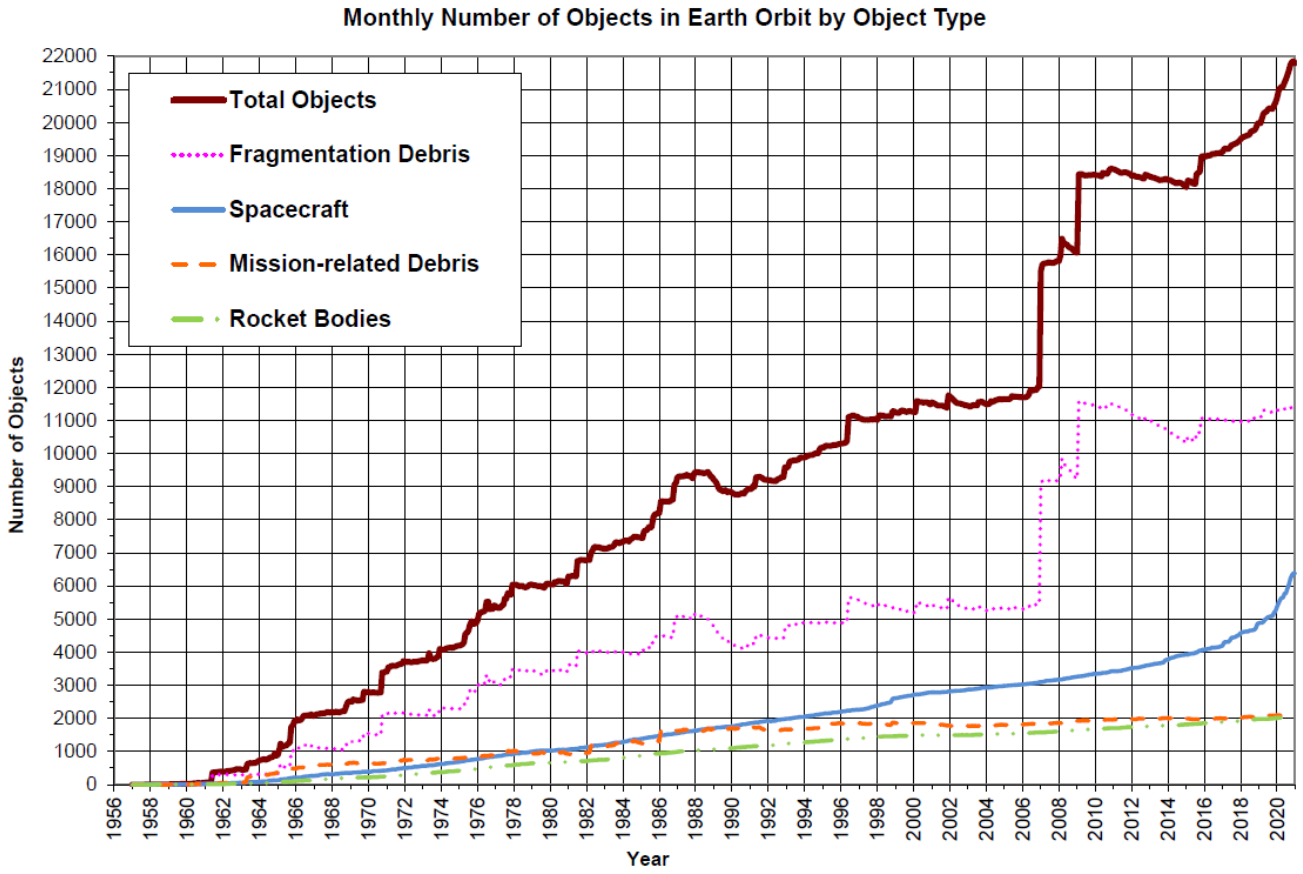
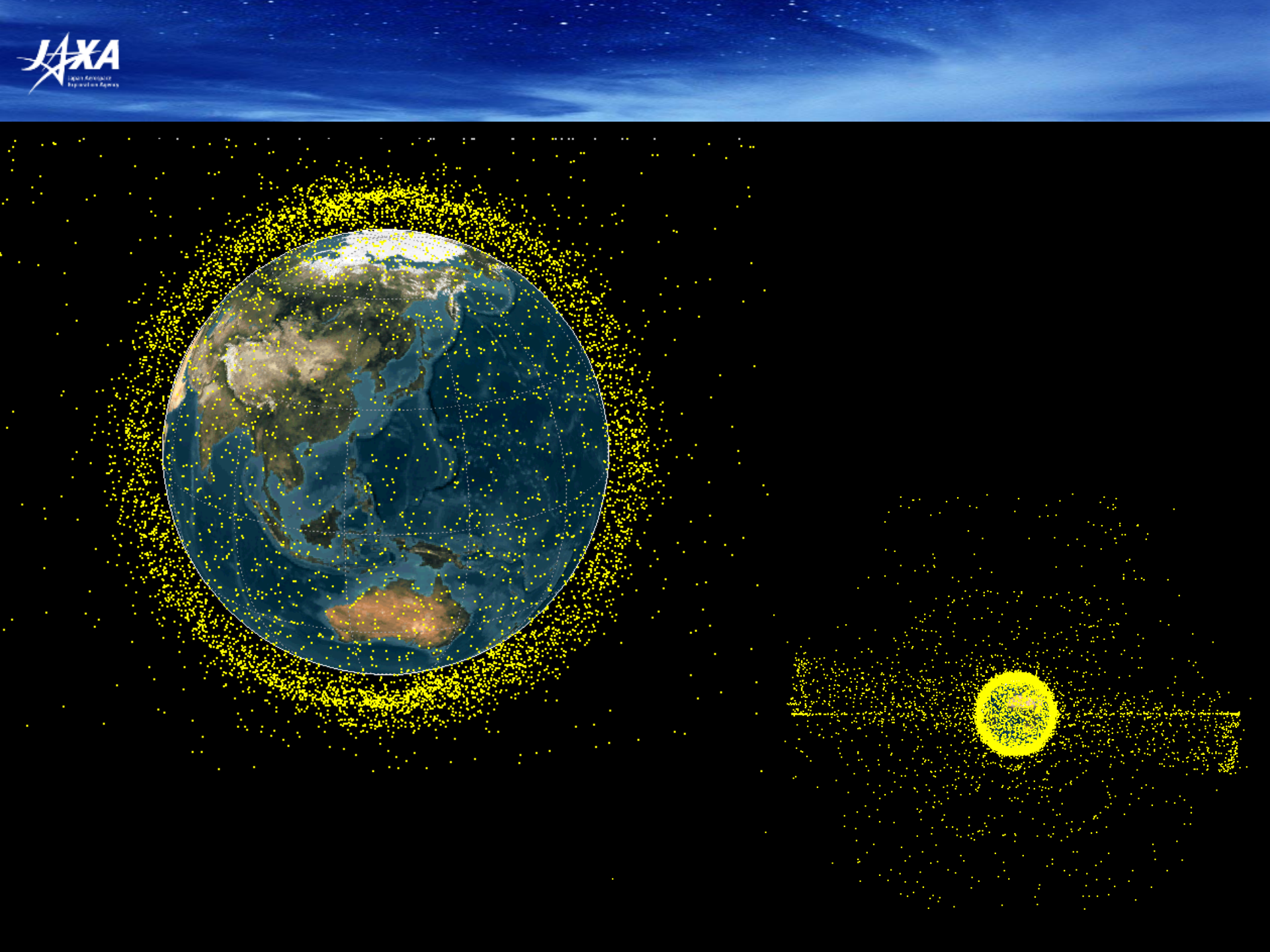
Apr. 20, 2021

Growth of the Space Debris Populations

- More than 22,000 catalogued objects > 10cm
- 50,000-90,000 objects > 1cm
- More than 100 million objects > 1mm

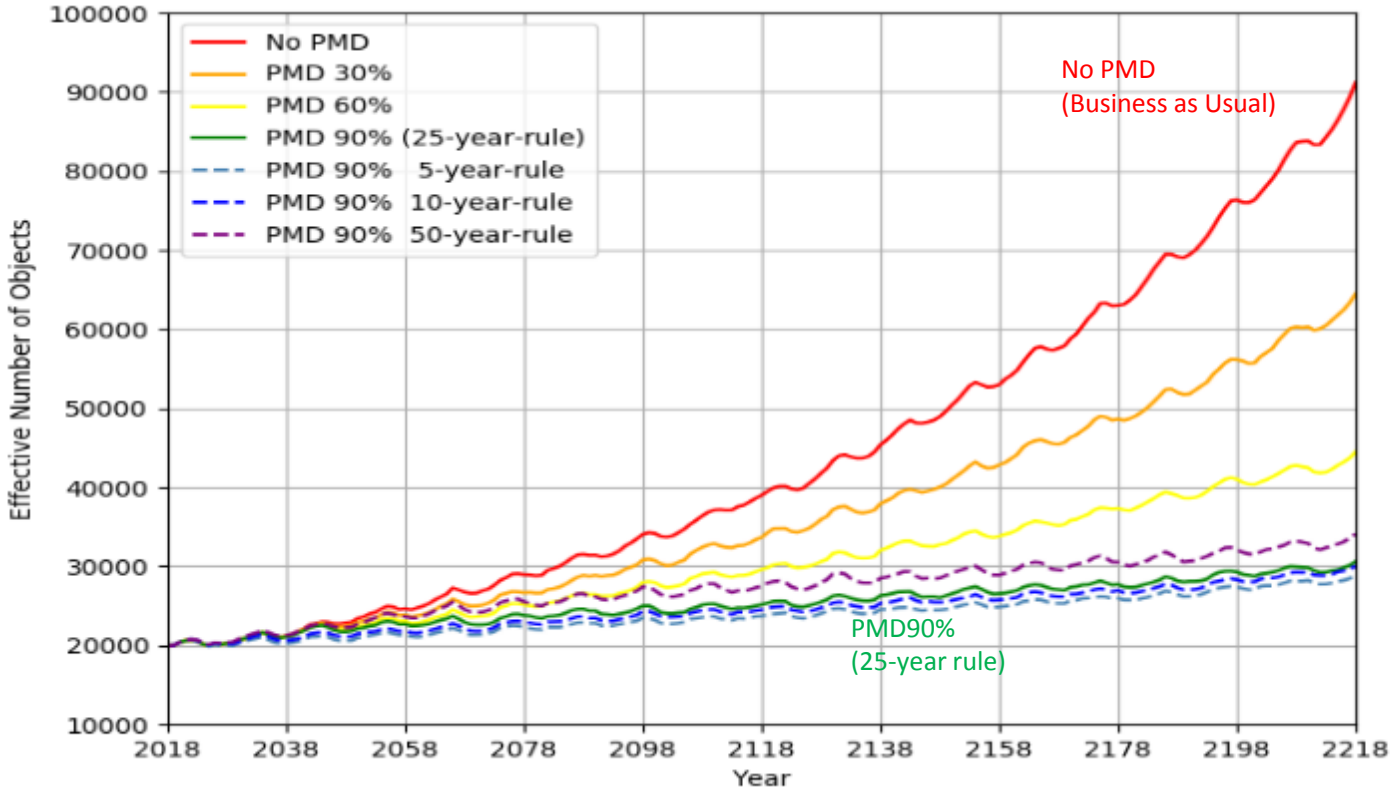


NASA The Orbital Debris Quarterly News 25-1 (2021, Feb)



Importance of PMD (Post Mission Disposal)

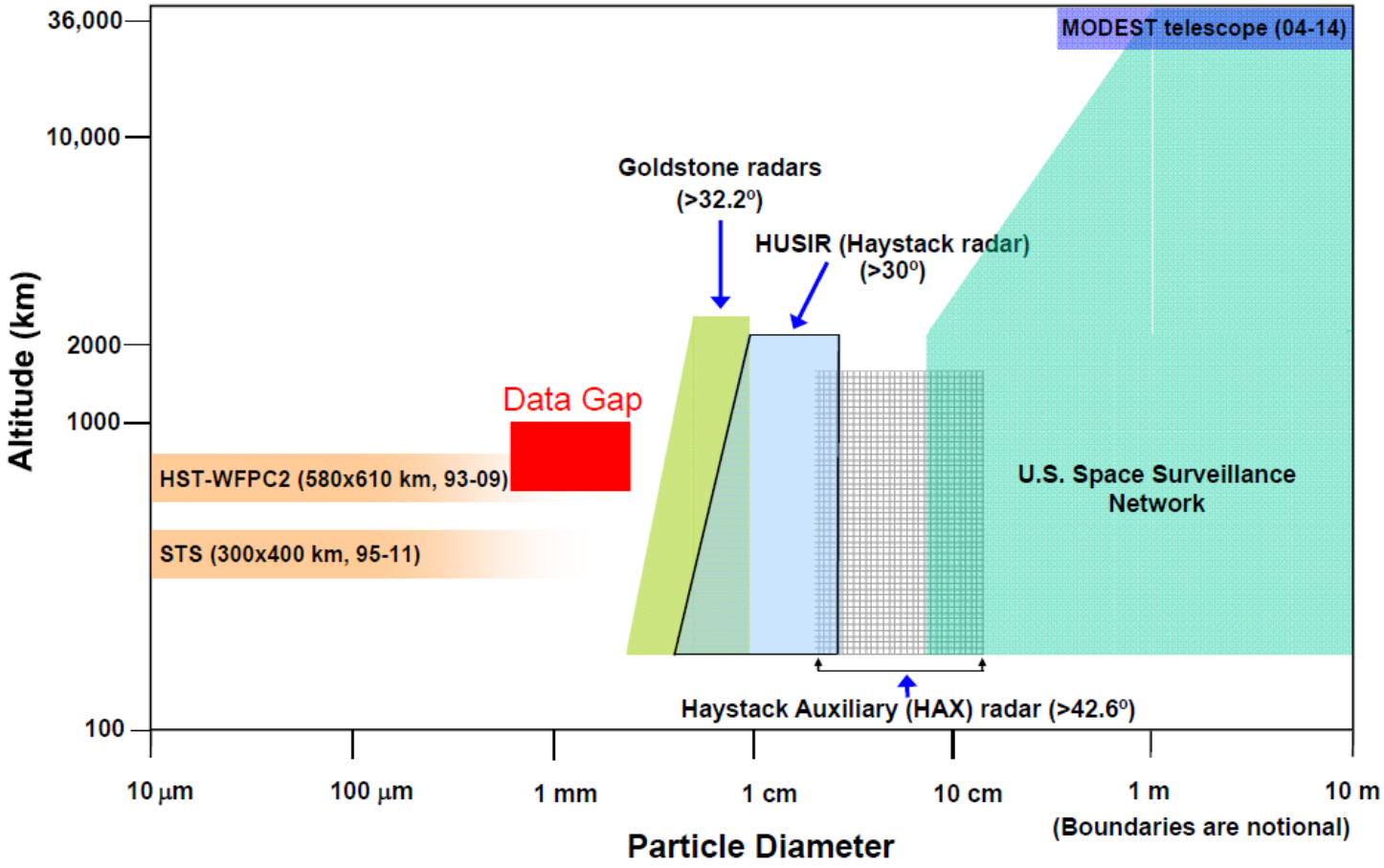
High PMD compliance rate is essential to preserve the space environment



Effect of PMD compliance rate

Importance of Small Debris Measurements

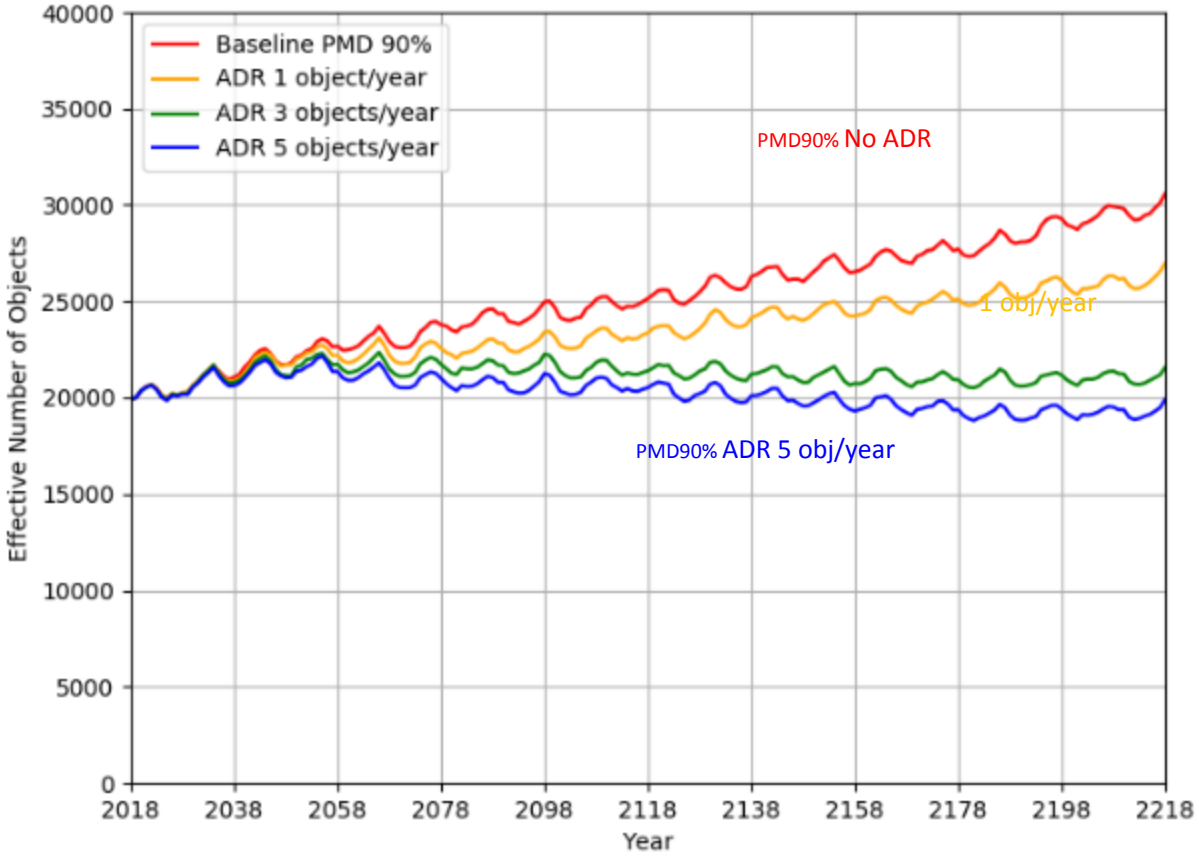
- Lack of small debris data (data gap)
- Even small debris is dangerous due to hyper velocity



Liou, Orbital Debris Activities at NASA, 2018

Importance of ADR (Active Debris Removal)

- Even with debris mitigation measures being implemented, the number of debris objects increases due to collisions between debris objects already existing on orbit.
- ADR of 3-5 objects per year can suppress the increase.

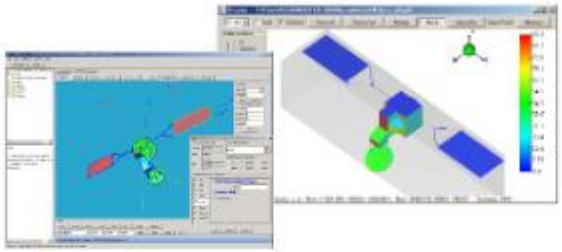


Effective number of objects with and without ADR

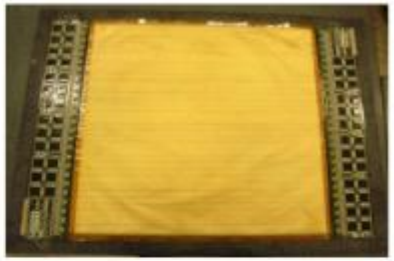
Key Technology Research and Development of JAXA

Observation

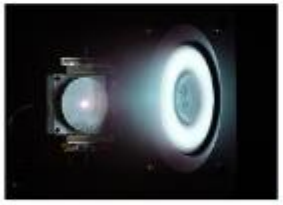

Modeling



In-Situ Measurement

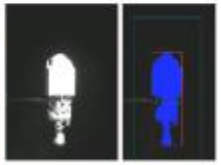


Propulsion

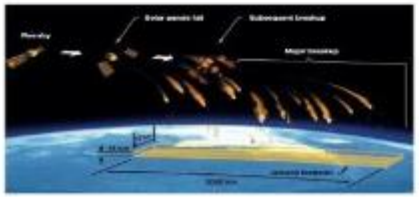



Capture

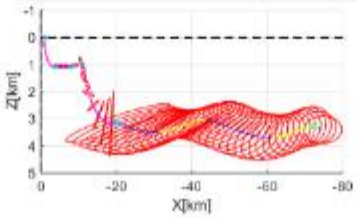

Rendezvous

Deorbit & Safe Reentry



Numerical Simulation



Ground Testing

In-situ Measurement of Small Debris

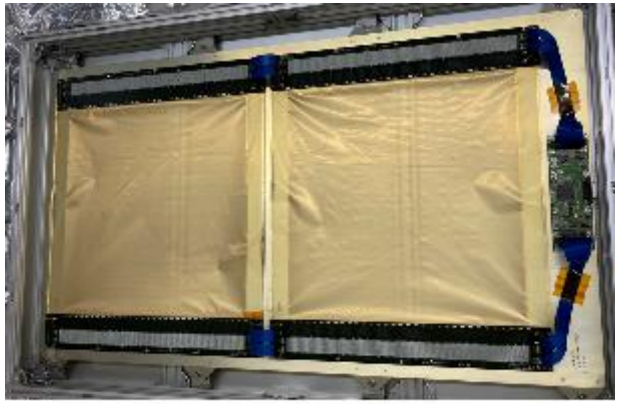
■ Space Debris Monitor (SDM)

- ➢ 100 um to ~3 mm sized debris under 1000 km orbit
- ➢ Flight experienced on HTV-5/ISS

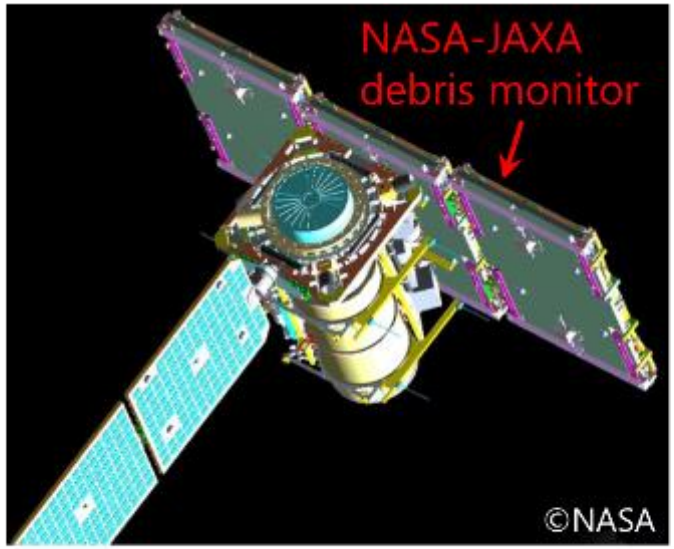
■ International Collaboration

- ➢ JAXA/NASA Joint Work
- ➢ JAXA BBM is ready for Hyper Velocity Test in the US

SDM on HTV-5

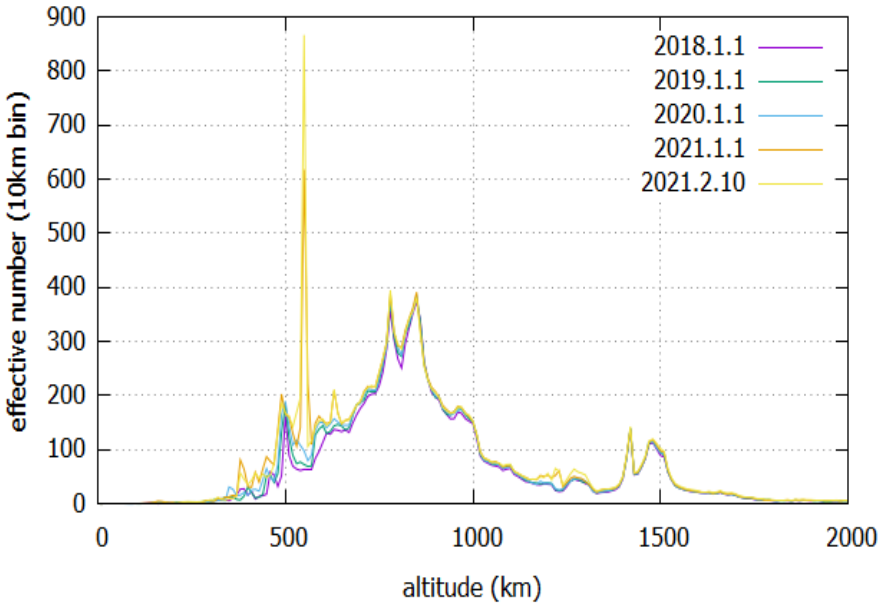


New SDM BBM for the collaboration



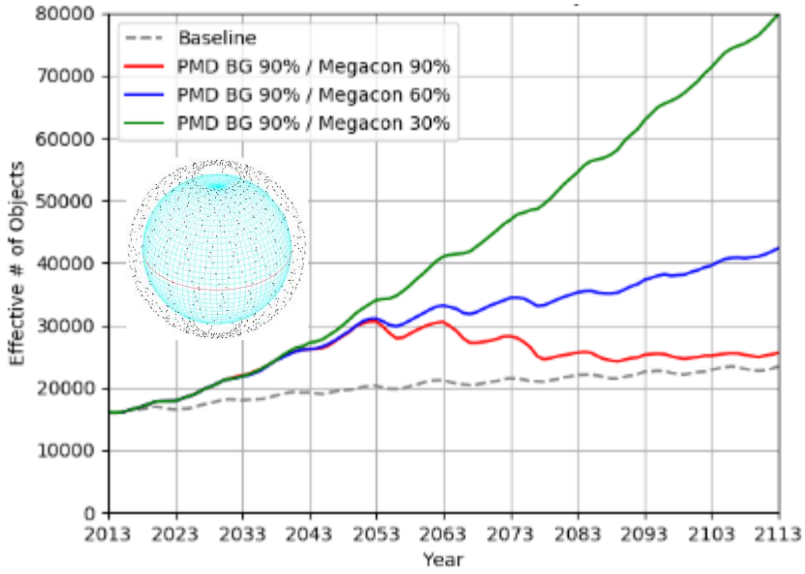
Conceptual illustration of debris monitoring

Study of Large Constellations affects



Distribution of catalogued objects

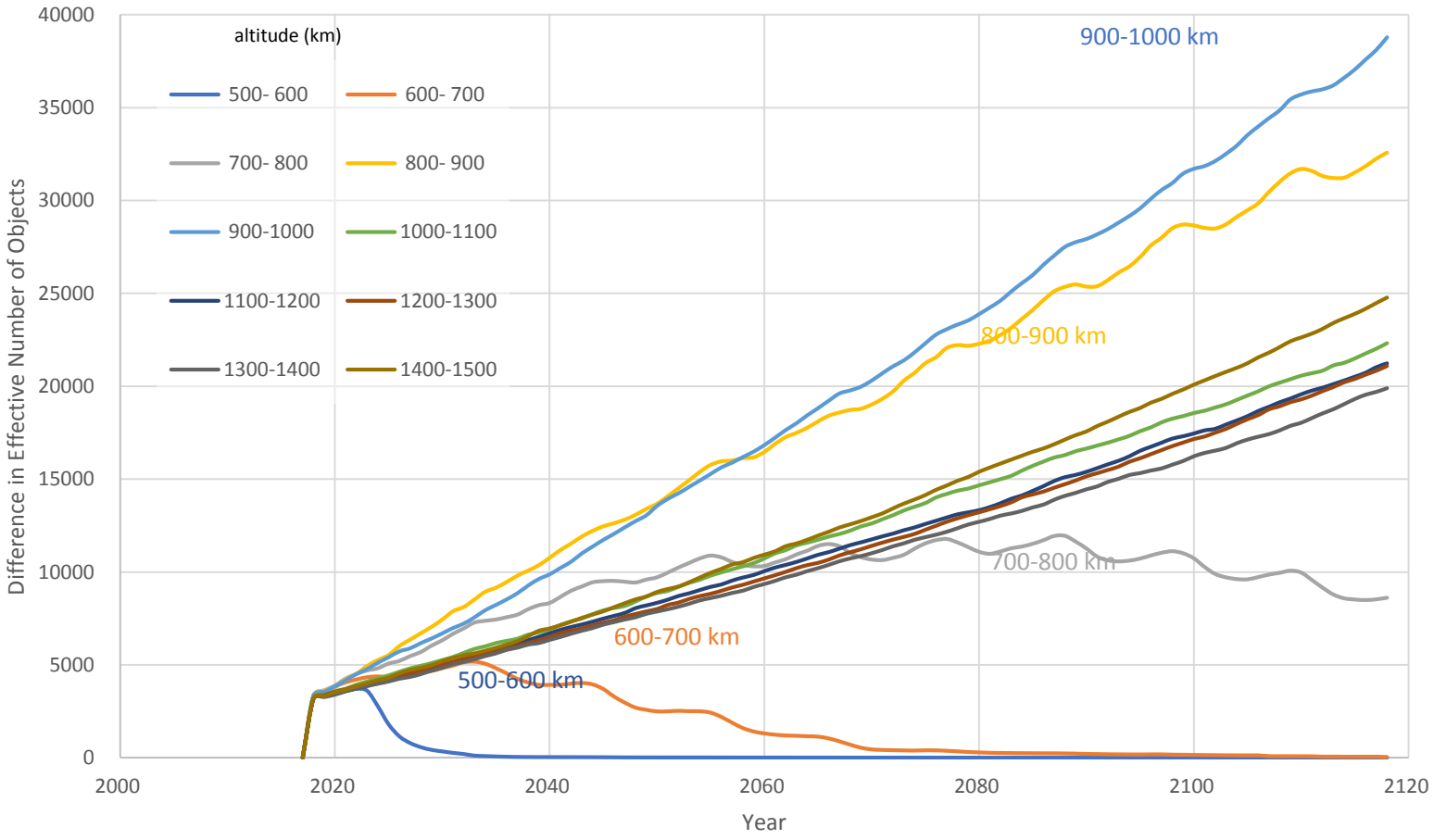
(based on SpaceTrack.org data)



Future projections using a debris evolutionary model

Study of the environmental capacity tolerance

For the purpose of effective utilization of the orbital environment, the environmental capacity tolerance of orbital insertions (launch objects) has been studied by JAXA.



Commercial Removal of Debris Demonstration (CRD2)

Aiming at the world's first Active Debris Removal in partnership with private enterprises

Demonstration of the removal of large space debris left in orbit in two phases

Phase-I

Planned for launch in FY2022

Key technologies demonstration

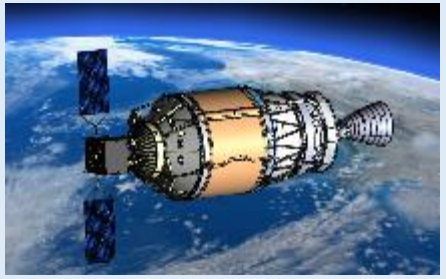
- **Non-cooperative rendezvous, proximity operation, inspection**

Phase-I demonstration satellite

Phase-II

FY2025~

ADR demonstration



Re-entry

- Non-cooperative rendezvous, proximity operation, inspection
- **Removal and re-entry of 2nd stage of launch vehicle**

Phase-I partner, Astroscale Japan Inc.

Technical background of JAXA

ETS-VII

Launched in 1997

- **The world's first unmanned rendezvous docking experiments in 1998**

HTV

Have been launched from 2009

- **Total 9 flights were successfully accomplished from 2009.**

Technical background of JAXA (cont'd)

HAYABUSA

Launched in 2003

HAYABUSA2

Launched in 2014

Ryugu

Image taken by the optical navigation camera (Altitude of about 25m)

- Non-cooperative rendezvous with Itokawa and Ryugu
- High efficiency electric propulsion system

Partnership with private sectors

A new partnership initiative with private sectors.

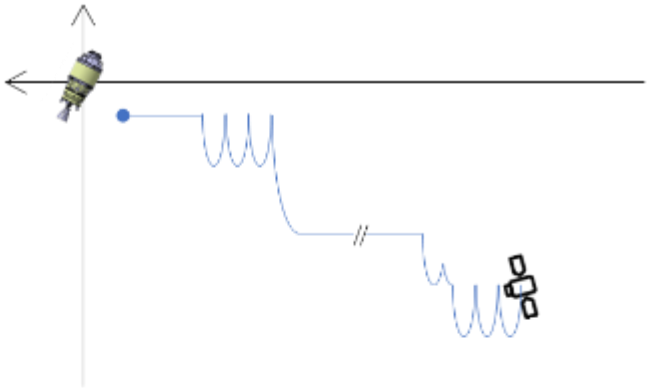
- As new partnerships with our industries, JAXA will focus on taking an “oversight role” with all the R&D assets, having partners strongly lead the system design to fulfill both our technical requirements and their business strategies.
- This new partnership will give our industries opportunities to advance their business to an upper stage.

Phase-I partner, Astroscale Japan Inc.

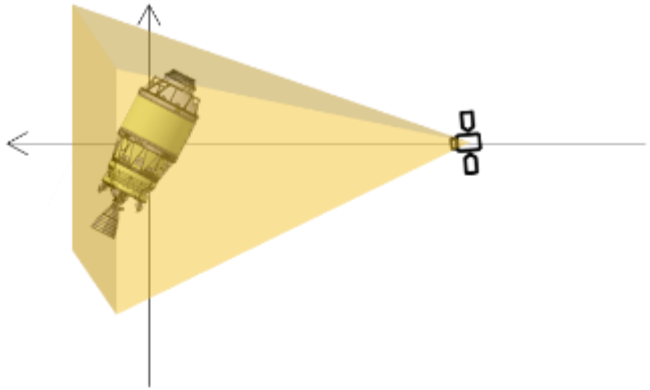
CRD2 Phase-I / Service specifications

- Target candidates
  - **Real** upper stages left in Low Earth Orbit
  - **Domestic** H2A upper stages
  - Altitude = **approx. 600 km** for safer demonstration

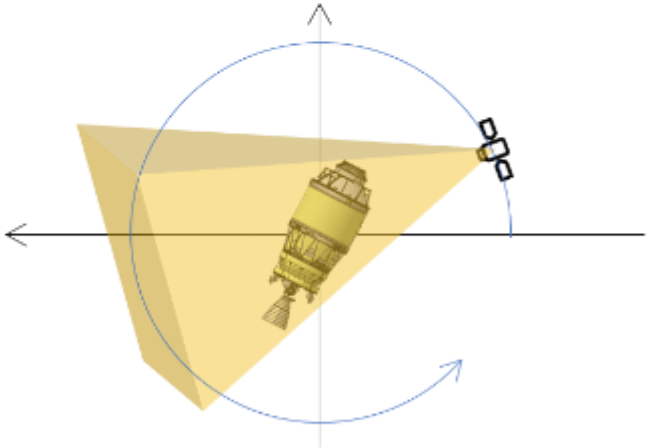
CRD2 Phase-I / Service specifications



(1) Rendezvous performance reporting service



(2) Fixed-point observation service

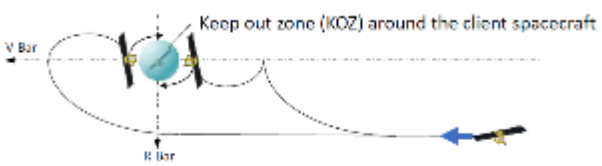


(3) Fly-around observation service

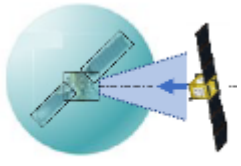
(4) Mission termination service

CRD2 Phase-I / Safety Requirements

- In order to limit, manage or avoid the risk or collision upon rendezvous, proximity and servicing operation, JAXA safety standard "**Safety Standard for ON-ORBIT Servicing Missions**" is defined and required for CRD2.



Sample trajectory in the far field


Sample approach path into KOZ

Basics in trajectory design

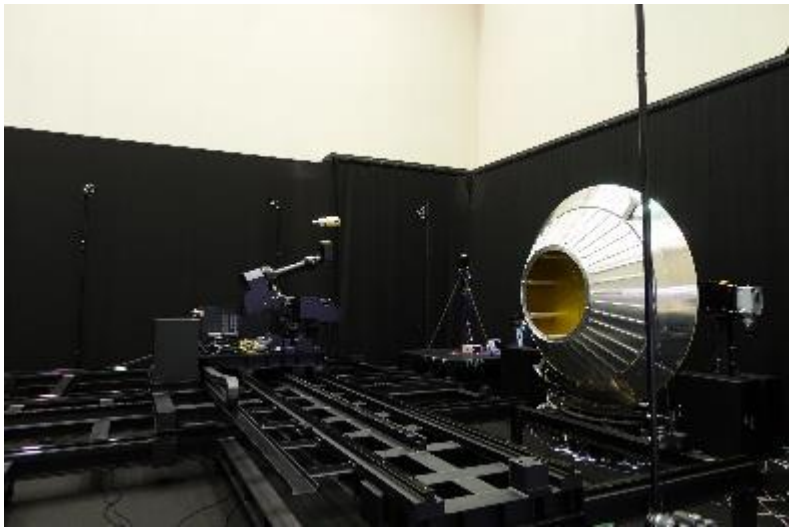
In the far field, the servicing spacecraft takes safe trajectory which does not interfere with Keep Out Zone (KOZ) even in the passive state.
In the closed approach, the servicing spacecraft comes into the designated approach path without crossing over the path boarder.

General requirements

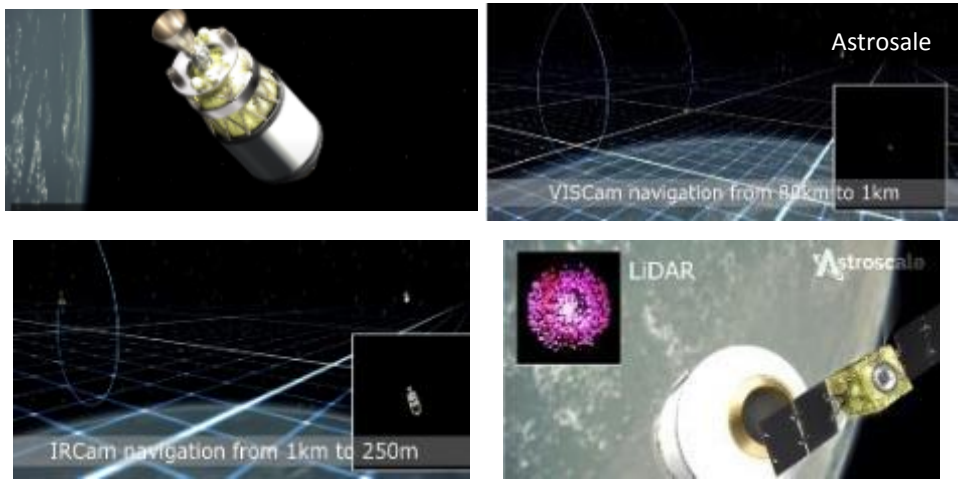
- The total system shall be one fault tolerant (1FT) to the critical event.
- No single failure shall not lead to collision, or loss of mandatory function for proper disposal.

CRD2 Phase-I / Milestone-1 status

- Preliminary design has been conducted
- Milestone 1 review is currently underway



COTS rendezvous sensor BBM test at the JAXA SATDyn facility

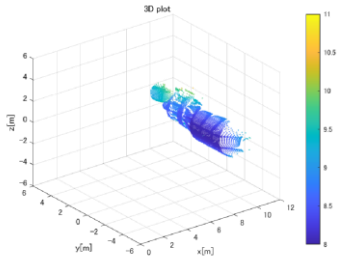


Preliminary design of navigation system for non-cooperative target with multiple types of COTS sensors

CRD2 Phase-II R&D in JAXA

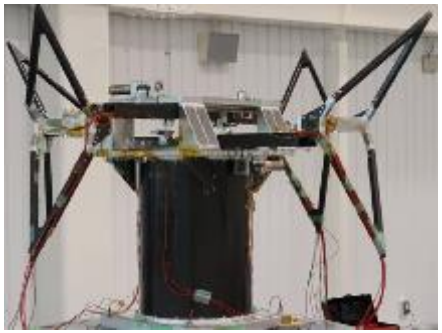
In parallel with the progress of Phase I, JAXA is conducting research and development of key technologies necessary for Phase II.

Phase-II concept study

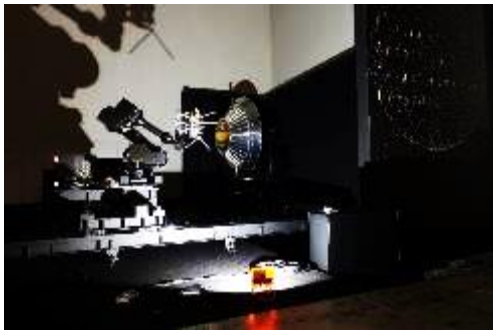


LiDAR measurement simulator

High total-impulse Electric Propulsion



Debris Gripper



Capture dynamics test facility