

A03

A study on safety requirements for on-orbit servicing missions

Hiroki ONODERA (JAXA)

On-orbit servicing (OOS) can be achieved when a servicing satellite successfully affects and/or interfere the state of the target object by approaching, rendezvousing, and contacting for giving a designated function.

On the other hand, JAXA's general space debris mitigation policy defined in "Space Debris Mitigation Standard (JMR-003C)" does not allow the intentional interference to the 3rd parties object, that could lead to a collision hazard, unless rendezvous, docking and corporative operation are arranged through joint mission agreement.

JAXA Research and Development Directorate sets up a mid-long term plan to demonstrate the Active Debris Removal (ADR), which is one aspect of OOS, for actively reducing the space debris on orbit. To accomplish this mission, the specific safety requirements for OOS are necessary as well as a related technology building.

This presentation introduces the purpose and outline of the safety requirements for OOS that are currently discussed in the working group.

Biography

Hiroki ONODERA

Engineer

System Safety Unit, Safety and Mission Assurance Department

Mr. Hiroki Onodera was appointed to Engineer of JAXA in 2017. He is in charge of mainly system safety of satellite and space debris of JAXA.

He is involving in the working group of orbit service safety plan.

During his carrier, he has been mostly involved in the development of commercial satellite mainly geostationary satellite. He was also served to the development of the government satellites as a mission assurance.





A study on safety requirements for on-orbit servicing missions

軌道上サービスミッションに対する安全要求検討の目論見と検討状況

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Hiroki ONODERA, JAXA



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JAXA 1. Introduction

- Overview of the Space Debris issue
 - Space debris is serious threat on a sustainable use of near earth space environment.
 - Collision avoidance operations are about 100 times per year.
 - Collision of spacecrafts will drastically growth the number of space debris, and could lead to unsustainable environmental condition.
- Active removal of space debris got to be a realistic option as a mitigation measure as well as limiting generation of space debris.

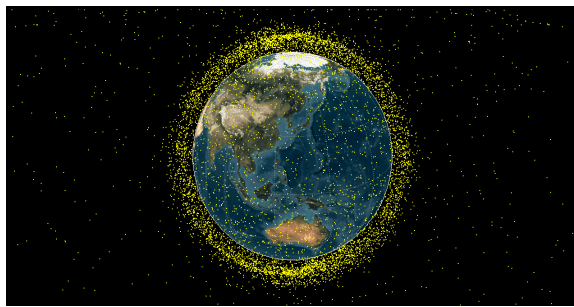


Fig.1 Image of Space Debris

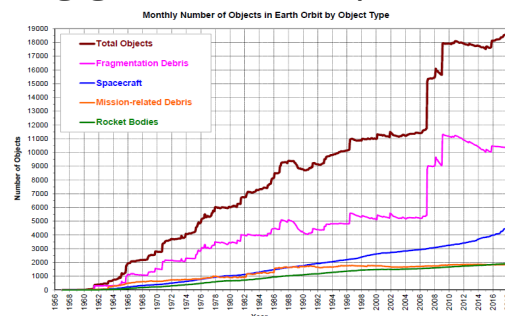


Fig.2 NASA Orbital Debris Quarterly News, Volume 22, Issue 1 February 2018

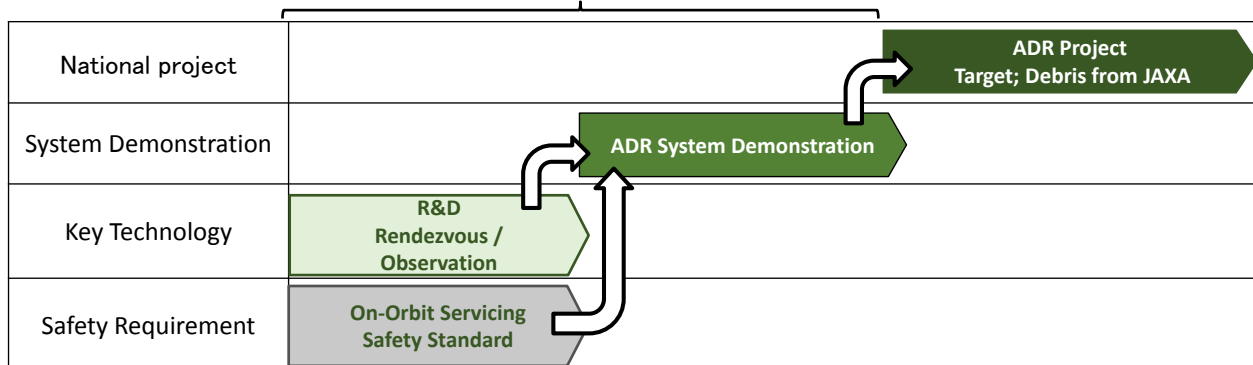
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JAXA 2. Background related to Debris Mitigation

■ BACKGROUND

- JAXA sets up a mid-long term plan to demonstrate the ADR aiming at the business of space debris solution this year.
- A safety regulation of on-orbit is being reviewed supporting the demand of on-orbit servicing missions all over the world.

The 4th Mid-Long Term Plan of JAXA



■ VISION

- To improve the orbital environment for sustainable development of space activities.
- To find the opportunity of a novel market as space debris measures.

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3. Space Debris Mitigation Standard of JAXA

■ Prevailing regulation

(1) Selection of operation orbit

Geostationary spacecraft operations should always be planned to maintain optimum relative distance between each other to avoid collisions and resultant breakups. Operations of spacecraft on other circular earth orbit should always be planned to avoid the risk of collision with other spacecraft operating at the same altitude, unless rendezvous or docking with other spacecraft or any other joint missions are being planned. In these studies, collisions with spacecraft of other organizations should be included for consideration.



■ Revising regulation

(1) Selection of operation orbit

Operations of spacecraft on other circular earth orbit always be planned to mitigate the risk of collision with other spacecraft operating at the same altitude as far as possible. **If rendezvous or docking with other spacecraft or any other joint missions are being planned, "Safety Requirement of On-Orbit Servicing(JERG-TBD)" is followed.**

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4. On-Orbit Servicing: OOS

■ On-Orbit Servicing: OOS

It is said that when a servicing satellite successfully affects and/or interfere the state of the of the target object by approaching, rendezvousing, and contacting for giving a designed function.

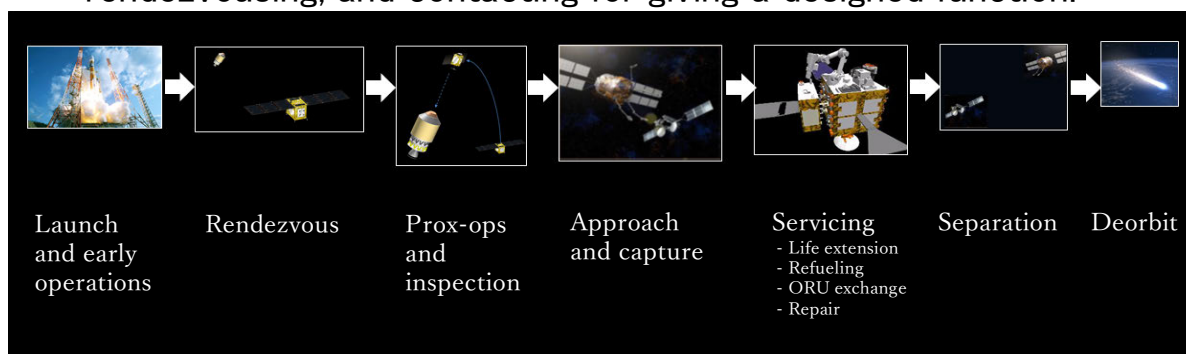


Fig.3 Mission operation baseline of OOS

■ Pending issue of OOS

If rendezvous or docking with other spacecraft or any other joint missions are failed following collisions and so on, space environmental conditions are getting worse and worse.

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5. Category of OOS

■ Scope of Category

- **Category1(Cooperative Rendezvous):**
The cooperative operation within the need for specification between satellites has been verified by development phase.
Ex. ETS-VII, HTV
- **Category2(Semi-Cooperative Rendezvous):**
A serviced satellite within the standard equipment like hook and so on is built in.
Ex. ELSA(Astroscale)
- **Category3(Non-Cooperative Rendezvous):**
The design and condition of a serviced satellite or rocket is estimated sufficiently.
Ex. ADR

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6. Discussion of OOS Working Group

■ Safety requirement of OOS

□ Satellite design

- Safety design guideline
1FT(one-fail tolerance):piece of equipment contains a system that makes the system stop working if one part of it fails.
- Electric Static Discharge(ESD)
- Electric Magnetic Compatibility(EMC)
- Plume impingement and contamination

□ Trajectory safety

- Approach Ellipsoid(AE)
- Keep-Out Sphere(KOS)
- Corridor
- Safety clearance

□ Operation procedures

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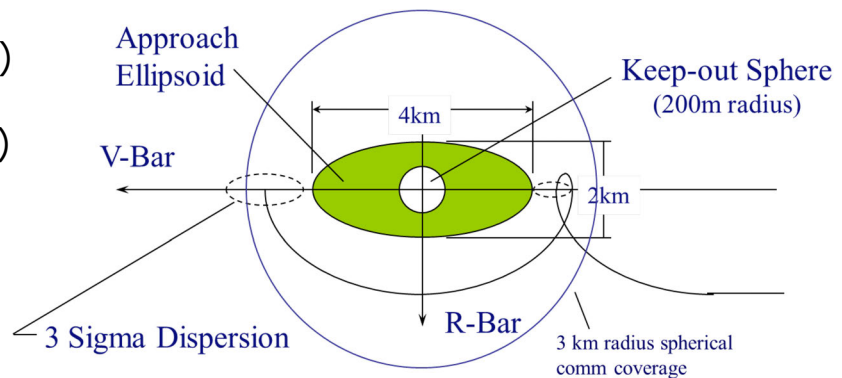


7. Concern with OOS Working Group

■ Point to note of OOS trajectory safety

- It's necessary to decide the target range of OOS trajectory safety requirement. Below ISS Rendezvous, Proximity Operations, Docking & Berthing Considerations.

- Approach Ellipsoid (AE)
; $4 \times 2 \times 2$ km
- Keep out Sphere (KOS)
; 200m radius
- Omni directional communications disk
; $3 \times 1 \frac{1}{2}$ km



Out of plane minor axis of AE is 2km

Fig.4 Regions Around ISS

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8. Future Plan

- JAXA is discussing the safety requirement of OOS in OOS WG, and the safety requirement of OOS is being established before ADR demonstration.
- The primary target of JAXA is to guarantee the safety of OOS and ADR missions, and to secure the safety of the space activities.
- JAXA will transmit the OOS information to the world space organizations.

Thank you for your attention.
ご清聴ありがとうございました！

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