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## ロケット上段計測システム及び小型デブリ除去衛星 の概念検討

Concept studies of an upper stage monitoring system and a small-sized ADR satellite

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Katsushi Shibata, Masafumi Miyanaga, Tomohiro Hoshino (MHI),  
Satomi Kawamoto, Junichi Aoyama (JAXA)

地球周りのスペースデブリ(以下「デブリ」とする)は年々増加の一途をたどり、特に高度数百 km の低軌道上ではロケット上段など大型のデブリが多数存在している。

三菱重工(MHI)は、H2A/H2B ロケット打上げ事業者として、悪化するデブリ環境の改善が必要と考えており、デブリ除去のシステム・関連技術の検討を実施している。

デブリ除去実現のためには、デブリへのアプローチや把持等の技術を確立するために、その前提となる軌道上のデブリの正確な姿勢運動の把握が必要である。このため、本報告では、まず、ミッション終了後の H-IIA ロケット第2段の姿勢計測システムを検討した。

本システムにより、計測データを入手できるだけでなく、地上観測データとの突き合せにより地上観測の精度向上が見込める。また、技術実証と今後の運用・量産を考慮して、低コストである小型のデブリ除去衛星の初期検討を行った。

This presentation describes the results of concept studies on an upper stage monitoring system which acquires and downlinks data related with the attitude, the rotation rate etc. of an upper stage in orbit around the Earth as space debris. The feasibility of a small-sized ADR satellite, which accesses, captures and deorbits space debris, is also discussed.

The conclusion of this report is that Mitsubishi Heavy Industries, LTD(MHI) will make a continuous effort to mitigate space debris, with our technological heritage of designing, manufacturing and operating space systems such as the H2A/H2B launch vehicles, the H-II Transfer Vehicle (HTV), and small-sized satellites.

## Concept studies of an upper stage monitoring system and a small-sized ADR satellite.

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2016.10.19

**MITSUBISHI HEAVY INDUSTRIES, LTD.**  
Integrated defense & Space Systems

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## Essence of this presentation

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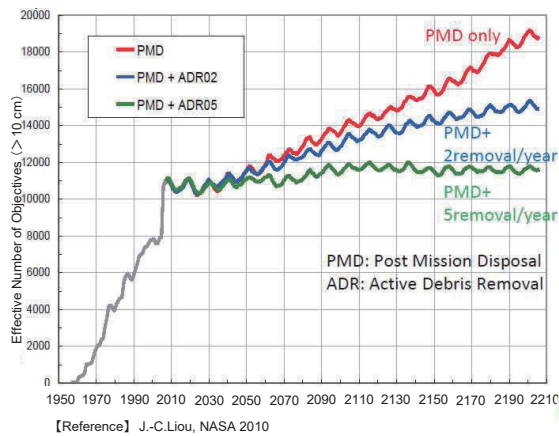
- (1) JAXA continues to study technologies for space debris monitoring and removal.
- (2) **MHI has also interest in improving the situation** where the number of space debris has increased. MHI studies system and related technologies for removing space debris.
- (3) JAXA and MHI study the idea that **an upper stage monitoring system and a small-sized ADR satellite are effective means** against space debris.
- (4) **MHI will make a continuous effort to mitigate space debris, with our technological heritage of designing, manufacturing and operating space systems such as H2A/H2B launch vehicles, H-II Transfer Vehicle(HTV).**

\*)ADR: Active Debris Removal

## 1. Introduction

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### Target debris



Removing large-sized debris, such as **upper stages of launch vehicles**, is considered as a valid way of reducing the number.

For removal of upper stages, it's better....

(1) to get the information about attitude and rotational motion of the targeted debris before study of the removal mission.

⇒ “Upper stage monitoring system”

(2) to consider not only technological demonstration but mass-production and operation of ADR satellite for the future mission.

⇒ “Low-cost, small-sized ADR satellite”

This presentation introduces the results of conceptual studies on “Upper stage monitoring system” and “Low-cost, small-sized ADR satellite”.

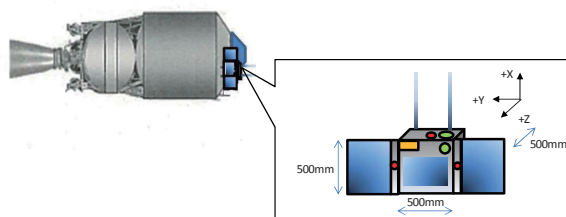
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## 2. Upper stage monitoring system

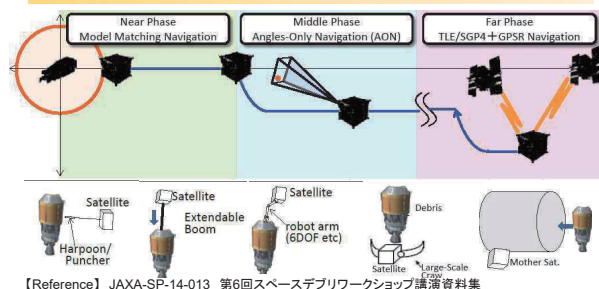
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### Upper stage monitoring system

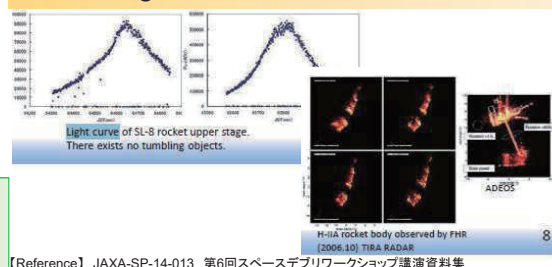


Monitoring the attitude and the rotation motion of the H2A 2<sup>nd</sup> stage for a long time.

### Feedback to guidance and control logic and capturing mechanism



### Improving debris observation accuracy from the ground.



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## 2. Upper stage monitoring system

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### Requirement

Item	Contents
Target	H2A 2 <sup>nd</sup> stage after completing orbit injection of satellites.
Monitoring Parameters	(first priority) attitude, rotating rate (second priority) surface temperature distribution, electric potential on the surface, impact scar of space debris
Monitoring Period	2 months+

### Policy of study

Applying heritage products to the system wherever possible.

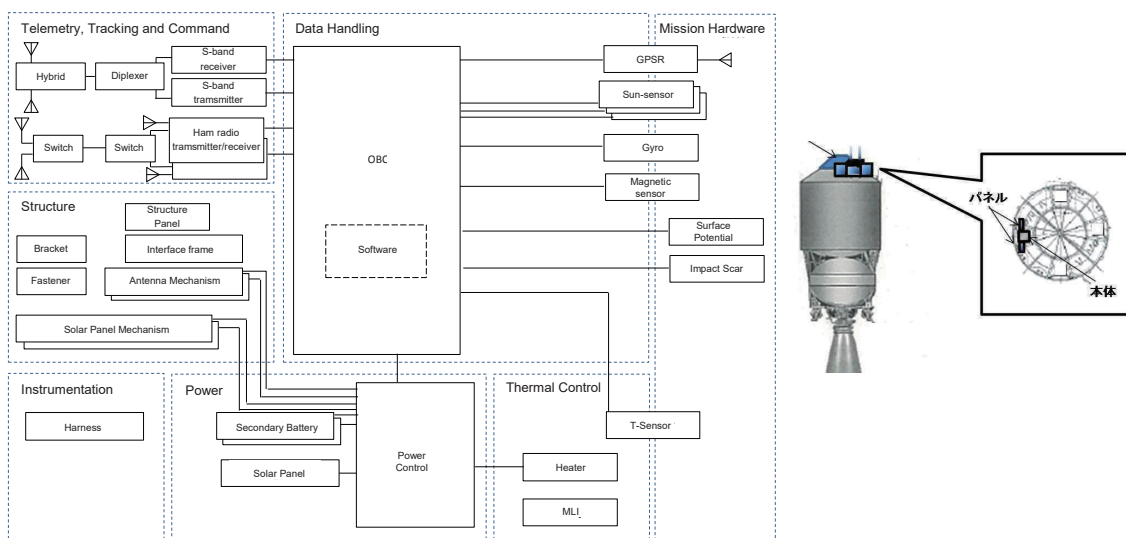
### Contents

- (1) System configuration and main functions
- (2) Sizing and installation of components
- (3) Telemetry, tracking and command subsystem
- (4) Power subsystem

## 2. Upper stage monitoring system

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### (1) System configuration and main functions



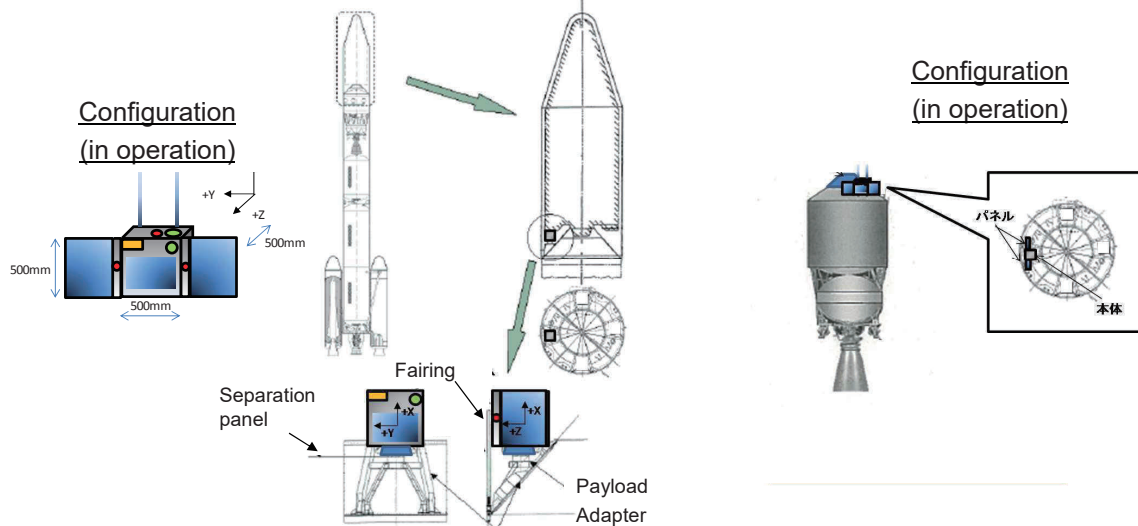
The battery life of the rocket is up to a few hours. It doesn't satisfy the requirement.  
 ⇒ policy: small-sized satellite with TTC, Power and DH installed on the rocket.

## 2. Upper stage monitoring system

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### (2) Sizing and installation of components

Configuration (enveloped in the fairing)



This solution satisfies the requirement “total mass: up to 50kg”.

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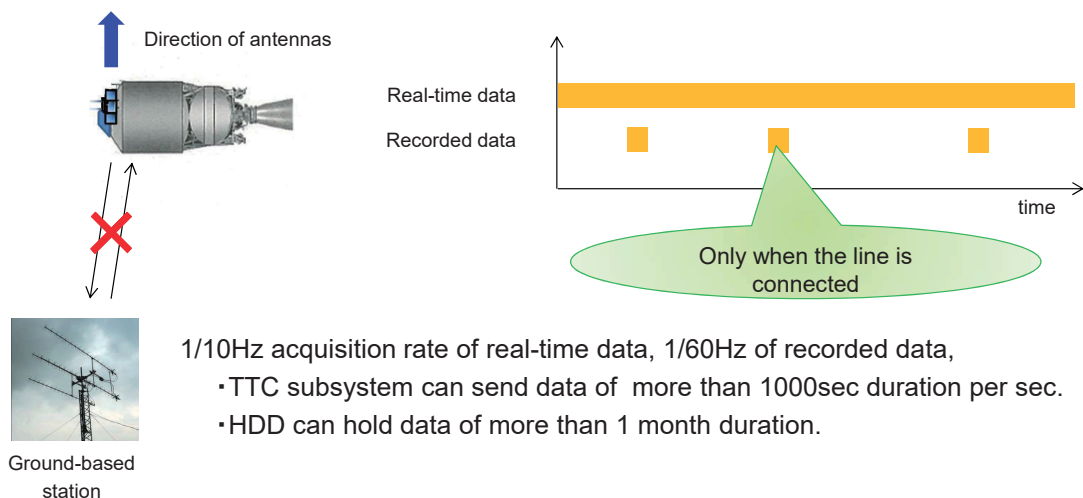
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## 2. Upper stage monitoring system

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### (3) Telemetry, tracking and command subsystem

Without GNC, the system can't direct the antennas to the ground-base station.



Policy: Increasing the chance to receive data on the ground-based station by both real-time data downlink and recorded data downlink

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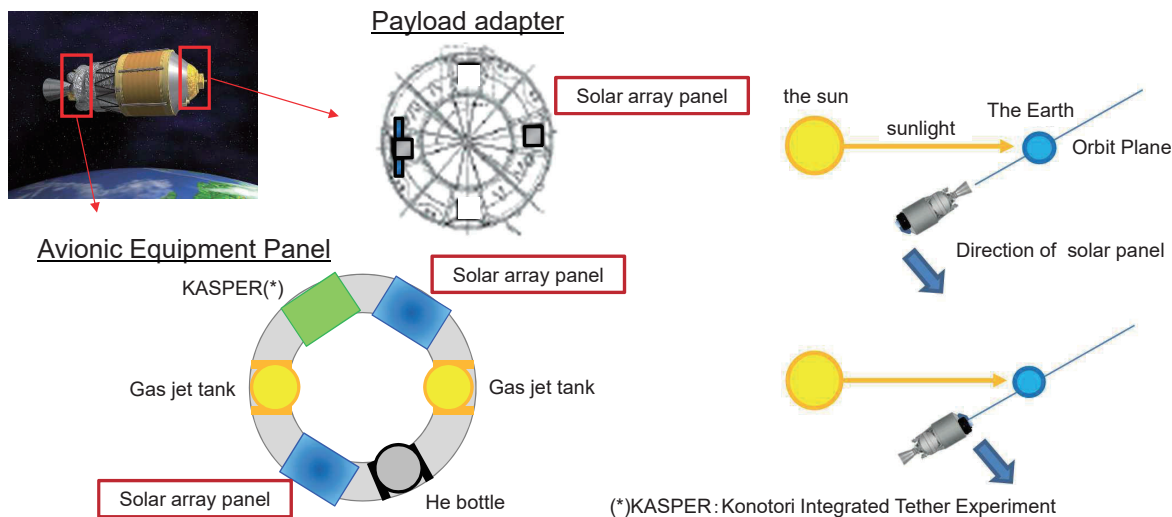
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## 2. Upper stage monitoring system

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### (4) Power subsystem

Without GNC, the system can't direct the solar array panels to the sun.



The system has feasibility of generating enough power with additional solar array panels on the avionic equipment panel and the payload adapter.

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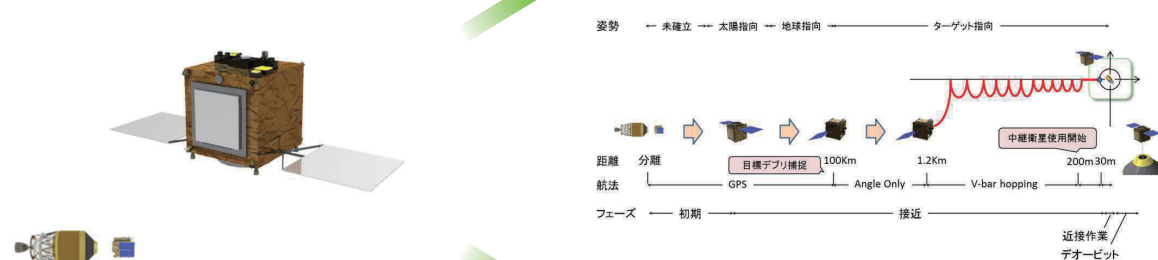
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## 3. Small-sized ADR satellite

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### Small-sized ADR satellite

### Early technological demonstration



Separation from the rocket

Approach to targeted debris

Capture

Demonstration on small-sized ADR satellite

### Low cost of design, manufacture

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### 3. Small-sized ADR satellite

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#### Requirement

Item	Contents
Rocket, Orbit	H2A launch vehicle(TBD), Sun Synchronous Orbit(SSO)
Total Mass	Up to 150kg
Mission Payload	Demonstration of approaching and attaching an propulsion system to a non-cooperative target, Demonstration of electrodynamic tether

#### Policy of study

Applying heritage products to the system wherever possible.

#### Contents

- (1) System configuration and main functions
- (2) Evaluating H-IIA's capacity
- (3) Visibility evaluation for TTC
- (4) Extension boom control

\*)TTC: Telemetry, Tracking and Command

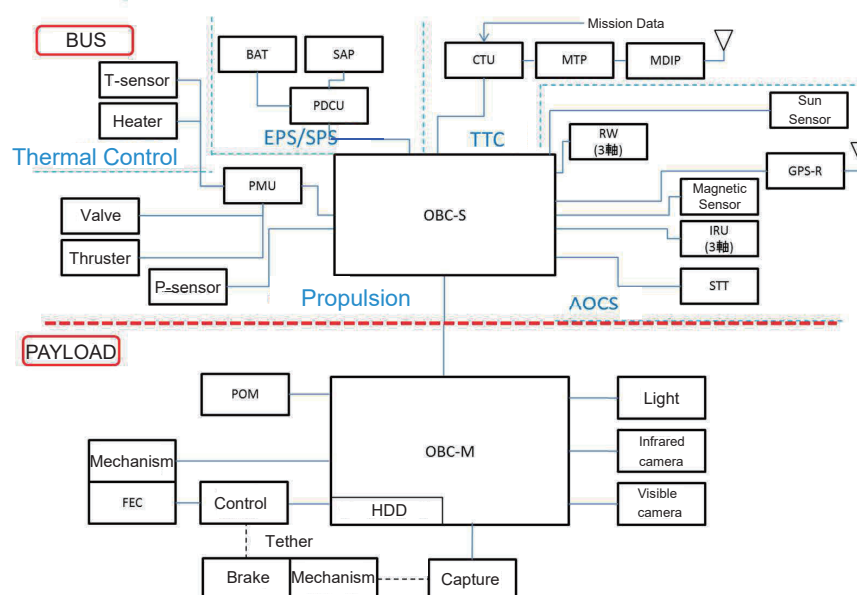
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### 3. Small-sized ADR satellite

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#### (1) System configuration and main functions



This solution satisfies the requirement "total mass: up to 150kg".

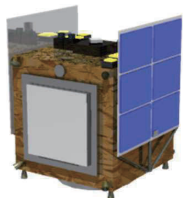
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### 3. Small-sized ADR satellite

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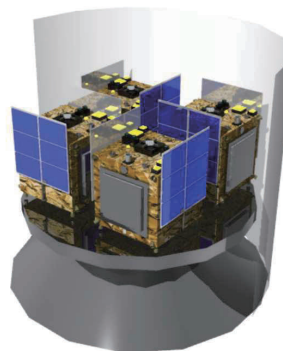
#### (2) Evaluating H-IIA's capacity of satellites



Configuration in launch vehicle



Configuration in operation



4 satellites enveloped in payload fairing

The satellite can be enveloped in H-IIA's payload fairing.

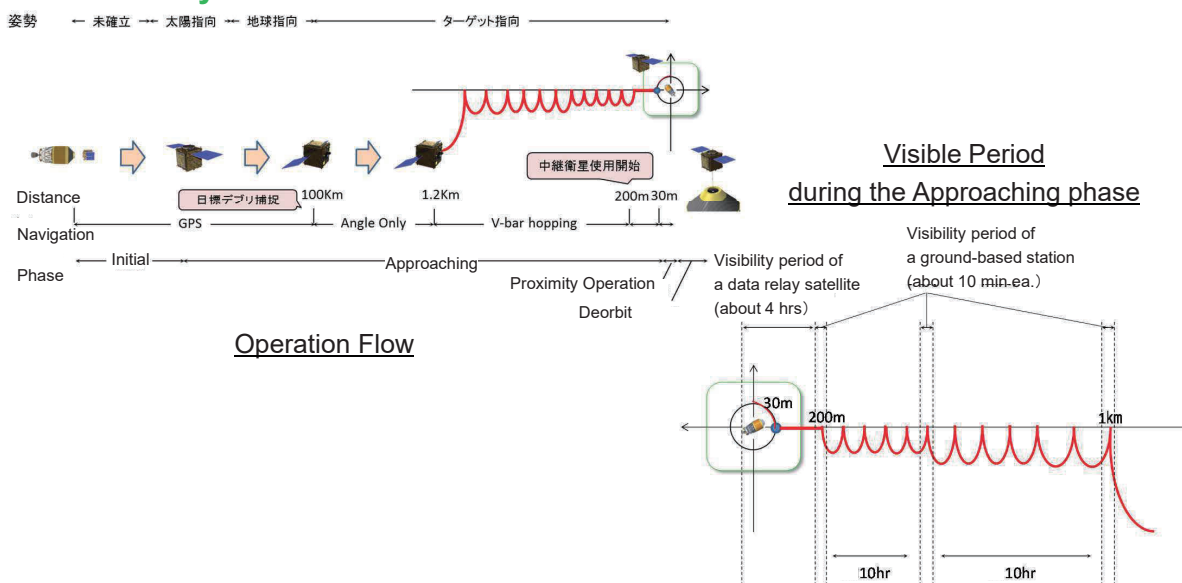
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### 3. Small-sized ADR satellite

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#### (3) Visibility evaluation for TTC



Visibility: 1 ground-based station + 1 data relay satellite (DRTS etc.)  
 ⇒ This solution doesn't consist with the policy "low-cost system".

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### 3. Small-sized ADR satellite

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#### (3) Extension boom control

Approach (~2m)



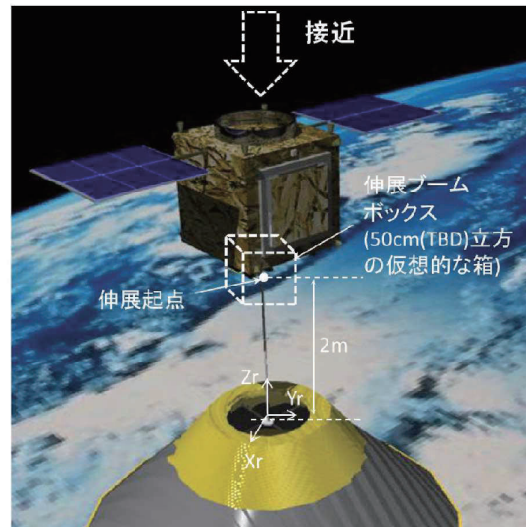
Stop and keep an appropriate distance from the debris



Extension boom control



Attach the removal device



To avoid interference between attitude control and extension boom control...

- First: stop and keep an appropriate distance from the debris.
- Second: extension boom control.

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### 4. Summary

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