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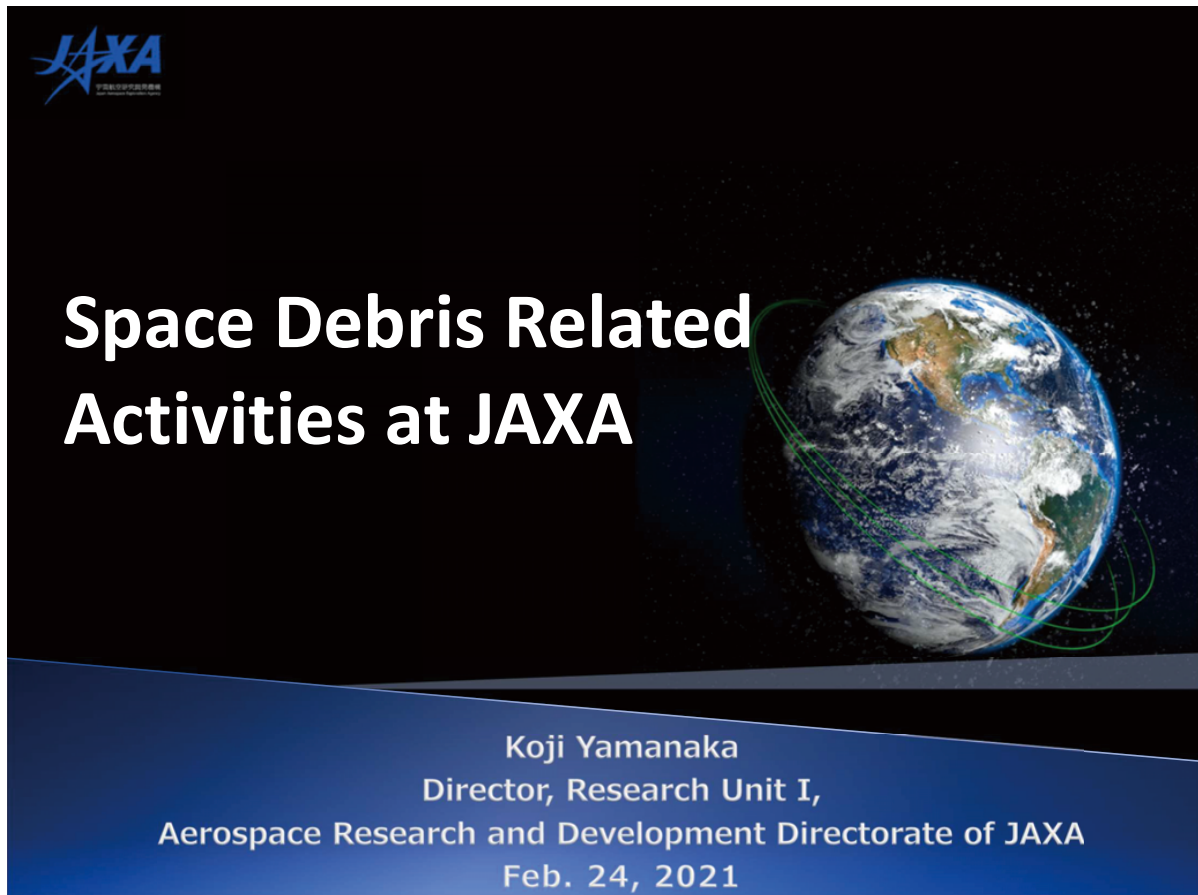
## JAXA のスペースデブリ関連活動紹介

### Space Debris Related Activities at JAXA

○山中 浩二 (JAXA)  
○YAMANAKA Koji (JAXA)

JAXA の最新のデブリ関連研究を紹介する。デブリ推移モデルの最新研究結果、地上からのデブリ観測能力の改善、微小軌道上デブリのモニタリング装置の開発状況、デブリ除去用の高効率なホールスラスタシステム開発、ロバスト性の向上を目指したデブリ捕獲機構の開発状況、デブリ捕獲の地上実証プラットフォームの開発など。また、デブリ除去に関しては、民間事業者の自立、国際競争力確保を促すための新たなパートナーシップ型の取り組みを開始し、フェーズ I のパートナーとして株式会社アストロスケールを選定した。その詳細についても紹介する。JAXA は今後も宇宙の持続的利用に貢献していく。

Space debris related activities at JAXA will be presented. They are, latest research results of the debris transition model, improvement of debris observation capability from the ground, development status of in-situ micro debris monitoring equipment, highly efficient hall-thruster system development for effective debris removal, development status of debris capture mechanism improving its robustness, ground platform for debris capture, etc. With regard to active debris removal, we have also launched a new partnership-type initiative to encourage the private sector activities, and have selected AstroScale, Inc. as a partner for Phase I. JAXA will continue to contribute to the sustainable use of future space.



## JAXA's activities on ensuring stable use of outer space

- ❑ As space utilization expands worldwide, threats and risks posed by space debris become serious issue. Securing the stable use of space is one of the most important and urgent concerns of all.
- ❑ Japan's Basic Plan sets Space Policy's objectives, such as ensuring National Security in Space and strengthening of national security ability.
- ❑ JAXA's activities contribute to Basic Plan are:
  1. Contribution for Space Situational Awareness(SSA).
  2. R&D for Space debris threats and risks.
  3. Support government in making international standards and regulations on space utilization.

*(February 28 2019, International Symposium on Ensuring Stable Use of Outer Space, JAXA Presentation).*



## Technology 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.
- HTV rendezvous with ISS (Client) cooperatively utilizing GPS and precise sensing capability.

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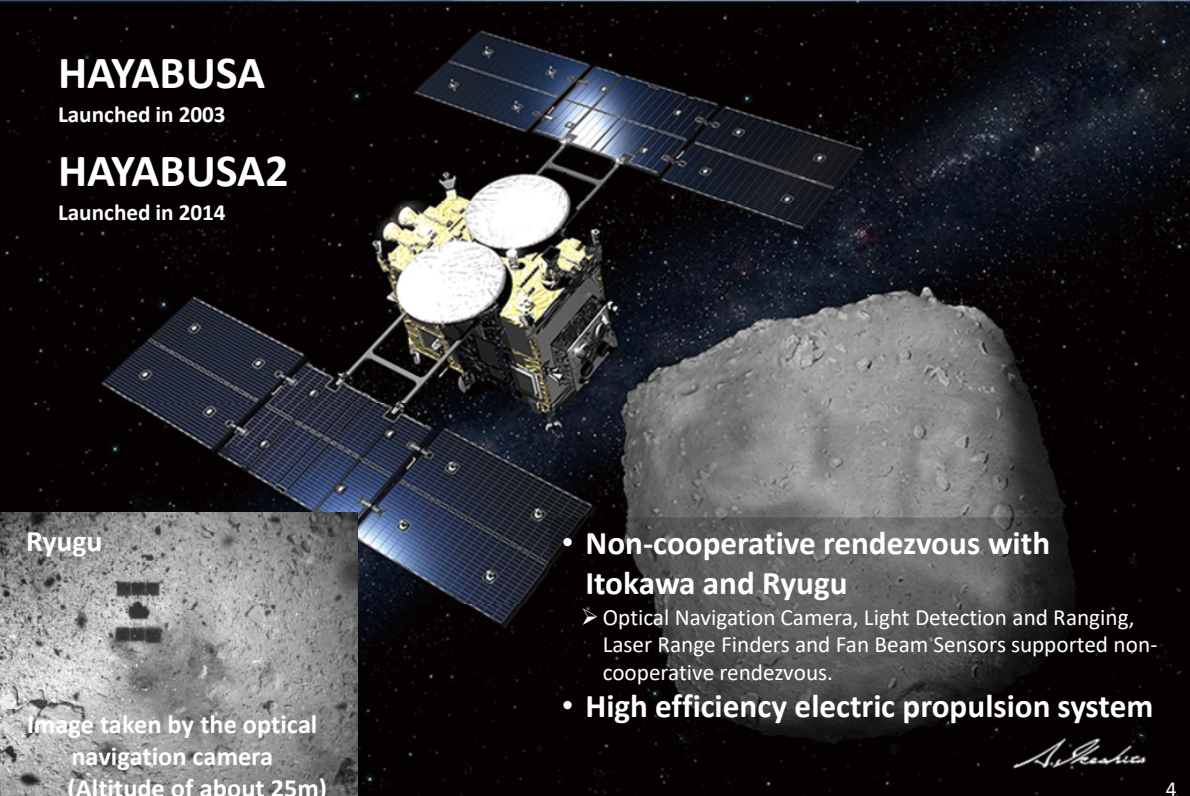
## Technology Background of JAXA (cont'd)

### HAYABUSA

Launched in 2003

### HAYABUSA2

Launched in 2014



Ryugu




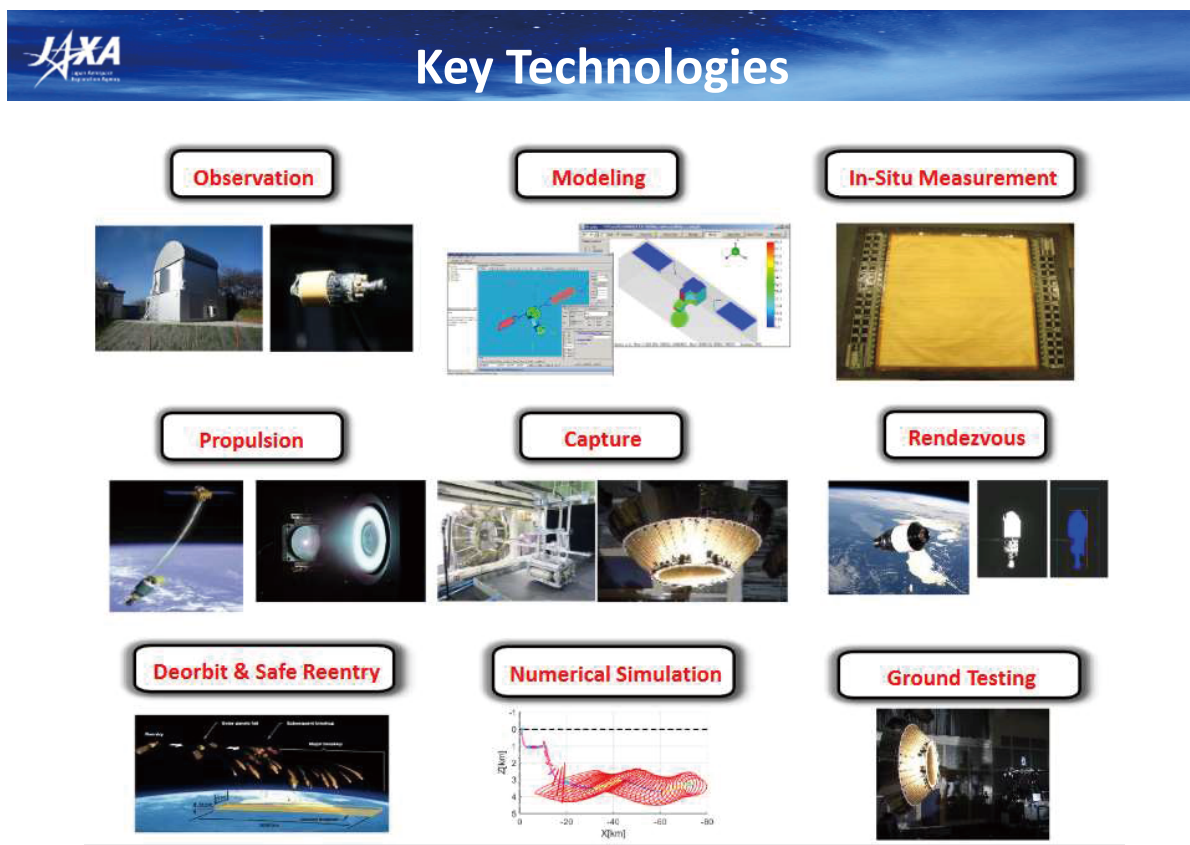
Image taken by the optical navigation camera (Altitude of about 25m)

- Non-cooperative rendezvous with Itokawa and Ryugu
  - Optical Navigation Camera, Light Detection and Ranging, Laser Range Finders and Fan Beam Sensors supported non-cooperative rendezvous.
- High efficiency electric propulsion system

*Asahi*

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## In-situ Measurement of Small Debris

### ■ Space Debris Monitor (SDM)

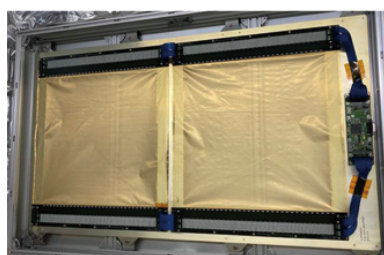
- 100  $\mu\text{m}$  to  $\sim 3 \text{ mm}$  sized debris under 1000 km orbit
- Flight experienced on HTV-5/ISS

### ■ International Collaboration

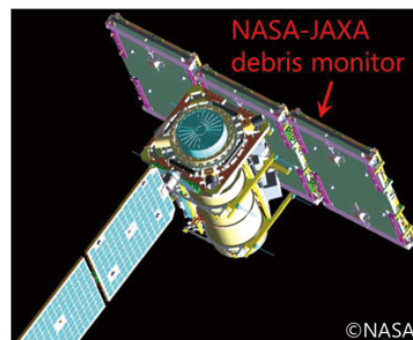
- JAXA/NASA Joint Work
- JAXA BBM is ready for Hyper Velocity Test in the US



SDM on HTV-5



New SDM BBM for the collaboration

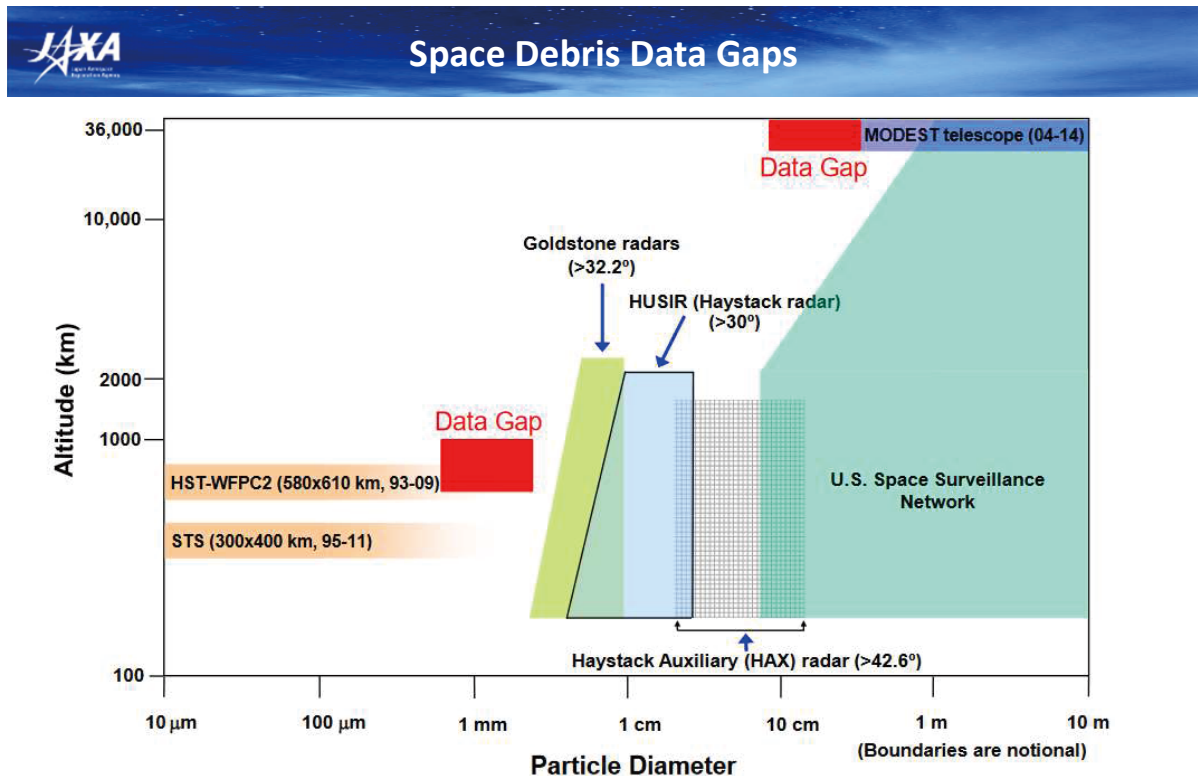


Conceptual illustration of debris monitoring

2月26日（金） 11：05～次世代型宇宙用デブリモニタBBMの開発, 松崎乃里子

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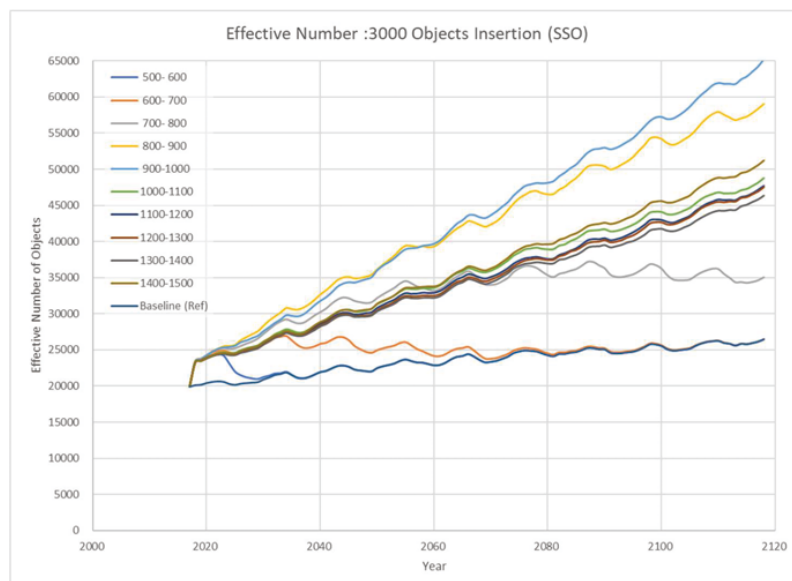


J.-C. Liou, "Risk from Orbital Debris", RAS Specialist Discussion Meeting on Space Dust and Debris in the Vicinity of the Earth, 9 November 2018 より

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## 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) is studied using an orbital debris evolutionary model (NEODEEM), developed in collaboration with Kyushu University.

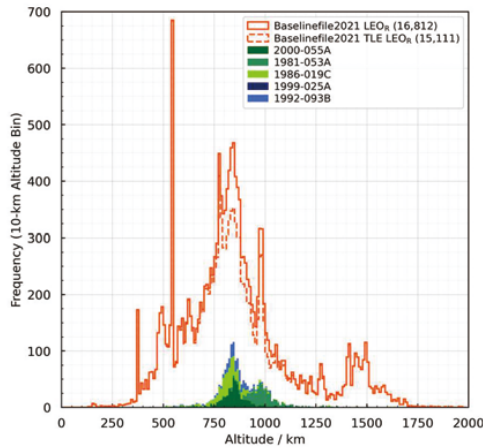


2月25日（木）10：20～推移モデルを用いた宇宙機の軌道投入許容量の検討,長岡信明

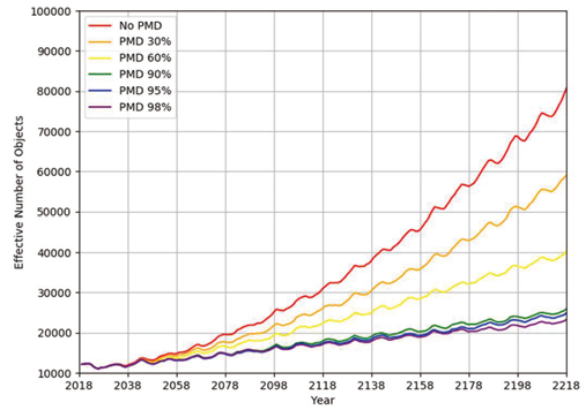
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## JAXA Development of JAXA's Original Baseline File for Debris Evolutionary Model

➤How to develop the baseline file, and evaluation results using the developed baseline file will be presented.



Altitude distribution



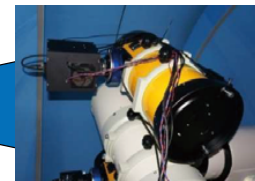
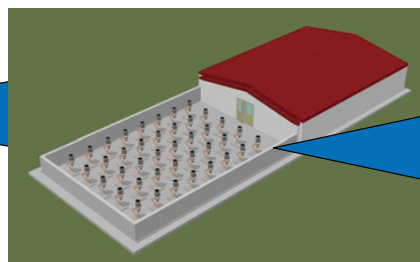
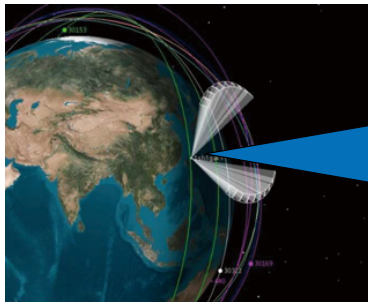
Sample results using JAXA's original baseline file and debris evolutionary model

2月25日 (木) 10 : 40～

JAXA独自のデブリ推移予測用ベースラインファイルの開発状況, 河本聡美

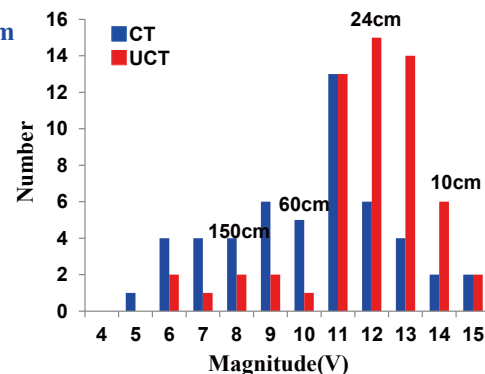
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## JAXA Optical Observation System for LEO Debris



Concept of optical observation system

By using optical sensors like CCD and CMOS, and using FPGA and GPU devices, the optical observation system that compensates current radar system for SSA will be developed with relatively low costs.

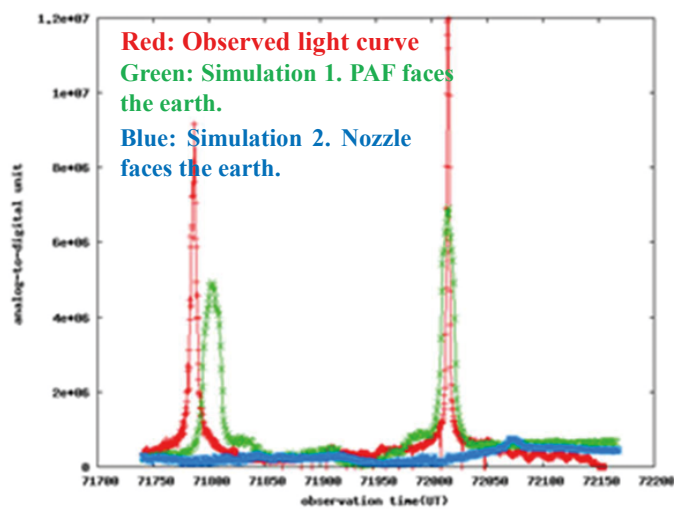


Detection ability of the basic optical equipment

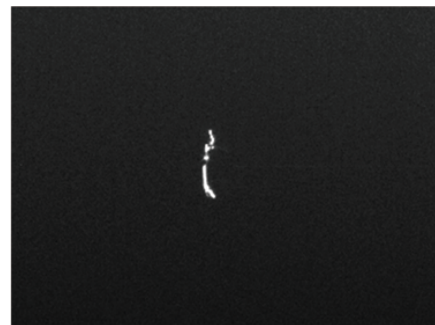
2月25日 (木) 15 : 30～ 低軌道デブリ光学観測システム, 柳沢俊史

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## JAXA Light Curve Observation and Reproduction Experiment Using Model of H-2A R/B



Comparison between observed light curve and simulated ones



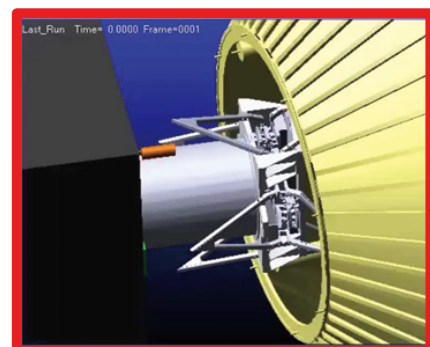
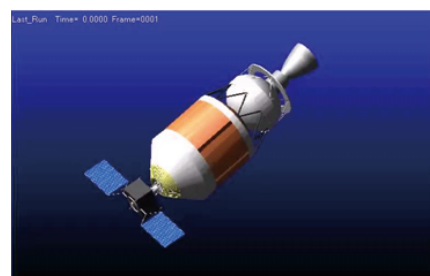
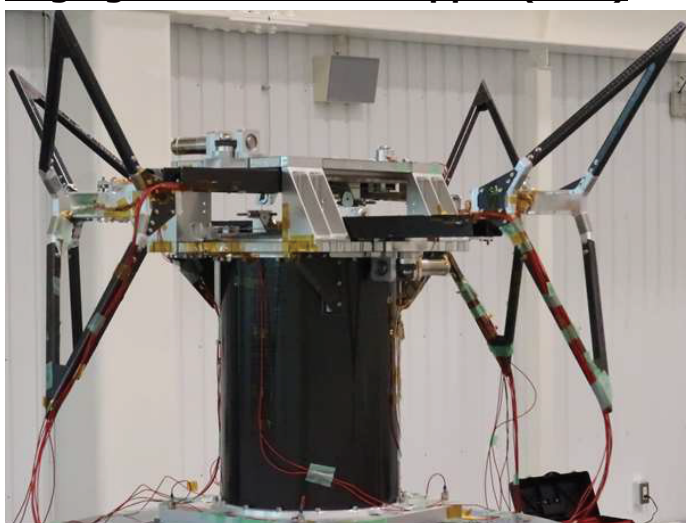
2月25日（木）16：40～

ライトカーブ観測とH-2A R/Bモデルを用いた再現実験, 黒崎裕久

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## JAXA Large Debris Capture System

### Caging Based Debris Gripper (HKK)



2月26日（金）16：35～

ロバスト性の向上を目指したデブリ捕獲機構のコンセプトと開発状況, 谷嶋信貴

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## **Novel 1-kW class Hall thruster system**



- Hall thruster with internal cathode
- Advanced materials and structures (patents to be published)
- High performance: Isp 1600sec, 65 mN/kW
- Long life: 10,000 hrs, 10,000 cycles(expected)
- System friendly: low-plasma oscillation, high-environmental resistance, beam divergence~30deg
- Cost-effective, low-mass power supply and flow controller

2月26日（金） 15 : 50～

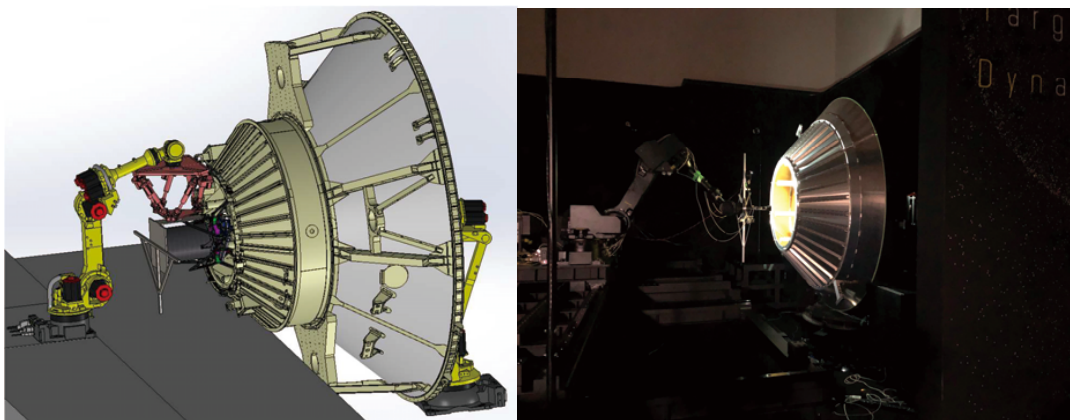
デブリ除去に向けた1kW級ホールスラスタシステムの研究開発, 張科寅

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## **Debris Rendezvous Test Facility**

### **SATDyn (Simulation Apparatus for Target capture Dynamics)**

- Numerical and Physical hybrid simulation system including contact dynamics
- ADR proximity operation simulation with real hardware (navigation sensor systems, capturing mechanics)
- 10m x 7m stroke 2DOF Gantry table with 3x6DOF Robotic arms for the chaser's relative motion simulation with external force torque measurements
- Solar simulator (Xe lump) and Full area motion capture system



2月26日（金） 16 : 55～

動ターゲット捕獲検証プラットフォーム（SATDyn）の開発, 岡本博之

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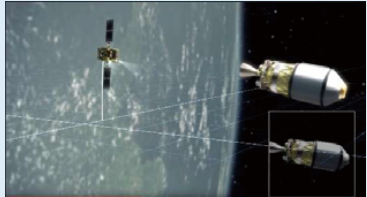
**JAXA** **Commercial Removal of Debris Demonstration**

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**

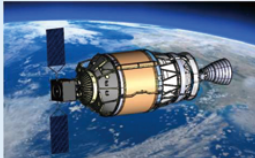



- Non-cooperative rendezvous, proximity operation, inspection

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.

2月24日（水）11：00～ JAXA 商業デブリ除去実証（CRD2：Commercial Removal of Debris Demonstration）の最新状況, 山元透

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**And much more, stay on-line!!**