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宇宙航空研究開発機構のスペースデブリ関連研究について

Overview of JAXA's Space Debris related Research Activities

伊東康之（宇宙航空研究開発機構）
Yasuyuki ITO, JAXA

Space debris is a risk factor for all the countries and organizations who perform space activities. For example, multiple collision damages are possible in a year for satellites with projected areas exceeding 10 m2. Efforts are required for mission assurance against debris. The protection design for critical components of a spacecraft, adding functions to complete self-disposal actions, etc.are considered. Almost all the debris experts in the world agree that the number of existing debris would continue to grow and the environment would go worse. Therfor, in addition to the mitigation efforts, more positive measures to remedy the environment should be globally discussed and implemented. In order to develop measures to remove debris, technology development is needed as well as international cooperation. Considering the above mentioned situation, JAXA's debris related research activities are introduced in this presentation.

スペースデブリは宇宙開発利用活動を行うすべての国、機関にとってリスクとなっており、ミッションの成功を保証するために努力が必要である。一例として、高度 1000km を周回する断面積 $1m^2$ の衛星には 1mmφのデブリが３年で１回の頻度で衝突すると推定されており、当たり所が悪いと人工衛星の機能の一部を喪失することとなる。より大きいデブリが衝突すれば衛星自体の喪失、破砕に至る。デブリは継続的に増加しており、その状況悪化の加速度を緩和するために、デブリ発生防止対策を徹底しなければならない。多くの対策は既に世界的に合意されているが、用済み後のシステムの除去や、落下時の地上安全の確保には更に徹底・配慮が必要な状況である。軌道上物体同士の衝突は近年現実的な脅威となっており、現状のデブリ発生防止対策を超えて、分布密度の高い高度域から使用済み衛星・ロケットを相当数除去する活動が、近い将来必要になるという認識が共有されつつある。この様な状況を踏まえ、宇宙航空研究開発機構におけるデブリ関連研究を概観する。

Biography

ITO, Yasuyuki
Associate Director General, JAXA

Place of birth : Osaka, Japan
Ms. and Bs. degree in Electrical Engineering
at Kyoto University

1980 - 2003: National Space Development Agency (NASDA)
2003 - : JAXA
< R & D Career >
Earth Observation Instrumentation at R&D Directorate: Synthetic Aperture Radar, Microwave Radiometer
Conceptual study of ENVISAT/AMI at ESA/ESTEC as Research Fellow
Earth Observation Satellite Project : ADEOS-II, Aqua/AMSR-E
< Administration/Management Career >
Strategic Planning Dept., Human Resources Dept., Audit & Evaluation Office, Earth Obs. Science Team Management

OVERVIEW OF JAXA'S SPACE DEBRIS RELATED RESEARCH ACTIVITIES

December 2014

6th Space Debris Workshop, Chofu, Tokyo

Yasuyuki ITO, JAXA

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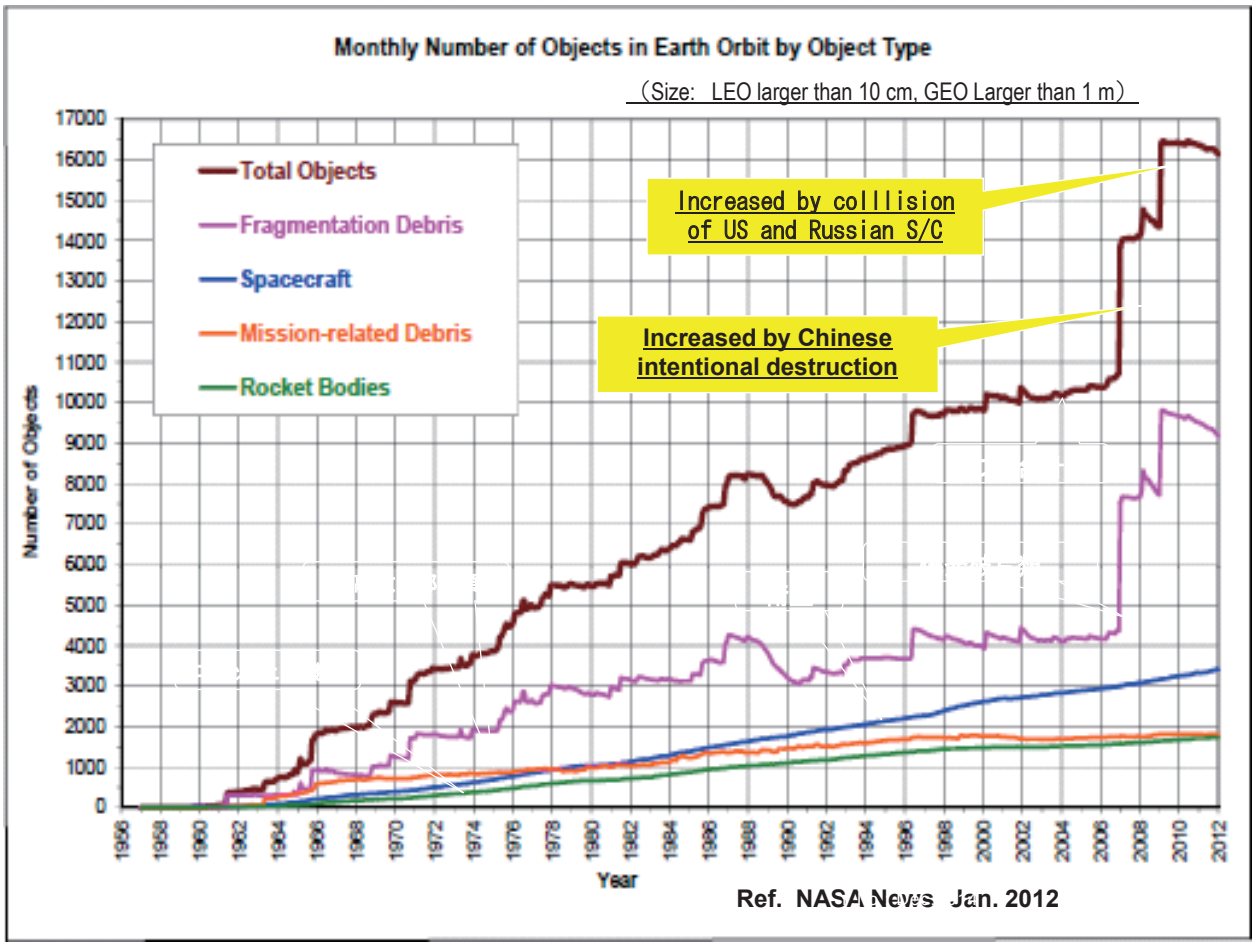
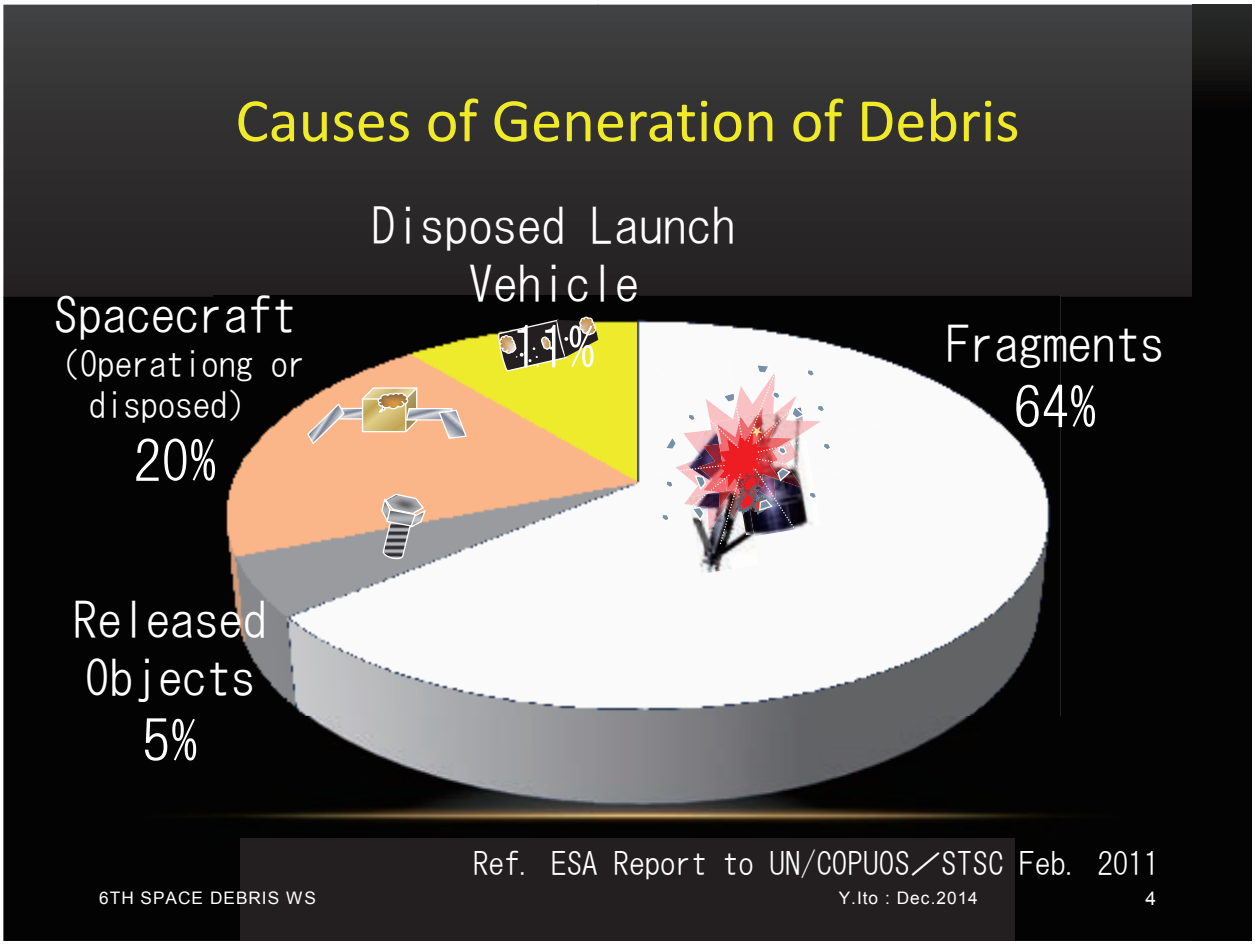
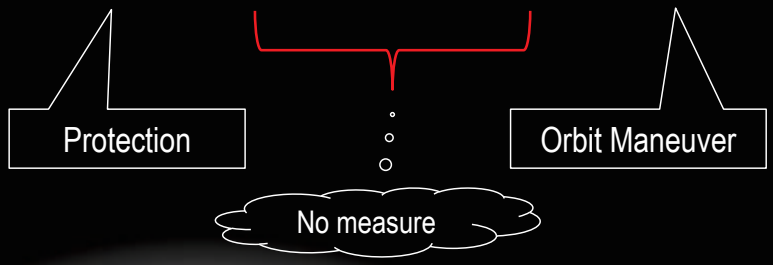




Estimated Annual Collision of Small Sized Debris to a Operating Satellite (1m^2 cross section at 800km altitude orbit)

Debris SIZE	0.1~1mm	1~10mm	1~10cm	10cm over
Estimated Annual Collision (times)	100	0.01*	0.0001	0.00001

Measures for Mission Assurance



* NASA analysis shows 0.1

Ref. :Analysis using ESA tool "MASTER"

Basic Plan on Space Policy, Second Issue : January 2013 (First Issue : June 2009)

JAXA has been positioned as the core organization that provides technical support for the entire governmental development and utilization of space projects.

Basic Policy

- Expanding the utilization of space
- Ensuring autonomy

Priority Subjects

- National Security and Disaster Management
- Industrial Development
- Progress in Frontier Areas including Space Science

Basic Plan on Space Policy, Draft for New Issue : for Public Comment in November 2014

Provisional Translation

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Description about Space Debris in the New Basic Plan Draft

Provisional Translation

4. Measures that the Government should take

(1) Systems of Governmental Measures for the Goal

① Ensuring Security in Space

ｉ）Sustainable Development and Utilization of Space

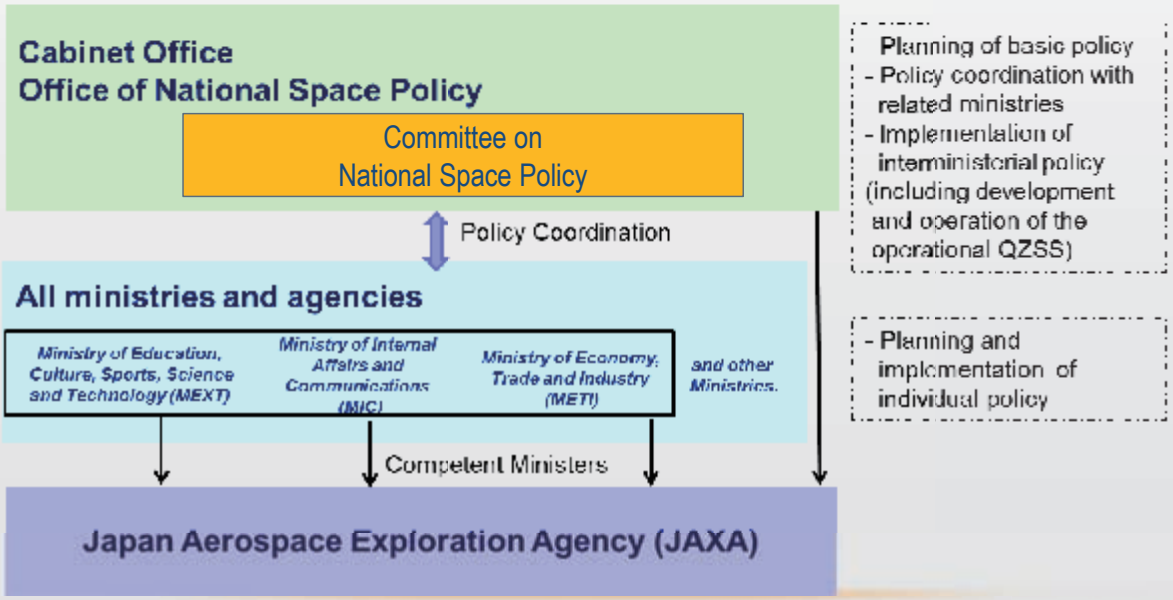
Space Situational Awareness (SSA) system acquisition and development of the capability

Capability for collision avoidance

Realize/strengthen the rule of law in space

Development of technologies for debris removal

Organization chart
(Space related ministries in Japan)



Ref.: Presentation by Office of National Space Policy, CAO

6TH SPACE DEBRIS WS Y.Ito : Dec. 2014 9

JAXA ORGANIZATION CHART


Naoki Okumura

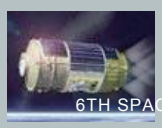
President

Senior Vice-President

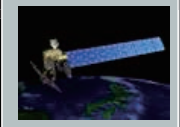
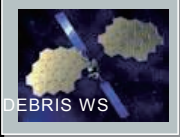

Kiyoshi Higuchi
IAF President

Policy Coordination | Admin. Management | Technical Management

Space Transportation Mission Directorate

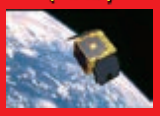



Satellite Applications Mission Directorate I

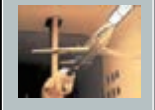
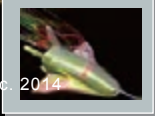
Human Spaceflight Mission Directorate

Aerospace Research & Development Directorate (ARD)

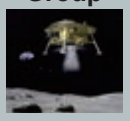



Institute of Space & Astronautical Science


Institute of Aeronautical Technology

Lunar & Planetary Exploration Program Group

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ISAS NAL NASDA

1996 : NASDA first Debris Standard

1999 : Japan proposed a specific committee to UNCOPUOS for debris issue

1995 : NASA first Debris Standard

1999 ~ 2007 : CNES first Debris Standard
European Code of Conduct

2002 : IADC released the IADC Debris Mitigation Guidelines

2003

JAXA First Mid-Term

2006 : JAXA Debris Committee

2007 : UN adopted the COPUOS Debris Mitigation Guidelines

2008

JAXA Second Mid-Term

2011 : ISO released “Debris Mitigation Requirements”

2012 : (Japan’s New Law)

2013

JAXA Third Mid-Term

< 6th Debris Workshop >

History of JAXA and World Debris Activities

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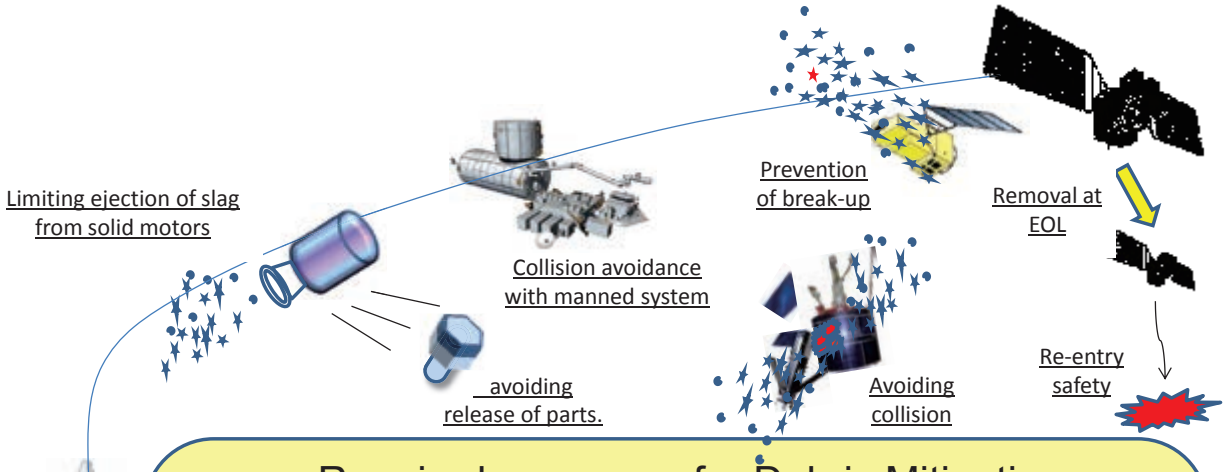


Required measures for Debris Mitigation

- Avoiding release of objects
- Collision avoidance at new launch
- Protection from impact of debris
- Collision avoidance with observable large objects
- Protection from impact of tiny debris
- Prohibition of intentional destruction, prevention from break-ups
- Removal form protective region at EOL
- Ensuring re-entry safety

Y.Ito : Dec. 2014 6th Space Debris WS 12

Major Elements of Strategy

Mission Assurance

Sustainable Development

Preventive Action
- Risk Identification ⇒ Observation, Modeling, Risk Analysis
- Protection measures ⇒ Protection Design STD

Detection
- Conjunction Assessment & Warning ⇒Monitoring, Conjunction Analysis
- Impact & Failure detection ⇒ On-Board Detector

Counter Actions
- Collision Avoidance ⇒ Avoidance Maneuver
- Damage Reduction ⇒ Separation of Function. etc.

Corrective Actions
- Preservation & Ground Safety ⇒ Mitigation Design & Operation Re-entry Safety Analysis
- Prevention of Chain Reaction ⇒Technology for Removal

Red : Primary R&D items,
Blue : Vehicles and spacecraft projects team will promote.

Mission Assurance: Ground Observation

Goals in next 5-year-plan

1. Objects smaller than 10 – 20 cm in GEO can be observed.
2. Conjunction with debris can be assessed by domestic facilities in sufficient precisions to support avoidance maneuver.

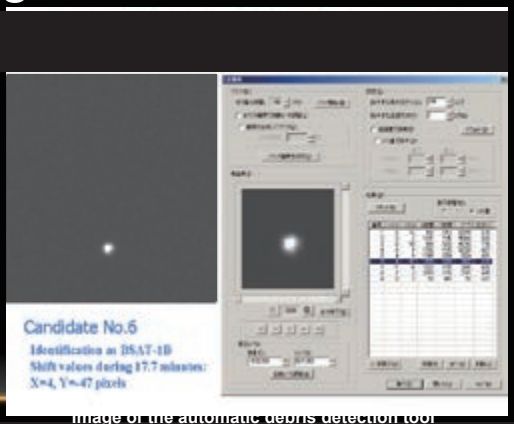
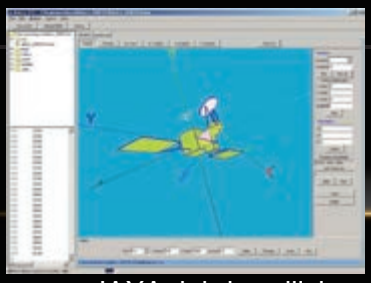


Image of the automatic debris detection tool

Mission Assurance: Modeling

Goals in Modeling

1. Future debris population can be prospected, and adequate policy can be implemented in advance.
2. Collision risk management will be conducted by analyzing the impact probability, damage estimation, and protection design.



JAXA debris collision risk analysis tool, TURANDOT

Mission Assurance: Protection Design

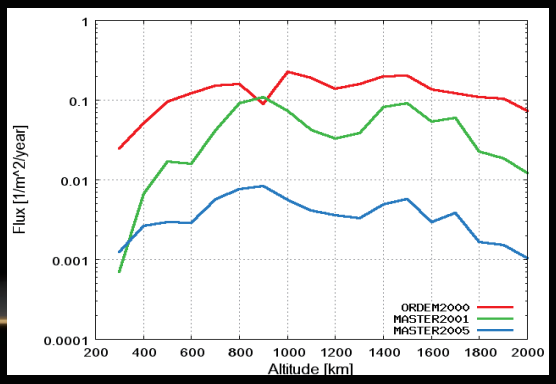
Goals in next 5-year-plan

1. Establishment of a Protection Design Standard
   - It enables adequate design depending on the mission characteristics.

Mission Assurance: Debris Detector

Goals in Debris Detector

1. The debris detector will be launched to confirm orbital debris distribution.
   1. The debris larger than 100μm will be detected with its size
   2. The data will contribute to the world debris models.



Disagreement in MASTER and ORDEM

Ground Safety

Goals in Ground Safety after deorbit

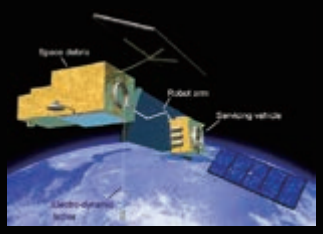
1. More reliable re-entry risk analysis can be done with improved database (material properties, human distribution, etc.)
2. Risky devices that survive re-entry will be minimized.

Titanium casing of the STAR-48B solid rocket motor found in northeastern Argentina.

Preservation and improvement of the environment

Goals in Active Debris Removal

1. First step: Key technology demonstration such as electro-dynamic tether (EDT) as economical deorbit devices.
2. Final Step : large intact debris such as rocket upper stages will be removed by international project.

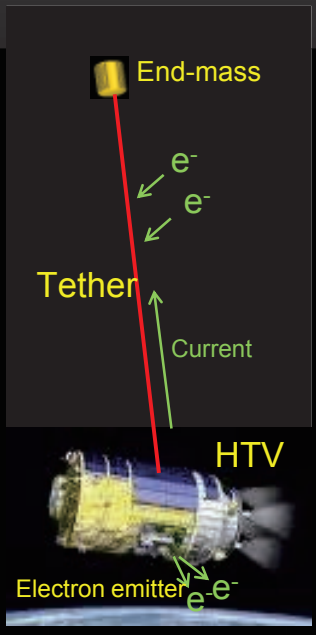


EDT Demonstration using HTV

EDT on HTV (H-II Transfer Vehicle)

- Objective
  - Demonstration of EDT key technologies
    - Deployment of bare tether
    - Electron collection by bare tether
    - Electron emission by field emission cathode
    - Current loop formation via plasma
    - Autonomous current control operation
- Flight Sequence
  - HTV leaves ISS and lowers altitude
  - Tether deployment
  - EDT operation
  - HTV re-enters atmosphere

7 days for EDT mission



Tether length	700 m
Max. tether current	10 mA