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. Therefore, 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.

**Biography**

ITO, Yasuyuki

Associate Director General, JAXA

Place of birth: Osaka, Japan

Ms. and Bs. degree in Electrical Engineering at Kyoto University

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 >

OVERVIEW OF JAXA’S SPACE DEBRIS RELATED RESEARCH ACTIVITIES

December 2014
6th Space Debris Workshop, Chofu, Tokyo
Yasuyuki ITO, JAXA

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1. about Space Debris
2. about Japan’s space policy and JAXA
3. Goals and Topics of JAXA Research activities
Causes of Generation of Debris

- Disposed Launch Vehicle
  - Spacecraft (Operating or disposed): 20%
  - Released Objects: 5%
  - Fragments: 64%

Ref. ESA Report to UN/COPUOS/STSC Feb. 2011
Estimated Annual Collision of Small Sized Debris to a Operating Satellite
(1 m² cross section at 800 km altitude orbit)

<table>
<thead>
<tr>
<th>Debris SIZE</th>
<th>0.1~1mm</th>
<th>1~10mm</th>
<th>1~10cm</th>
<th>10cm over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Collision (times)</td>
<td>100</td>
<td>0.01*</td>
<td>0.0001</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

Measures for Mission Assurance
- Protection
- Orbit Maneuver
- No measure

* 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
Table of Contents

0. Introduction
1. Current circumstances
2. Goals
3. Basic Policy
4. Measures that the Government should take

Description about Space Debris in the New Basic Plan Draft

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
History of JAXA and World Debris Activities

- 1996: NASA first Debris Standard
- 1999: Japan proposed a specific committee to UNCOPUOS for debris issue
- 2003: JAXA First Mid-Term
  - 2006: JAXA Debris Committee
- 2008: JAXA Second Mid-Term
- 2013: JAXA Third Mid-Term
- 2002: IADC released the IADC Debris Mitigation Guidelines
- 2007: UN adopted the COPUOS Debris Mitigation Guidelines
- 2011: ISO released "Debris Mitigation Requirements"
- 2012: (Japan's New Law)

< 6th Debris Workshop >
Major Elements of Strategy

Preventive Action
- Risk Identification \(\Rightarrow\) Observation, Modeling, Risk Analysis
- Protection measures \(\Rightarrow\) Protection Design STD

Detection
- Conjunction Assessment & Warning \(\Rightarrow\) Monitoring, Conjunction Analysis
- Impact & Failure detection \(\Rightarrow\) On-Board Detector

Counter Actions
- Collision Avoidance \(\Rightarrow\) Avoidance Maneuver
- Damage Reduction \(\Rightarrow\) Separation of Function, etc.

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

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.
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.

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 electrodynamic 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

<table>
<thead>
<tr>
<th>Tether length</th>
<th>700 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. tether current</td>
<td>10 mA</td>
</tr>
</tbody>
</table>