C7

デブリ除去プロジェクト考察
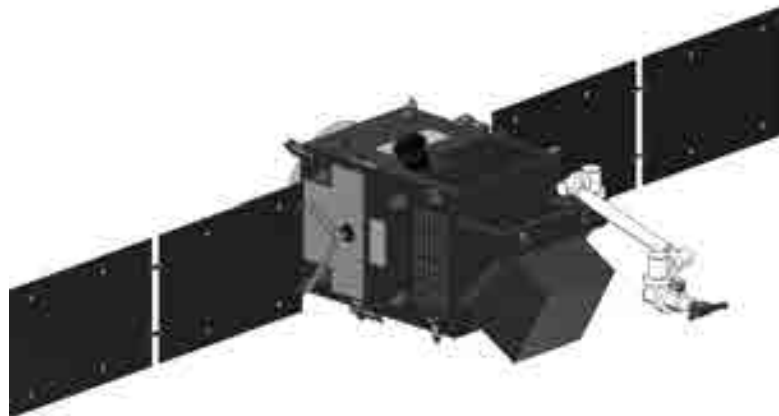## Study of Active Debris Removal Project

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　人工衛星クラスのデブリの除去は、デブリそのものの低減と共に、更なるデブリ発生を抑制するという点で、重要なミッションである。人工衛星クラスのデブリに相対接近、搭載ロボットアームでの把持、EDT 装置取付、EDT によるデブリの軌道離脱というミッションを想定し、そのミッションを遂行する衛星に対するシステム概念、機器構成、ミッション機器／バス機器性能、軌道上シナリオなどのシステム設計を報告する。合わせて、デブリ除去の事業の仕組み／原資調達などの観点からの成立性を検討する。

　Active removal of satellite-sized space debris is very useful to reduce both of the number of space debris and the collision between orbital debris. Suppose the mission by an active-debris-removal satellite (ADR satellite) to approach a satellite-size space debris, capture by a manipulator, set an EDT equipment and de-orbit the debris by EDT, system design concept for ADR satellite will be reported. And from the business point of view, investigation of the space debris removal project will be discussed.

Space Debris Work Shop#5

Study of Debris Removal Project

Jan. 22, 2013
NEC
Project Promotion Department
Akiko OTSUKA

Sustainable Space Development & Utilization for Humankind

UNCOPUOS2010 NASA   ESA HP   NASA HP

An Active Debris Removal Parametric Study
for LEO Environment Remediation
Dr. J.-C. Liou NASA, ASR-D-11-00022R1

ISS always operates Debris Maneuver

Studies of the debris population in the LEO indicate that the LEO population will increase without any new launches. To preserve the environment for future generations, ADR must be considered.

Space Debris Control Measures

★★Control Measures★★
・Space debris model
・Mitigate the number of new debris
・<u>Active Debris Removal（ADR）</u>

To be studied as a business project

ADR Project
●Points to be considered
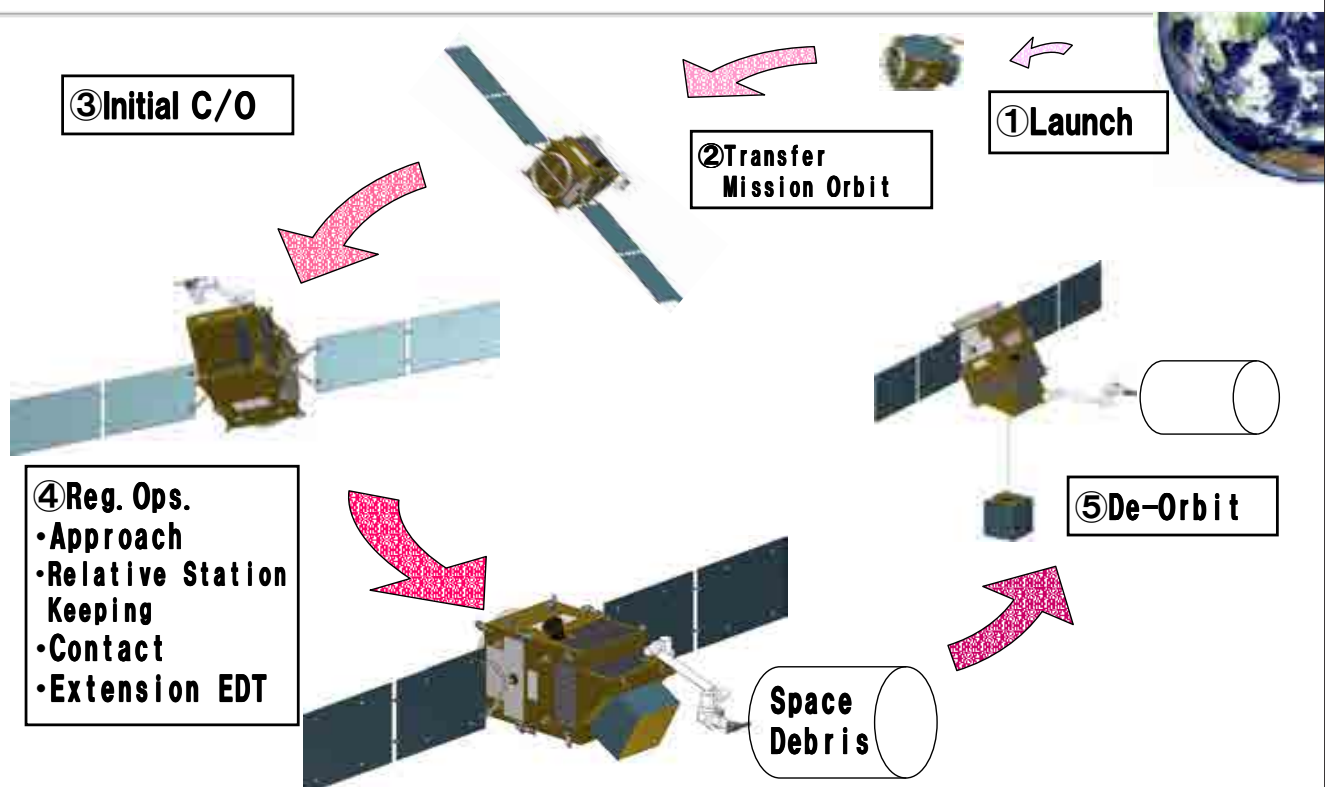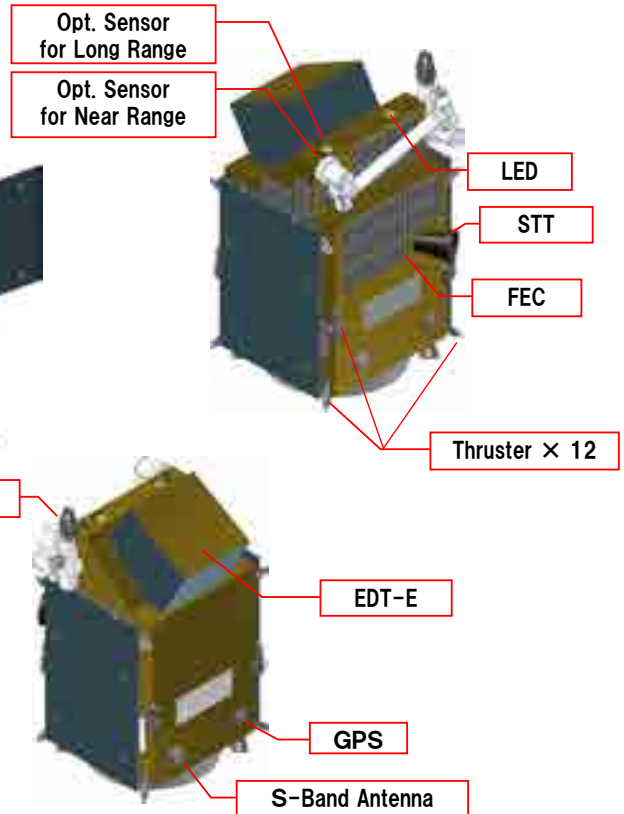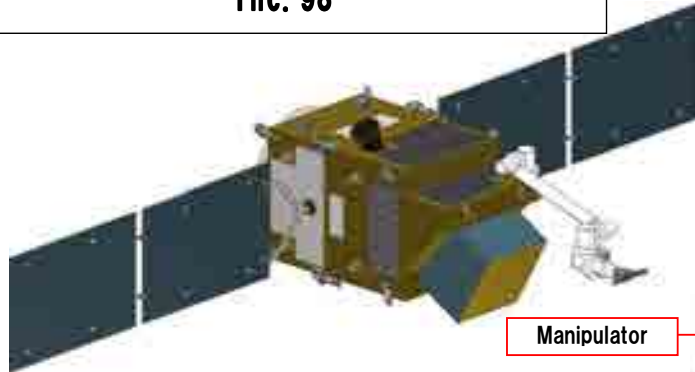 **Technology**
  Scheme
  Cost
  Law

ADR Operation Sequence

③Initial C/O

②Transfer Mission Orbit

①Launch

④Reg. Ops.
・Approach
・Relative Station Keeping
・Contact
・Extension EDT

⑤De-Orbit
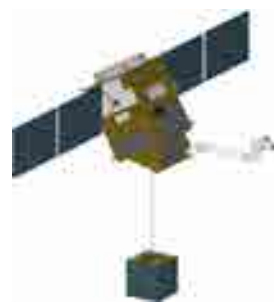
Space Debris

ADR Satellite

Condition
Satellite Bus:NEXTAR 300kg-class
Space Debris：Alt.800-1000km
Inc. 98°

Opt. Sensor for Long Range
Opt. Sensor for Near Range
LED
STT
FEC
Thruster × 12
Manipulator
EDT-E
GPS
S-Band Antenna

Item		Spec.
Mass		500kg
EPS	Paddle	2 panels/wing Rotation type
	Power	900W@EOL
RCS	Thruster	4N×12
	Propellant capacity	60kg

ADR Satellite Key Technology

●Solar Array Panel
 Simulation of Power Balance indicates that ADR satellite should be equipped with rotation type SAP.

Earth
S

After one-orbit, DOD will not be recovered to 0.
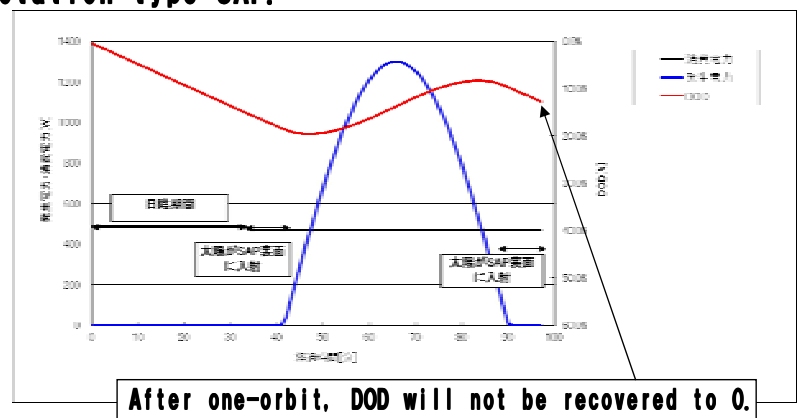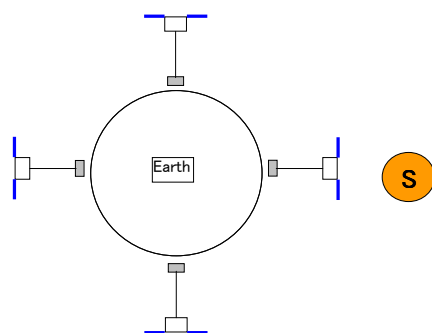
●Location of thrusters

 12 thrusters are needed for approach and relative station keeping
 →Detail analysis should be needed
      on design of pipe lay-out or assembly work

ADR Satellite Key Technology

●**Approach and Observing**

Approach and observing Space Debris will be done by Attitude and Orbit control system and Optical system.

Optical system

| Item	Spec.
Star Sensor 　FOV 　dynamic range	**Relative range >50 km** **15°** **1 ～ 4 Visual Magnitude** （**Detect of more darker stars than camera for near range**）
Opt. Sensor for long range 　FOV 　Mim. range 　Max. range	**6° (H-direction) (focal point 90mm)** **10m** **300km**
Opt. Sensor for near range 　FOV 　Mim. range 　Max. range	**20° (H-direction) (focal point 9mm)** **0.5m** **20m for approach/10km for observing**

→**Detail analysis should be needed on selection of effective optical sensors**

ADR Satellite Key Technology

●**Manipulator system**

Manipulator with 5 joints
- **6-DOF will be achieved by collaborating with Attitude and Orbit Control system.**
- **Small and light-weight manipulator system**
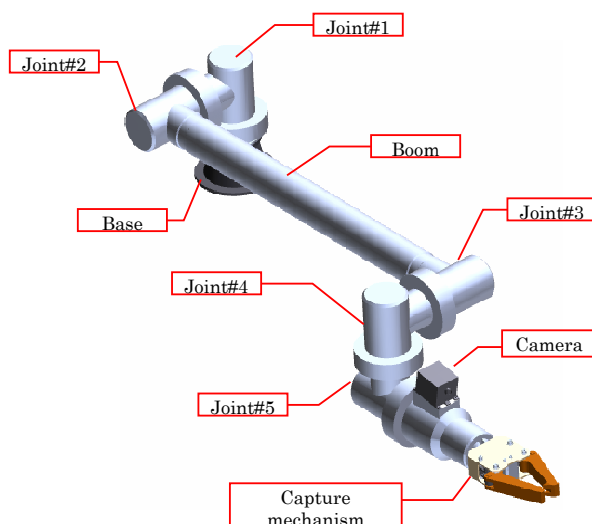
→**The most critical operation, to contact with Space Debris should be studied.**

This document is provided by JAXA.

# ADR Satellite Key Technology

●Extension Mechanism of EDT

Requirements

Prevent End-mass tumbling during ejection
Prevent tether loosening before extension
Prevent tether cut-off during extension
Prevent tether entwisting by loosening during extension
The tether tension directs to center of ADR satellite mass.

End-mass
Brake
Tether
146
?135
N E A
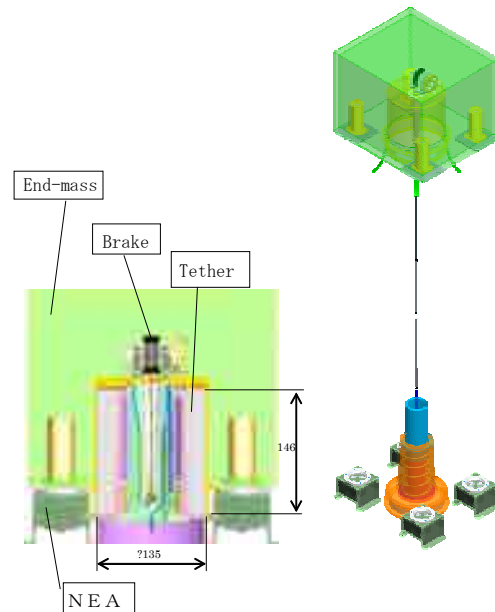
ADR Project

Three key items of business model

Stakeholder
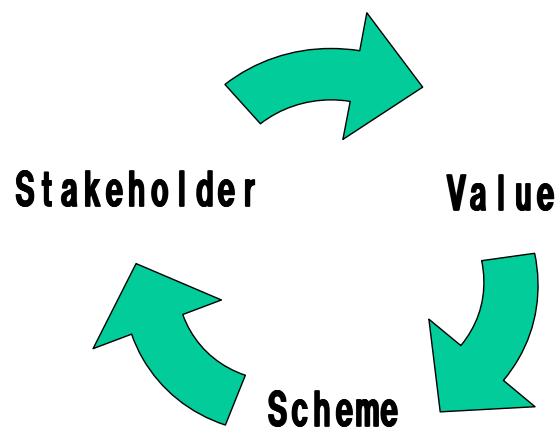
Value

Scheme

●CVCA (Customer Value Chain Analysis)
  Diagram to illustrate stakeholder interface by value/money/service

Notes:
In our study, "Scheme" is defined
as the system how to manage/operate
the business.

Ref:
Ishii, K. Course Materials,
Design for Manufacturability
(ME317).
Stanford University, USA, 2003.

ADR Project ～CVCA～

Project#1
●Value：
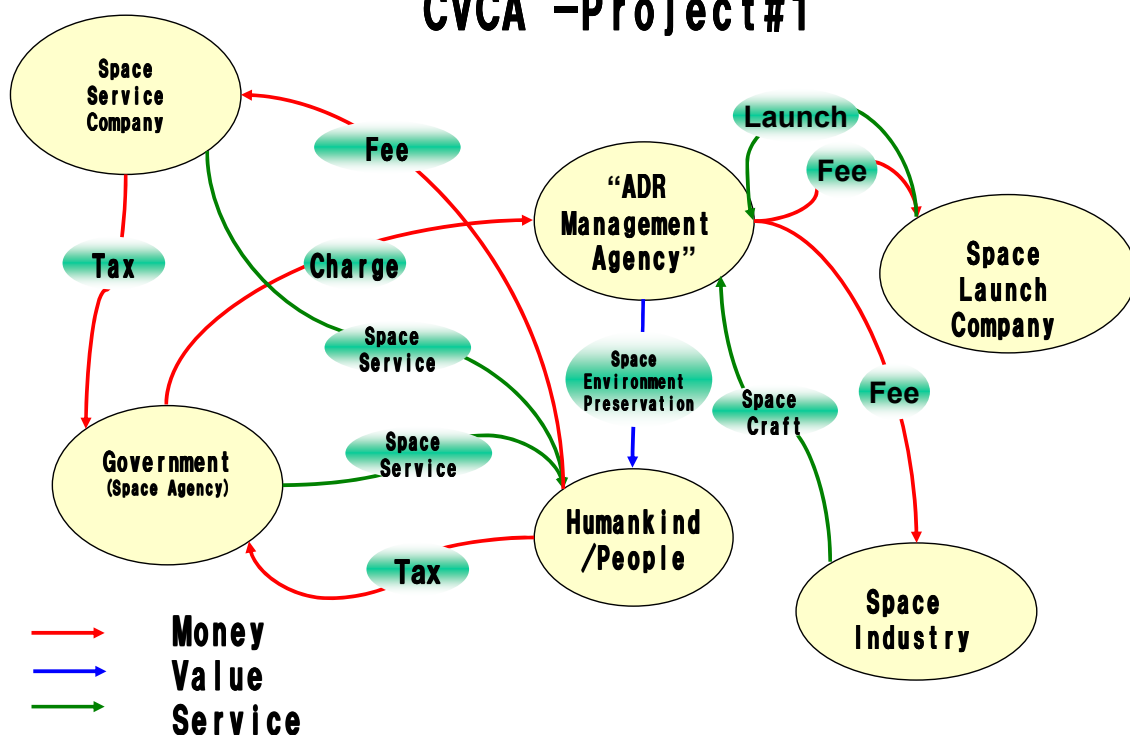 To preserve space environment
●Stake holder:
 Humankind
●Scheme:
 Manage by "ADR management agency"
 Charge each country based
 on the number of existing space debris

ADR Project ～CVCA～

CVCA -Project#1

Legend:
- Money (red arrow)
- Value (blue arrow)
- Service (green arrow)

Nodes: Space Service Company, ADR Management Agency, Space Launch Company, Government (Space Agency), Humankind/People, Space Industry

Flows: Fee, Tax, Charge, Space Service, Space Environment Preservation, Launch, Space Craft

ADR Project 〜CVCA〜

Ｐｒｏｊｅｃｔ#1　Ｉｓｓｕｅ
●Space Service Company gets benefit by ADR
　and is free to be charged.
→Need some scheme
　　　　to charge Space Service Company

●Risk to accept value
　(=activity to preserve space environment)
　by humankind/people
→Need to enlighten people
　　　　on space environment

ADR Project 〜CVCA〜

Project#2
●Value：
　To mitigate collision risk for specific spacecraft
●Stake holder：
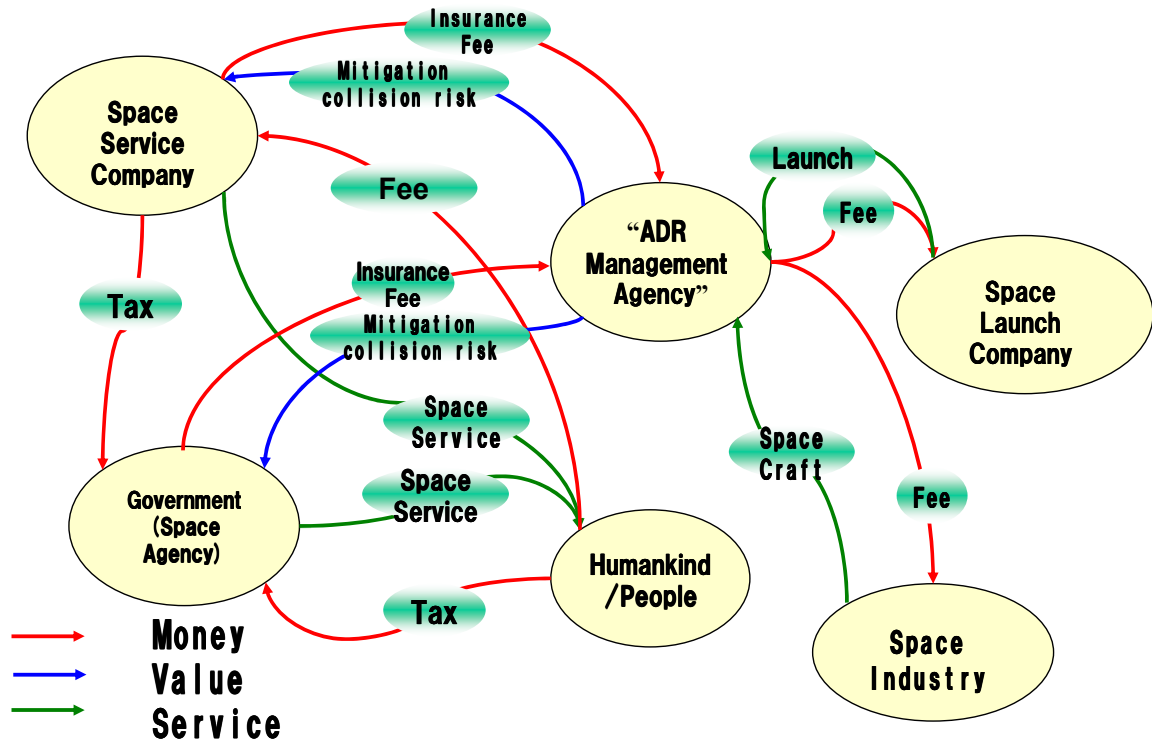　Space Agency or Commercial company
　　　　　to operate the spacecraft
● Scheme：
　Manage by "ADR management agency"
　Charge each space agency or commercial company
　as insurance fee when they launch their spacecraft

ADR Project ～CVCA～

CVCA -Project#2

Money
Value
Service

ADR Project ～CVCA～

Project#2 Issue

●Space debris to collide is different
　from each spacecraft
→Select space debris to be removed
　and set the priority

Conclusion

●Several studies on ADR project are done.

●Some hard issues of technical and/or scheme are identified.

●To solve these issues and realize ADR as business project, we will keep further studies .

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