

B2

宇宙航行の安全と低軌道における経済圏の発展

Spaceflight safety in a rapidly growing LEO economy

岡田光信 (Astroscale)

Nobu Okada (Astroscale)

低軌道 (LEO) においては、活動領域が広がり市場経済が形成されつつある。プレーヤーは民間主体へと移行過程にある。彼らはビジネスを考えるにあたり、オペレーション中のスペースデブリとの衝突ならびに衝突回避によるダウンタイム・故障リスク等を具体的に織り込む必要が出てきた。利益最適化のためにどのようなリスク軽減策をとるか考慮する必要がある。Astroscale では、今後多数打ち上がる衛星が宇宙空間に残存しないよう End-of-Life (EOL) サービスを提供する衛星 ADRAS 1 を開発しており、この技術は中期的には Active Debris Removal に発展させることを考えている。また、宇宙機にもっとも頻度高くダメージを与える微小デブリについては、その密度を観測するために微小デブリ監視衛星 IDEA OSG 1 を間もなく打ち上げる。本発表では、LEO 市場経済を最大化するために、宇宙機の安全航行の必要性とそれを担保するための Astroscale のソリューションについて紹介する。

Market economy is evolving in Low Earth Orbit (LEO) due to various types of space initiatives. The new LEO players are mostly private sectors, and they have to consider business risks in business projections, which comes from collision with space debris as well as collision avoidance activities. They need to optimize profit by mitigating the space debris risk. Astroscale is developing End-of-Life service satellite, ADRAS 1, to make sure no defunct satellites remain in space in the era of satellite proliferation. We plan to evolve its technology to Active Debris Removal (ADR) technology in mid-term. Also, Astroscale is going to launch a satellite, IDEA OSG 1, which aims at continuously sampling the sub-millimeter size debris environment. Timely mapping and tracking capabilities for space debris in sub-millimeter size regime are essential to model the LEO environment. This presentation explains why we need to secure spaceflight safety, and introduces Astroscale's solutions for it.



Spaceflight Safety in a rapidly growing LEO Economy

ASTROSCALE PTE. LTD.

October 18, 2016 @ 7th JAXA Debris Workshop

Strictly Confidential Copyright (c) ASTROSCALE PTE. LTD. All Rights Reserved

Growing LEO Economy



SATELLITES



- Mission Dev, planning & testing
- Manufacturing/Operations
- Mission operations

LAUNCH & TRANSPORT



- Rocket (non-) reusable
- Non-human sub/orbital
- Near-space/balloon

HUMAN SPACEFLIGHT



- Near-space, space-diving
- Sub/orbital flight
- Lunar, interplanetary

MICROGRAVITY RESEARCH



- Experiment platforms
- 3D printing
- Parabolic flights

HABITATS & REAL ESTATE



- Spaceports
- In-orbit destinations
- Training facilities

IN SPACE SERVICES



- Debris removal & EOL
- Re-fueling
- Inspect, repair, reuse

SPACE RESOURCES



- On-planet mining
- In-orbit mining
- Space robotics

SPACE ENERGY



- ON-planet gathering
- In-orbit gathering
- In-situ production

Spaceflight safety does matter

Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

ASTROSCALE



Mission: Spaceflight safety

Created in 2013

27 members

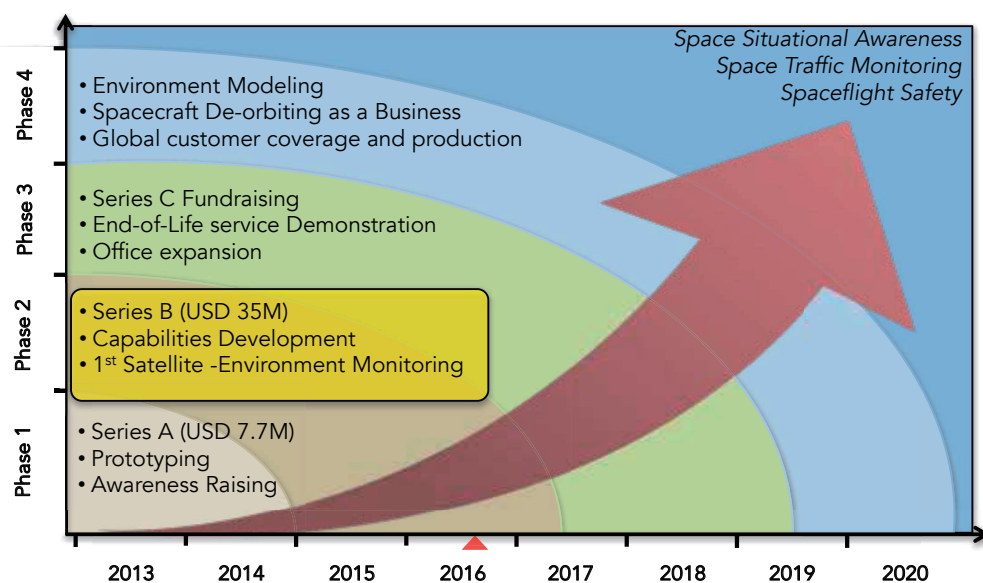
USD 42.7M Raised

2 Space Missions in Development

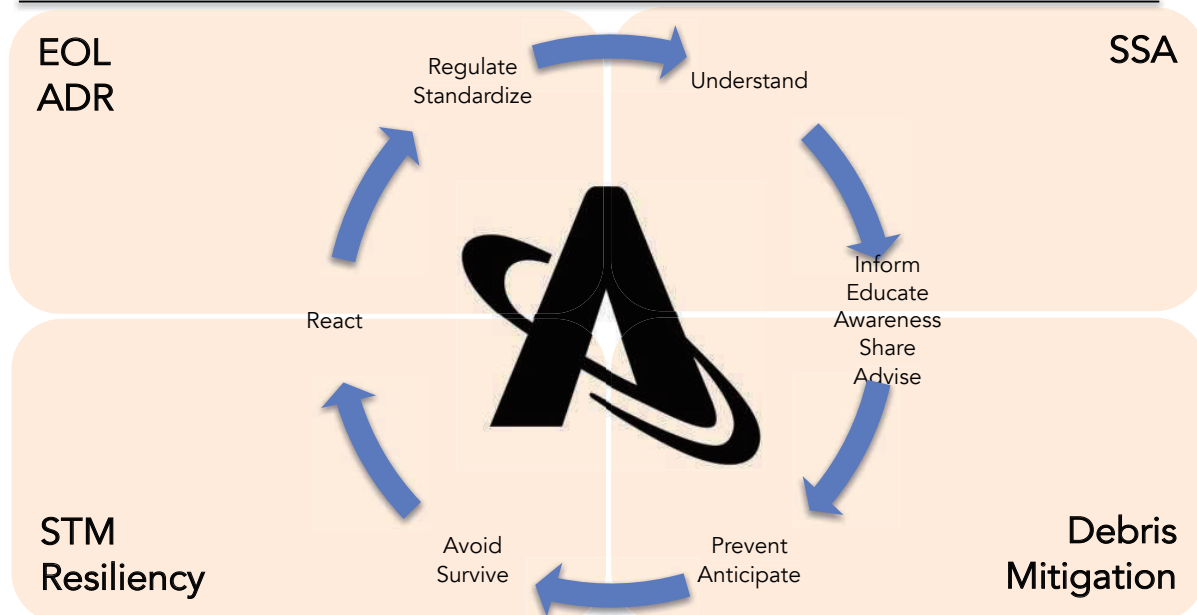
- In-situ measurement of sub-millimeter debris (2017)
- Debris removal demonstration (2018/19)

Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

Timeline



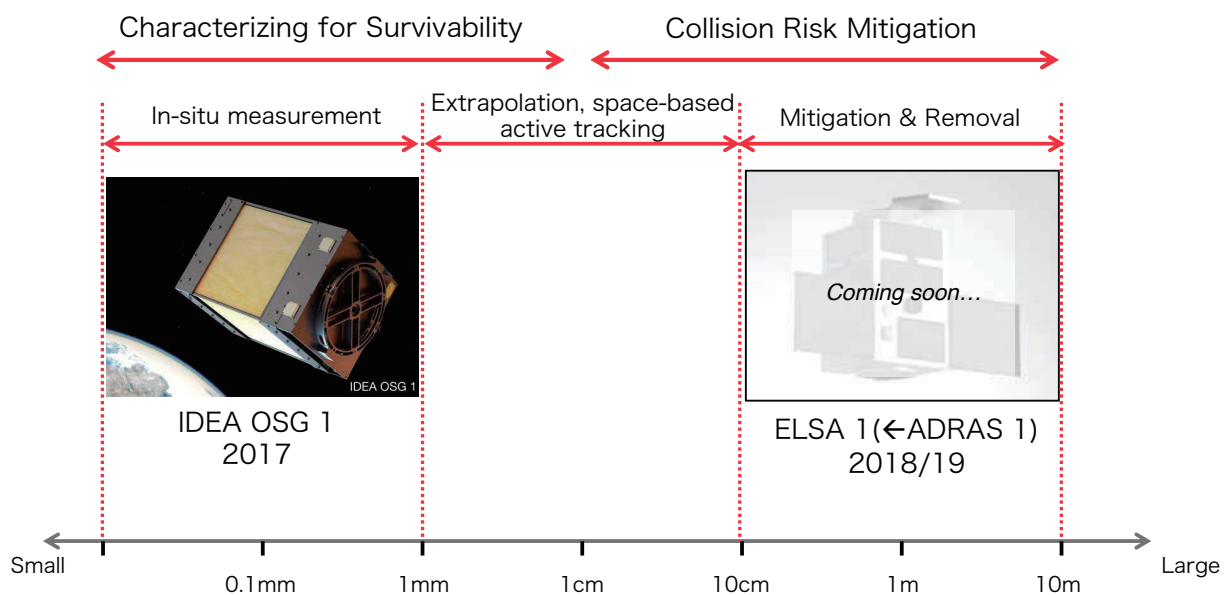
Space Sustainability Business



Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

6

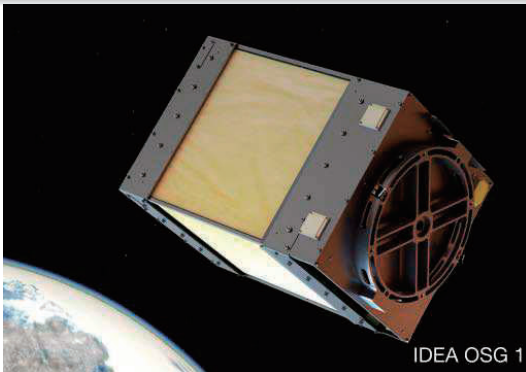
Understand, Prevent & React



Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

6

IDEA OSG 1



Space Debris Monitor



Retractable de-orbit device

Mission

- Sampling capabilities for sub-millimeter size debris
- Retractable deorbiting device

Characteristics

- 540 x 800km orbit
- Launch end of 2016 to early 2017
- Space Debris Monitor (SDM) developed by JAXA

Value Proposition

- Data analysis and distribution
- Environment modeling calibration and validation

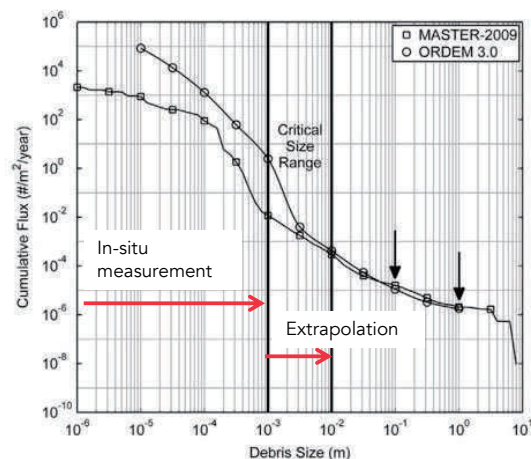
Further details will be presented by Mr. Uetsuhara on 19th.

Values of Data



- Prompt and clear understanding of submillimeter-size debris environment
- High temporal-spatial resolution
- Estimates impacts on the future submillimeter-size debris environment
- Inputs concerning the required shielding for spacecraft
- Contribute to Debris Environment Models
- Dynamically updates submillimeter-size debris environment

ORDEM 3.0 and MASTER-2009 orbital debris fluxes for the SSO orbit in 2014



Kristo et al. Acta Astronautica 113 (2015) 204-211

Data Distribution Timeline

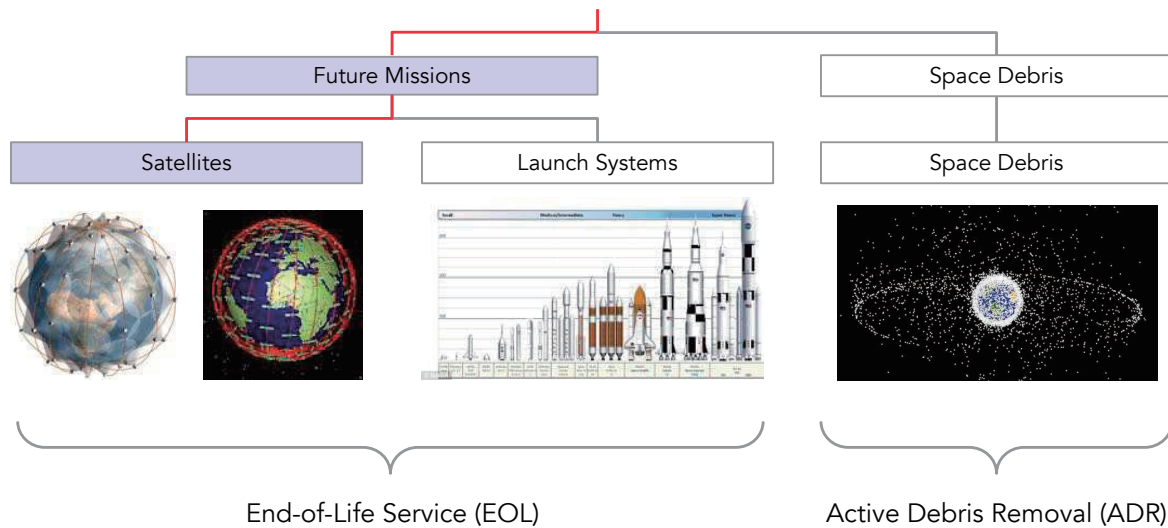


| Data distribution direction | Item | The kickoff timing of data distribution (X: Launch) | Data distribution timeliness after the kickoff |
|--------------------------------|--------------------------------------------------|-----------------------------------------------------|------------------------------------------------|
| IDEA OSG 1 to ASMCC (downlink) | Bus telemetry data (satellite bus status) | ≥X+1 day | ≤24 hours after sampling |
| | Mission telemetry data * except for SDM raw data | ≥X+1 week | ≤24 hours after sampling |
| ASMCC to data users | Bus telemetry data (satellite bus status) | ≥X+ 1 month | ≤24 hours after downlink |
| | Mission telemetry data * except for SDM raw data | ≥X+ 1 month | ≤24 hours after downlink |
| | Impact data (screened) | ≥X+ 6 month | ≤48 hours after impact |
| | SDM raw data | ≥X+ 6 month | ≤48 hours after impact |

Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved



Targeted Market Segments



Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

EOL vs ADR



| | End-of-Life service | Active Debris Removal |
|----------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------|
| Target objects | Satellites reaching end of operational lifetime | Environment Critical Objects |
| Mass | 50kg ~ 500kg | 500kg + |
| Rationale | Retrieve satellites allowing timely replenishment operations | Remove space debris to improve safety and risks of collisions |
| Key Technologies | Semi-Collaborative approach and capture | Non-collaborative approach and capture |
| Value proposition | Operational Orbit sustainability Maximize revenue Mitigate Collision Risk | Long-Term sustainability |
| Regulations/ Authorization | B2B Commercial contract following mission approval from launching State | Requires International consensus |

Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

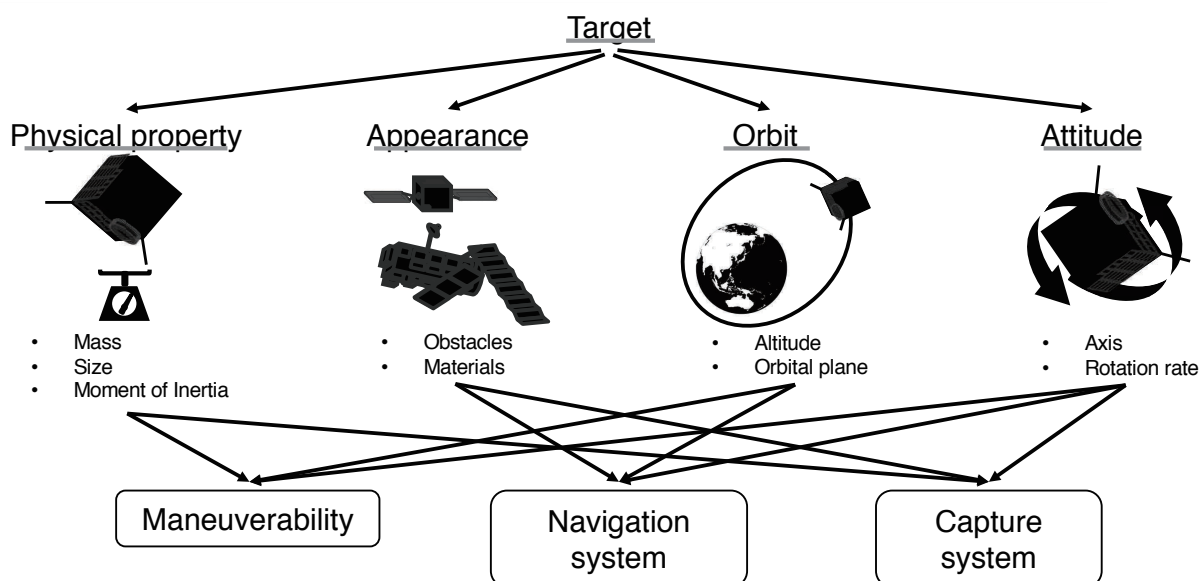
Value Propositions



| | | |
|---|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Orbit sustainability | Contributing to customers' business sustainability , by developing services able to retrieve and deorbit spacecraft reaching end of operational lifetime |
| 2 | Maximize Revenue | Prevent service disruption by supporting large-scale replenishment operations |
| 3 | Maximize PMD Rate | Offer reliable and cost-efficient spacecraft retrieval solutions ensuring full compliance with international guidelines |
| 4 | Responsible Brand | Join the club of responsible spacecraft operators and confirm corporate commitment to long-term space sustainability |

Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

Service Design



Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

Educate and Raise Awareness



Space industry



Elite



Ordinary people



Next generations



Copyright(c) ASTROSCALE PTE. LTD. All Rights Reserved

15



ASTROSCALE

For a Responsible Use of Space