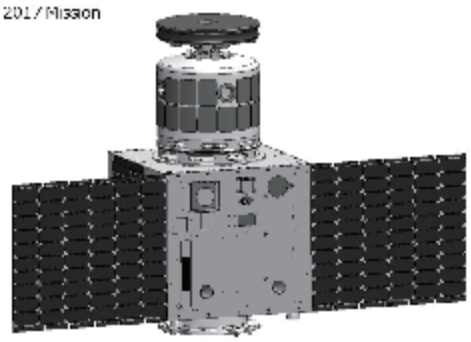
A4

民間企業による ADR サービス実現の具体的方法

A private company's solution to implement space debris removal service

岡田光信（ASTROSCALE CEO）
Nobu Okada, ASTROSCALE, CEO

Currently, the national space agencies around the world are investigating the active space debris removal technologies. There are numbers of the space debris which all vary in its materials, sizes and orbit, therefore, the removal technology must be affordable and sustainable. ASTROSCALE aims to provide affordable space debris removal service for medium to large scale space debris. The company targets to launch its first mission towards the end of 2017. In this session, the presentation focuses on the company's strategy for the team structure, technological development, fund raising, structuring the business model, and regulatory compliance. The company aims to provide sustainability to the space environment by establishing itself as a supplementary position to the existing space agencies.



スペース・デブリ除去の技術は現在各国の宇宙機関で検討されているが、スペース・デブリは数も多く、種類も大きさも軌道も多様であるため、安価で、持続的な除去技術の構築が必要である。ASTROSCALE は民間として独自の技術で中型～大型デブリの除去サービスを安価に提供することを考えており、2017 年後半に初号機を打上げる予定である。チーム作り、技術開発、資金調達、ビジネスモデル構築、コンプライアンス遵守をどのように進めているのかを説明する。宇宙機関の補完的な役割を担うことによって、持続的な宇宙環境を維持できることを期待している。

Biography

岡田 光信（おかだ みつのぶ）
1973 年生まれ。兵庫県出身。シンガポール在住。東京大学農学部卒業。Purdue University MBA 修了。宇宙ゴミ（スペース・デブリ）を除去することを目的とした宇宙ベンチャー、ASTROSCALE PTE. LTD. のＣＥＯ。大蔵省（現財務省）主計局に勤めたのち、マッキンゼー・アンド・カンパニーにて経営コンサルティングに従事。自身で経営を行いたいとの思いが募り、ＩＴ会社ターボリナックス社を皮切りに、SUGAO PTE. LTD. ＣＥＯ等、ＩＴ業界で 10 年間、日本、中国、インド、シンガポール等に拠点を持ちグローバル経営者として活躍する。幼少より宇宙好きで高校１年生時にＮＡＳＡで宇宙飛行士訓練の体験をして以来、宇宙産業への思いが強く、現在は宇宙産業でシンガポールを拠点として世界を飛び回っている。

Mr. Nobu Okada founded ASTROSCALE PTE. LTD. in Singapore in 2013 to address growing threat of space debris by incubating removal technologies while arousing a passion for space exploration among ordinary citizens. Prior to this, he managed IT companies in Japan, China, India and Singapore, one of which had a successful IPO. Before joining IT industry, Nobu worked for McKinsey & Company and the Japanese Ministry of Finance. Nobu received his Bachelors degree in Genetics from University of Tokyo in 1995 and an MBA in Krannert School of Business, Purdue University in 2001. Braunschweig, Germany and conducted more than 4 years of detailed research in the area of space debris environment and observation modeling.

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ASTROSCALE

CEO Nobu Okada

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Can I remove space debris by myself?

Yes, most probably, we can do it.

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Who we are

How we do

2017 Mission

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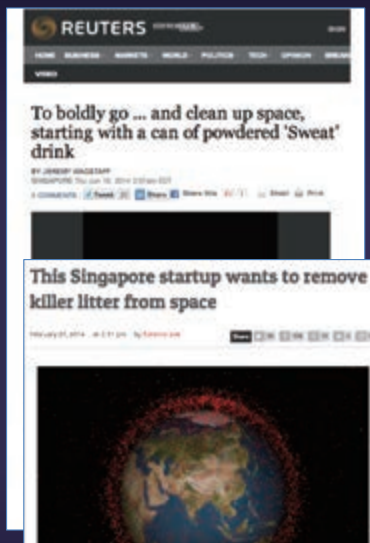
Awards/Conferences

Web news


REUTERS

To boldly go ... and clean up space, starting with a can of powdered 'Sweat' drink

This Singapore startup wants to remove killer litter from space

TV, Magazines

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Lunar Dream Capsule Project

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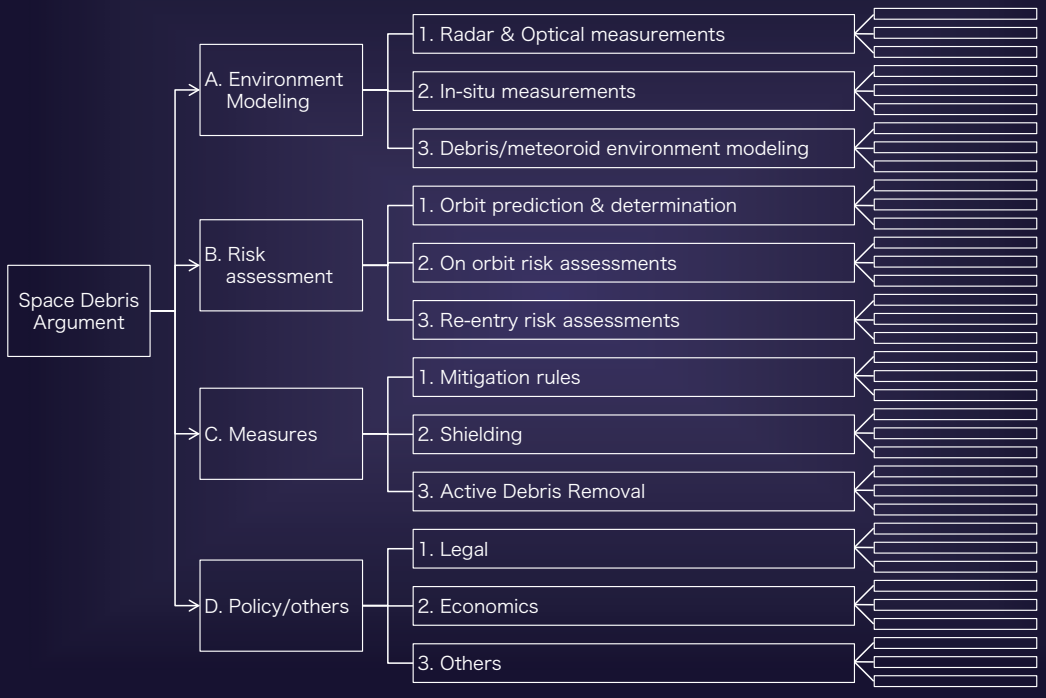
SPACE DEBRIS ARGUMENT



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Technologies

Fund

Rules/laws

Someone needs to crack the code for sustainable ADR.

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WHY PRIVATE SECTOR?

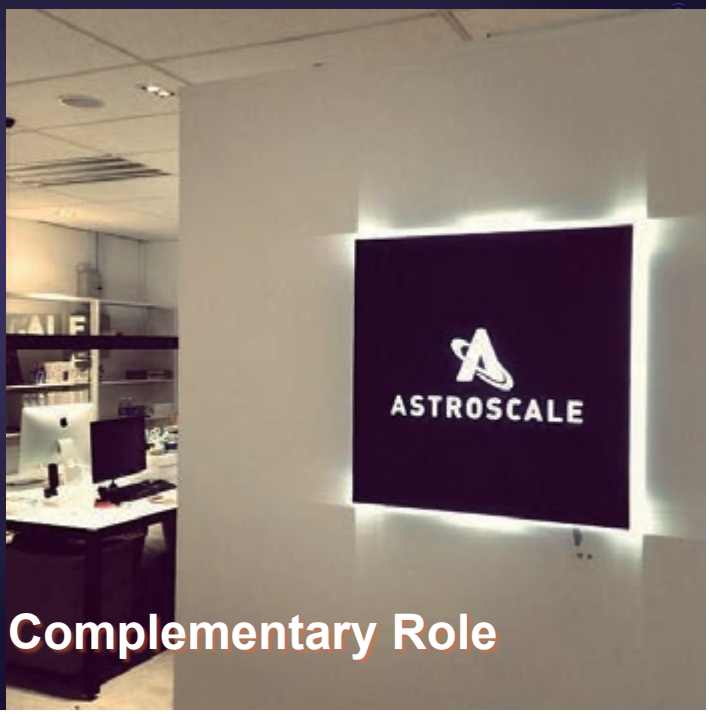
Cost effective

Quick try and error

No border

Biz model

Pure business



Breakthrough & Complementary Role

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Team

Goal & Solution

Initial Money

Biz model

Compliance

Space Sweepers

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Space Sweepers

	Who/Lab	Organization	Role
1	Prof Nakasuka Lab – Intelligent Space System	University of Tokyo	BUS Design, AOCS
2	Prof Kimura Lab	Tokyo University of Science	Unmated approach, C&DH
3	Prof Sahara	Tokyo Metropolitan University	Propulsion system
4	Assoc. Prof Koizumi Lab	University of Tokyo	Propulsion system
5	Mr. Nakano	Tokyo Metropolitan University	Propulsion system
6	Prof Hanada – Space Systems Dynamics Lab	Kyushu University	Orbital mechanics
7	Assoc. Prof Iwata – Micro satellite testing	Kyushu Institute of Technology	Space environment testing
8	Yuki Precision		Design and mfg of satellite parts
9	ASTROSCALE		Project management and coordination, and ALL

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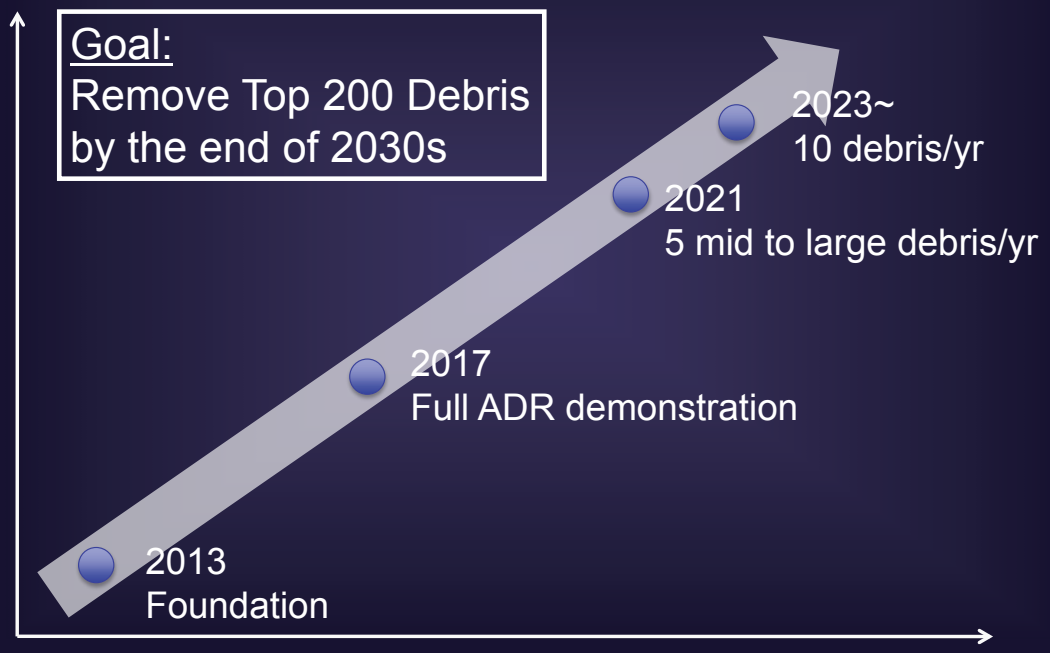
GOAL & TIMELINE



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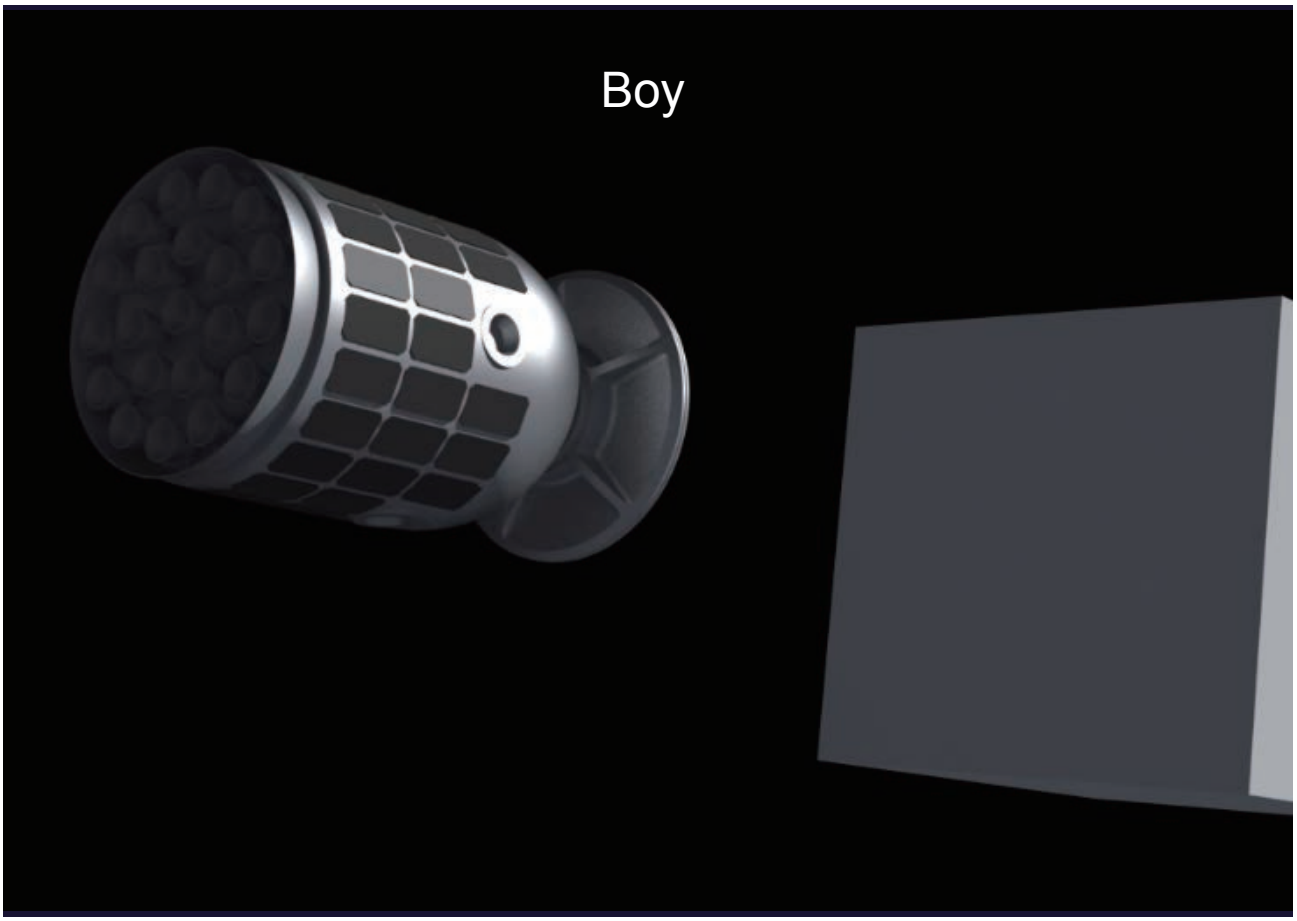

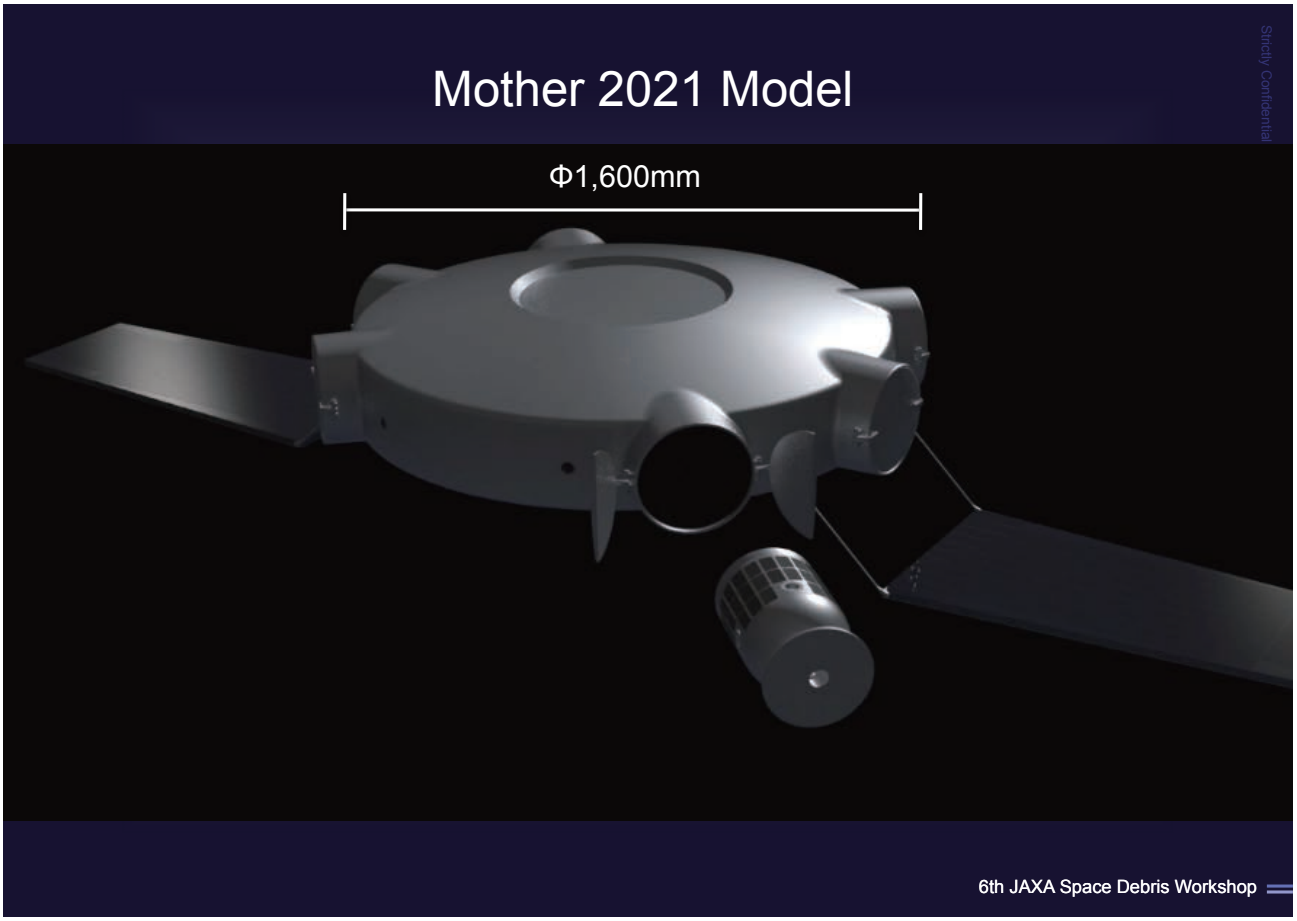

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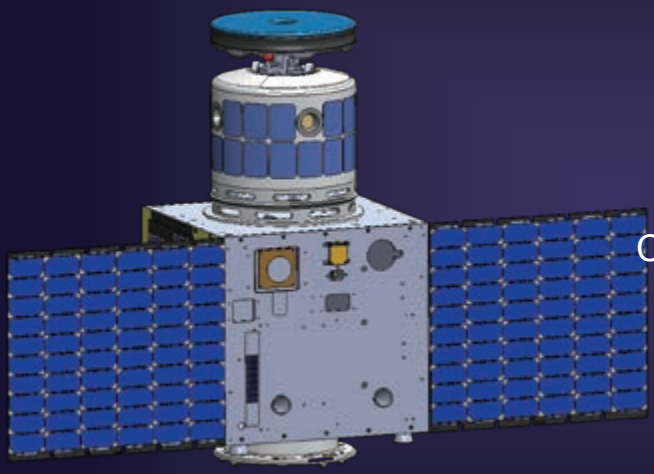
2017 Mission



Concept	1 Mother + 1 Boy
Size	50 x 50 x 90cm
Mass	<80kg
ACS	3 axis stabilization
Communication	X-band, S-band
Orbit Control	Xe-propelled Ion thruster
	H2O2-propelled RCS

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Mission Overview

	Missions
1	Launch & Commissioning
2	Unmated approach demonstration
3	Proximity operations demonstration
4	Diagnosis demonstration
5	Release & Capture demonstration
6	Tugboat demonstration
7	Partially controlled reentry demonstration

Full range of ADR

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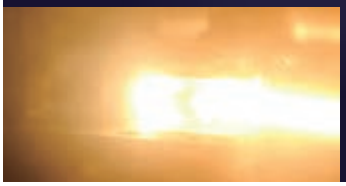
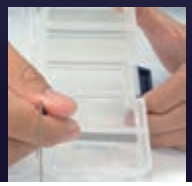
Boy 2017 Model

Concept	Small but powerful
Size	Φ300mm x 40cm
Mass	20kg+
Others	Adhesive compound
	Solid propellant
	37 nozzles
	Gimbal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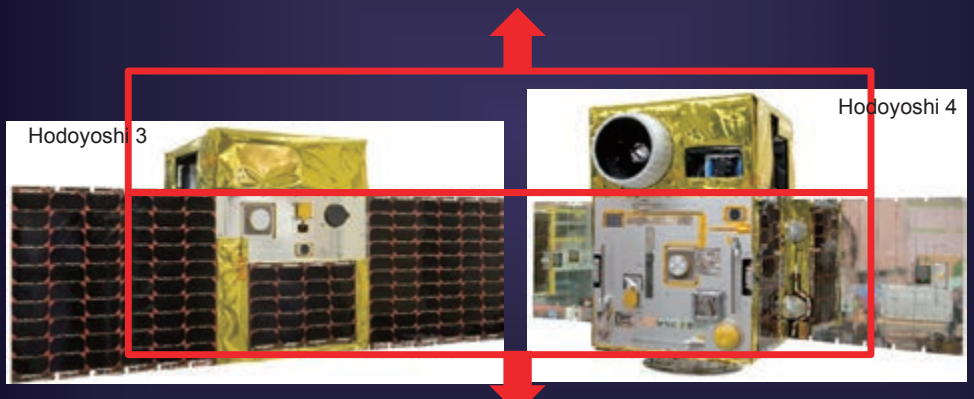
Heritage from Hodoyoshi

ASTROSCALE inherits Hodoyoshi core team to explore more Microsat applications

Application layer to Boy



ASTROSCALE Bus
+ RCS, Unmated approach capability, Release mechanism

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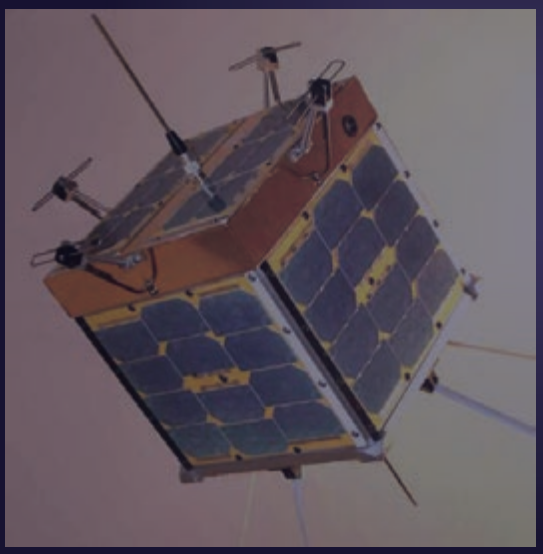
Target Debris

Free Launch Opportunity!



Bring with Mother/Boy in the same rocket.

- Satellite owner to pay development cost
- ASTROSCALE to pay launch cost
- 50 x 50 x 50cm or less
- <40kg
- Mission duration < 2 months
- Surface can be uneven

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UNMATED APPROACH (1)

Steps	0	1	2	3	4	5
Stage	Launch	Far range			Middle range	Near range
Distance		>10,000km → 10km			10km → 1km	1km → 50m
Orbital elements		Inclination, RAAN	Semi major axis	Phase		
Thruster		Xenon-propelled ion thruster 300μN			H2O2-propelled RCS, 350~500mN	
Duration		2~5 months			1~2 days	1~2 days
Chaser location		GPS			GPS	GPS
Target location		TLE			Optical camera	LIDAR
Comments					Angle-only approach, Batch processing	Real-time processing

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UNMATED APPROACH (2)

Steps	6	7	8	9	10
Stage	Fly-around	Proximity operation			Release & Capture
Distance	30-50m	→ 5m	5m	→20cm	20cm
Orbital elements	Final tuning		Rotation and target surface		
Thruster	--	RCS	RCS	RCS	
Duration			1 round		
Chaser location	GPS	GPS			
Target location	LRF	LRF/Optical camera			
Comments	Abort mode standby	3 Axis control w RW and RCS	--	3 Axis control w RW and RCS	

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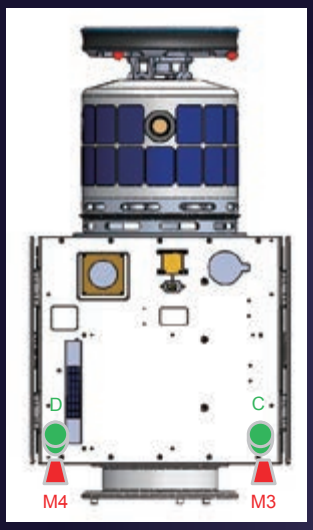
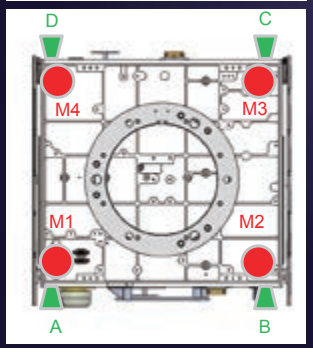
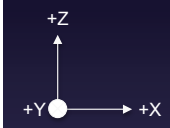
RCS







	Dtetails
Nozzles	Translation (M) 4 on –Z Attitude Control (A, B, C, D) : 4 on ±Y w 30° angle
Translations	+X Translation : No (Z axis 90° Rotation, +Y Translation) -X Translation : No (Z axis 90° Rotation, -Y Translation) +Y Translation : C+D+M3+M4 -Y Translation : A+B+M1+M2 +Z Translation : M1+M3 or M2+M4 or M1+M2+M3+M4 -Z Translation : A+B+C+D
Rotations	+X Rotation : C+D or M1+M2 -X Rotation : A+B or M3+M4 +Y Rotation : A+D or M1+M4 -Y Rotation : B+C or M2+M3 +Z Rotation : A+C -Z Rotation : B+D
Redundancy	Enough redundancy except –Z translation

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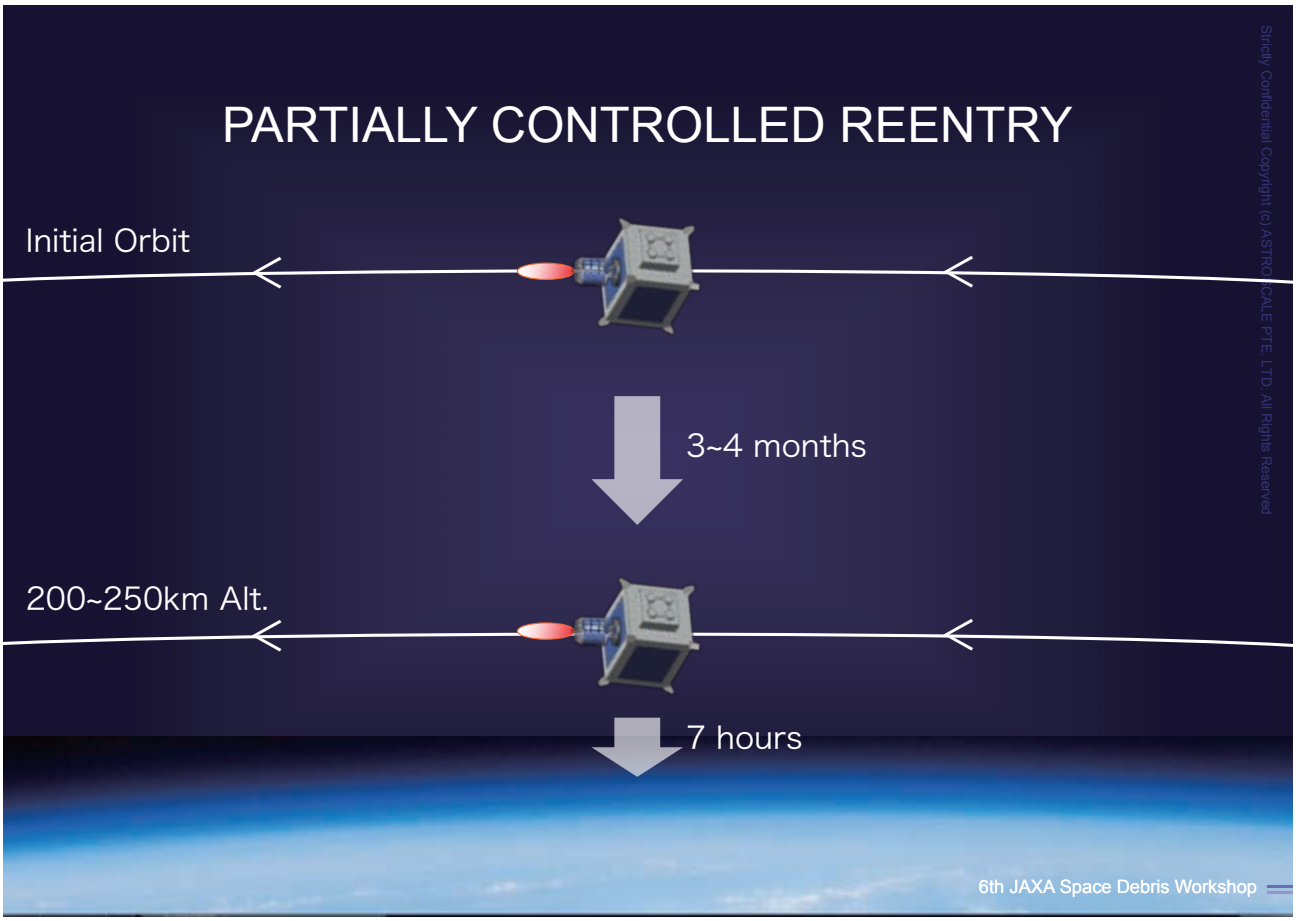

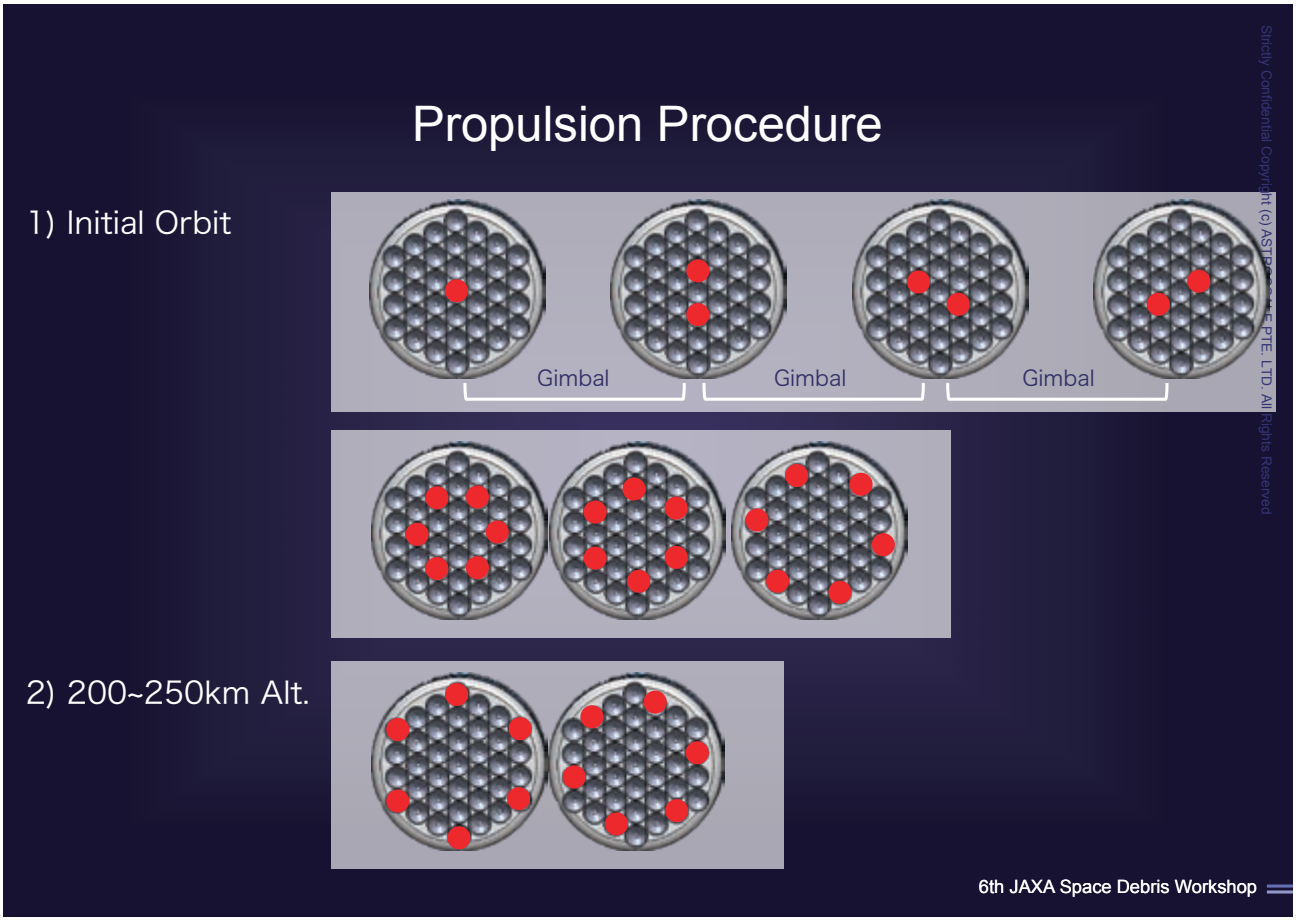

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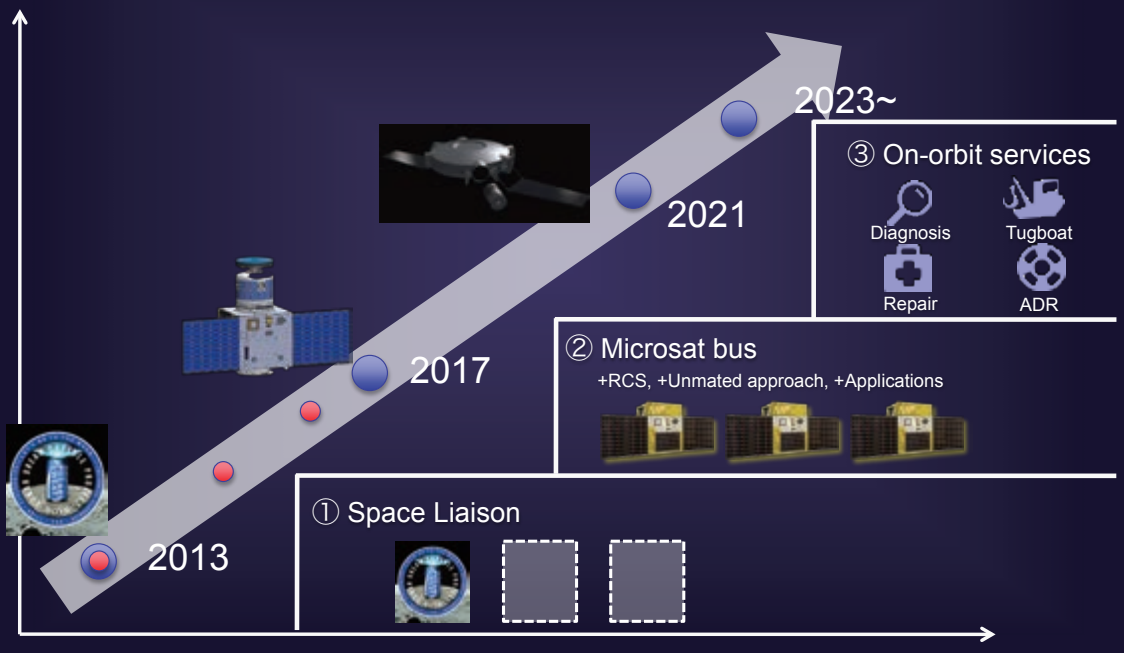
BUSINESS MODEL



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COMPLIANCE

	Regulation	Guidelines	
1	UN COPUOS Space Mitigation Guidelines	• Limit the probability of accidental collision in orbit • Limit the release of debris during operations • Compulsory post-mission disposal • Limit the long-term presence of spacecraft and launch vehicle orbital stages in LEO and GEO region after the end of mission	Compliant
2	UN Outer Space Treaty		
3	IADC Space Debris Mitigation Guidelines		
4	ISO 24113 Space Debris Mitigation Requirements		
5	European Code of Conduct for Space Debris Mitigation		
6	NASA Space Debris Mitigation Standards	If casualty risk to population on ground is greater than 10^-4, • Avoid uncontrolled reentry in atmosphere • Ensure pre-defined impact footprint over an ocean area with sufficient clearance of landmass and traffic routes	Compliant
7	ESA Space Debris Mitigation for Agency Projects		
8	French Space Operation Act	Components should be placed in an orbit that does not interfere with protected regions more than one year.	Compliant

	Transparency	Actions
1	Space industry	-Submit papers for technological progress to space conferences -Discuss at space debris communities
2	Ordinary people	- Proactively talk to media to increase awareness of debris issue

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POTENTIAL COLLABORATION WITH SPACE AGENCIES

	Collaborations (examples)	Details
1	Ground equipment	More ground stations. Need compatibility
2	Launch	Provide launch opportunity, while we provide navigation data etc
3	Others	Let's discuss

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CONCLUSIONS

Progress

- Team is there
- Mother/Boy undergoing design, EM to be completed by April 2016
- Fund raising in good progress
- Factory to open in April 2015
- Rocket contract to be made late 2015

2017 Mission Novelty

- First full range of ADR mission
- First small satellite on-orbit-service demonstration
- First private company's demonstration

Keep you updated at Space Conferences and HP

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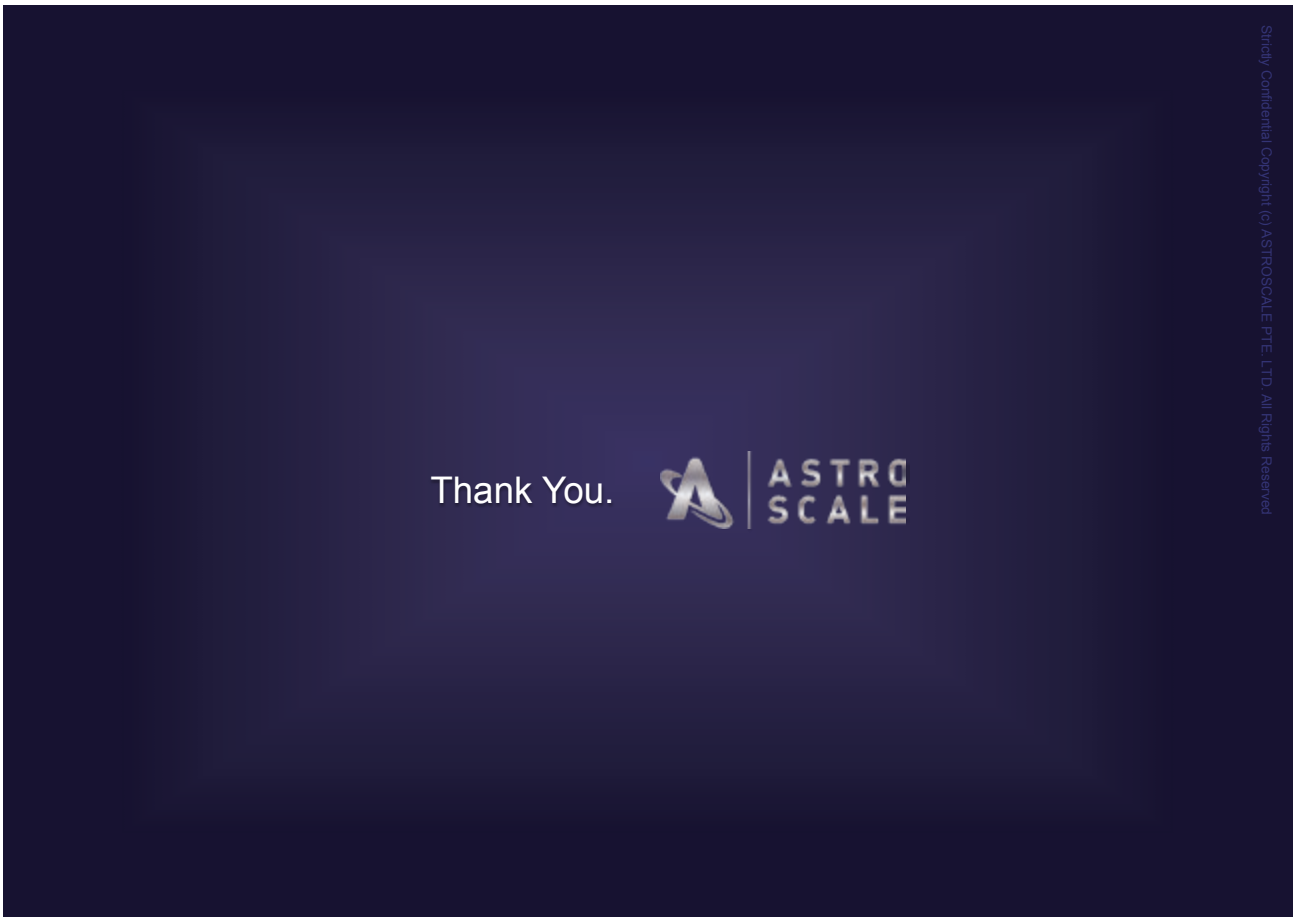

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