

B06

## **Astroscale: Developing a Comprehensive Solution for Space Debris Removal**

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Since the beginning of the space era, Earth's orbital environment has grown progressively more polluted. The number of pieces of space debris of varying sizes has progressively increased to the point where the orbital environment now consists of millions of pieces of uncontrolled and potentially dangerous objects. The current amount of debris will likely grow significantly with the upcoming launch of several large low-Earth orbit (LEO) constellations into already crowded orbits. ASTROSCALE is one of the few companies in the world that is preparing to address this threat.

Founded in 2013, ASTROSCALE's mission is to secure long-term spaceflight safety by becoming a provider of reliable and cost-efficient spacecraft retrieval services. ASTROSCALE proposes to aide in the removal of orbital debris through the provision of two services: end-of-life (EOL) targeting the LEO constellations, and active debris removal (ADR) targeting existing larger space debris.

The company is planning to launch its first semi-cooperative spacecraft retrieval mission, ELSA-d, in early 2020. The groundbreaking mission, which will be a prelude technology and capability demonstrator for future services, will consist of two satellites, a target and a chaser, launch together. The chaser is equipped with proximity rendezvous technologies and a magnetic capture mechanism, whereas the target has a docking plate (DP) which enables it to be captured. Through a series of release and capture activities, ELSA-d will demonstrate a range of key technologies proving capabilities for a full customer mission. This presentation will outline key capabilities including: target search, target inspection, target approach and rendezvous, and target capture.

This presentation will also overview ASTROSCALE's activities in the areas of space debris policy and regulation. Up until recently regulation of space sustainability matters had been discussed mainly at UNCOPUOS and IADC. Recently though, various parties from government, space agencies, satellite operators, and others are developing norms and principles for space activities. The latest update of these activities will be discussed.

## Astroscale: Developing a Comprehensive Solution for Space Debris Removal

Chris Blackerby  
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JAXA Space Debris Workshop  
December 4, 2018

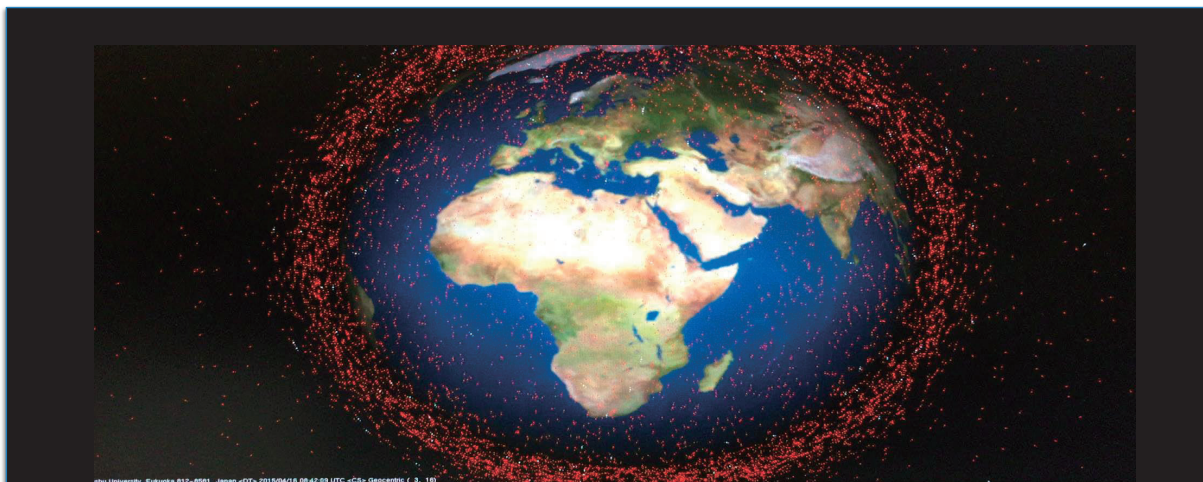
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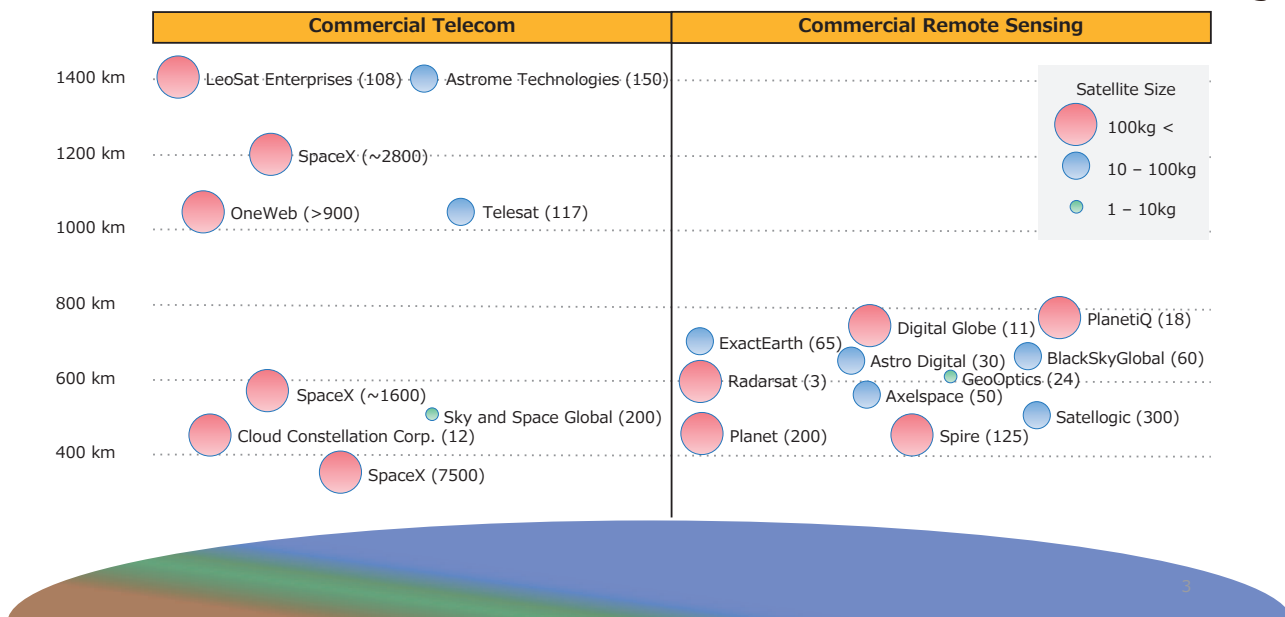
## Existing space debris poses a constant threat



- Over 95% of objects in orbit are debris
- ~34,000 objects 10 cm or more; ~900,000 objects 1 cm or more; over 130 million objects under 1 cm

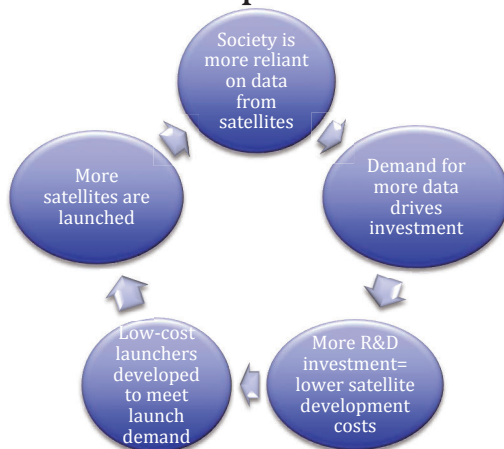


# Sample of Planned Constellations (estimated)



## More satellites are being launched than ever before...

...which leads to more potential for collisions



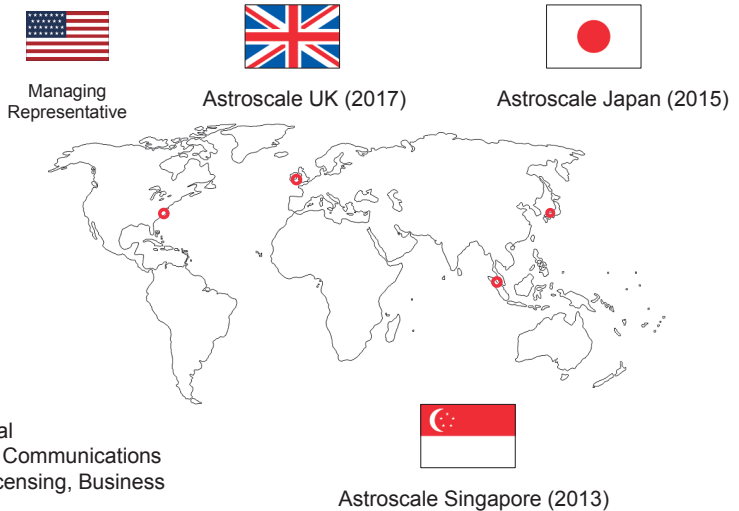
- ~30 commercial operators building small satellite capabilities
- Potentially 10-15,000 satellites will launch in next 10 years; only ~7,000 launched in previous 60



Astroscale: An international company solving a global problem



**Founded:** May 4, 2013  
**Team:** ~60 (80% engineers)  
**Capital raised:** \$103M  
**Offices:** Singapore – HQ, Finance, Legal  
 Japan – R&D, Ground Station, Communications  
 UK – Ground Control, R&D, Licensing, Business Development

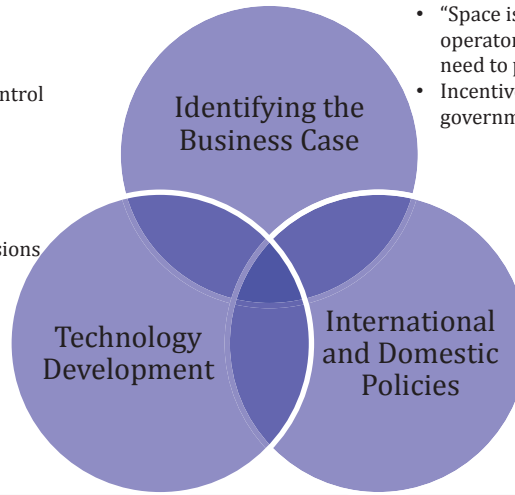


# Major challenges to solving orbital debris problem



Technology

- Need to develop and integrate technologies for difficult mission:
  - Guidance, Navigation and Control
  - Proximity operations
  - Propulsion
  - Capture
  - Software
  - Ground Control
- Make/buy decision for future missions



Business Case

- “Space is big” concept: Commercial satellite operators and governments haven’t seen the need to pay for removal
- Incentive growing for both private sector and governments to support sustainable orbits

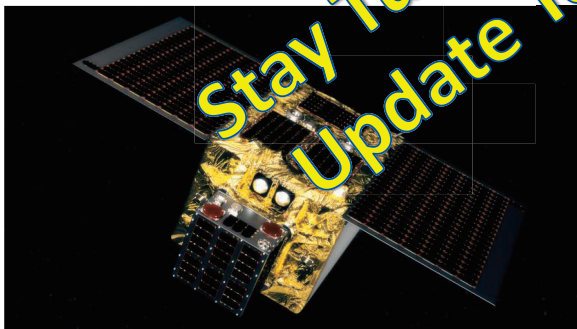
Policy

- No regulation forcing companies to remove debris
- Public awareness of the problem is lacking
- Limited government investment in ADR

# End of Life Services by Astroscale-Demonstration (ELSA-d)



- Scheduled launch: 2020
- World’s first EOL demonstration proving end-to-end debris removal technologies.
- Chaser –optical sensing and capture mechanism
- Target – equipped with a rescue package
- Semi-co-operative magnetic capture



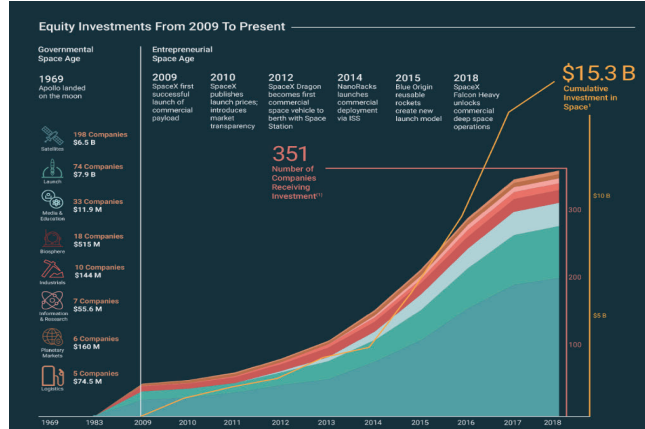
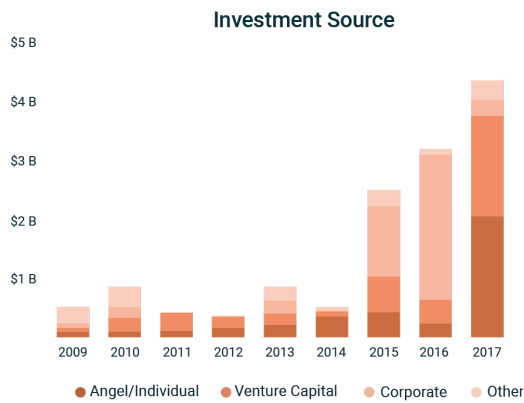
Stay Tuned - Detailed Update Tomorrow



# Investment in space is rapidly growing

- 2018: Market for space activities: \$339 billion
- 2040: Market for space activities (est.): \$1-3 trillion  
(Morgan Stanley, Bank of America)

## Equity investment in space from 2009 to present



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# Two primary business models



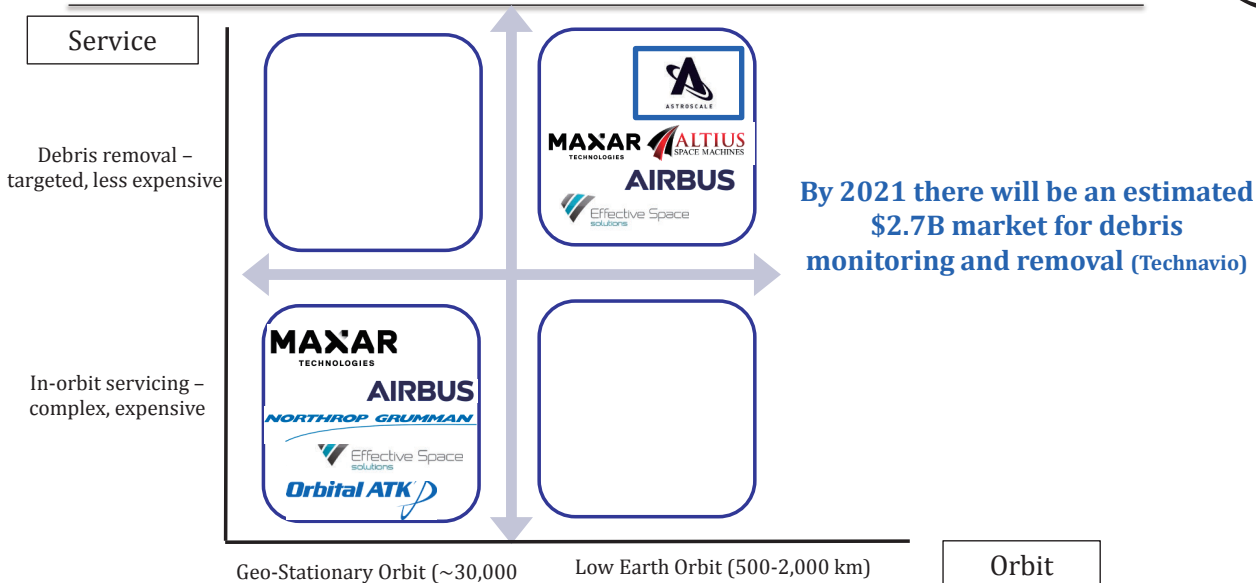
	Active Debris Removal (ADR) (Existing Debris)	End of Life (EOL) services (Future Debris)
<b>Who</b>	Governments	Commercial operators
<b>What</b>	Over 30,000 pieces of debris >10 cm Hundreds of objects >500 kg	~10,000 satellites to launch in next 10 years
<b>Where</b>	Most debris is at 500-1200 km	Most will be in mid to high LEO (500-1400 km)
<b>Why</b>	Societal benefits for citizens	Maintain business continuity
<b>Problem</b>	<ul style="list-style-type: none"> <li>• May not degrade for 100s of years</li> <li>• Constant threat to all satellites</li> </ul>	<ul style="list-style-type: none"> <li>• Experts predict 5-10% of new satellites will fail</li> <li>• ~500-1,000 pieces of new debris</li> </ul>
<b>Funding</b>	<ul style="list-style-type: none"> <li>• Governments</li> <li>• Innovative Prizes</li> <li>• Intergovernmental organizations</li> </ul>	<ul style="list-style-type: none"> <li>• Satellite operators</li> <li>• Public Private Partnerships</li> <li>• Tax/Insurance incentives and pooling</li> </ul>

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**Removing orbital debris is essential for environmental and business sustainability**

Companies with plans for servicing and debris removal



# Current National Space Policy Developments



Governing Body		Activity
Japan		<ul style="list-style-type: none"> <li>Developed Task Force for Space Business Environment</li> <li>Funded past R&amp;D missions for debris removal</li> <li>Strong support among government for future activity</li> </ul>
UK		<ul style="list-style-type: none"> <li>In-orbit robotics and servicing is one priority research area</li> <li>Capping third-party liability in new space policy</li> <li>Provided mission licensing for past in-orbit servicing missions</li> <li>Funding National In-Orbit Servicing Control Centre</li> </ul>
EU		<ul style="list-style-type: none"> <li>Funded RemoveDebris</li> <li>European Cooperation on Space Standardisation addressing SSA and debris</li> </ul>
ESA		<ul style="list-style-type: none"> <li>Funded studies on debris removal (SOADR, e.Deorbit)</li> <li>ESA Space Debris Office closely involved in debris tracking/simulation</li> <li>Request for outline concept to remove ESA-owned satellite</li> </ul>
US		<ul style="list-style-type: none"> <li>Space Policy Directive-3 calls for action on SSA and STM policy and standards</li> <li>Designation of Department of Commerce as control tower for SSA and STM</li> </ul>

# Astroscale Participation in Commercial and Non-Governmental Efforts



Astroscale presentation to IADC, June 2018

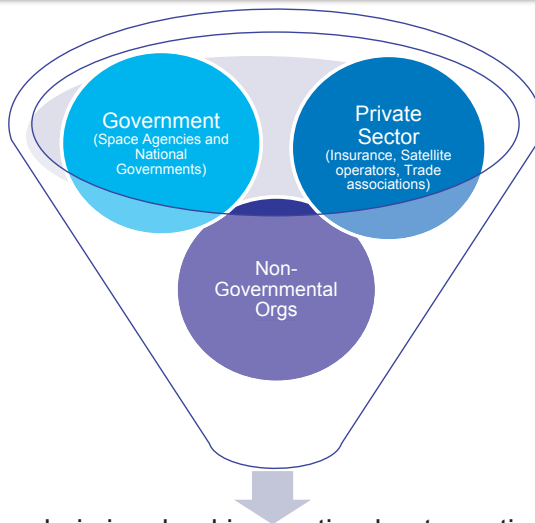


UNISPACE+50, June 2018





## Best practices for end-of-life are being created



Astroscale is involved in creating best practices for orbital sustainability

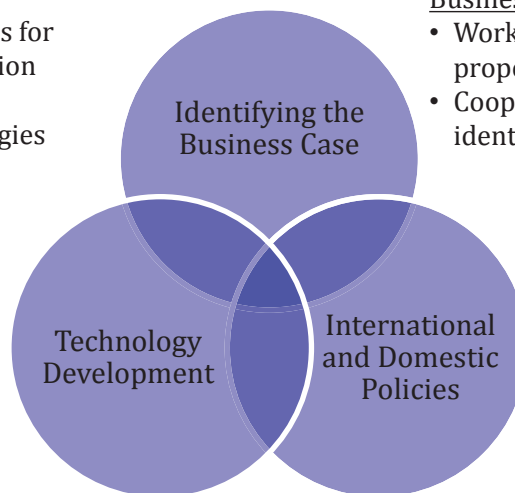
- Multiple parties are working together to draft norms/principles for orbital activities.
- Pressure will increase on satellite operators to prepare satellites for retrieval prior to launch.
- Sustainable orbits must be maintained for viability of future business.
- Increasing public awareness leads to actions for mitigation.

## Solving the challenges



### Technology

- Developing technologies for technology demonstration mission
- Roadmapping technologies for future missions



### Business Case

- Working with private sector on proposed funding for missions
- Cooperating with governments to identify budget lines

### Policy

- Participation on international groups to develop global standards
- Active engagement with government policy makers on regulations

