Overview of Active Debris Removal

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Overview

- Why is active debris removal (ADR) needed?
- Where does ADR fit in with other mitigation methods?
- What should the objective for ADR be?
- What are the main challenges for ADR?
  - Technical
  - Non-Technical

WHY ACTIVE DEBRIS REMOVAL IS NEEDED

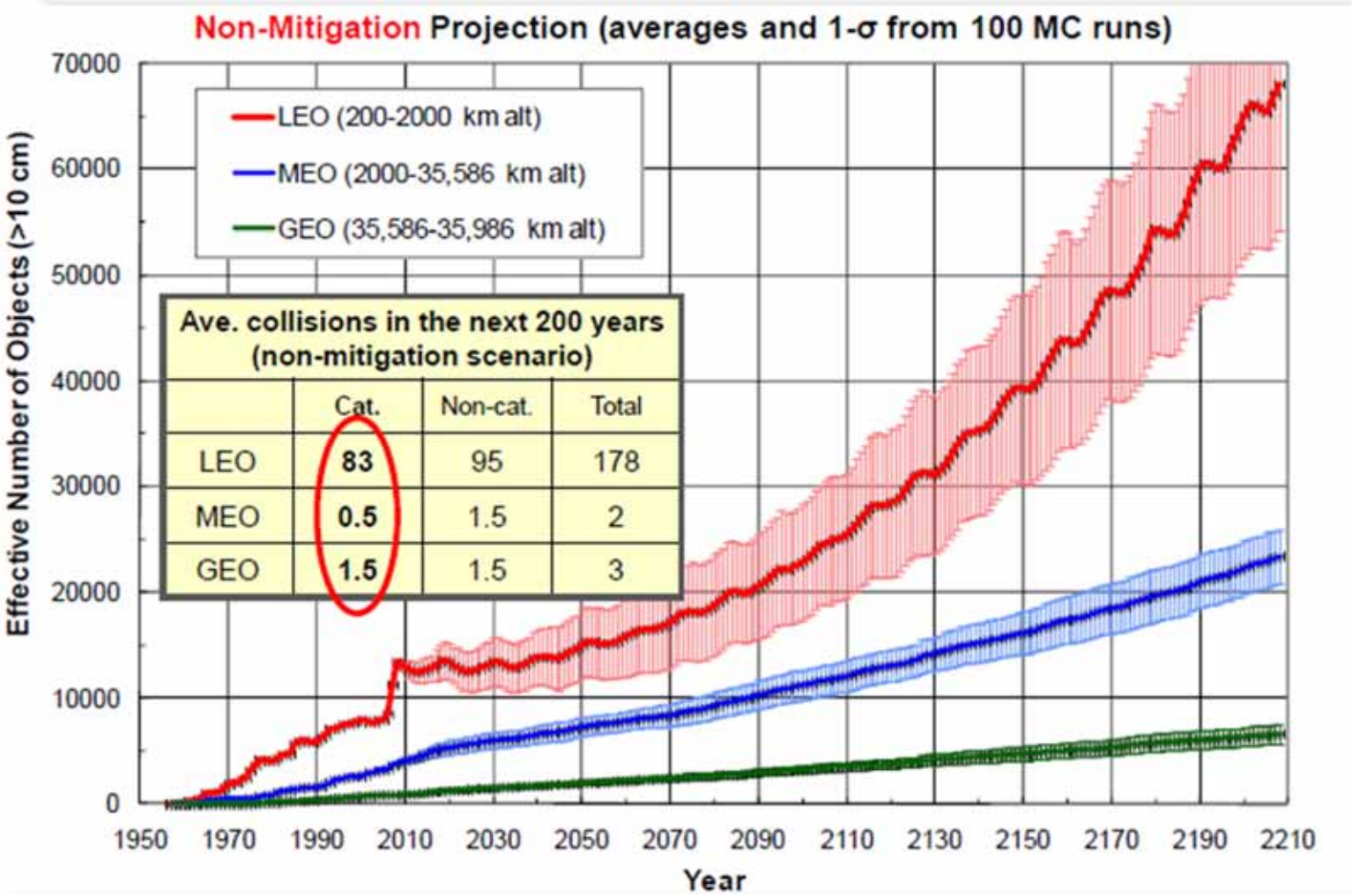
Space sustainability

- Space provides many benefits to everyone on Earth
  - Socioeconomic
  - National security
  - International security and stability

- More and more countries are using space
  - Ten countries have the ability to launch satellites
  - Over 60 entities now own or operate satellites

- The long-term sustainability of Earth orbit is in jeopardy, in part due to the growth of space debris and the increase in use of space

The next 200 years, without any action

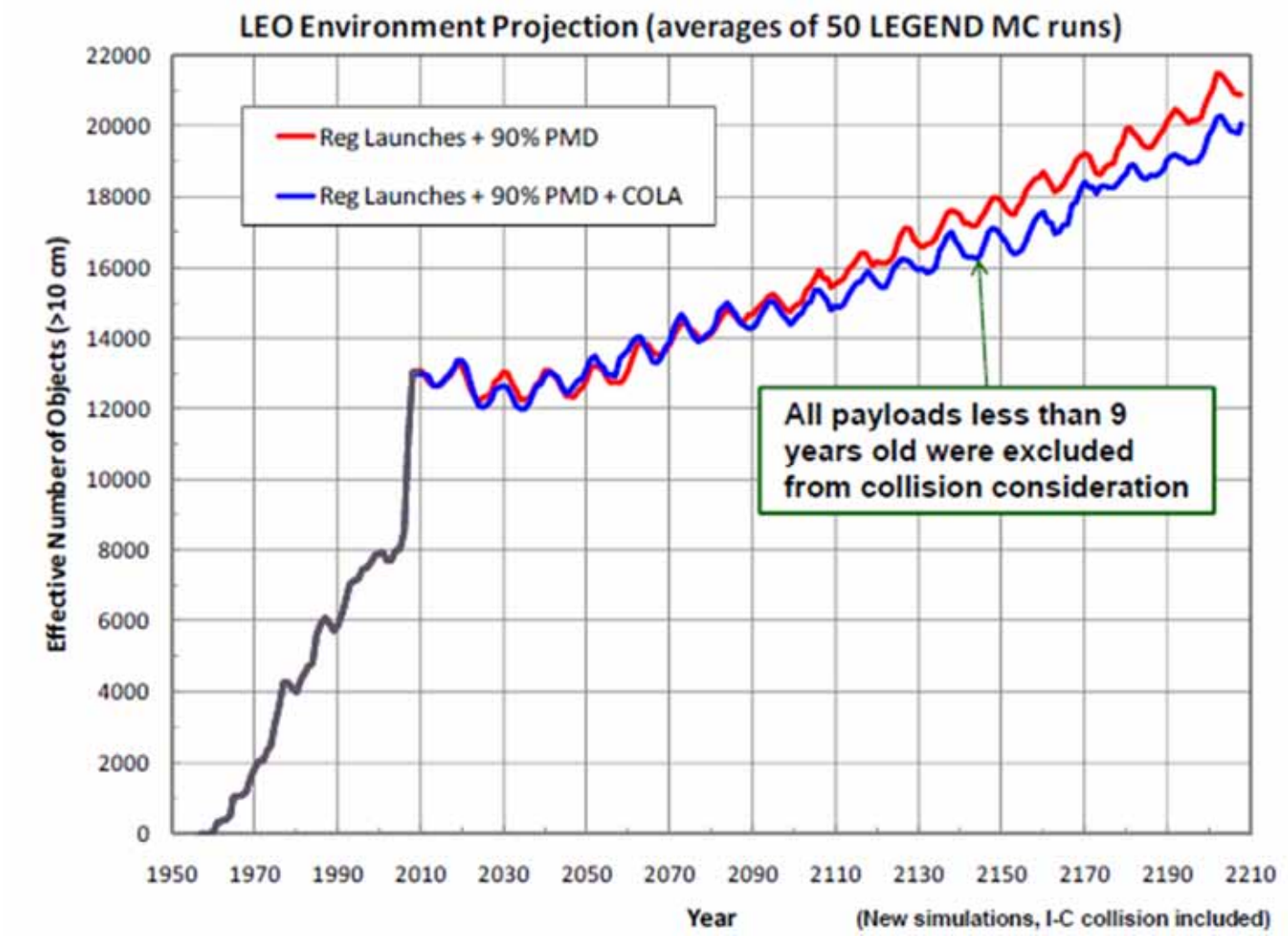


Ave. collisions in the next 200 years (non-mitigation scenario)

	Cat.	Non-cat.	Total
LEO	**83**	95	178
MEO	**0.5**	1.5	2
GEO	**1.5**	1.5	3

J-C Liou, NASA Orbital Debris Program Office

Collision avoidance (COLA) helps, but not much



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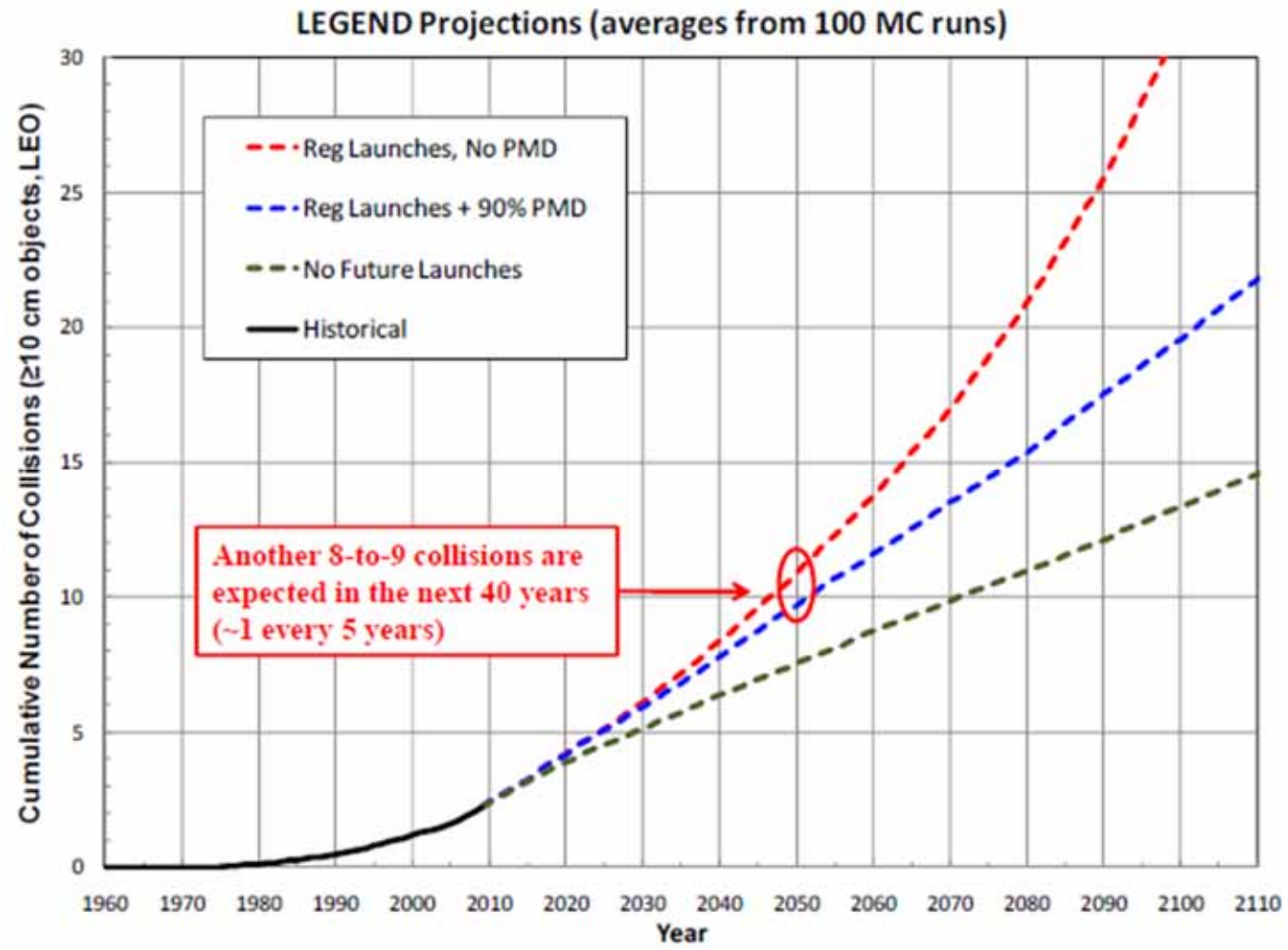
Post-mission disposal (PMD) helps more



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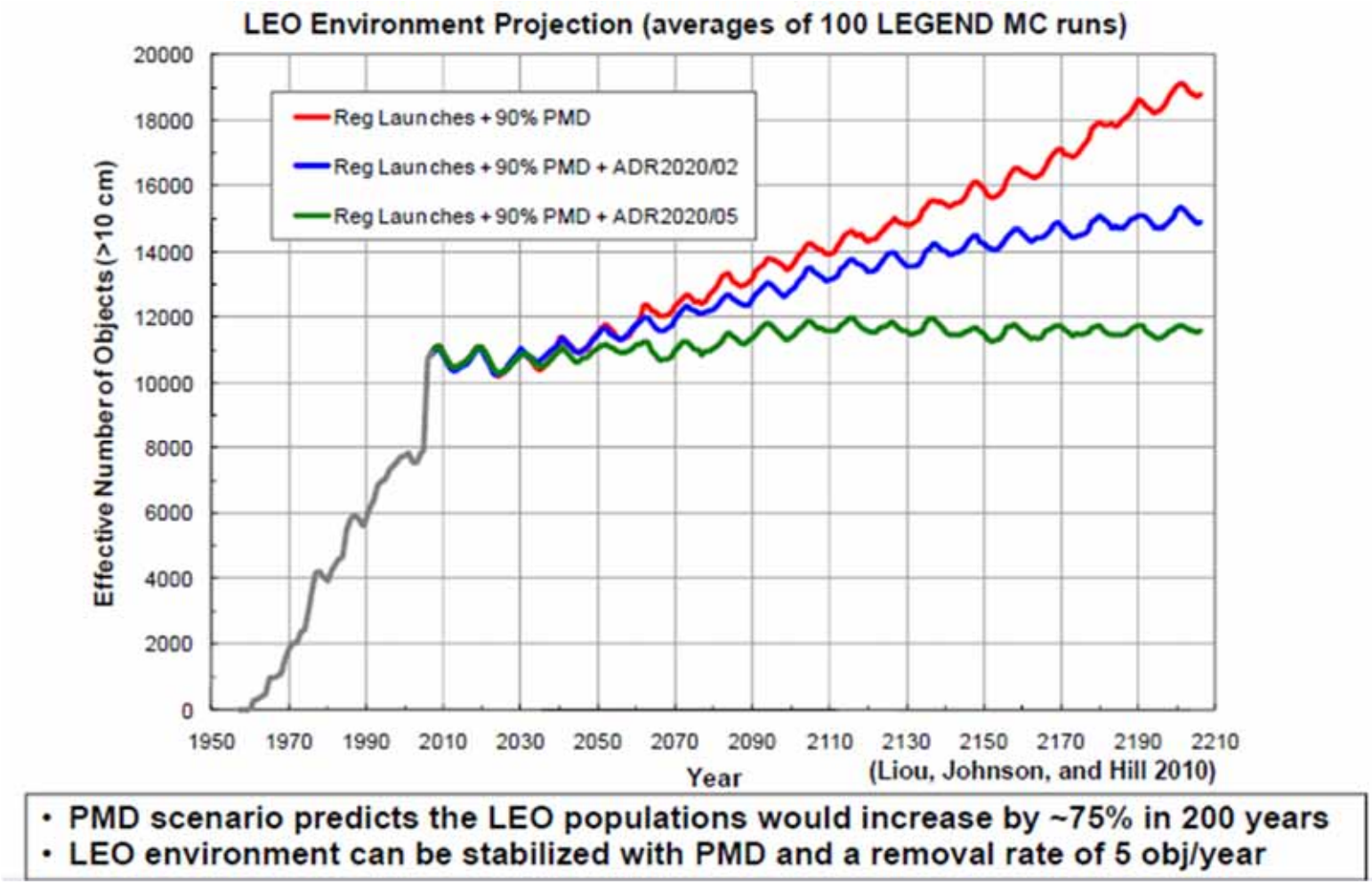
Long term need is for PMD + COLA + ADR



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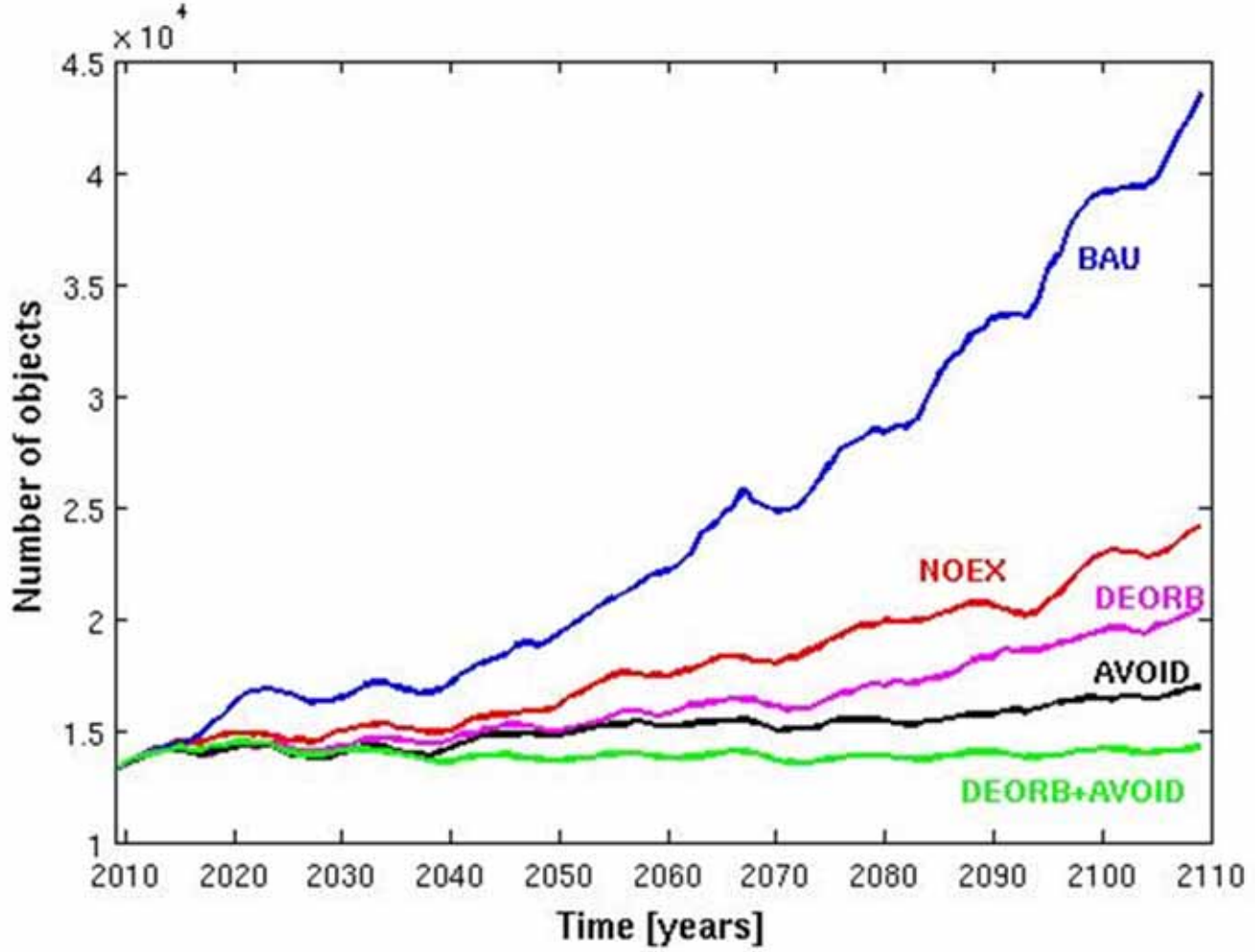
ESA models show the same



Business as Usual

No Explosions

Remove 5 large debris/year

COLA for all active satellites

Rudi Jehn, ESA/ESOC, using SDM software

Main points

- Without active debris removal, the LEO debris population will see a non-linear growth in the future, resulting in many more collisions

- ADR is not a priority for MEO and GEO, assuming that current debris mitigation and end-of-life disposal measures are implemented and followed

- Collision avoidance helps protect active spacecraft, but does not significantly reduce future growth in the debris population

- Removing large debris objects helps stabilize population growth over the long-term, but does not protect satellites in the short-term.

WHAT SHOULD BE REMOVED?

Which size debris is the priority?

Category	Definition	Estimated Population	Impact
Trackable	Greater than 10 cm in diameter	19,000+	Source of new debris
Potentially Trackable	Greater than 1 cm in diameter	Several hundred thousand	"Bullets" which hit larger objects and create more debris
Untrackable	Less than 1 cm in diameter	Many millions to billions	Minor threat to active satellites and creation of new debris

What is the objective of ODR?

- If the objective is to reduce the collision threat for active satellites in the short-term

  ➡ ADR goal and priority should be to remove the "bullets" (debris objects 1 to 10 cm in size with high Probability of Collision with large objects

- If the objective is to stabilize the long-term growth in the debris population

  ➡ ADR goal and priority should be to remove the "cars" (debris objects with the highest value of Mass x Probability of Collision)

SUMMARY OF ADR TECHNIQUES AND CHALLENGES

Summary of ADR techniques vs size

Deorbit to atmosphere

	Size < 1cm		Size 1-10cm	Size > 10cm	
	metal	other		cooperating	tumbling
Orbit LEO	Magnetic Field gen.		Ground/Air/Space based Laser Foams Thruster exhaust	Ret. Surf. Tethers Magnetic sail Prop. Module Tentacles	Net Tentacles
	Retarding surface Sweeping surface Space based Laser Foams Thruster exhaust				
Orbit GEO	Foams Thruster exhaust [trackability is difficult]			Capture Vehicle Momentum Tether Solar sail	Net Tentacles

graveyard

sub-system damages → Catastrophic damages

J. Olympio, presentation at CNES Orbital Debris Removal Workshop, Paris, 22 June, 2010

Some technical challenges

- Consensus on objective/priority for ADR (small or large objects) and a metric for determining which objects to go after
- Tumbling/spinning and fragile/unstable objects during capture, docking, and acceleration
- Controlling atmospheric re-entry of large objects to prevent potential damage to humans/property on Earth
- Screening laser firings into space to de-conflict with operational satellites

Some non-technical challenges

- What is a "space debris" as legally distinct from a functional satellite
  - Who makes the determination?

- Who is allowed to remove an object?
  - Launching State retains jurisdiction over their objects in perpetuity
  - What about the 6,000+ tracked objects that have no assigned Launching State?

- Who has the reference catalog of space objects to determine which objects should be removed?

More non-technical challenges

- How do you distinguish ADR tech development and operations from ASAT development and operations?
  - How do you increase transparency and build confidence?
- What are the intellectual property rights over space debris?
- Who has liability for ADR attempts that go wrong?

Conclusions

- All models currently indicate that ADR is a necessary part of managing debris, protecting satellites, and ensuring the long-term sustainability of Earth orbit

- Technical community needs to do more research on feasible ADR techniques, and metrics for determining objectives and priorities

- Non-technical community needs to work with the technical community on the legal and policy issues

- An international, cooperative technology demonstration mission could promote progress on both the technical and non-technical fronts

Questions?

Thank you

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