How Small Satellites Can Be Hazardous in Comparison to Massive Satellites?

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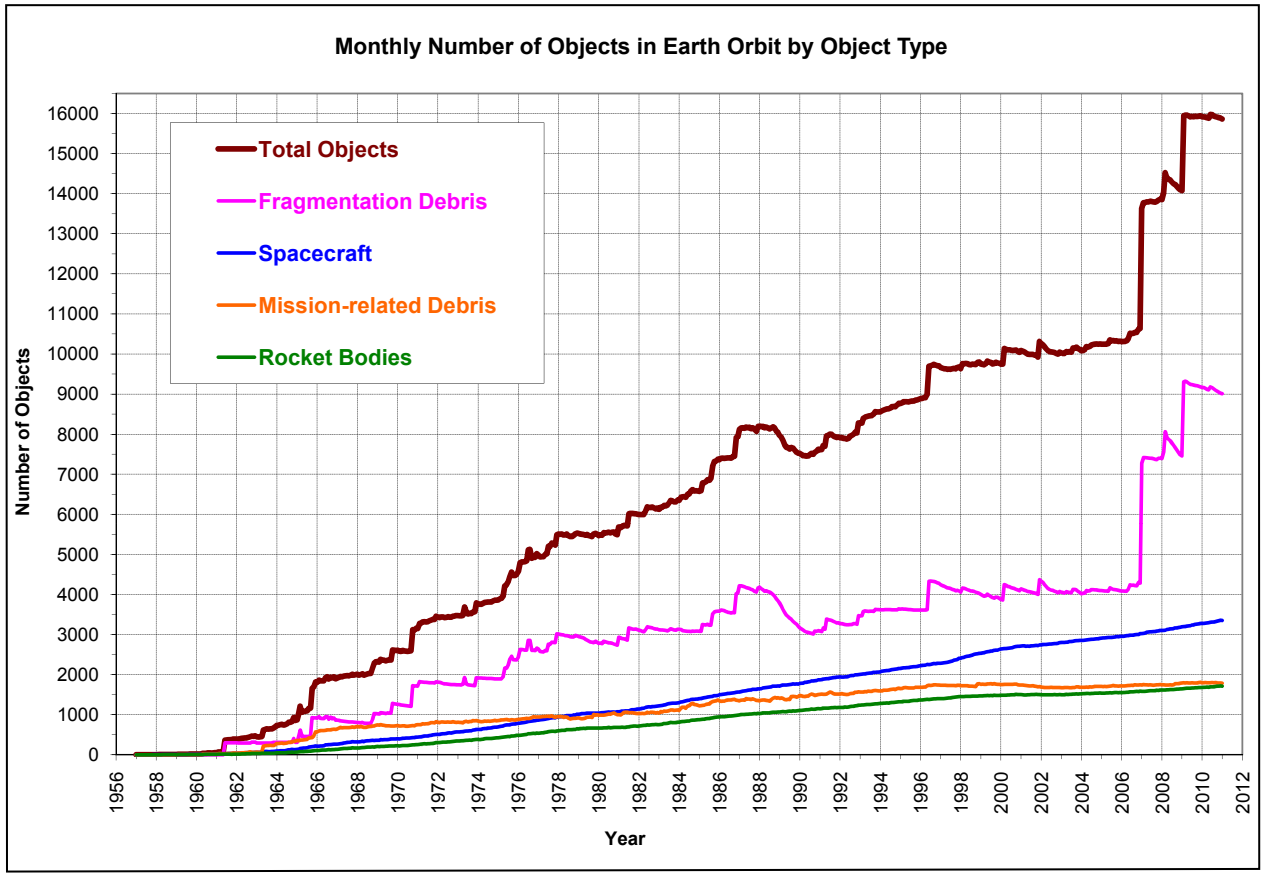
Focus points of this presentation

- Space debris issues related on small satellites
- Space debris mitigation guidelines
  - Limitation of the long-term presence in the low-Earth orbit region
  - Limitation of the probability of accidental collisions with existing objects
- Comparison of probability of accidental collisions
  - Small satellites
  - Massive satellites

Space Debris Issues

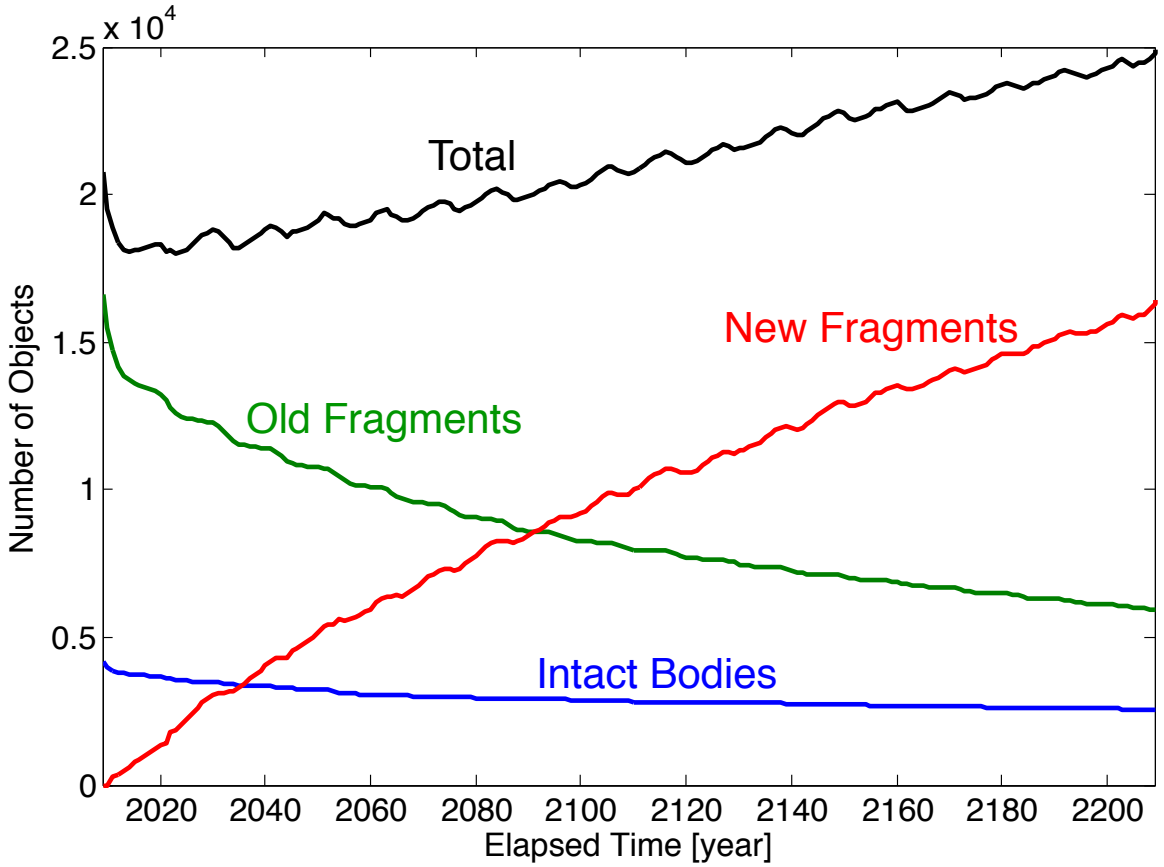


Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.

NASA Orbital Debris Quarterly News 15-1

Space Debris Issues

- Collision cascading (Kesseler Syndrome)



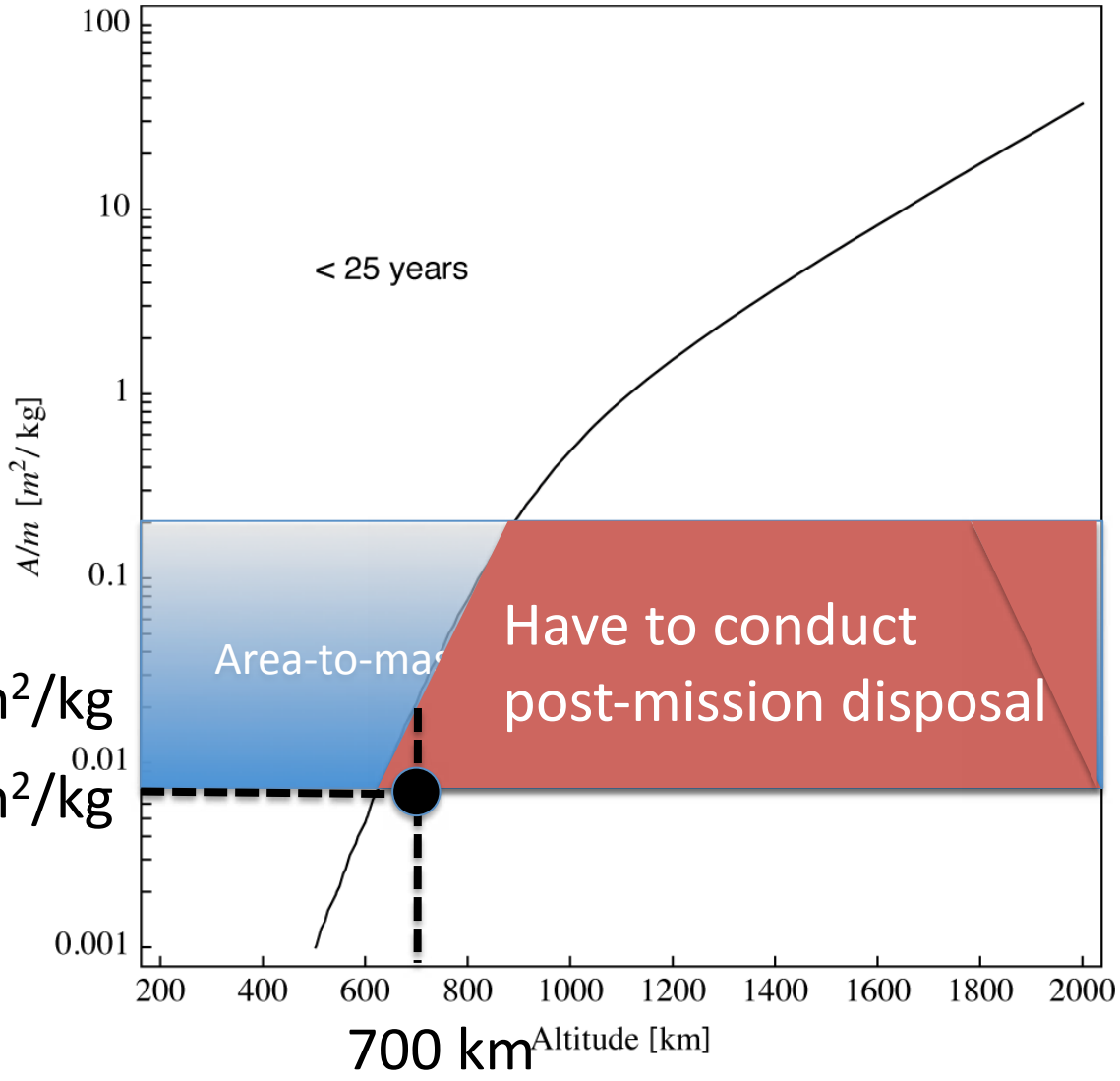
Space Debris Mitigation Guidelines

- Inter-Agency Space Debris Coordination Committee (IADC, 2002)
- Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (STSC of UN COPUOS, 2007)
  - Guideline 3
    Limit the probability of accidental collision in orbit
  - Guideline 6
    Limit the long-term presence of space craft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission

Comply with Guideline 6 (25-year rule)

- Typical massive satellites
  - launched as primary payloads
  - Allowed propulsion system
- Typical small satellites
  - Launched as secondary payloads
  - Banned propulsion system

Orbital Lifetime versus Area-to-Mass Ratio



0.026 m²/kg

0.0075 m²/kg

700 km

Comply with Guideline 6 (25-year rule)

- Typical massive satellites
  - launched as primary payloads
  - Allowed propulsion system
- Typical small satellites
  - Launched as secondary payloads
  - Banned propulsion system

- Most small satellites have to enlarge their cross-sectional area at the beginning or the end of mission
- Enlarging cross-sectional area may conflict with Guideline 3 (limitation of probability of accidental collision)

Comparing Probability of Accidental Collisions

- Objectives
  - Evaluating probability of accidental collisions for small satellite
  - Comparing small satellites' probability of accidental collision with massive satellites' one
- Evaluation procedures
  - Probabilities of accidental collisions with existing objects are calculated by NEODEEM
  - Typical small and massive satellites are defined
  - Probability calculation starts after mission term

Evaluation Tool (NEODEEM)

- Space debris environment evolutionary model
- Developed by JAXA and Kyushu University
- Initial environment
  - As of May 1 2009
  - Objects with perigee altitudes < 2000 km

Small Satellites versus Massive Satellites

- Assumed typical satellites

	Small satellite		Massive satellite	
Post-mission disposal	Success	Failure	Success	Failure
Mass at the end of life [kg]	50	50	1750	1750
Cross-sectional area [m^2]	1.3	0.375	14.875	14.875
Area-to-mass ratio [m^2/kg]	0.026	0.0075	0.0085	0.0085
Perigee height [km]	700	700	555	700
Apogee height [km]	700	700	700	700
Inclination [deg]	98.2	98.2	98.2	98.2
Orbital lifetime [year]	23	86	24	75

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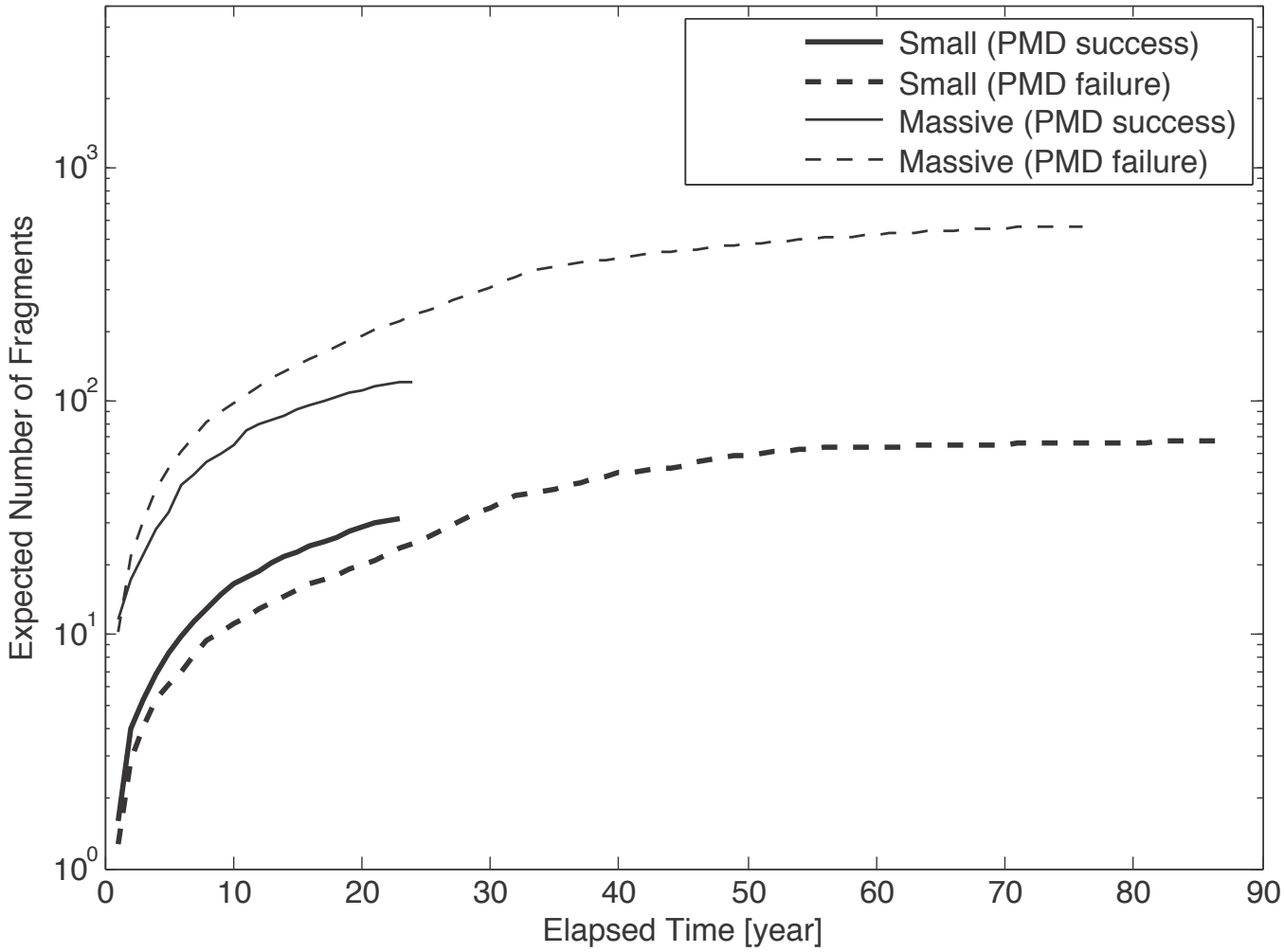
Use propulsion system

Enlarge cross-sectional area

Small Satellites versus Massive Satellites



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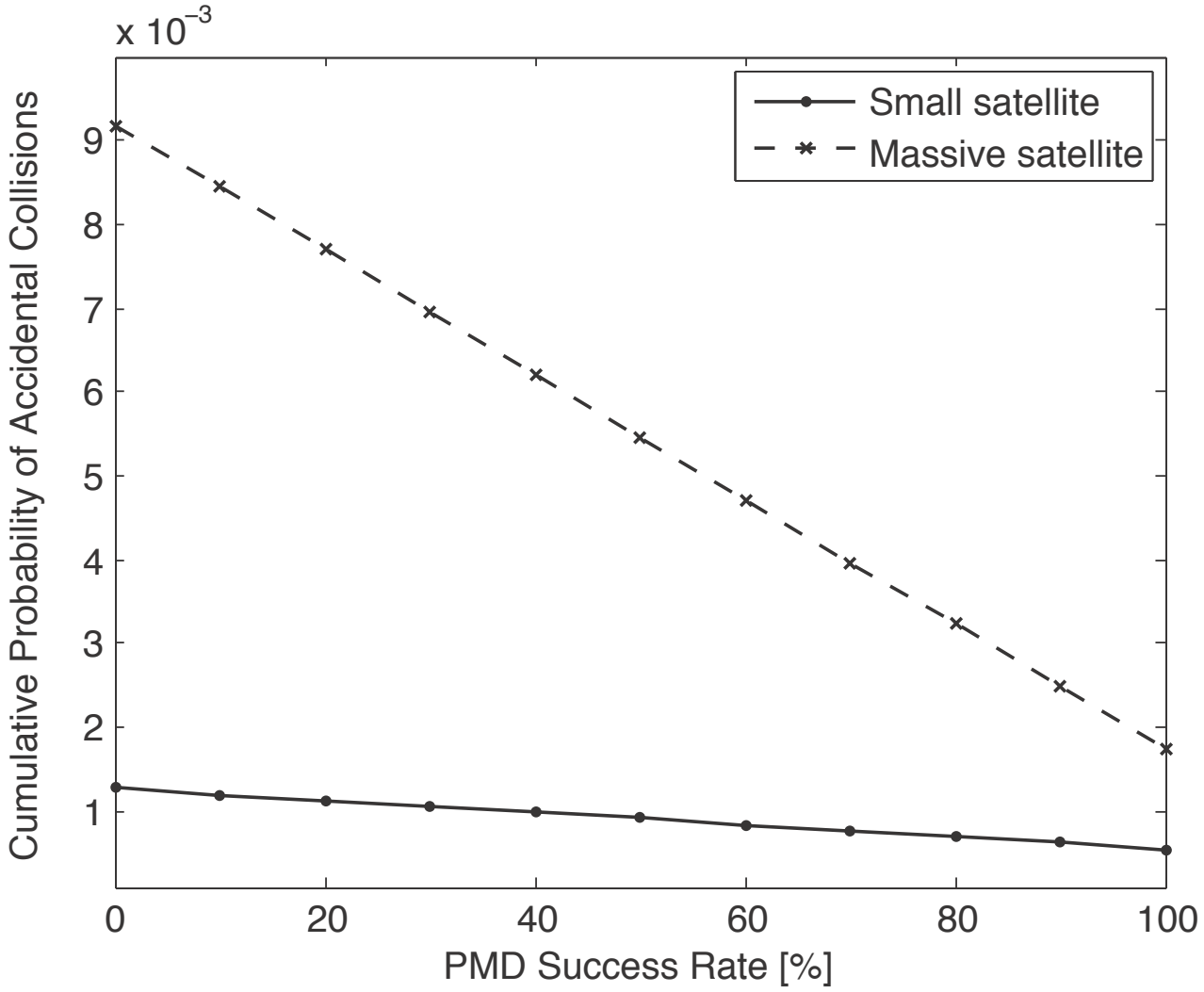

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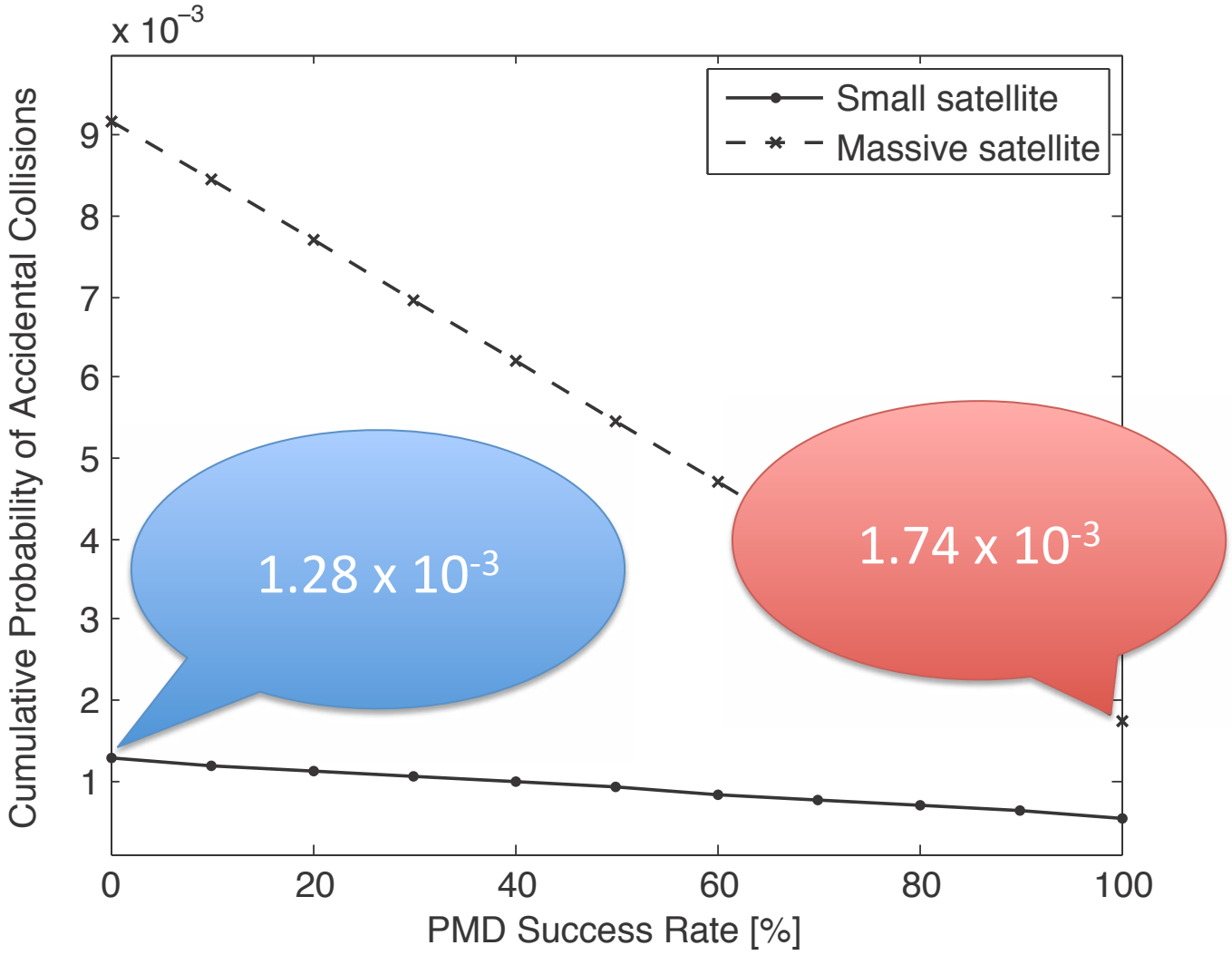

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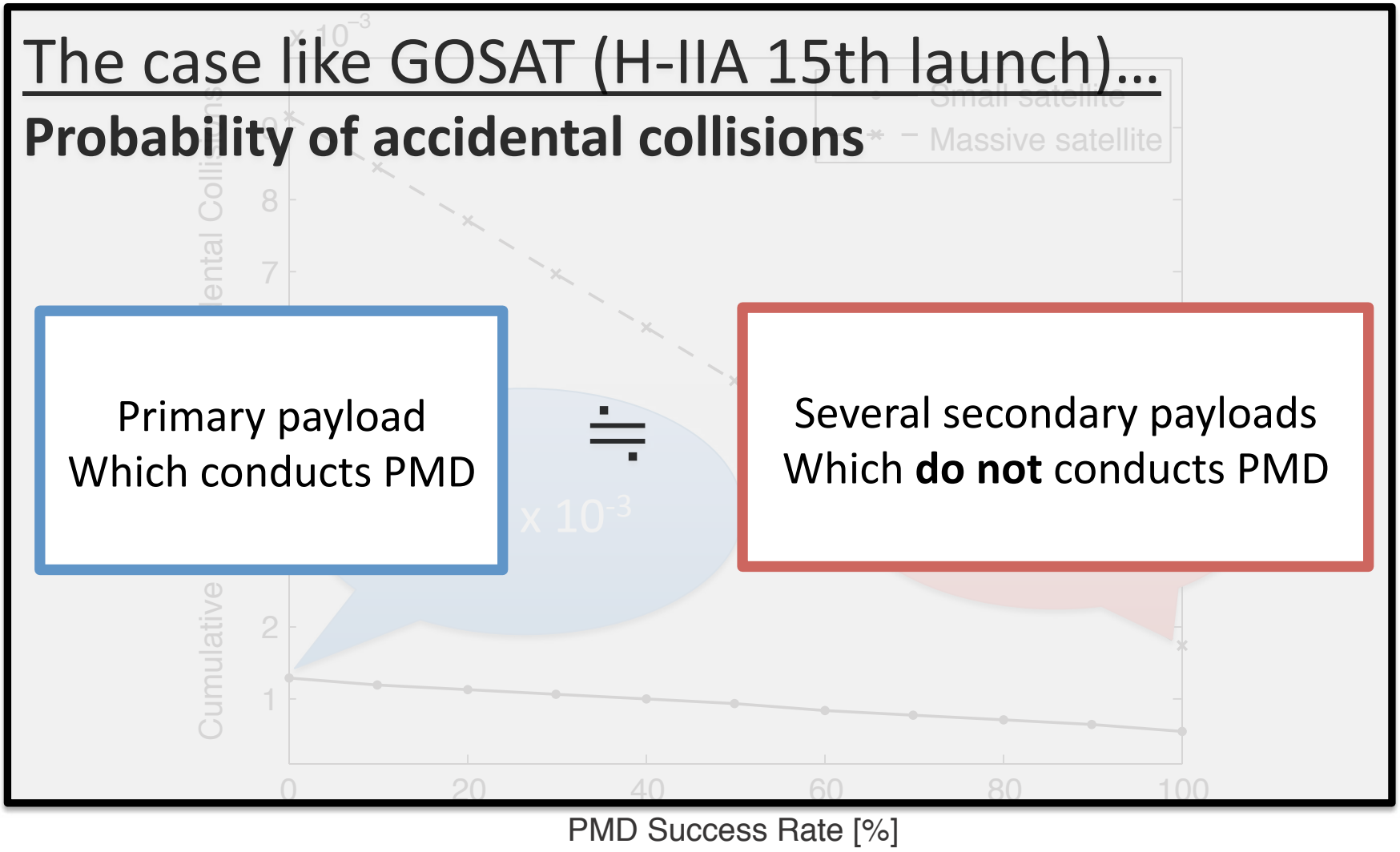

Concluding Remarks

- Calculated probability of accidental collisions
- Compared probability of small satellite with that of massive satellite
  - Collision probability of a small satellite is about half of collision probability of a massive satellite which conduct post-mission disposal
  - If small satellites is inserted into same orbit, collision probability of the constellation is same as that of a massive satellite

Of cource,
All satellites in LEO should be decay and reenter into the Earth at the end of mission lifetime for sustainable space activities.

Backup slides

Cumulative Probability of Accidental Collisions