Overview of Space Debris and Cubesats

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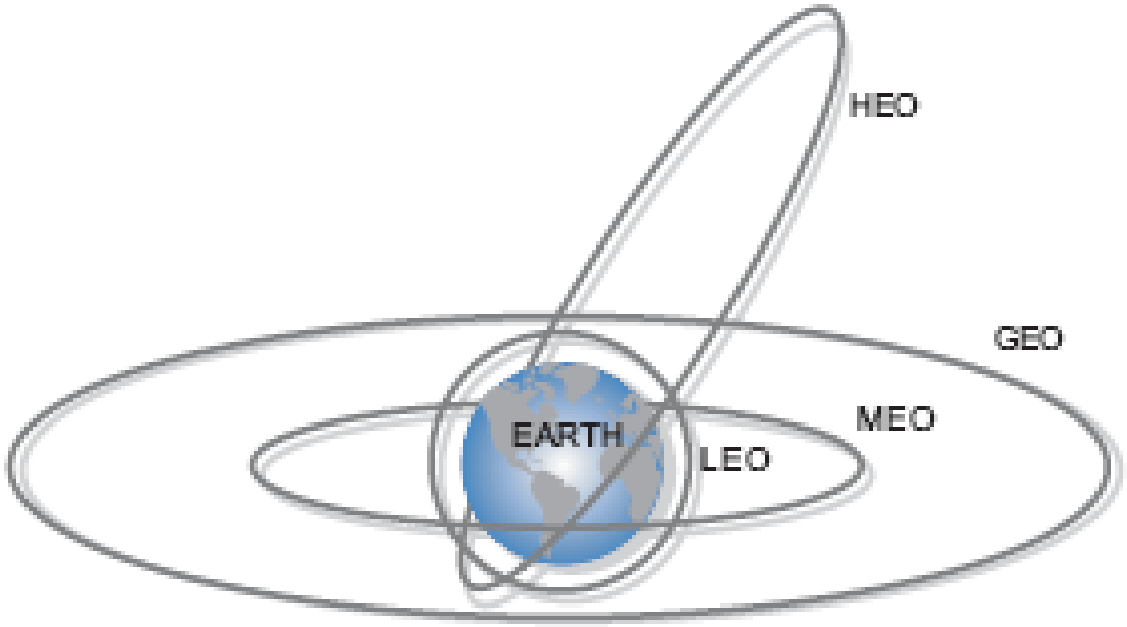
SPACE DEBRIS 101

Current satellite population



	Name	Altitude	Inclination	Shape	Active Satellites
LEO	Low Earth Orbit	250 - 2,000 km	Varies, many 80-100°	Mostly circular	**669**
MEO	Medium Earth Orbit	10,000 - 12,000 km	Varies	Circular	**94**
HEO	Highly Elliptical Orbit	1,000 km (perigee) 40,000 km (apogee)	63°	Elliptical	**37**
GEO	Geostationary Earth Orbit	36,000 km	Typically 0°	Circular	**465**
				Total	**1,265**

Source: Union of Concerned Scientists Satellite Database (includes launches through 31 Jan 2015)
http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html

Current space debris population

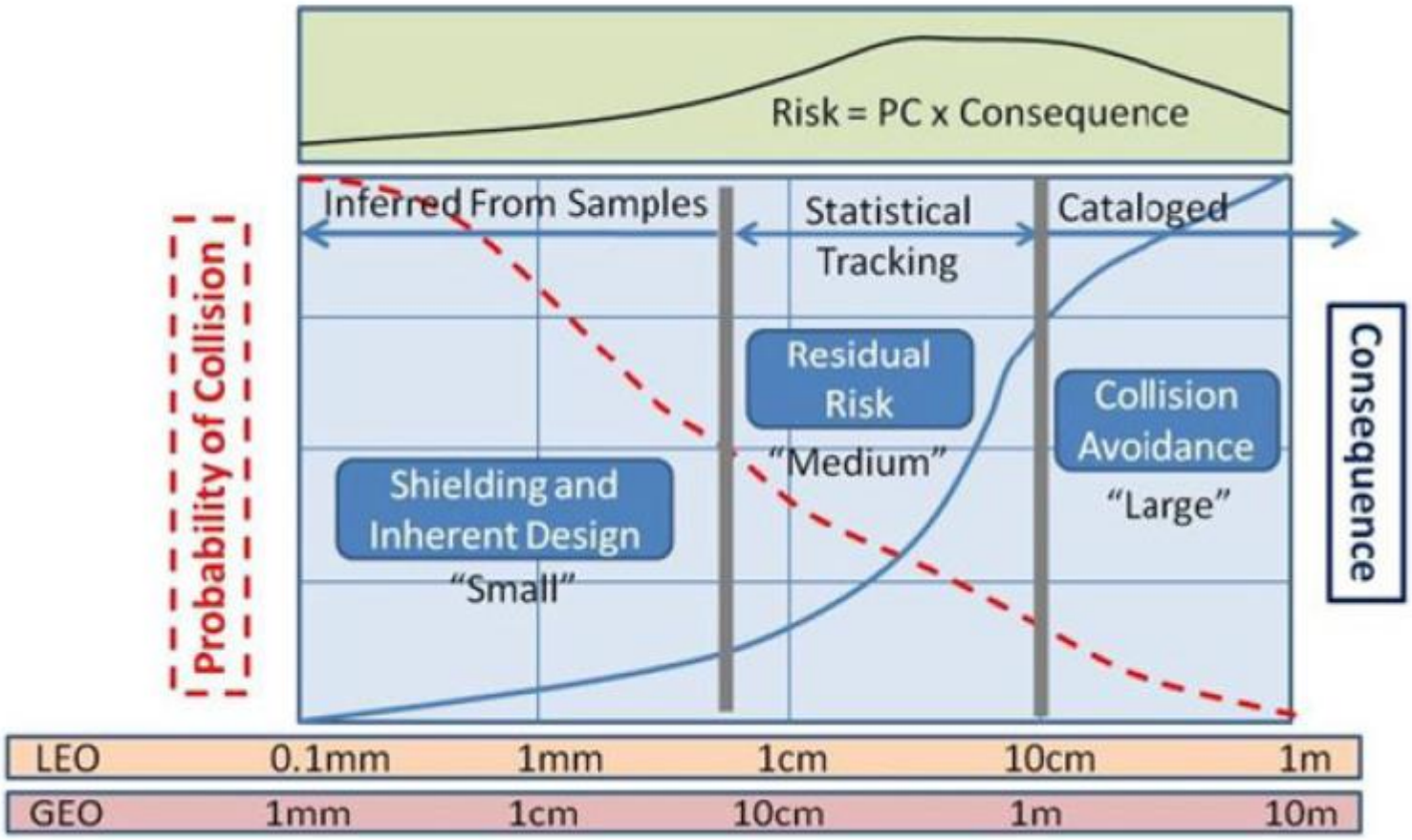
Softball size or larger (≥10 cm): ~20,000 to 22,000 (tracked by the U.S. Space Surveillance Network, SSN)

Marble size or larger (≥1 cm): ~500,000

Dot or larger (≥1 mm): >100,000,000 (a grain of salt)

J-C Liou, NASA Orbital Debris Program Office, 2014

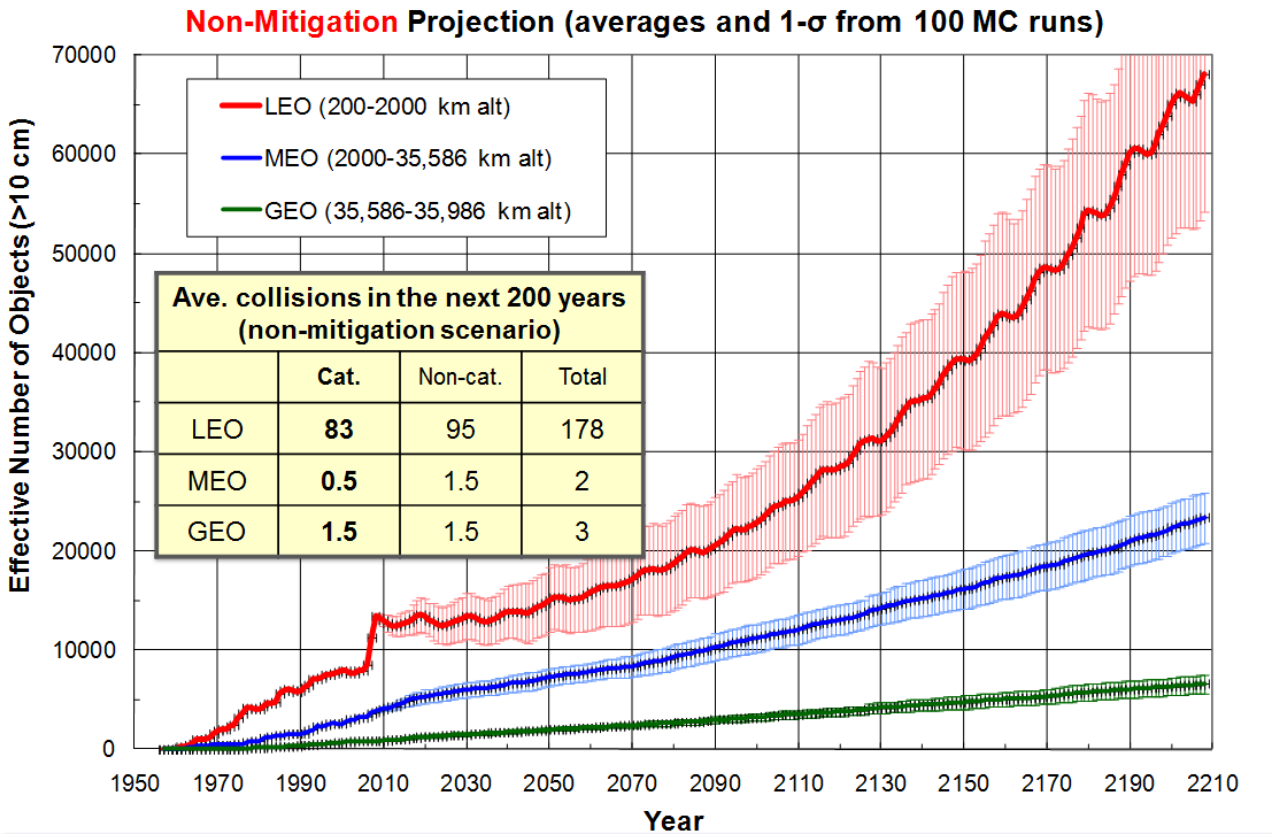
Collision risk to spacecraft



McKnight & Di Pentino (2013)

Kessler Syndrome

Collisional cascading: debris-on-debris collisions generate more new debris than is removed through atmospheric decay



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, 2009

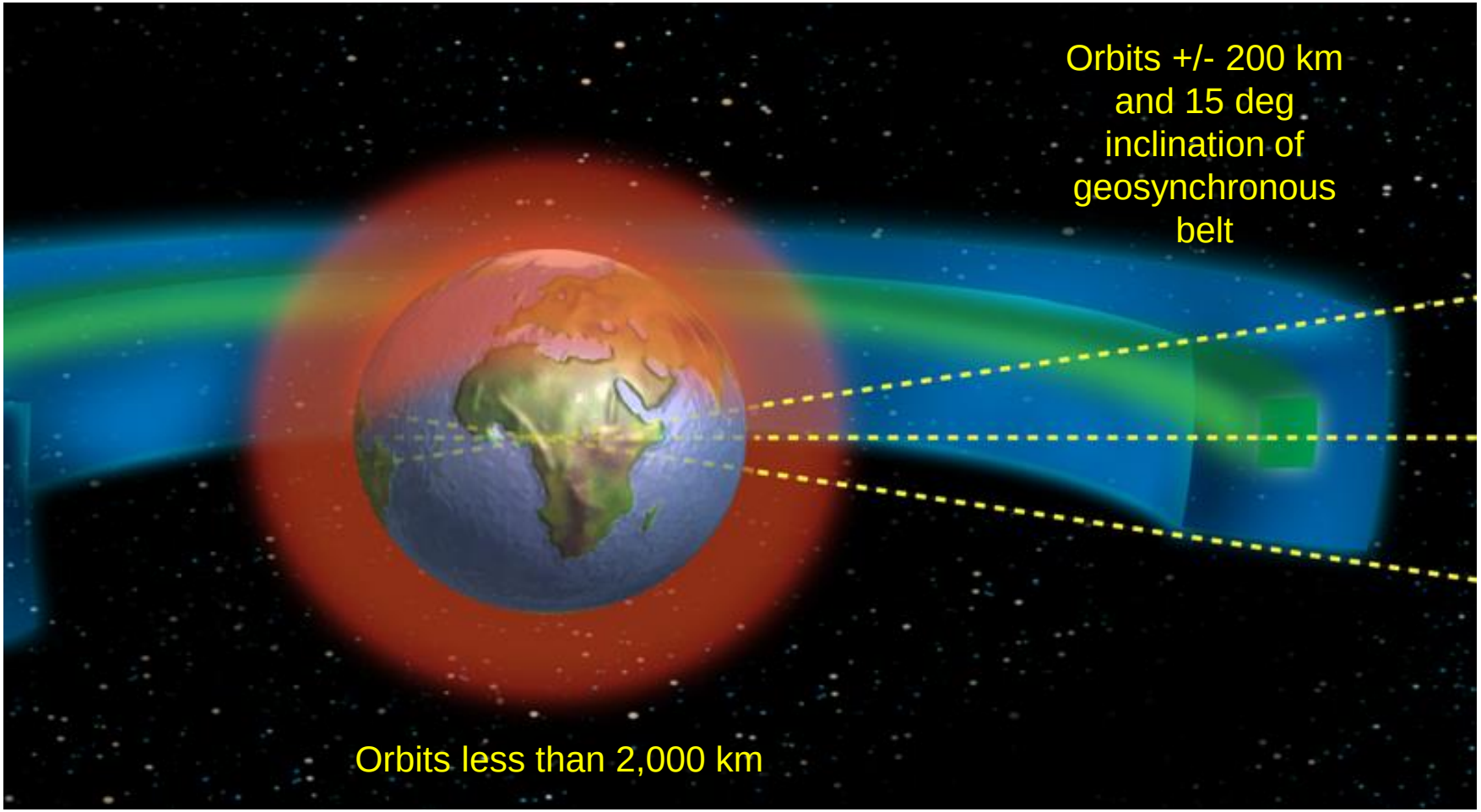
Debris mitigation guidelines

- Inter-Agency Space Debris Coordination Committee (IADC)
  - Created in mid-1990s by several major space agencies
  - 2007: Published voluntary technical guidelines for mitigating space debris
  - 2009: Simplified version endorsed by the United Nations (but still voluntary)

- **25-year rule**: no objects associated with a launch should be left in critical regions more than 25 years after end of mission
  - LEO: Less than 2,000 km
  - GEO: +/- 200 km and 15 deg inclination of geosynchronous belt

- Up to countries to put in place national law/policy to implement/enforce

IADC protected regions



The debate over active debris removal (ADR)

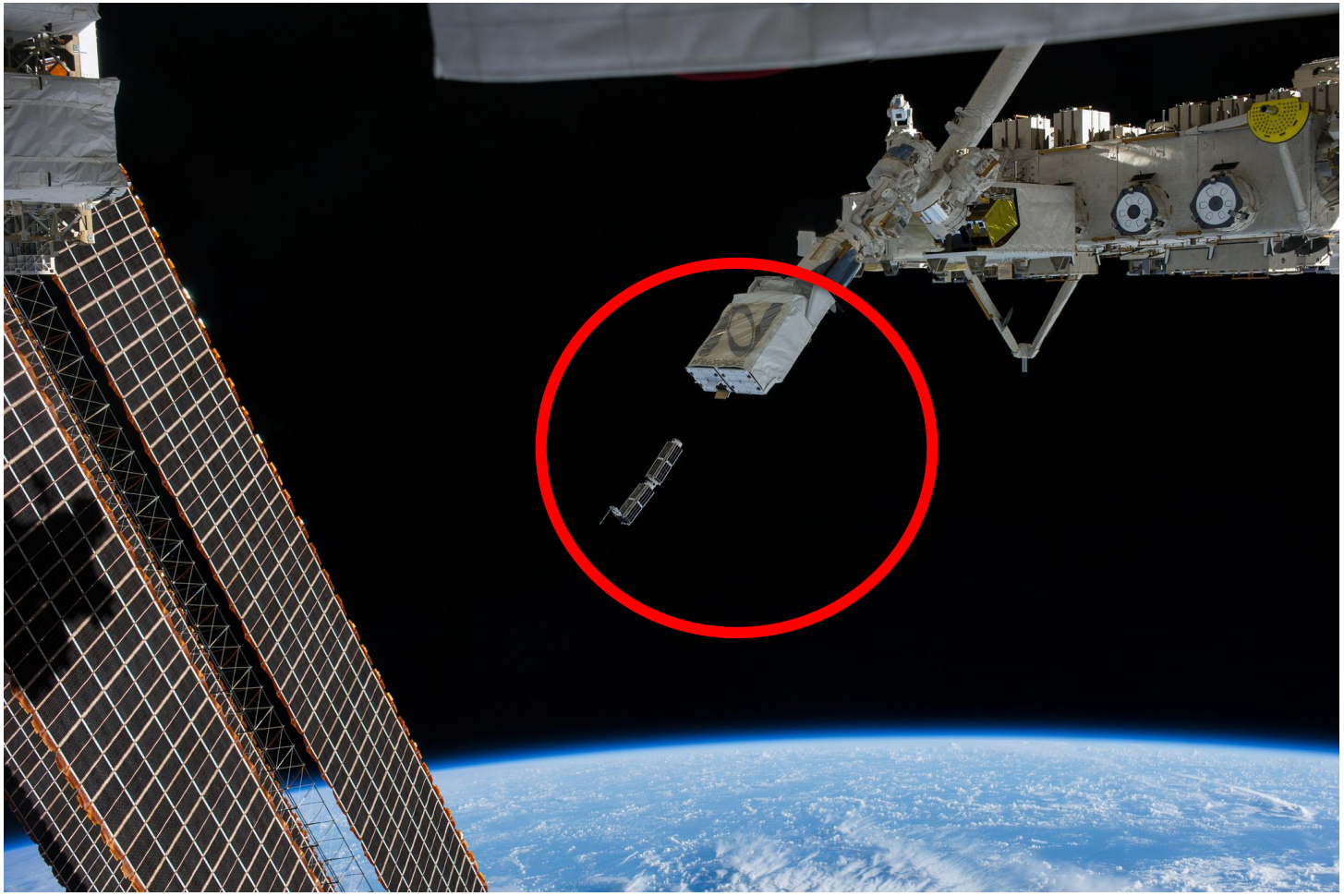
- **Remove the big stuff**
  - Remove 5-10 of the most massive objects per year
  - Reduces long-term growth in debris population & future risk
  - Does little for the short/medium-term risk to satellites
- **Remove the little stuff**
  - Target debris 1-10 cm in size we can't currently track or avoid
  - Reduces the short/medium-term risk to satellites
  - More challenging technically & legally
- **"Just-in-time collision avoidance"**
  - Use lasers to change the orbit of debris to eliminate debris-on-debris collisions
  - Delaying tactic, could give more time to develop technology for other solutions
  - Lots of policy challenges

SPECIFIC CHALLENGES WITH CUBESATS

Main challenges with cubesats

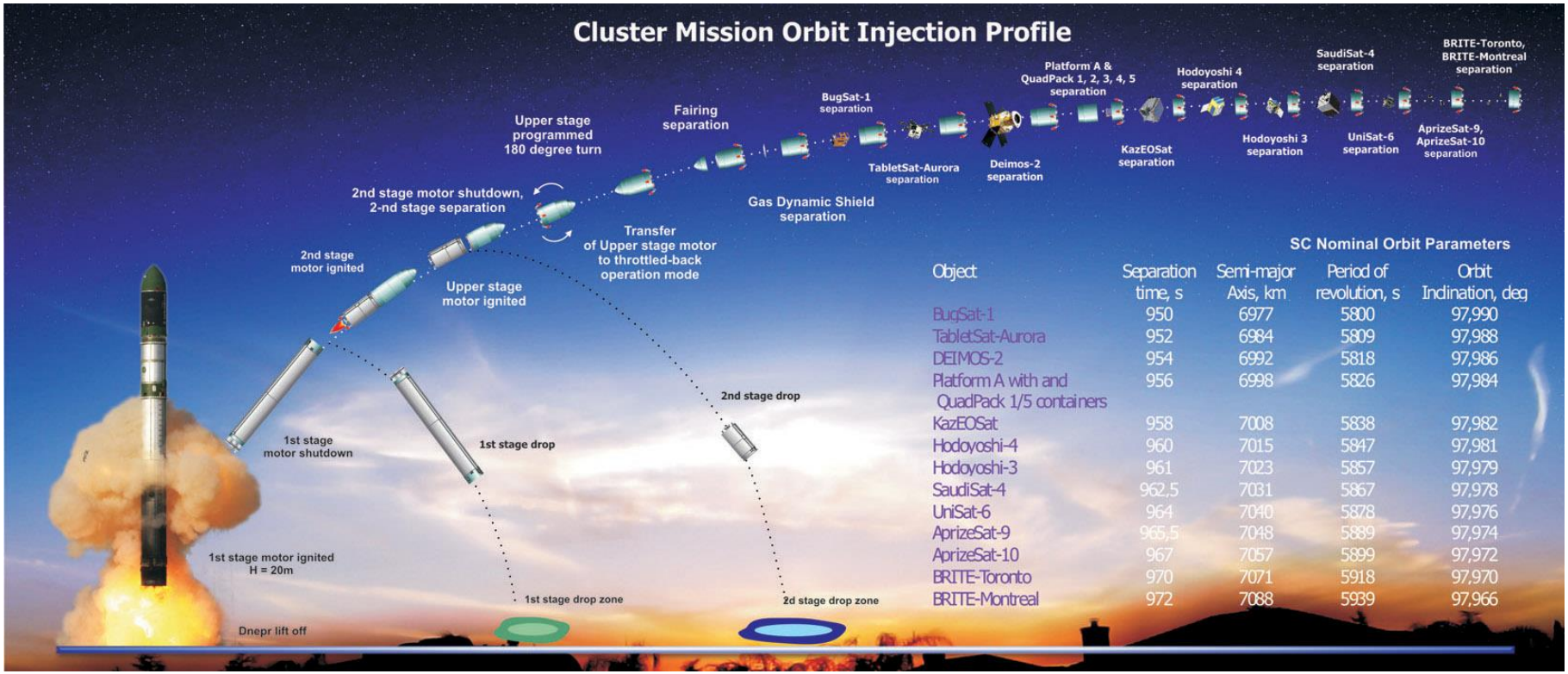
- Relatively hard to track (with currently deployed technology)
- Hard to positively identify
  - Often deployed in clusters, lack distinguishing features
- Limited or no maneuverability
  - Cannot themselves maneuver to avoid a potential collision
  - Cannot comply with "25-year rule" (unless by original constellation design)
- Cubesat operators may have little to no experience in satellite operations
- Some cubesats are being launched by countries that may not have much national regulation/oversight in place

Deployment of Cubesats from ISS



Deployment of PlanetLabs 3U cubesats from NanoRacks deployer on ISS
Photo: NASA

Dnepr cubesat deployment



Object	Separation time, s	Semi-major Axis, km	Period of revolution, s	Orbit Indination, deg
BugSat-1	950	6977	5800	97,990
TabletSat-Aurora	952	6984	5809	97,988
DEIMOS-2	954	6992	5818	97,986
Platform A with and QuadPack 1/5 containers	956	6998	5826	97,984
KazEOSat	958	7008	5838	97,982
Hodoyoshi-4	960	7015	5847	97,981
Hodoyoshi-3	961	7023	5857	97,979
SaudiSat-4	962,5	7031	5867	97,978
UniSat-6	964	7040	5878	97,976
AprizeSat-9	965,5	7048	5889	97,974
AprizeSat-10	967	7057	5899	97,972
BRITE-Toronto	970	7071	5918	97,970
BRITE-Montreal	972	7088	5939	97,966

Image: ISC Kosmotras
http://www.kosmotras.ru/en/launch15/

Atlas V cubesat deployment

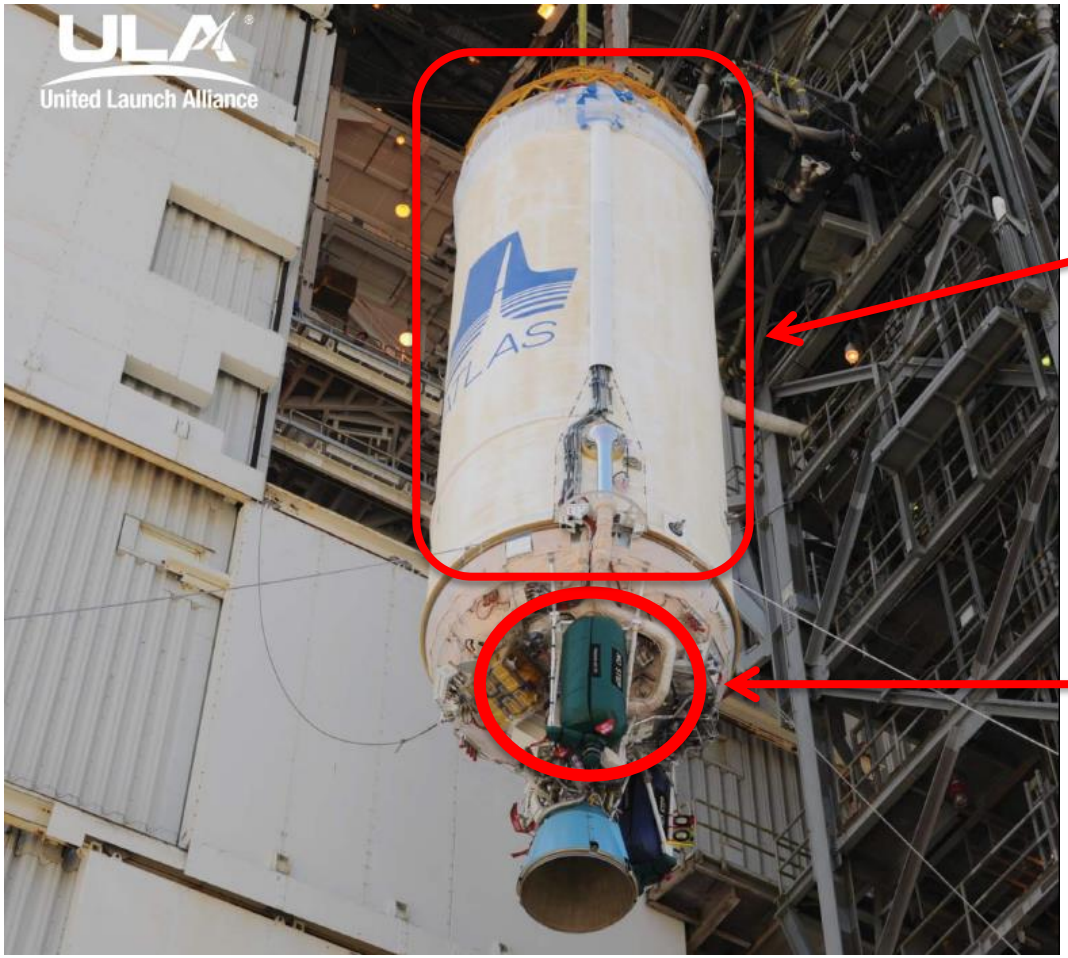
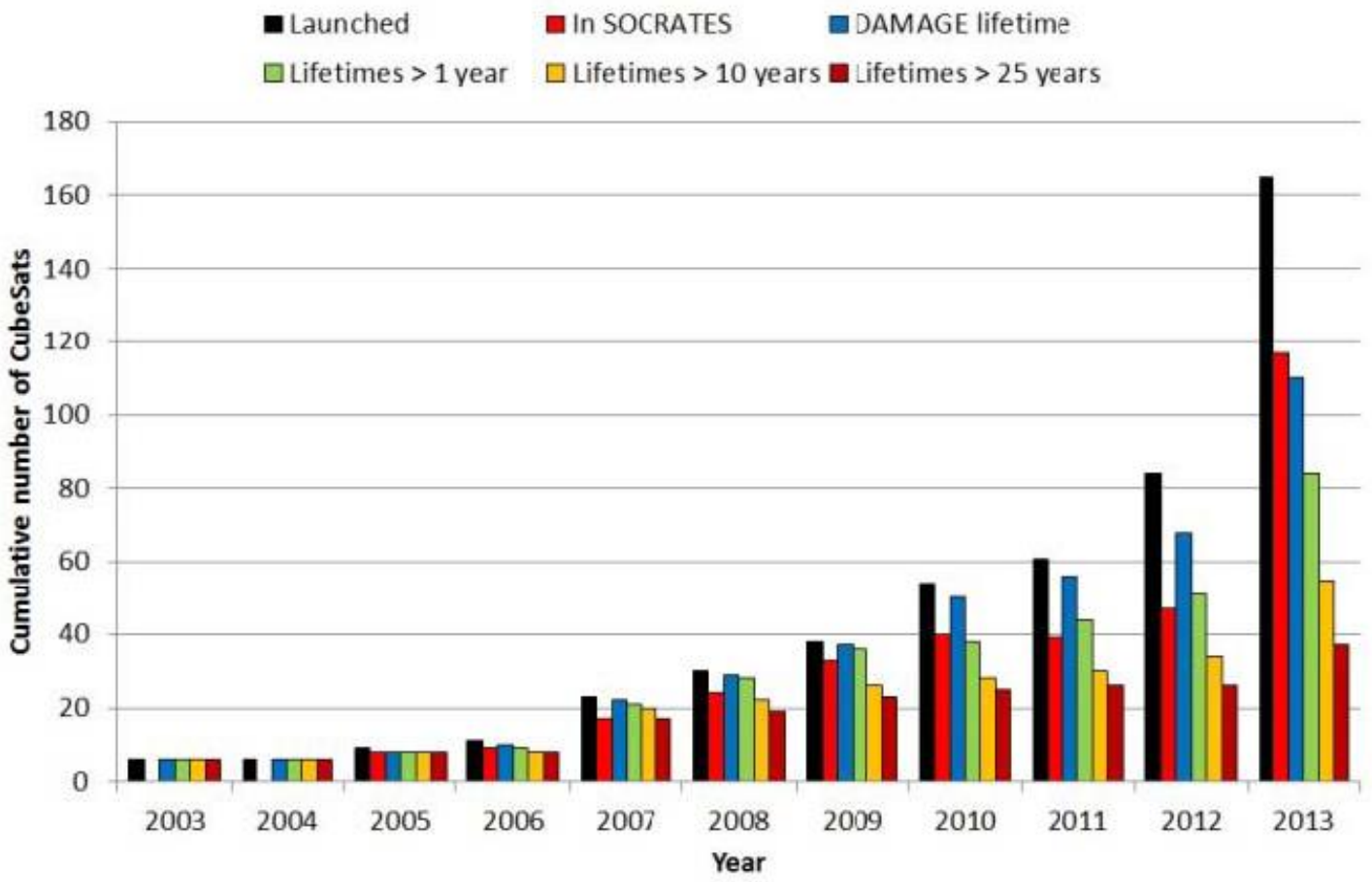


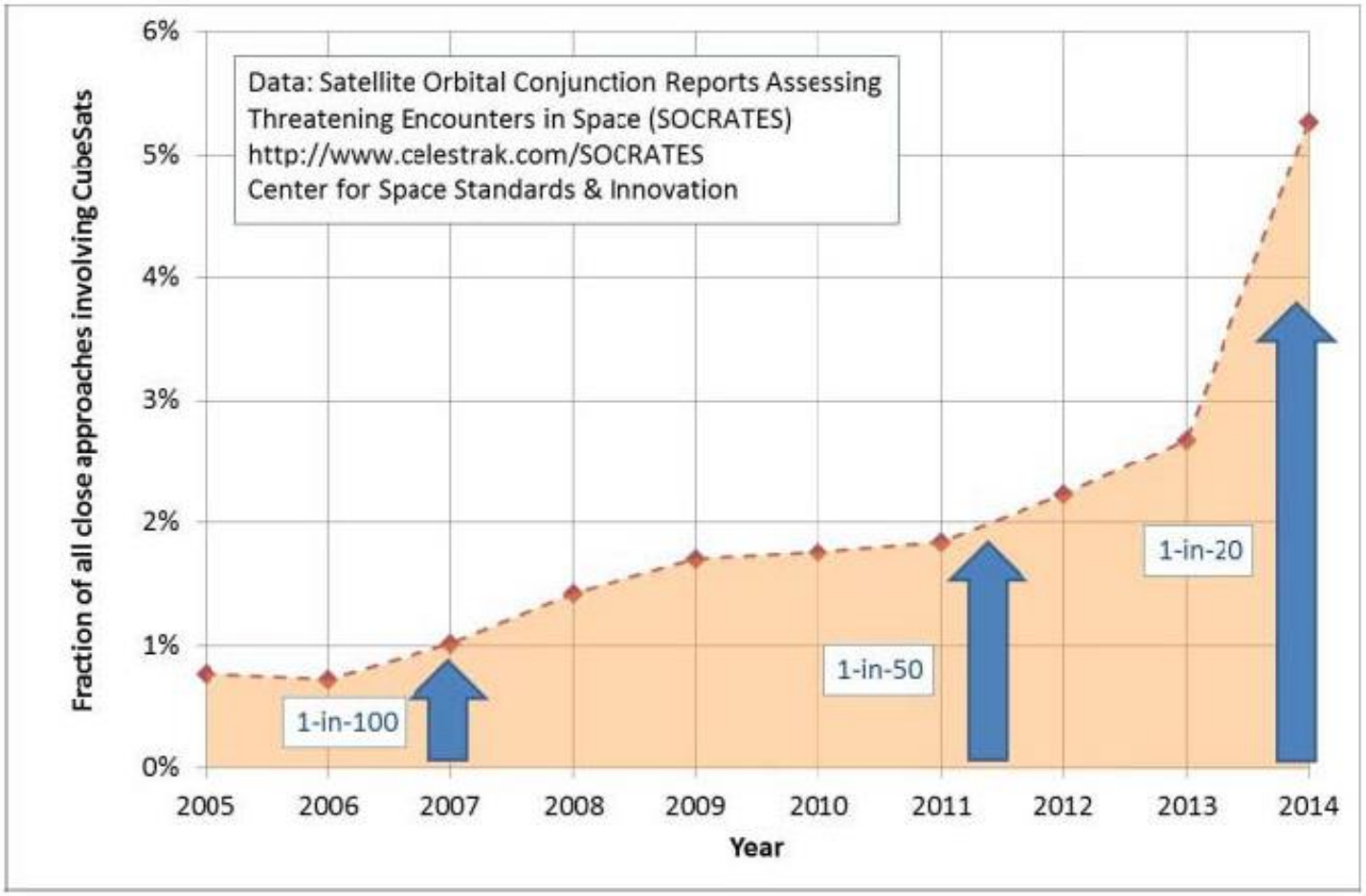
Image: United Launch Alliance
http://www.ulalaunch.com/uploads/docs/launch_vehicles/abc_users_guide_2014.pdf

Cubesat lifetimes



Lewis, Schwarz, George, and Stokes (2014)

Close approaches involving cubesats



Lewis, Schwarz, George, and Stokes (2014)

Major policy issues being debated

- Should cubesats in protected regions be required to have "transponders" or "RFID" tags to facilitate tracking and identification?
- Should cubesats be restricted to low altitudes when they naturally decay within 25 years (< 500 km)?
- Should cubesats in certain regions (ISS?) be required to have maneuvering capability?
- Should launching entities enforce debris mitigation guidelines?

Open research questions

- Do cubesats pose more of a threat than large satellites?
  - Less area, which means less likely to collide
  - Less mass to create new debris as a result of a collision

- Is the surge in cubesats a ***substitution*** for or a ***complement*** to large satellites?
  - Complement is more worrisome

- How to quantify the actual risk posed by space debris and cubesats?

Thank you. Questions?

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