



Promoting Cooperative Solutions for Space Sustainability

Current Issues in Space Sustainability and Space Traffic Management

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Active Satellites

Satellite Quick Facts			
Total number of operating satellites: 1167			
LEO: 605	MEO: 77	Elliptical: 38	GEO: 447
United States: 502	Russia: 118	China: 116	
Total number of U.S. Satellites: 502			
Civil: 20	Commercial: 210	Government: 120	Military: 152

includes launches through 1/31/2014

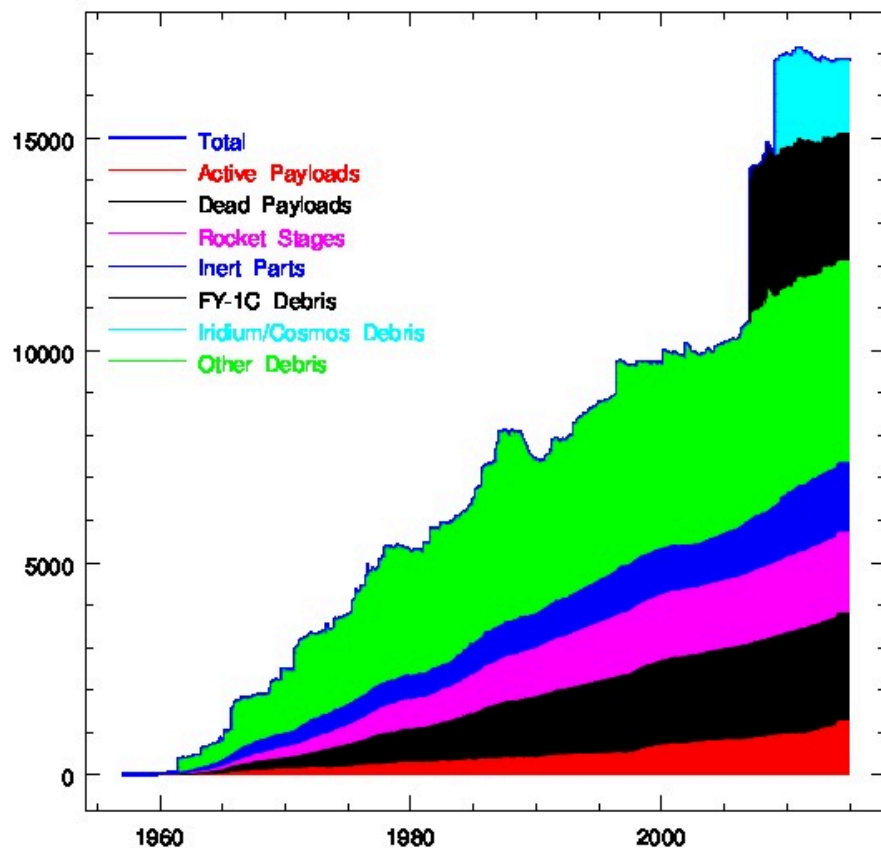
Union of Concerned Scientists Satellite Database

Space Debris

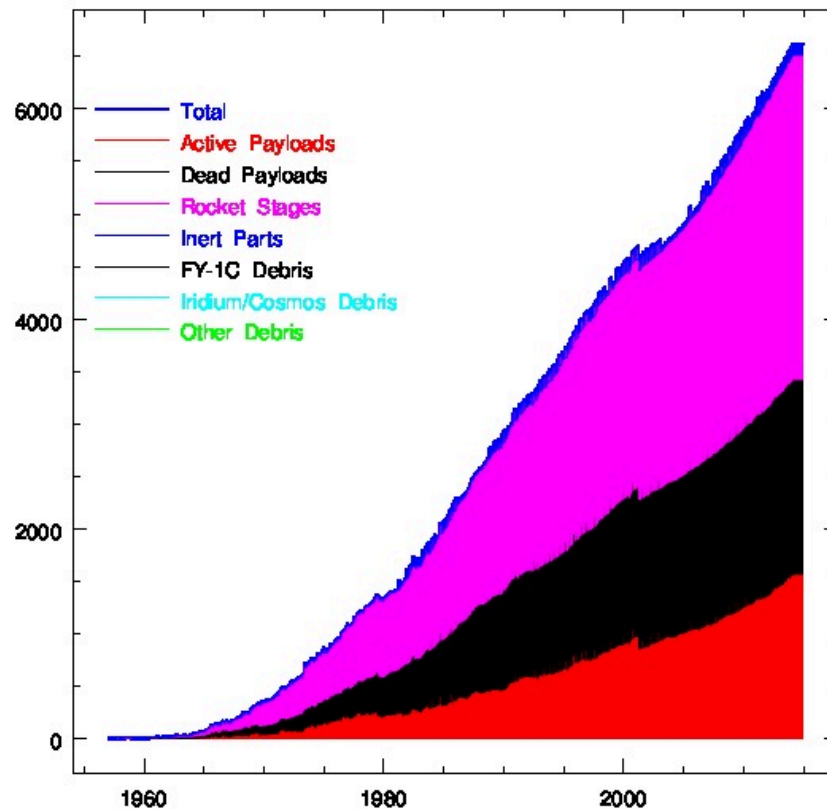
Larger than 10 cm	~22,000	Sources of new debris
Between 1 and 10 cm	~500,000	Can cause major damage
Smaller than 1 cm	Lots	Can cause minor damage

David Wright, Scientificamerican.com

Total objects in orbit over time



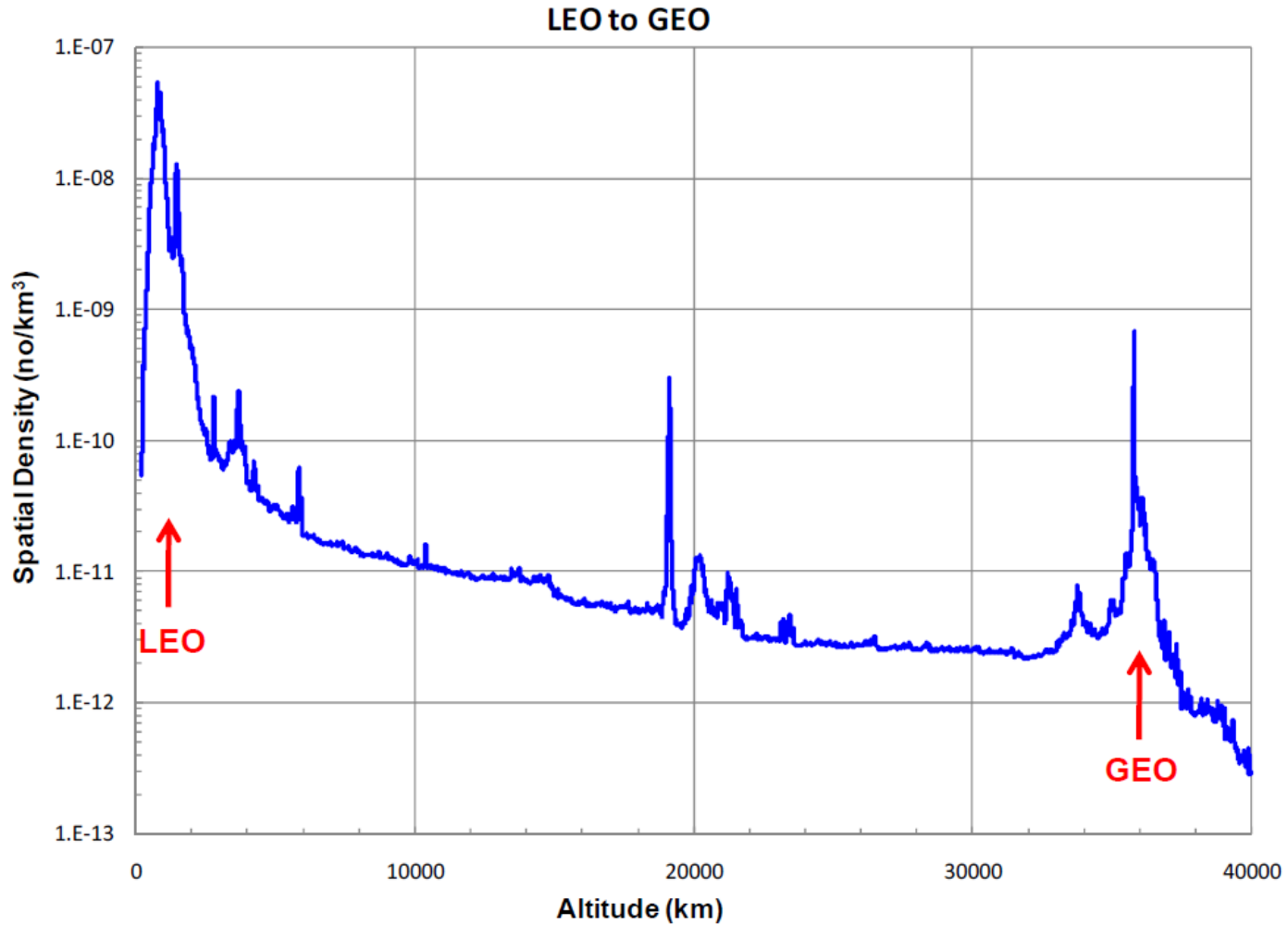
Number of objects



Mass of objects

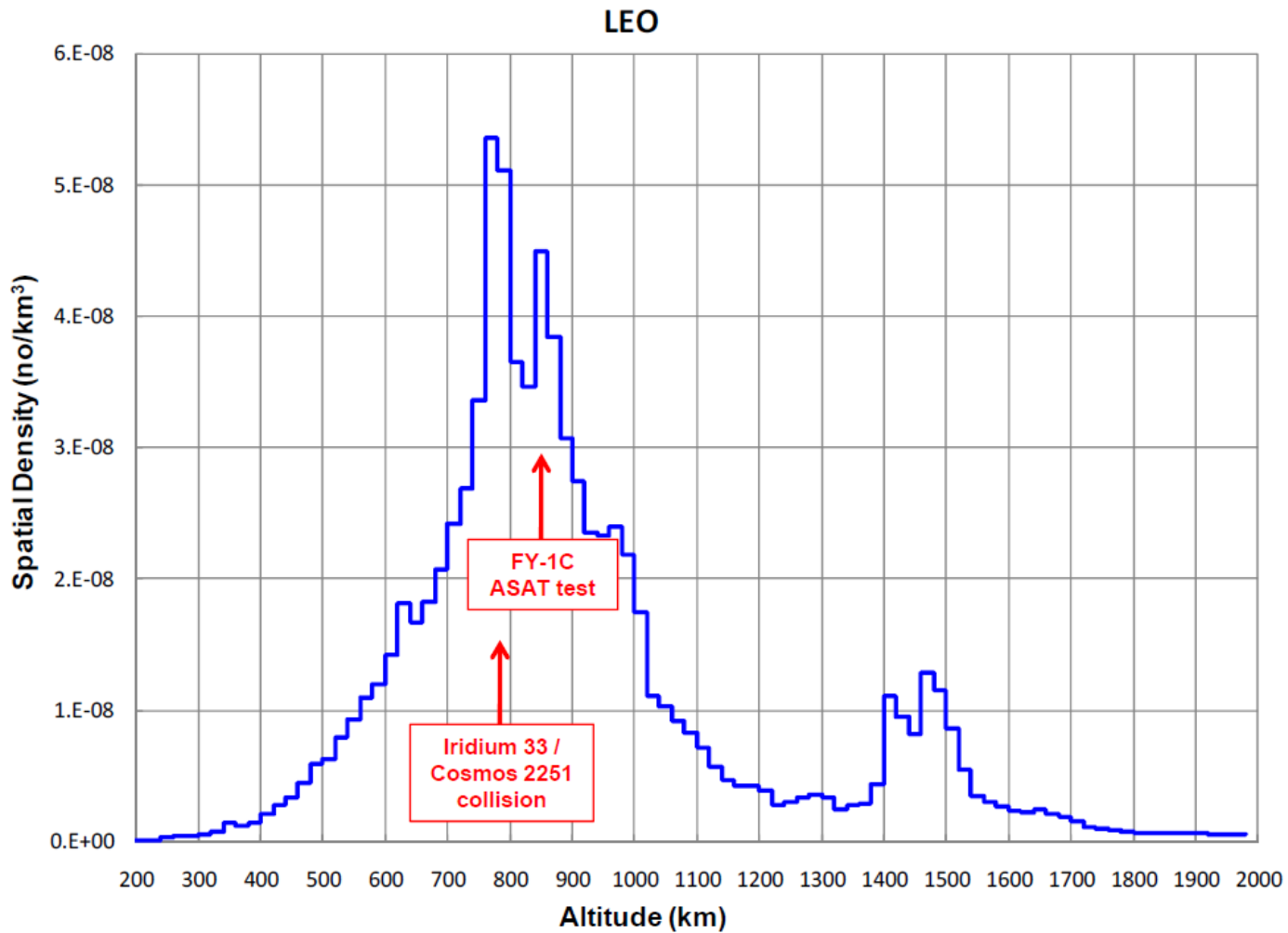
Graphs from Jonathan's Space Page <http://planet4589.org/>

Density of space objects



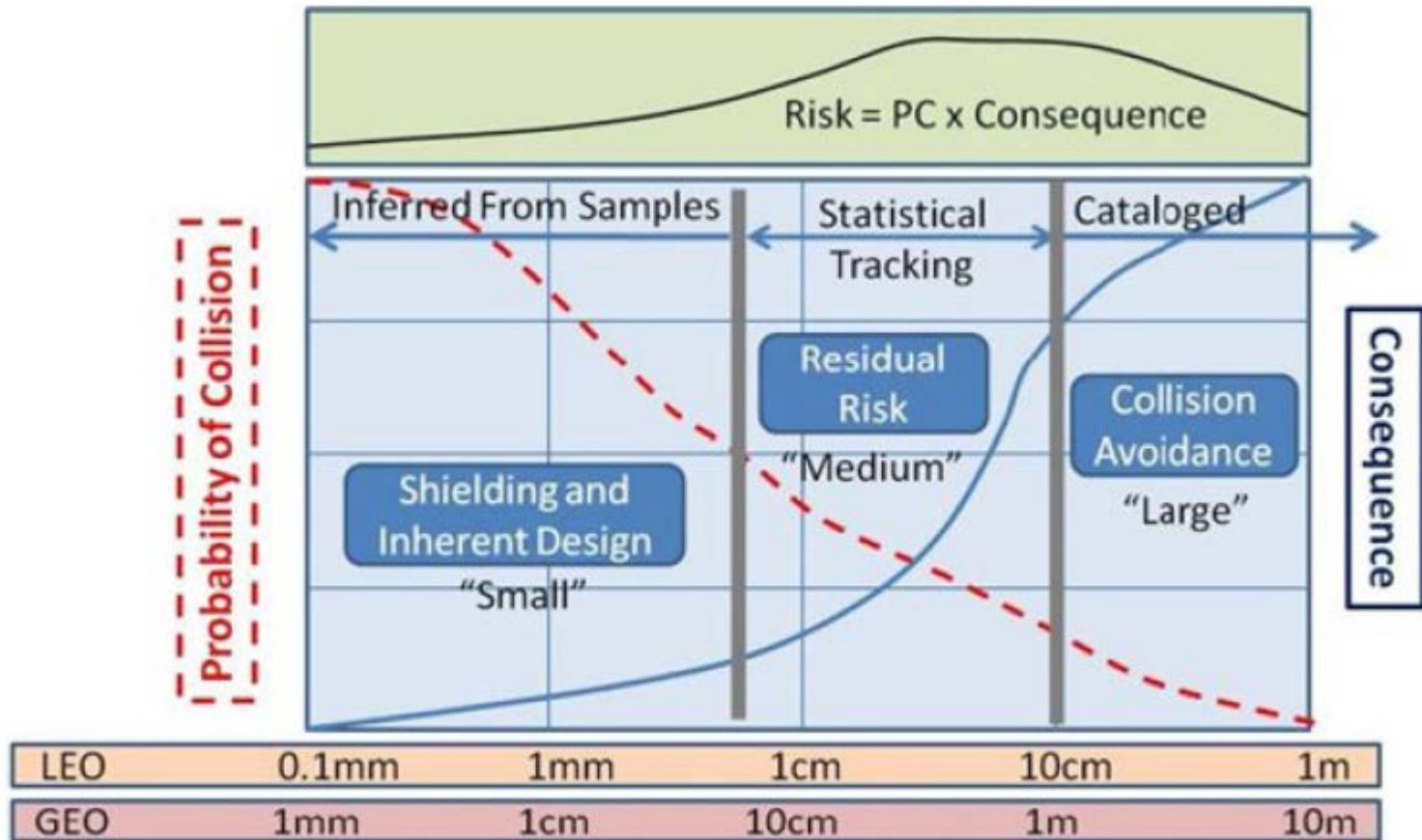
J-C Liou, NASA Orbital Debris Program Office

Highest congestion is in LEO



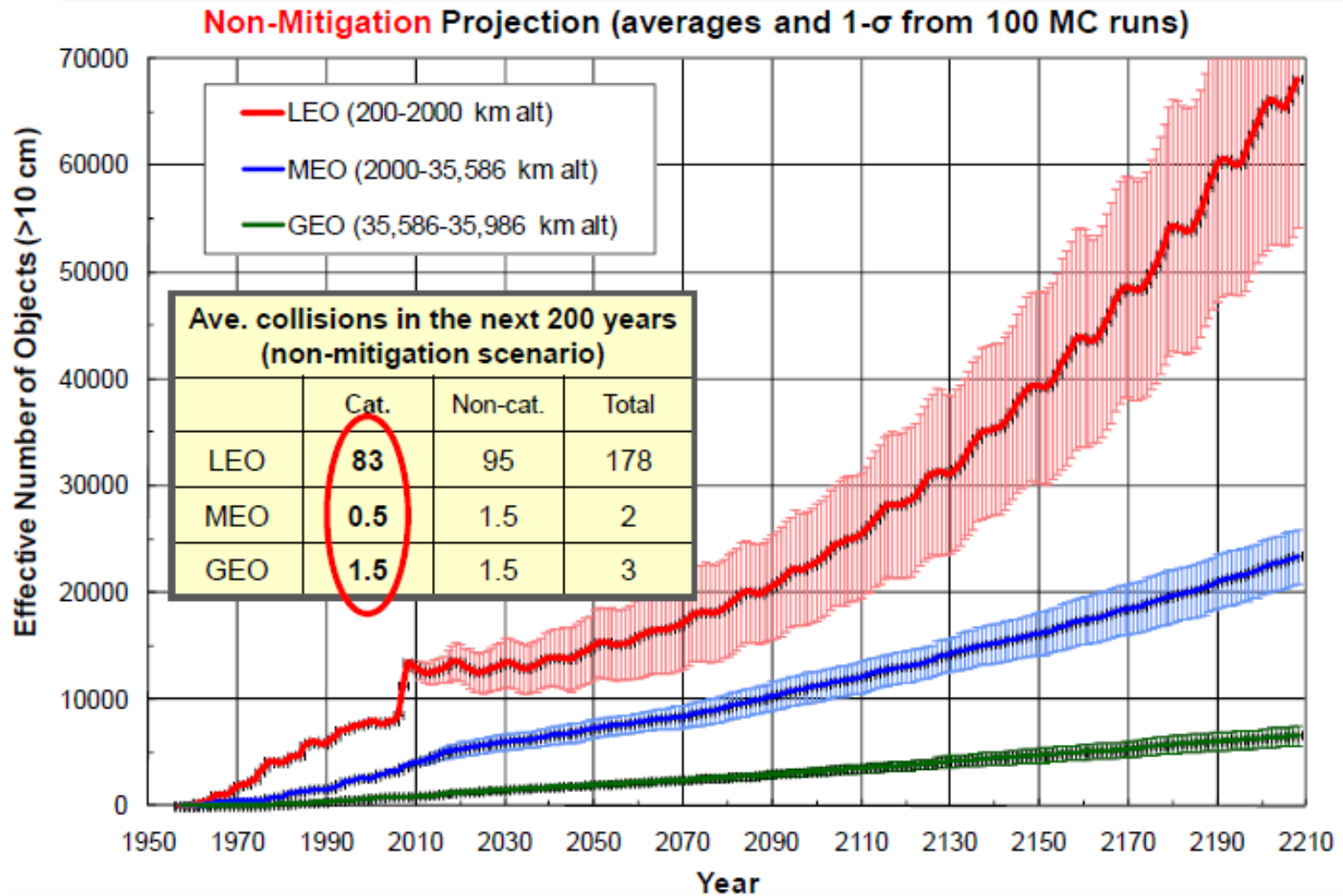
J-C Liou, NASA Orbital Debris Program Office

Debris threat to satellites



McKnight & Di Pentino (2013)

The next 200 years, without any action



J-C Liou, NASA Orbital Debris Program Office

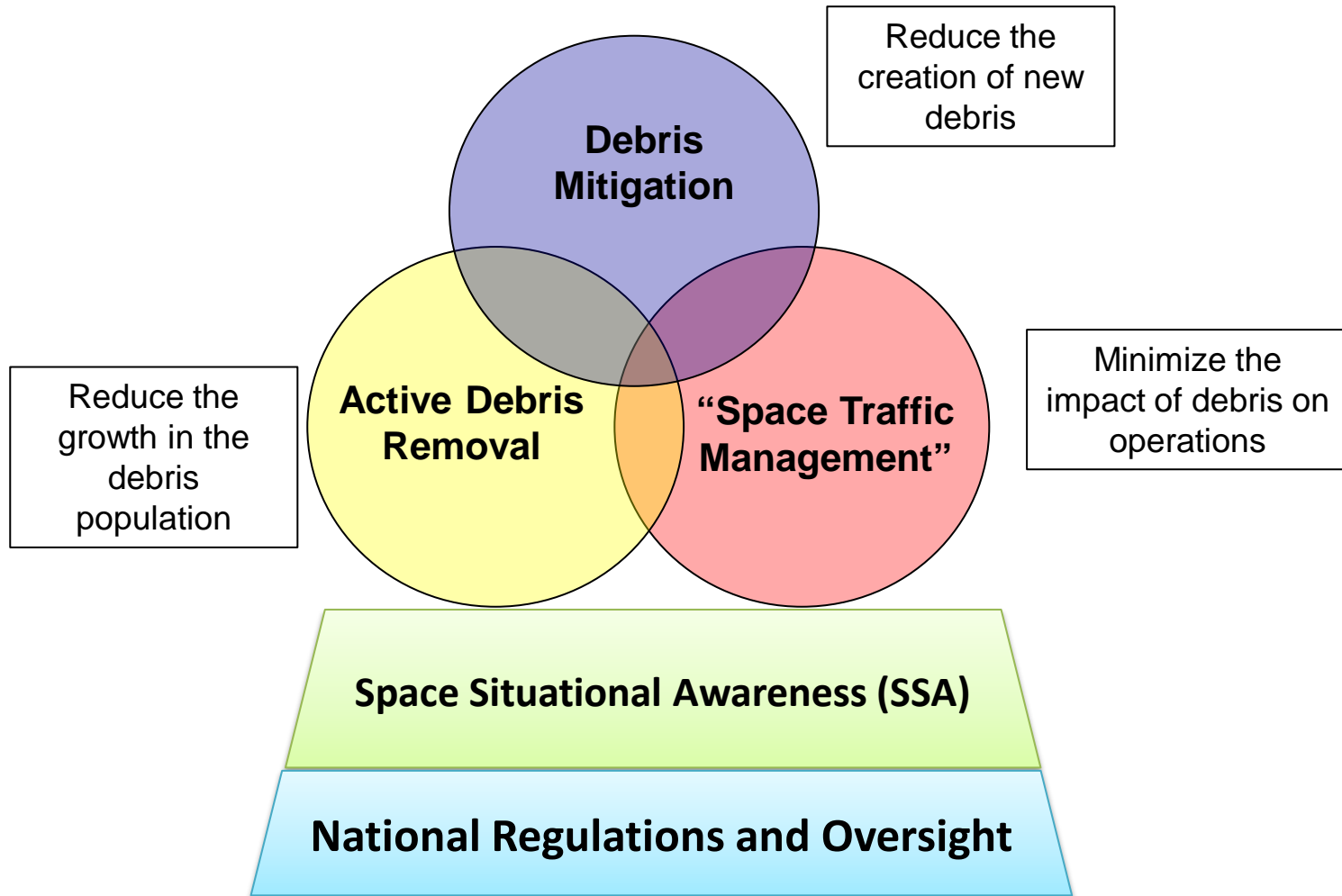


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Drivers of change

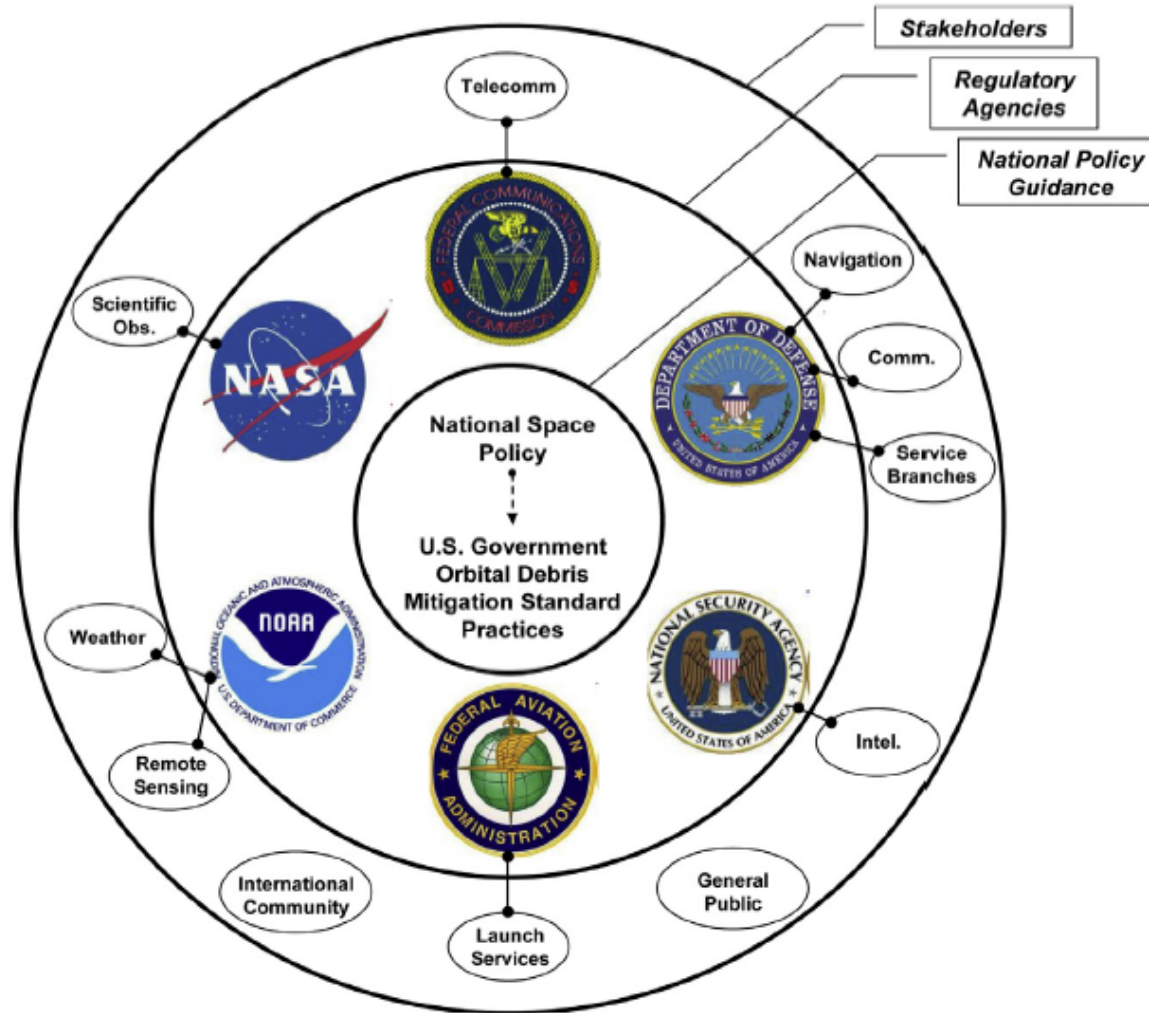
- More countries doing more things in space
 - 60+ countries have at least one satellite
 - 11 countries have indigenous space launch capability
- Significant increase in private sector space activity outside of satcom
 - Commercial cargo and crew
 - Remote sensing startups
 - Kickstarter
- Commoditization of basic space technology and cubesats
 - Drastically lowering the barriers to entry for companies and countries alike

Space sustainability realized



- Inter-Agency Space Debris Coordination Committee (IADC)
 - Members are national space agencies
 - 2007 published debris mitigation guidelines
 - Established “protected zones” in LEO and GEO, 25 year rule
 - UN endorsement in 2008, urged States to adopt on voluntary basis
- Some progress on national implementation
 - US, France, Germany, Russia, Canada, UK, Japan, and China implemented or working on implementation
- ESA research indicates 40-60% compliance with 25-year rule
 - Less compliance in LEO than GEO
 - No significant increase over last 13 years

US Policy process for debris mitigation



Space situational awareness

Definition: Information about the space environment and activities in space

“Civilian”

- Metric Data (Catalog)
 - Locations of objects in space and the ability to predict where objects were in the past and will be in the future
- Space Weather
 - Measurement, warning, and forecasting of the effects of Solar activity on objects in orbit
- Object Status
 - Health, telemetry, planned maneuvers (usually provided by owner/operator)

“Military”

- Intelligence
 - Information about objects in orbit (images, signals, capabilities, behavior) collected on objects in orbit

Current capabilities - USA

- United States military has the best set of SSA capabilities, although not ideal
 - Operates global network of 30+ ground based radars and optical telescopes, plus a satellite in orbit
 - Maintains the most complete satellite catalog of 16,000+ space objects (23,00 total)
 - Data fed to Joint Space Operations Center (JSpOC) in California
 - Provides a range of data and services for US government, satellite operators, and public
- Limitations
 - Primary customer & focus is US military
 - Antiquated hardware and software
 - No real coverage in Southern Hemisphere



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Emerging private sector SSA capabilities

- Space Data Association (SDA)
 - Not-for-profit entity created by major commercial satellite operators
 - Membership includes 27 satellite operators controlling 350+ satellites
 - Provides members services to support conjunction analysis (CA), collision avoidance (COLA) & radio frequency interference (RFI) detection
- Analytical Graphics, Inc.'s Commercial Space Operations Center (ComSpOC)
 - Negotiating contracts with dozens of radars, telescopes, & RF sensors around the globe
 - Use proprietary software to create SSA products from the sensor data
 - Plan to offer subscription SSA services similar to JSpOC

Space traffic management?

- 2007 IAA Cosmic Study: “the set of *technical and regulatory provisions* for promoting *safe access* into and out of space, *operations* in outer space *and return* from outer space to Earth *free from physical or radiofrequency interference*”
 - Post-mission disposal (PMD) of spacecraft
 - Conjunction assessment (CA) and collision avoidance (COLA)
 - RFI mitigation
 - Launch/re-entry operations
 - Interface between space traffic and air traffic
- No consensus definition
 - Debate over “management” vs “control”
 - Who sets the rules?

Space vs air traffic management

- Space traffic operates at ***much*** higher velocities
 - Typical conjunction in LEO is in excess of 10 km/s (22,200 mph)
 - Visual flight rules (VFR) impossible (except for pre-planned rendezvous)
- Never a definitive “yes/no” answer for a conjunction in space
 - Decisions are made based on predictions several days into the future
 - Decisions are based on ***probabilistic analysis and risk tolerance***
- Less than 5% of space traffic have any ability to maneuver (compared to 100% of air traffic)
- No “national airspace” in orbit
 - States have jurisdiction over their own objects, but no one has jurisdiction over orbital regions
- No international framework for harmonizing national regimes

House hearing on STM



Witnesses:

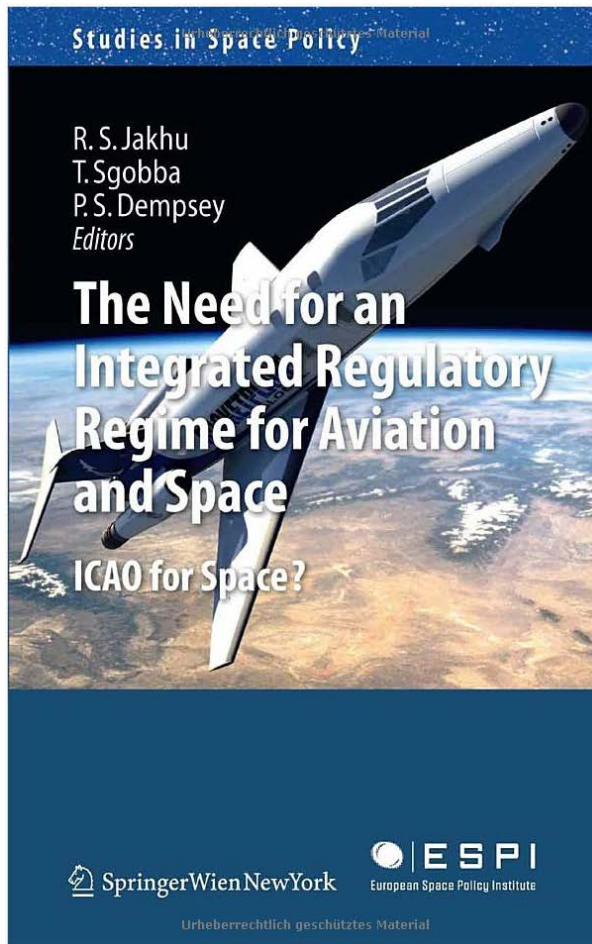
- LtGen Jay Raymond, USSTRATCOM
- Mr George Zamka, FAA
- Mr Robert Nelson, FCC
- Mr PJ Blount, U. of Miss Law School
- Mr Brian Weeden



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Major issues from hearing

- Federal agency roles/responsibilities for implementing space debris mitigation guidelines
 - Gaps or duplication in current authorities?
- Should DoD retain all responsibility for SSA?
 - Which non-DoD entity gets the mission?
 - Which parts stay with DoD?
- Who should have authority for on-orbit operations?
 - FAA request for authority
 - Power to mandate collision avoidance maneuvers?
- Active removal of space debris
 - Which agency does it?
 - Who pays?



- Global regulations for space traffic interaction with air traffic?
- Harmonization of space regulations between countries?
- International regulations?

International initiatives on space

- UN Group of Governmental Experts (GGE) on Transparency and Confidence Building Measures (TCBMs) for Outer Space Activities
 - Recommendations for improving security & stability
 - Delivered their report in October 2013
- Draft International Code of Conduct for Space Activities
 - Negotiations currently ongoing between many countries
 - Focus mainly on security but also debris mitigation and some elements of STM
 - Potential completion in 2015
- UNCOPUOS Best Practices for Long-Term Sustainability of Space
 - Four expert groups developed recommended technical guidelines
 - Working Group of States currently debating guidelines
 - Expected to complete in 2015

Why not economic incentives?

- There have been various proposals for microeconomic incentives to tackle space debris
 - Space usage or debris tax
 - Cap and trade
 - Insurance fees
- Unlikely that economic incentive models will work for space debris at this time
 - Debris problem is worst in LEO, but almost all commercial activity is in GEO
 - 95% of insured space assets are in GEO
 - Primary actors in LEO are governments using public money to provide public goods



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Big issues going forward

- Evolution of governmental oversight of private sector activities
 - How to deal with new categories of activities?
 - Flags of convenience?
- Legal regime centered on national sovereignty, but space is becoming more international and less State-centric
- Private sector is the forcing function but national security bias will continue hinder policy change
- Difference in priorities between developed and developing countries



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Thank You Questions?

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