



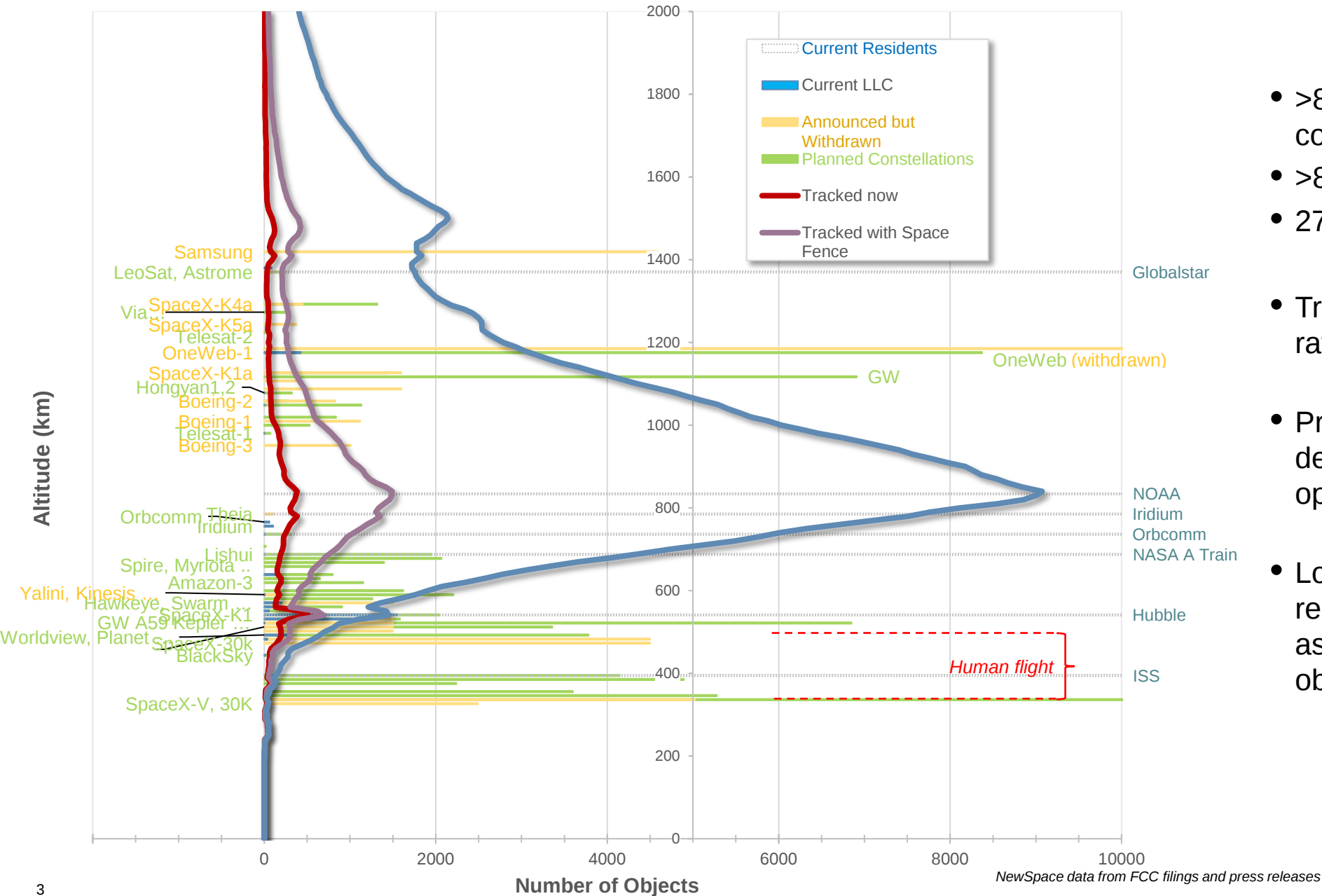
Space Traffic Management Challenges

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New Space Activity is dramatically changing the landscape



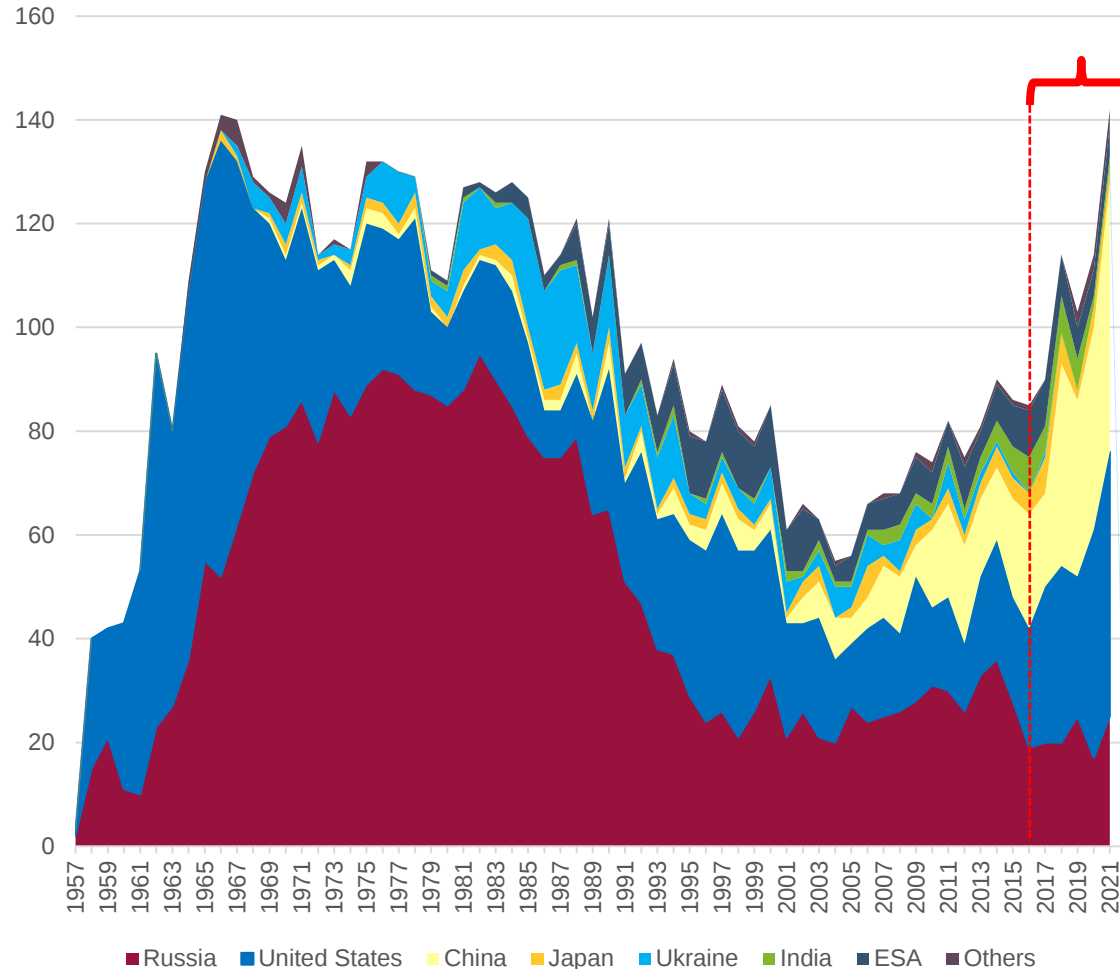
- >85,000 sats in large LEO constellations (LLCs) planned
- >82,000 sats in canceled LLCs
- 2785 sats in LLCs are flying
- Traffic patterns and conjunction rates are changing
- Predicted changes in orbital density and the impact on operations are occurring
- Long-used safety practices relying on no-maneuver assumptions are becoming obsolete

NewSpace Activity shows dramatic changes in all metrics

The proportion of active spacecraft is rising fast



Launches per Year



Population

NASA Orbital Debris Quarterly

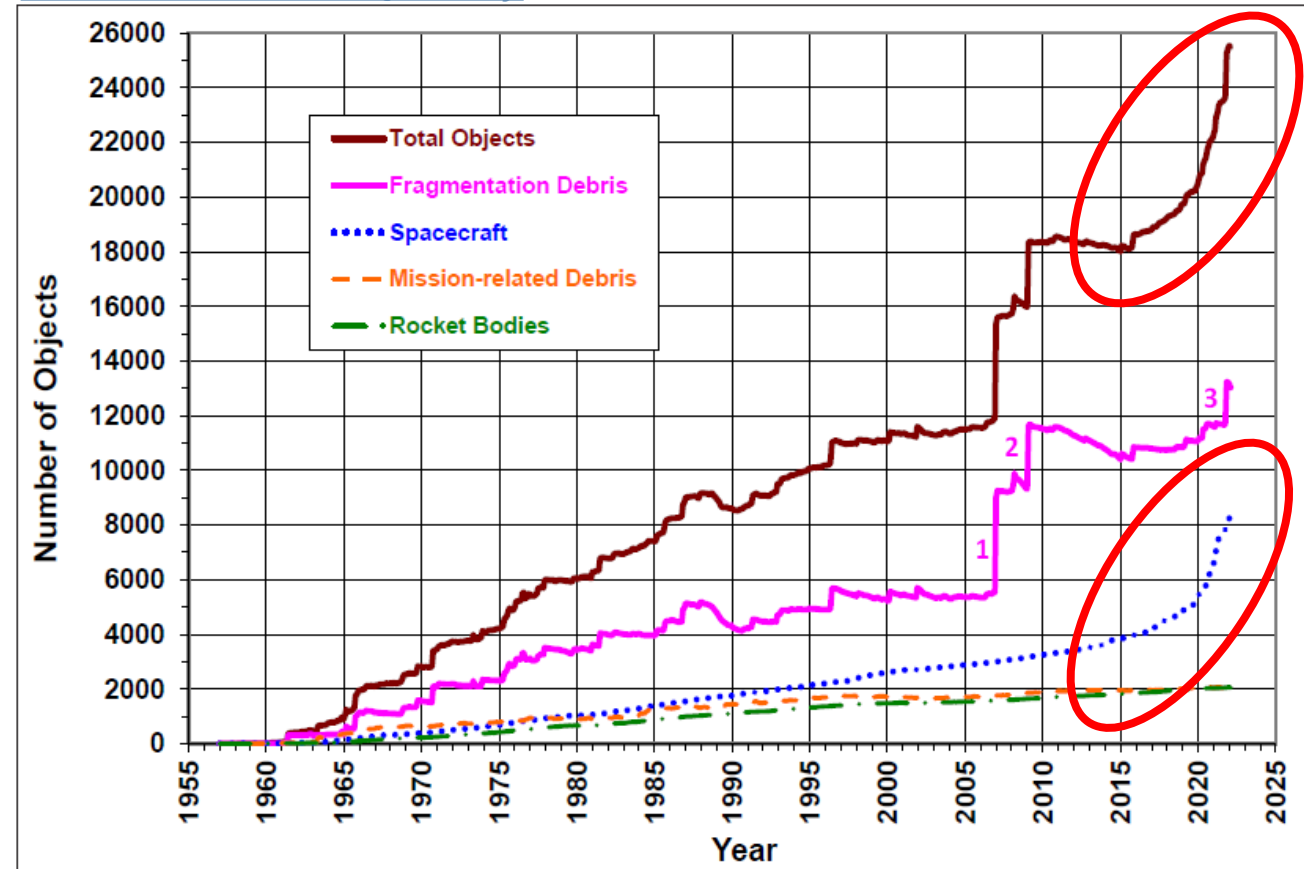


Figure 4. Historical increase of the cataloged objects based on data available on 1 March 2022. The three upward jumps in fragmentation debris correspond to (1) the ASAT test conducted by China in 2007, (2) the accidental collision between Iridium 33 and Cosmos 2251 in 2009, and (3) the ASAT test conducted by the Russian Federation in November 2021. More Cosmos 1408 fragments are expected to be added to the catalog in the coming weeks and months.

Changes in Conjunction Rates

Rates are increasing rapidly; shift to more active sats involved; debris is a factor

- Conjunctions are not quite the issue they were in 2015
- Some anecdotal evidence that as operators increase automation, conjunction response is less of an issue.
- More willingness by operators to wait and see?
- Large constellations are building in automated responses

Conjunctions with $P_c > 1e-6$

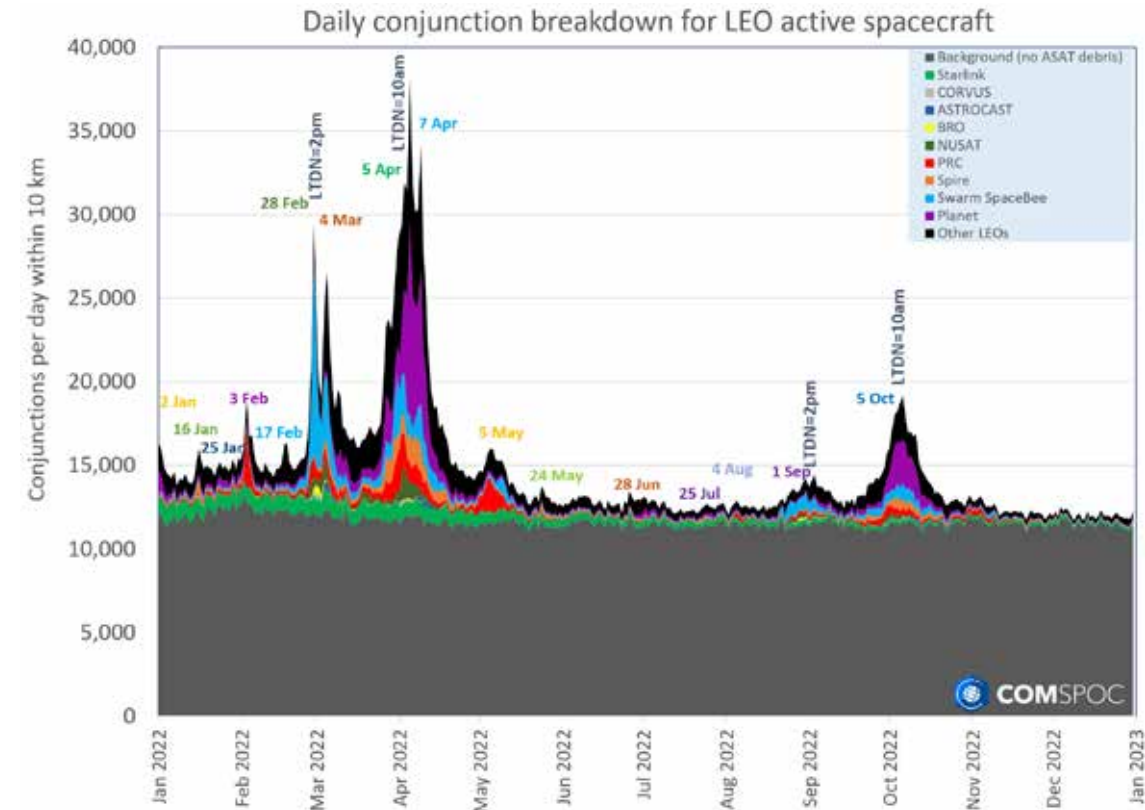
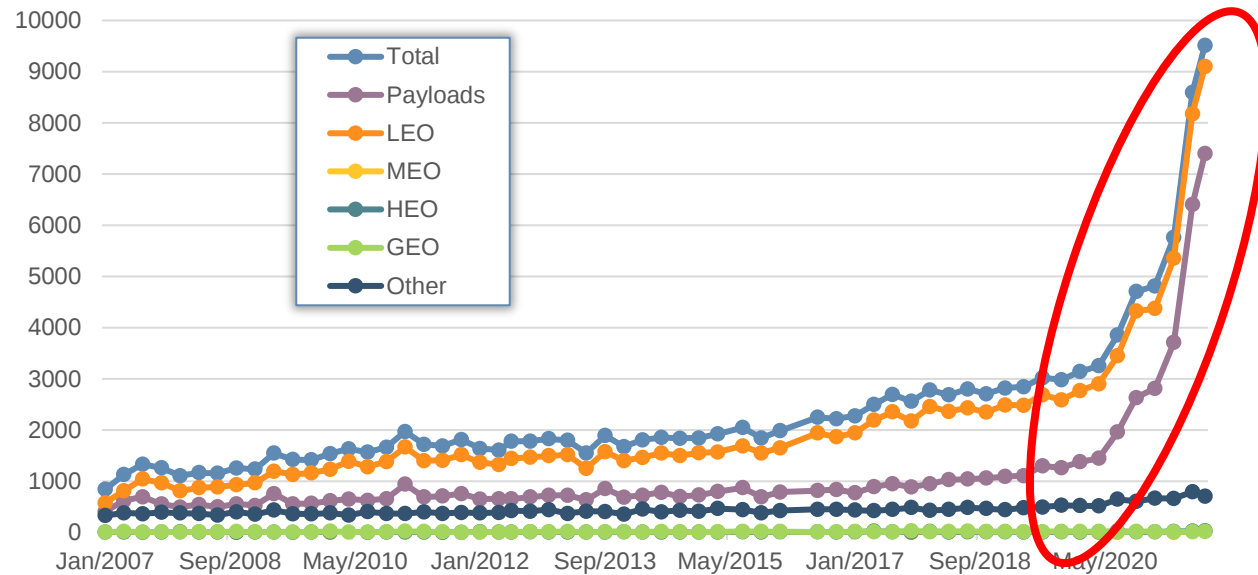


Image courtesy of D. Oltrogge, COMSPOC

Recent launches and ASAT debris are driving a rapid increase in conjunctions and warnings

Astronomy is Adversely Affected



- Light pollution from New Space is interfering with astronomical observations and research
 - *Most (perhaps all) telescopes are “overbooked”*
 - *Any reduction in utility has a severe impact to operations and costs*
- Analysis example: Large Synoptic Survey Telescope, 1296 satellites in LEO
 - *Figure shows number of satellites illuminated at winter and summer Solstice*
 - *Orange bars show satellites at 1200 km, blue bars are at 500km*
 - [Riesbeck_SatLightPollution_03122020.pdf](#)



Major Objectives for OSC

Goal is for OSC to provide the safety mission; SF to concentrate on defense

- Key SPD-3 goals
 - *Enhanced basic safety service, provided free of direct charge as a public good*
 - *Maximize use of commercial SSA data and services*
- Farmer's Market analogy: Government provides enabling infrastructure, vendors provide services
- Defining architecture & procurement; planned to be flexible to maximize commercial participation, allow incorporation of new providers and services
 - **Basic service:** *Issue conjunctions warnings. What the 18th does now, remains free of user fees*
 - *Enhanced by incorporating new sources of data, maneuver plans, improving response times, ...*
 - **Advanced service:** *Provided by commercial SSA service providers*
- Building an integrated master schedule:
 - *FY23: GEO Pilot shadowing demonstrations*
 - *IOC: FY24*
- Considering the role of commercial SSA
 - *Observations of poorly tracked objects (~4000); shore up the catalog*
 - *Negotiating commercial data purchases*

Must be a balance between the NSS "Authoritative Catalog", and opening the door for commercial SSA

Non-Government Space Community Steps Up

Norms and Standards Developments

- **CONFERS** - Consortium for Execution of Rendezvous and Servicing Operations
 - Developing best practices from government and industry on PRO and on-orbit servicing (OOS)
 - Developing a new foundation of space-based capabilities through multi-stakeholder experts from industry, academia, government, and international community
 - Publishing non-binding, consensus-derived technical and operational standards for RPO and OOS
- **Space Safety Coalition**
 - Ad hoc coalition of companies, organizations, and industry stakeholders
 - Developing best practices for the sustainability of space operations
 - Focus on collision avoidance, launch, debris reentry, radio interference
 - Published "Best Practices for Sustainability of Space Operations"; revising now
- **Space Safety Institute** at the Aerospace Corporation
 - Providing independent assessments on space safety, sharing of best practices, and safety education
 - Promoting activities that are safe, supporting economic and scientific development, foster LTS of outer space
 - Mission Areas: Human Spaceflight Safety, Launch and Reentry, SSA, Space Operations, Cyber and Spectrum
 - Current initiatives: **Space Safety Compendium 2022** (expected release October 2022); Framework of commercial human spaceflight safety; Framework to bridge the gap from research to operations; New Actors Workshops



Several bottom-up initiatives focusing on safety



- The overarching goal for space debris mitigation is to **STOP MAKING MORE**
- Encourage all operators to safely remove ALL objects from orbit as soon as possible at the completion of the mission
 - *Even if this potentially increases reentry risk*
- Compliance with post-mission disposal is the single most critical element
 - *HIGH reliability for accomplishing PMD: 90% minimum threshold; 100% goal*
 - *The “25 or 5 Year Rule” is not as critical as high PMD compliance*
- Where possible, treat debris at the system or constellation level, not at the individual satellite level
- Space traffic management options:
 - *Transponders, flight plans, ephemeris sharing*
 - *Rules limiting impacts on neighbors: right-of-way, proximity operations*
- Address **remediation**, in addition to **mitigation: Take more active steps toward Active Debris Removal**



Summary

The predicted changes that NewSpace is driving are happening

- Government is making progress in implementing SPD-3
 - *Steady, but slower than many in the community have hoped*
- The broader community is stepping up with bottoms-up approaches to norms of behavior and standards
- New approaches to collision warning and avoidance will need to be developed for space safety
 - *Must drive down orbit covariances to keep from being overwhelmed by false alarms, identify truly dangerous conjunctions*
 - *On-board, owner-operator data with GPS-level accuracy needed*
 - *Real-time data sharing is essential*
 - *Autonomous maneuvers are problematic, automation is essential*
- Approaches to maintaining the space environment
 - *Should focus on goals, not prescribe solutions*
 - *Start with norms of behaviors and guidelines*
 - *Should be rooted in analysis that shows the rule accomplishes the goal, including cost/benefit*
 - *Should be scaled to the operational and environmental impact*