Space Traffic Control and Space Debris

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Topic to be covered

- UN Space Debris Mitigation Guidelines
- Preventing Collisions
- Space Traffic Control Service
- Service Requirements and Issues
- Possible Organizational Approach
- How Might Service Affect Debris Growth?
- Current Capabilities
- Summary & Conclusions

Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space

Guideline 1: Limit debris released during normal operations

Guideline 2: Minimize the potential for break-ups during operational phases

Guideline 3: Limit the probability of accidental collision in orbit

Guideline 4: Avoid intentional destruction and other harmful activities

Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy

Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission

Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission

Perspective of this Briefing

IADC Guideline 3: Limit the probability of accidental collision in orbit

Options:

1. Remove dead or dying objects from orbit (Guidelines 6 & 7)
   - *Recent NASA study recommends removal of 2 or more large debris objects from highly populated regions*
   - *Would slow debris growth*
2. Move satellites to avoid collisions
   - *Reduce collisions with operating satellites*
   - *Slow debris growth*

Past On-Orbit Collision Events: Could they have been prevented?

- 1991: Non-operational Russian Cosmos navigational satellite collided with debris from a sister Cosmos satellite
  - *No control over objects*
  - *Collision unavoidable*
- 1996: French satellite CERISE damaged by fragment from Ariane rocket body
  - *Collision severed stabilizing boom on Cerise; some functionality recovered*
  - *Collision probability ~1x10^{-6}*
  - *Data quality not sufficient for maneuver*
  - *In theory, could have been avoided*
- 2005: Final stage of a US Thor Burner 2A rocket collided with fragment from upper stage of Chinese Long March 4
  - *No control over objects*
  - *Collision unavoidable*
- 2009: Iridium and COSMOS
  - *Collision probability ~1x10^{-5}*
  - *Data quality not sufficient for maneuver*
  - *In theory, could have been avoided*

Space Traffic Control Service

A service that uses space tracking and other data to look for and assess close approaches among orbiting objects and provides timely warnings to satellite operators of close approaches that exceed an action threshold

- Warnings to operators of close approaches by tracked objects
- Warning of other interference events (e.g., radio frequency interference (RFI))
- Assistance to operators in assessing maneuvers
- Assistance to governments (regulatory, compliance information, other information)

Top-Level Requirements

- Incorporate data from ALL operators
  - *All private operators*
  - *All government-operated satellites*
- Operator requirements
  - *Protect proprietary and sensitive data*
  - *Satellites able to maneuver*
  - *Satellite operators coordinate maneuvers with others*
  - *Operators provide data on satellite positions and maneuvers*
- Government requirements
  - *Protect sensitive data*
  - *Get information on satellite maneuvers*
  - *Know what satellites are operating where to assist government regulators in the assignment of operational orbits and slots.*
  - *Assure operators meeting government requirements*
    - Regulatory, licensing or treaty requirements
    - Space debris mitigation requirements

Service Requirements

- Ongoing, reliable (24 hour/7 days a week)
- Includes best-available tracking data on all orbiting objects
  - *Operator data on satellite locations and maneuvers*
  - *Government tracking data*
  - *Good quality commercial tracking data and services*
- Available to all satellite operators
- Provides accurate, timely, meaningful warnings
- Assists operators with problems
  - *Verifies maneuver plans for collision avoidance*
  - *Provides contact points for mitigation planning*
  - *Provides specialized services (e.g., mission planning, orbit insertion)*
- Works with governments
  - *Information on operator activities (spacecraft deorbits, repositioning)*
  - *Contact points*

Issues

- Assuring that service meets operator and government needs
- Assuring protection includes all tracked objects
- Liability for space traffic control service provider
- Liability for satellite operator that fails to take action given notice
- Liability if operator takes action and something bad happens
- Sources of data and data protection
- Organization type and structure that is trusted by governments and non-governments

Possible Organizational Approach

- International Space Operations Clearinghouse (ISPOC)
  - *Nonprofit organization*
  - *Board of directors with members from*
    - Governments of space-faring nations
    - Major non-government satellite operators
  - *Accept and integrate tracking and maneuver data from governments, operators, other sources; Board assures data is protected*
  - *Provide data to governments on locations, planned maneuvers of subscriber's satellites (governments conduct own analyses for sensitive satellites; interface with ISPOC or operators if problems predicted)*
  - *Provide warnings of coming close approaches customized for specific operators*
  - *Verify that planned maneuvers lower probability of collision, don't create future hazard*
  - *Could expand to provide warnings of radio frequency, other interference*

Impact on Space Debris Growth

Study of risk to GEO satellites*+

- Risk of collision at GEO is 1 every 135 years
  - *Debris on debris: 1 every 1086 years*
  - *Involving active satellite: 1 every 155 years*
- Maneuver each active satellite to reduce collision probability by factor of 10 (90% reduction)
- Residual risk of collision of active GEO satellite with another object reduced by factor of 5 (1 every 776 years)
- Overall collision rate dropped factor of 3.3 to 1 every 454 years

*Ailor, W.H. and Peterson, G.E., "IAC-04-IAA.5.12.3.01, 55th International Astronautical Congress of the International Astronautical Federation, the International Academy of Astronautics, and the International Institute of Space Law, Vancouver, British Columbia, Oct. 4-8, 2004.

+Assumes 2000 catalog, no additions or subtractions; >400 primary satellites (within 300 km of GEO altitude) plus all objects passing through; actual tracking data

Current Capabilities

- The Aerospace Corporation & MIT/Lincoln Laboratory have provided services
- Consortium of private operators and commercial company (Center for Space Standards and Innovation of AGI) providing prototype service for GEO satellites
- ESA, others providing service for several satellites
- Air Force and NASA provide coverage for crewed vehicles
- Predictive tools available
- Challenge is developing acceptable, comprehensive service that uses best data

Summary & Conclusions

- Space traffic control could lower probability of active satellite being involved in collision and slow growth of space debris population
  - *Could drop collision rate for active GEO satellite by factor of 5; overall GEO collision rate by factor of 3*
  - *Similar trend expected for other orbital regimes (recommend study of effect on evolution of LEO debris population)*
  - *Projections of debris evolution should include effect of active space traffic control service*
- Risk of low probability collisions among tracked objects remains
- Space traffic control service must protect all active satellites
- Task is doable given tracking data of sufficient quality
- Need to develop approach acceptable to governments and commercial satellite operators