

Massive Collision Monitoring Activity (MCMA)

Examining Urgency and Options for Debris Remediation

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Dr. Darren McKnight

International Association for the Advancement of Space Safety

in cooperation with

International Academy of Astronautics

Integrity Applications, Incorporated

Are we solving the right problems?

Relevant to consider, but...

- Cascading effect of collisions (i.e., Kessler Syndrome) over many decades
- Constellations of smallsats
- Debris interactions are random and difficult to predict making active debris removal (ADR) seem less urgent

... should focus more on.

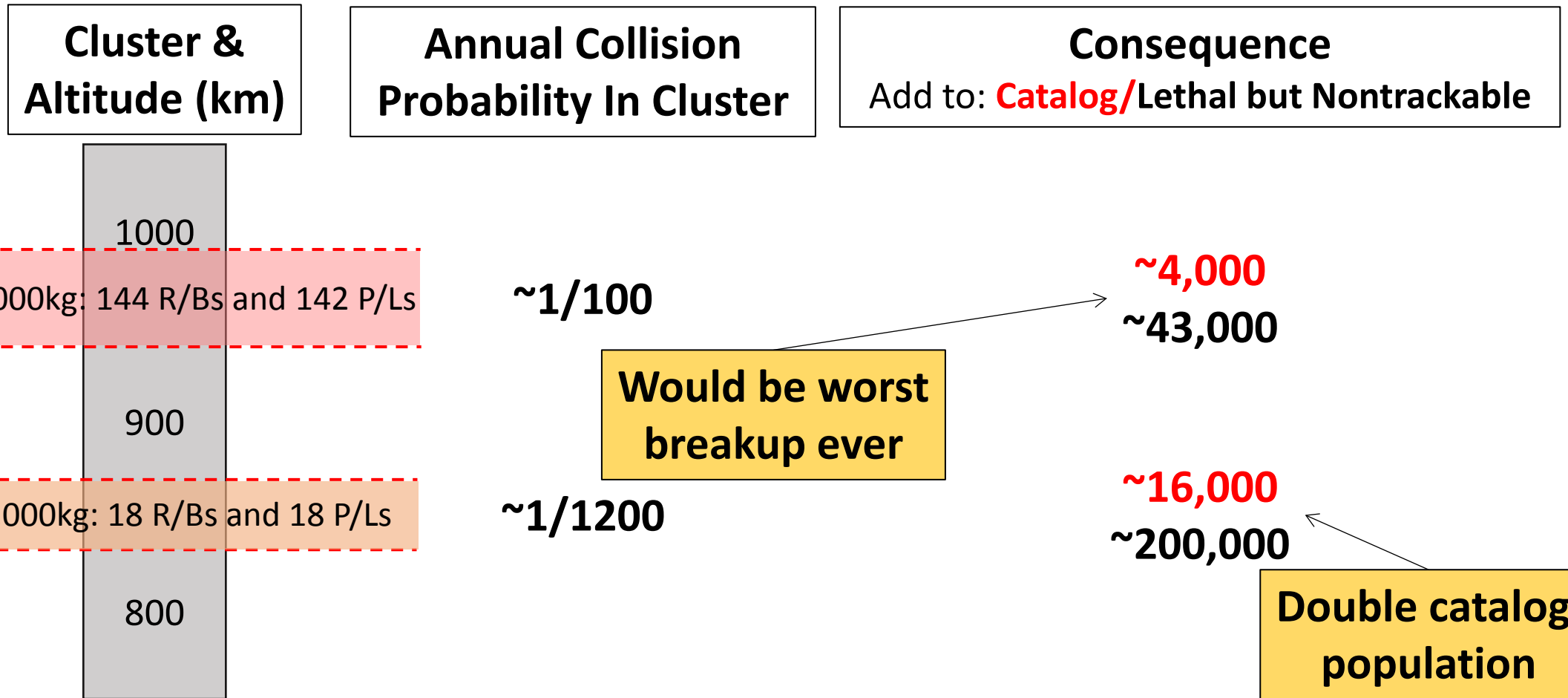
- Space flight safety – how and how often are satellite operations disrupted by debris
- Clusters of massive derelicts
- Special subsets of massive derelicts encounter each other at higher rates with greater consequence – **act now!**

How to Proceed – The “Right” Questions!

- Focus on highest risk events
 - ✓ Probability → not random, in clusters
 - ✓ Consequence → most mass will create most debris
- Determine “true” probability
 - ✓ Monitor encounter rates and compare to typical models
- Characterize cluster dynamics
 - ✓ Leverage behavior to reduce future risk from debris

$$\text{Risk} = \text{Probability} \times \text{Consequence}$$

Cluster Risk – Greater Than “Average”

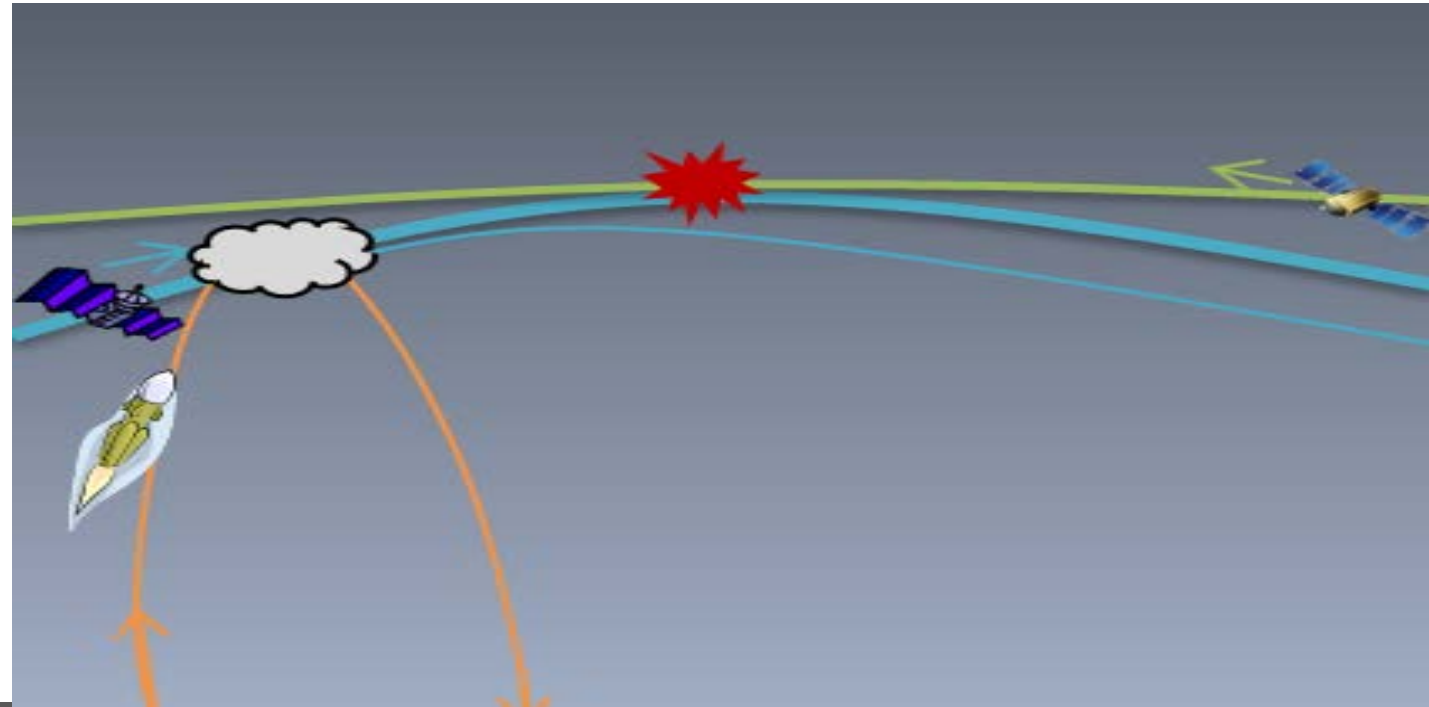


MCMA Results – Clear warning: Do Not Ignore!

- C975 (~4,000 frags) has had 10 near misses less than 100m in last year
 - ✓ **10% chance that two of these would have already collided**
- C850 (~16,000 frags) has had 3 near misses less than 500m in last year
 - ✓ **1% chance that two of these would have already collided**
- Clusters are interacting at rates several times faster than anticipated
- **Near misses and increased interactions motivate need for ADR urgency!**
- Can predict conjunctions between cluster members 5-7 days in advance
 - ✓ This may enable new debris remediation approaches

New Debris Remediation Options/Insights

- If we can predict the most consequential events 5 days in advance then...
 - ✓ Just-in-Time Collision Avoidance (JCA) → “Nudge” a satellite to prevent collision
 - Work cooperatively with ADR
- Just-in-Time ADR (JADR) might greatly improve return on investment of ADR
 - ✓ Each JCA/JADR mission prevents one massive collision
 - ✓ “Typical” ADR needs 35-50 removals to stop one collision



Observations and Conclusions

- **There should be renewed urgency...**
 - Understand the probability and outcomes of **massive-on-massive collisions**
 - Focus on culture of safety → **cannot ignore near misses**
 - Start executing ADR missions → maybe even **Just-in-Time ADR**
 - Refine Just-in-time Collision Avoidance (JCA) → **emergency response**