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AGI

APPLICATION OF NEW DEBRIS RISK EVOLUTION AND DISPERSAL (DREAD) TOOL TO CHARACTERIZE POST-FRAGMENTATION RISK

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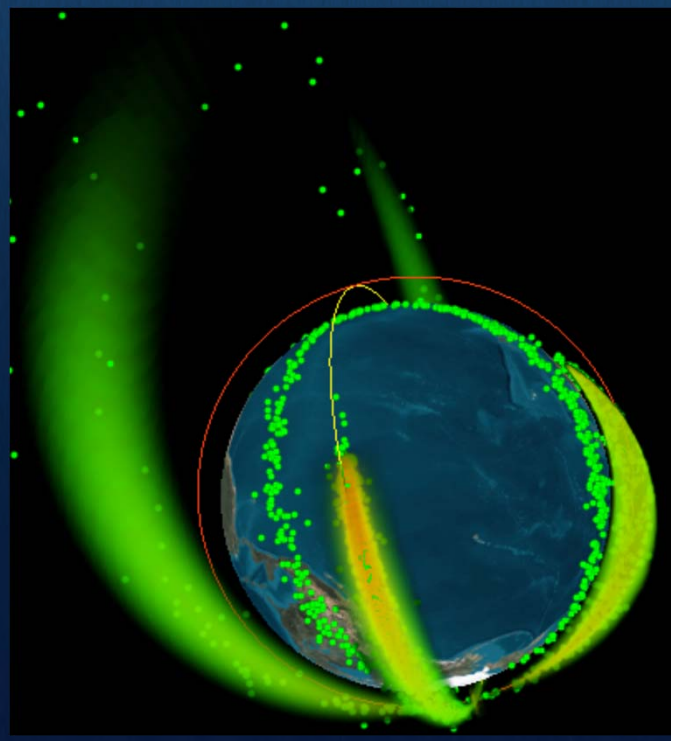
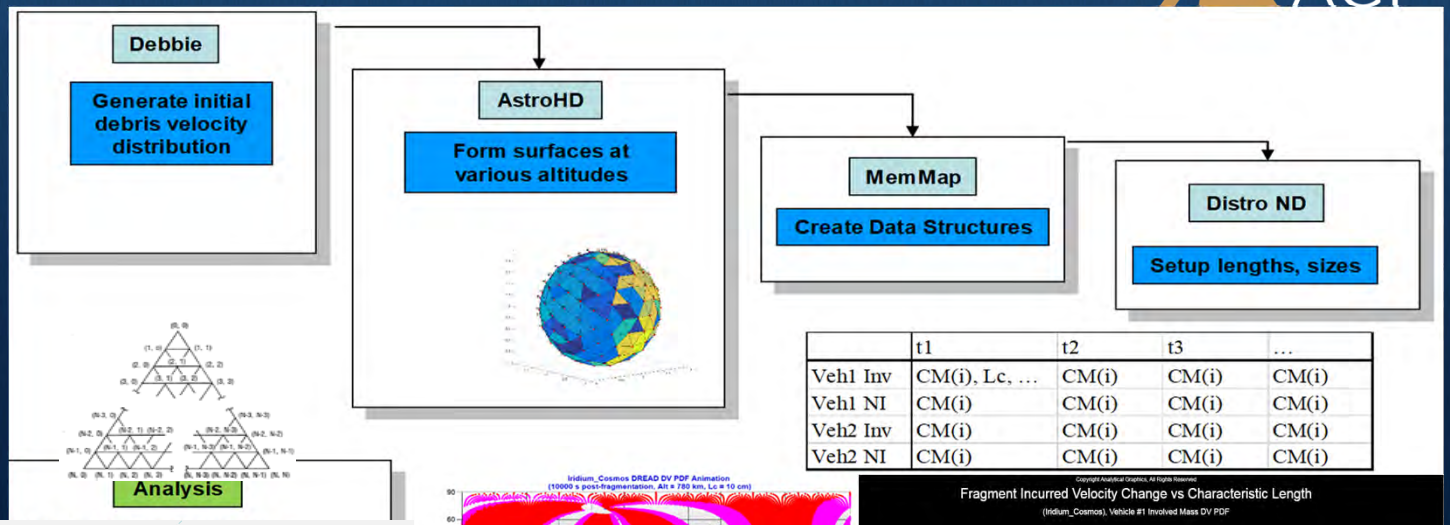
Overview

- DREAD tool
  - Purpose: Determines post-fragment Debris Risk Evolution and Dispersal in first week
  - Complementary w/Lewis/Colombo activity for longer-term debris field evolution
- Validation against Iridium/Cosmos
- Additional Case Studies
  - GEO Case: Hypothetical low velocity
  - LEO Case: Iridium-Cosmos explosion
  - GEO Case: Hypothetical explosion

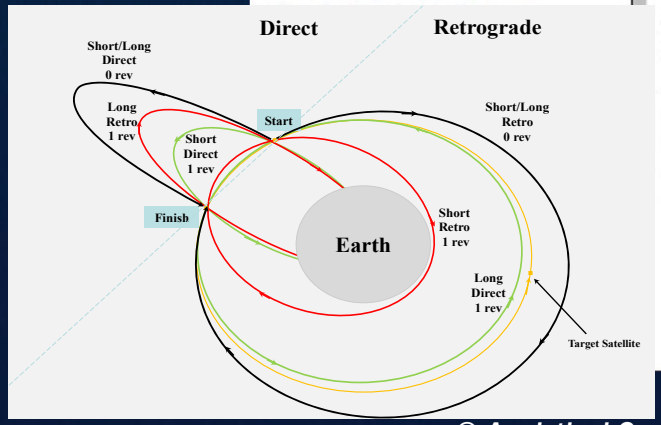


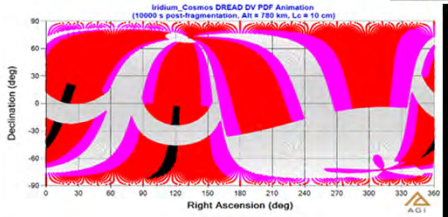
DREAD Overview

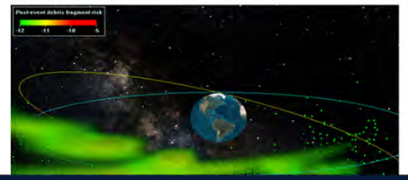


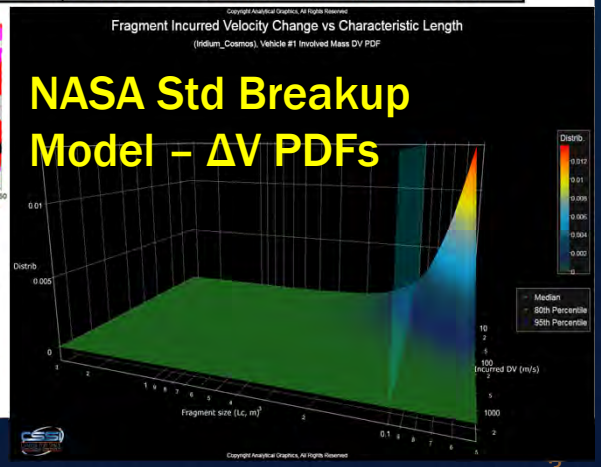
	t1	t2	t3	…
Veh1 Inv	CM(i), Lc, …	CM(i)	CM(i)	CM(i)
Veh1 NI	CM(i)	CM(i)	CM(i)	CM(i)
Veh2 Inv	CM(i)	CM(i)	CM(i)	CM(i)
Veh2 NI	CM(i)	CM(i)	CM(i)	CM(i)

Lambert problem & full complement of solutions









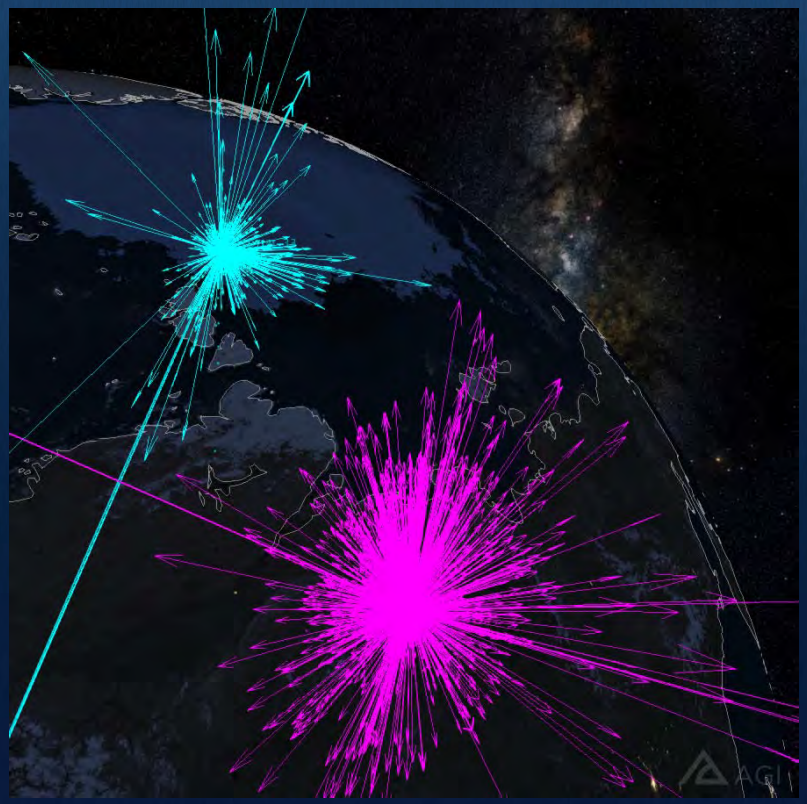
“Validation” Against Iridium/Cosmos Collision

- Difficult to have definitive test cases
  - Rely on publically released TLEs
    - Larger fragments dominate
    - Timing/release of TLEs spans years
- Iridium/Cosmos good validation case
  - Many fragments, many still in orbit
- Evaluated 29.3 billion DREAD event-to-grid point cases
- Generated 2D and 3D animations

Fragmentation imparted velocity distributions

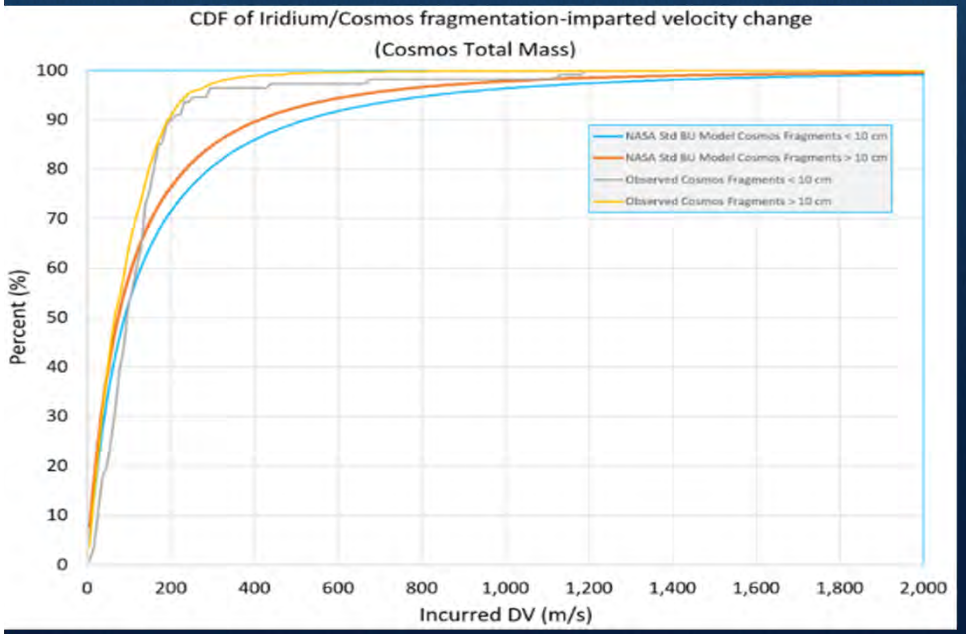
TLE-based relative velocity spread
(T.S. Kelso, AMOS, 2009)

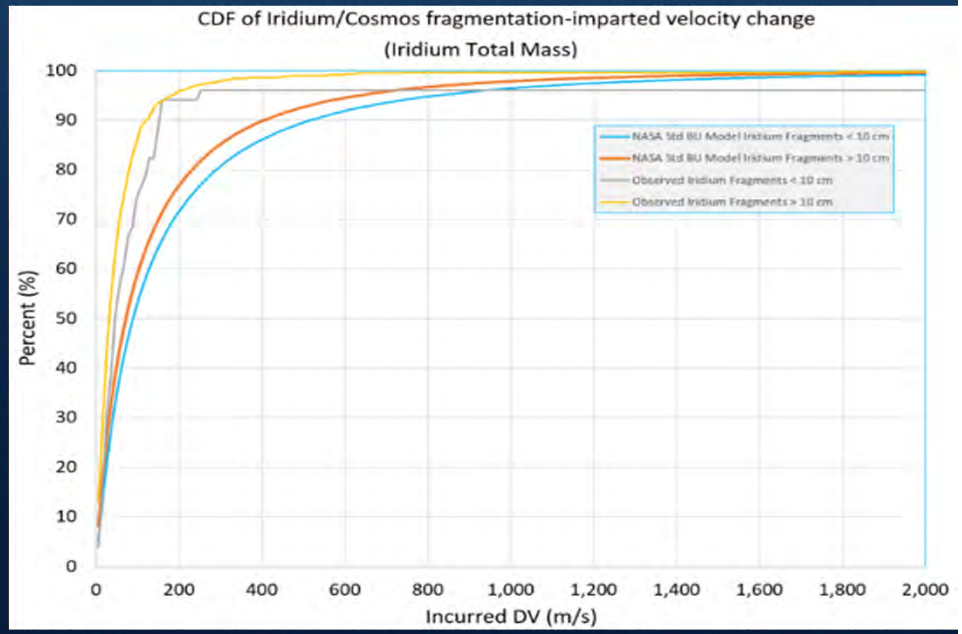
(Iridium 33/Cosmos 2251)



TLE-based relative velocity spread
(2017)

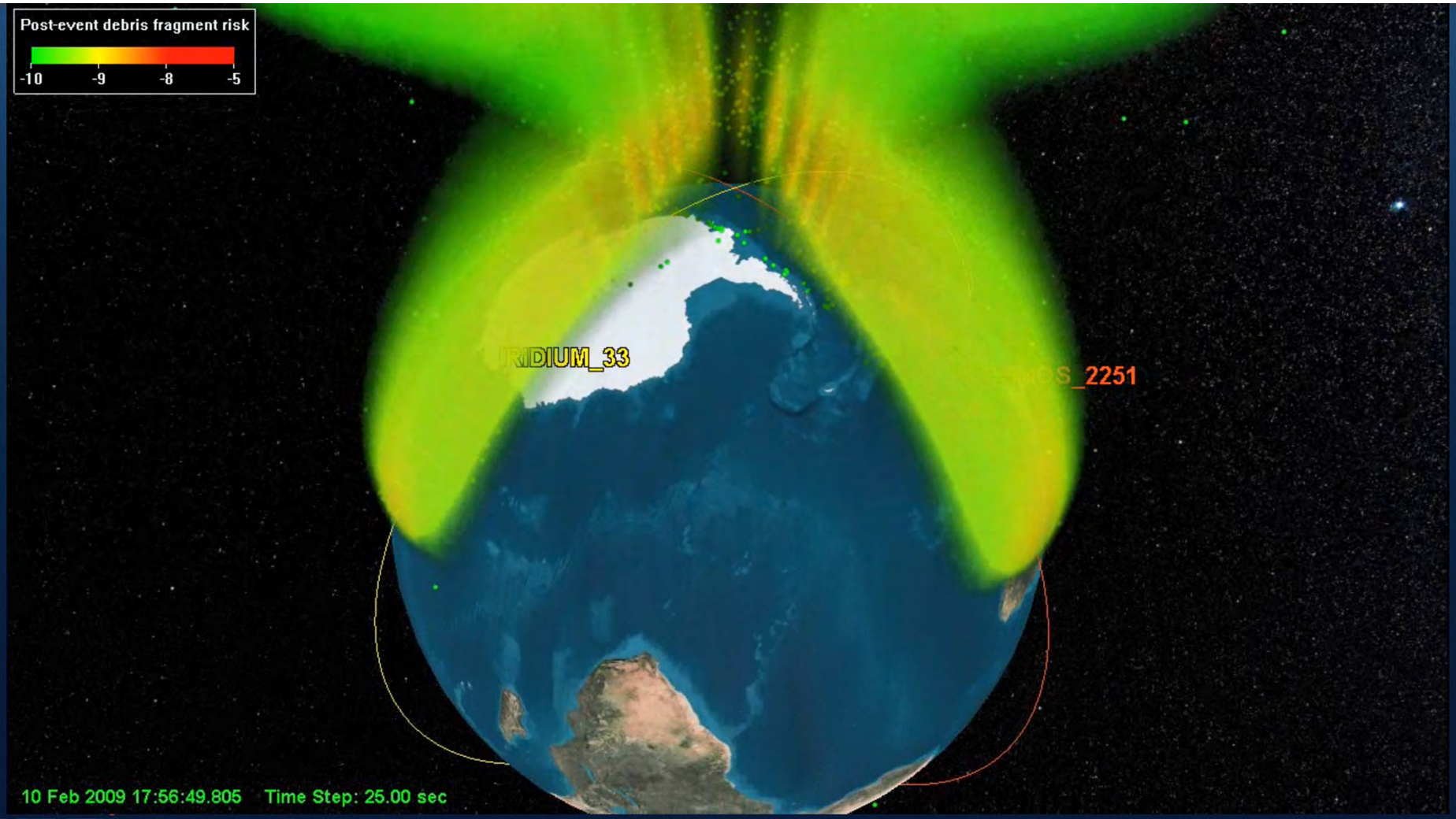
Cumulative Velocity Distribution



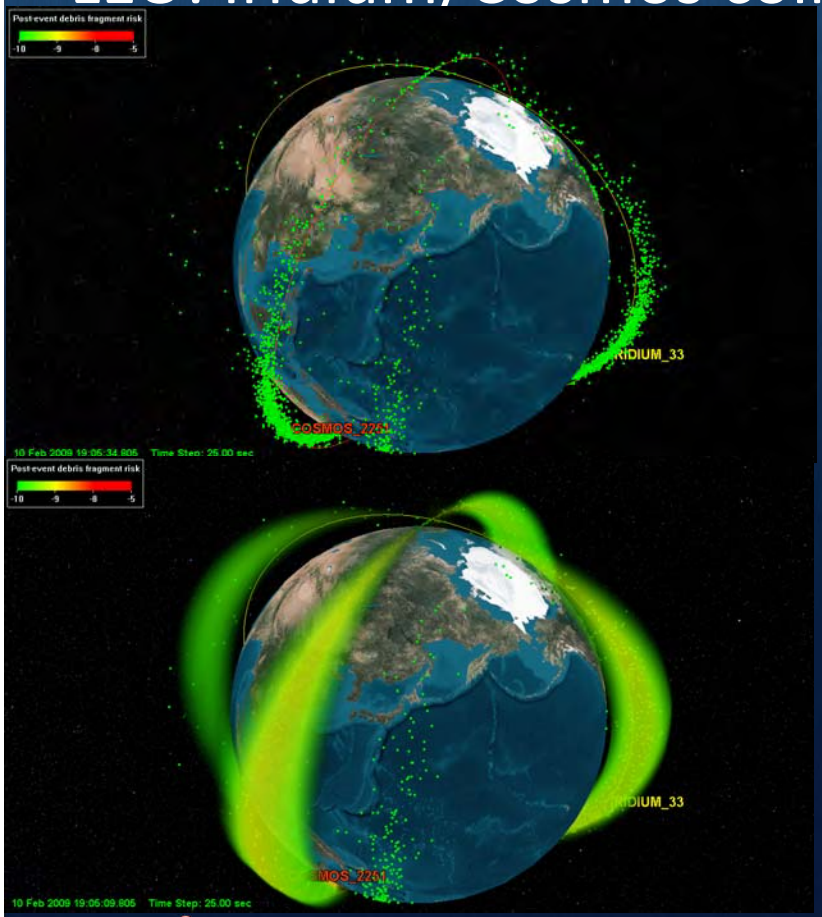


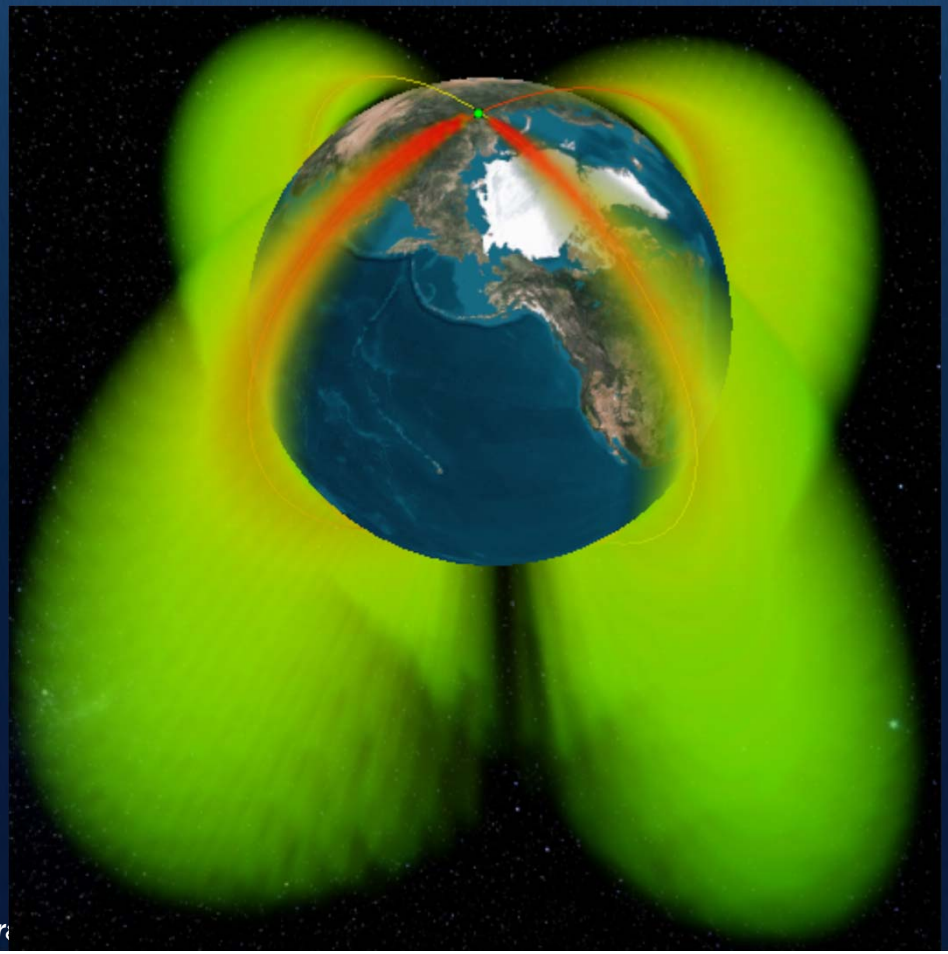
Cosmos

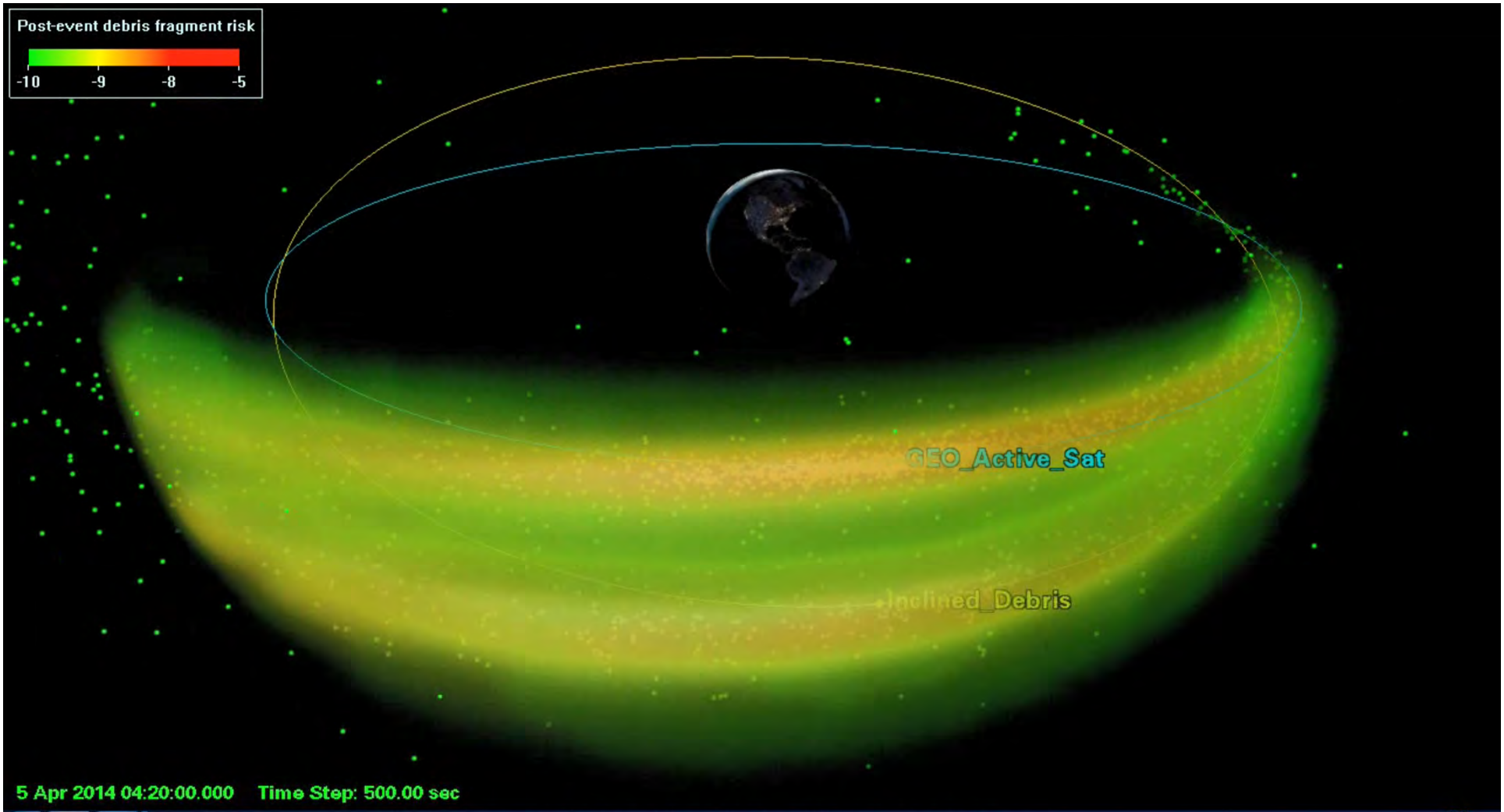
Iridium



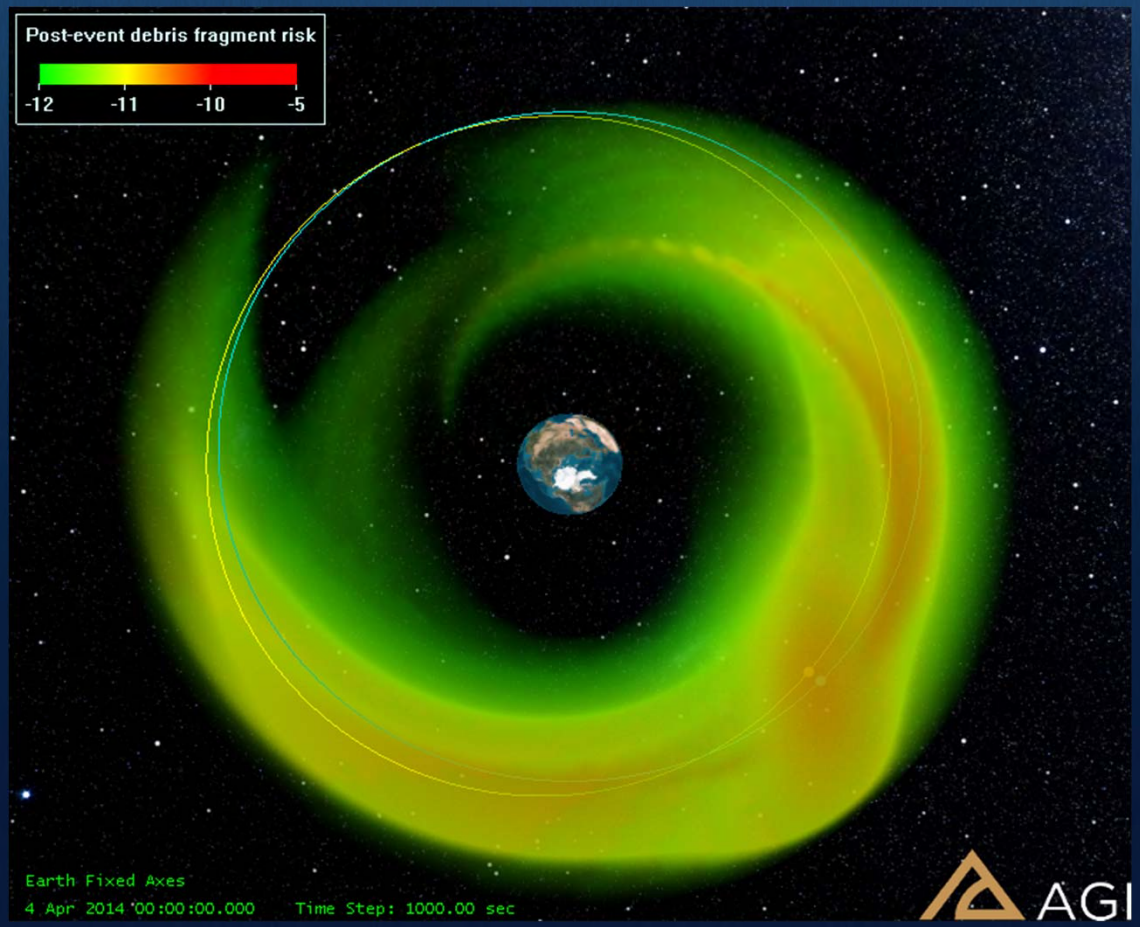
LEO: Iridium/Cosmos collision







Aggregated risk over 100,000 sec simulation…



Identifying satellites at greatest risk from debris

- Can then fly all active satellites thru DREAD debris portrayal
  - Integrate combined relative probability along trajectories
  - Sort resulting identified S/C in descending order of risk
- DREAD facilitates notifying satellite operators in advance if greatest relative risk periods

Iridium/Cosmos: Top 20 S/C (greatest relative risk)

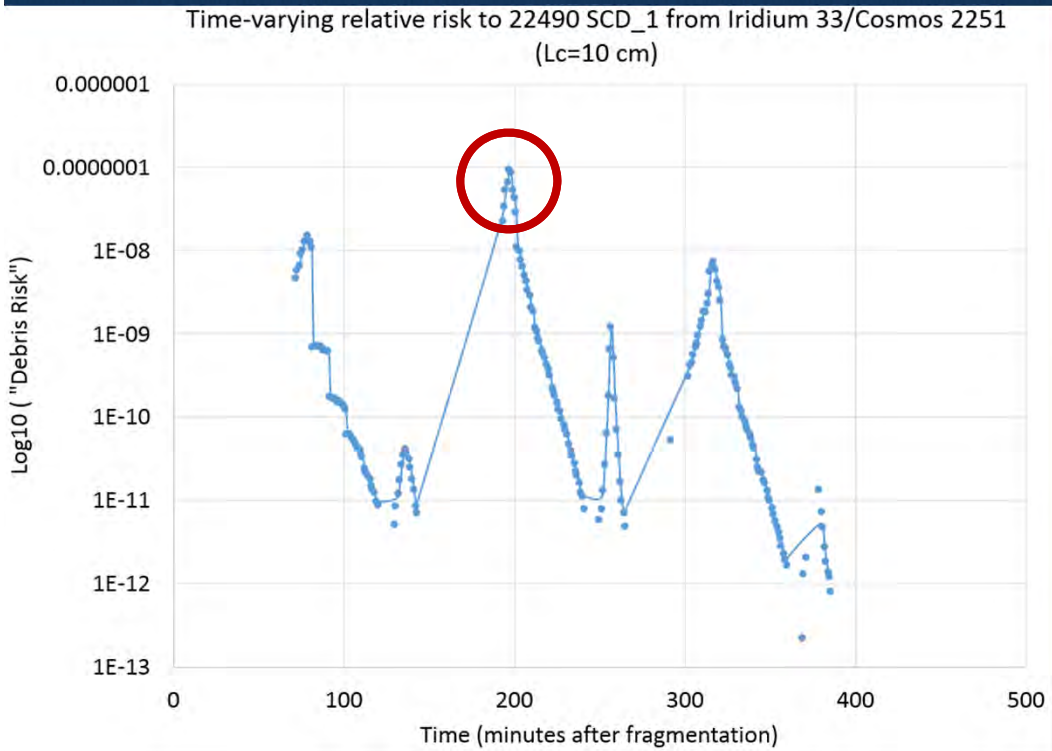
SSC	Intl Desig	Risk to S/C
22490	SCD 1	7.32E-07
24949	IRIDIUM 30	3.06E-07
25274	IRIDIUM 58	2.51E-07
25475	ORBCOMM FM21	2.05E-07
24869	IRIDIUM 15	2.02E-07
15427	NOAA 9	1.87E-07
27375	IRIDIUM 95	1.76E-07
27374	IRIDIUM 94	1.72E-07
24950	IRIDIUM 31	1.53E-07
25272	IRIDIUM 55	1.38E-07
25414	ORBCOMM FM18	1.35E-07
31118	SAUDISAT 3	1.28E-07
27372	IRIDIUM 91	1.21E-07
25275	IRIDIUM 59	1.17E-07
31124	SAUDICOMSAT 5	1.03E-07
24795	IRIDIUM 5	1.01E-07
25117	ORBCOMM FM05	1.01E-07
29499	METOP-A	9.66E-08
25276	IRIDIUM 60	9.06E-08
33321	HUANJING 1B (HJ-1B)	7.03E-08

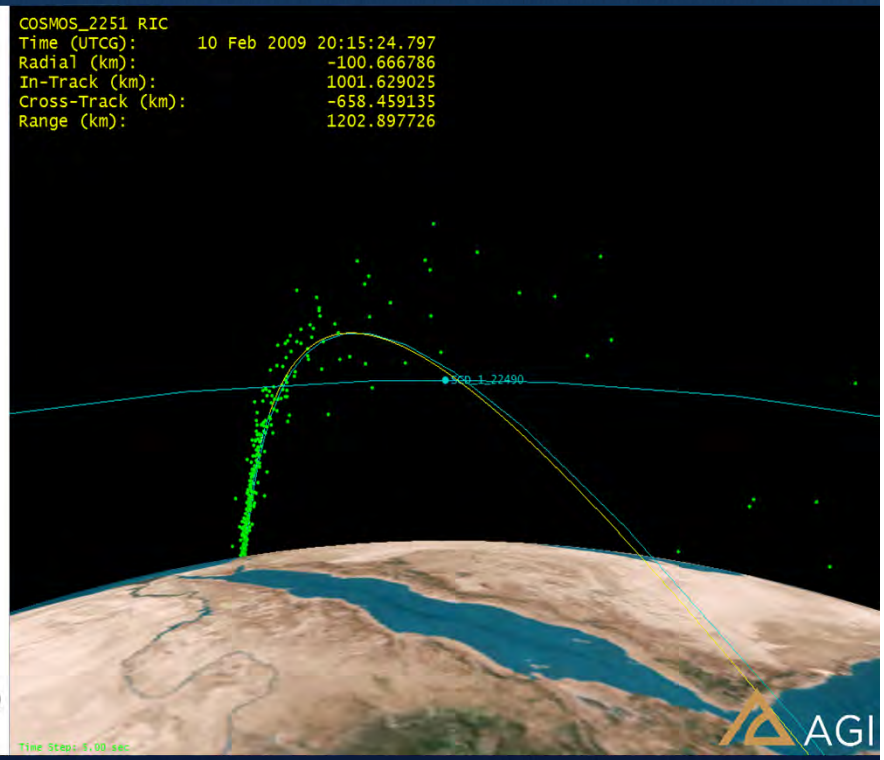
Hypothetical GEO: Top 20 S/C (greatest relative risk)

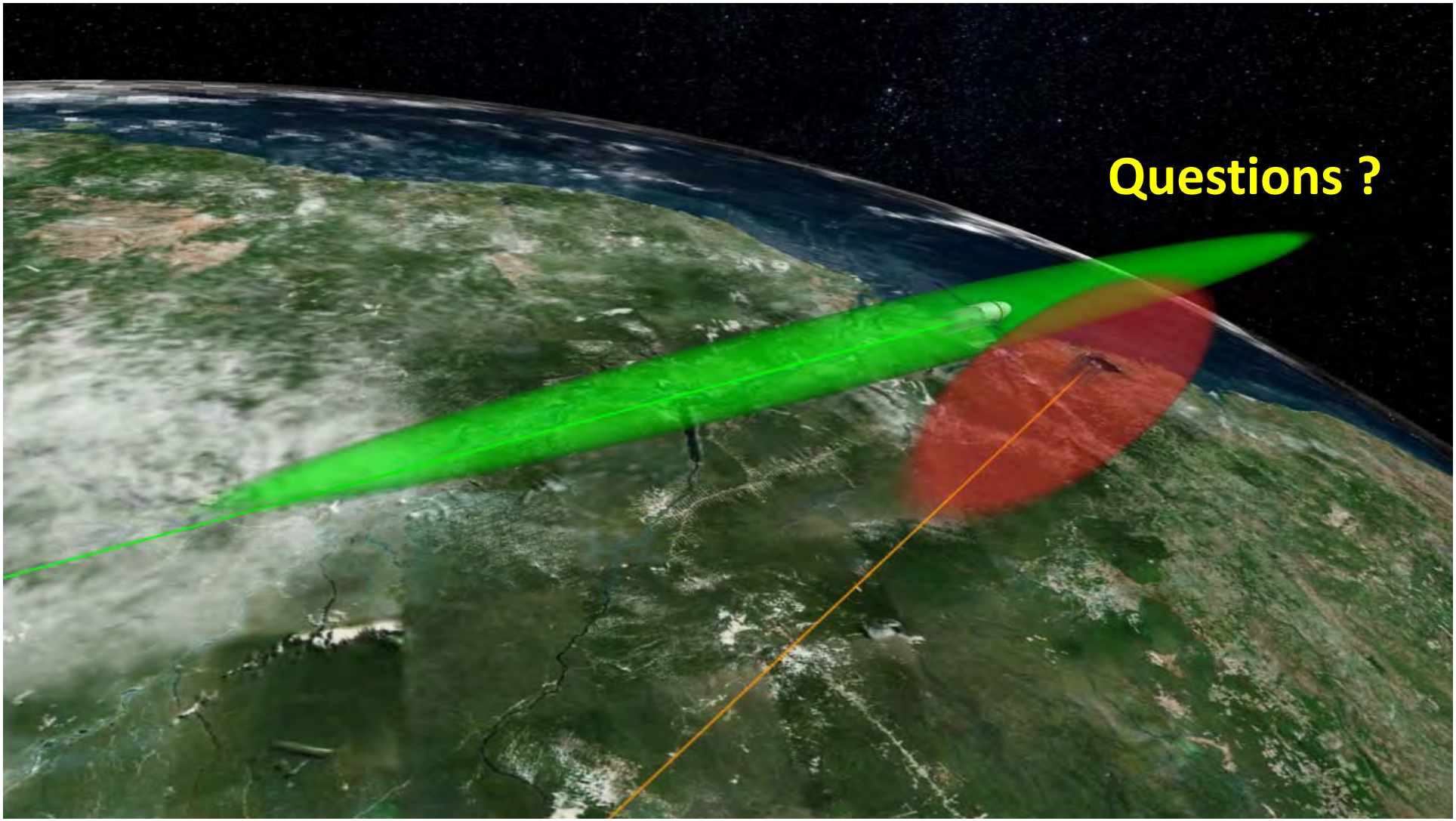
SSC	Intl Desig	Risk to S/C
25740	NIMIQ 1	2.52E-07
26469	BRASILSAT B4	2.41E-07
38551	ECHOSTAR 17	2.07E-07
27426	DIRECTV 5 (TEMPO 1)	1.98E-07
28868	ANIK F1R	1.92E-07
27501	ECHOSTAR 8	1.58E-07
29236	GALAXY 16 (G-16)	1.45E-07
27445	GALAXY 3C (G-3C)	1.43E-07
36397	INTELSAT 16 (IS-16)	1.43E-07
28472	AMC-16	1.32E-07
37809	SES-2	1.22E-07
37816	EUTELSAT 7 WEST A	1.17E-07
33275	AMC-21	1.13E-07
27854	GALAXY 23 (G-23)	1.05E-07
38342	NIMIQ 6	1.00E-07
25371	INTELSAT 805 (IS-805)	9.12E-08
32951	GALAXY 18 (G-18)	8.91E-08
24315	AMC-1 (GE-1)	8.82E-08
35873	NIMIQ 5	8.41E-08
23754	ECHOSTAR 1	8.26E-08

Comparison of DREAD and DEBBIE (in STK)

- SCD 1 flying thru fragmentation field at peak relative risk






Questions ?