Low Earth Orbit Kinetic Space Safety Workshop

Closing Comments…

Darren McKnight
Senior Technical Fellow
LeoLabs

4-5 May 2022
Lausanne, Switzerland

LEO LABS clearspace today AXA EPFL SECURE WORLD FOUNDATION

Thanks to all in attendance and on-line…

amazing event!

- Neutral country but not a time to be neutral on space safety.
- Support governments, manufacturers, investors, insurers, and operators who are trying to move the community forward.

It Must Be Simple… but It May Not Be Easy!

IMPACT TOLERANCE

- Impact protection: do it early to be most cost-effective
- Fault tolerance: Iridium reduced exposed area in RAM (Iridium to Iridium NEXT) and reduced debris effects
- Largest variable is environment models

COLLISION AVOIDANCE

- Avoid overlapping constellations
- Operator ephemeris sharing and covariance realism are critical
- Standards and best practices for CA globally useful

MANY OF THESE ARE DRIVEN BY HUMAN INTERACTIONS/PERCEPTIONS

DEBRIS PREVENTION

- Ban ASAT testing
- 25-yr rule is outdated
- Poor prevention adds to remediation and collision avoidance burden

DEBRIS REMEDIATION

- Reduce statistical risk of bad neighborhoods since debris-generating potential driven by dead-on-dead encounters
- Need catalyst to truly launch debris remediation industry
- ADR requires managing reentry risk, as it displace risks, does not eliminate it

Don’t Care About Opinions When Facts Are Available

Close out with a flurry of facts that provide perspective on characterizing efficacy of space safety activities

If You Are Not Moving Forward…

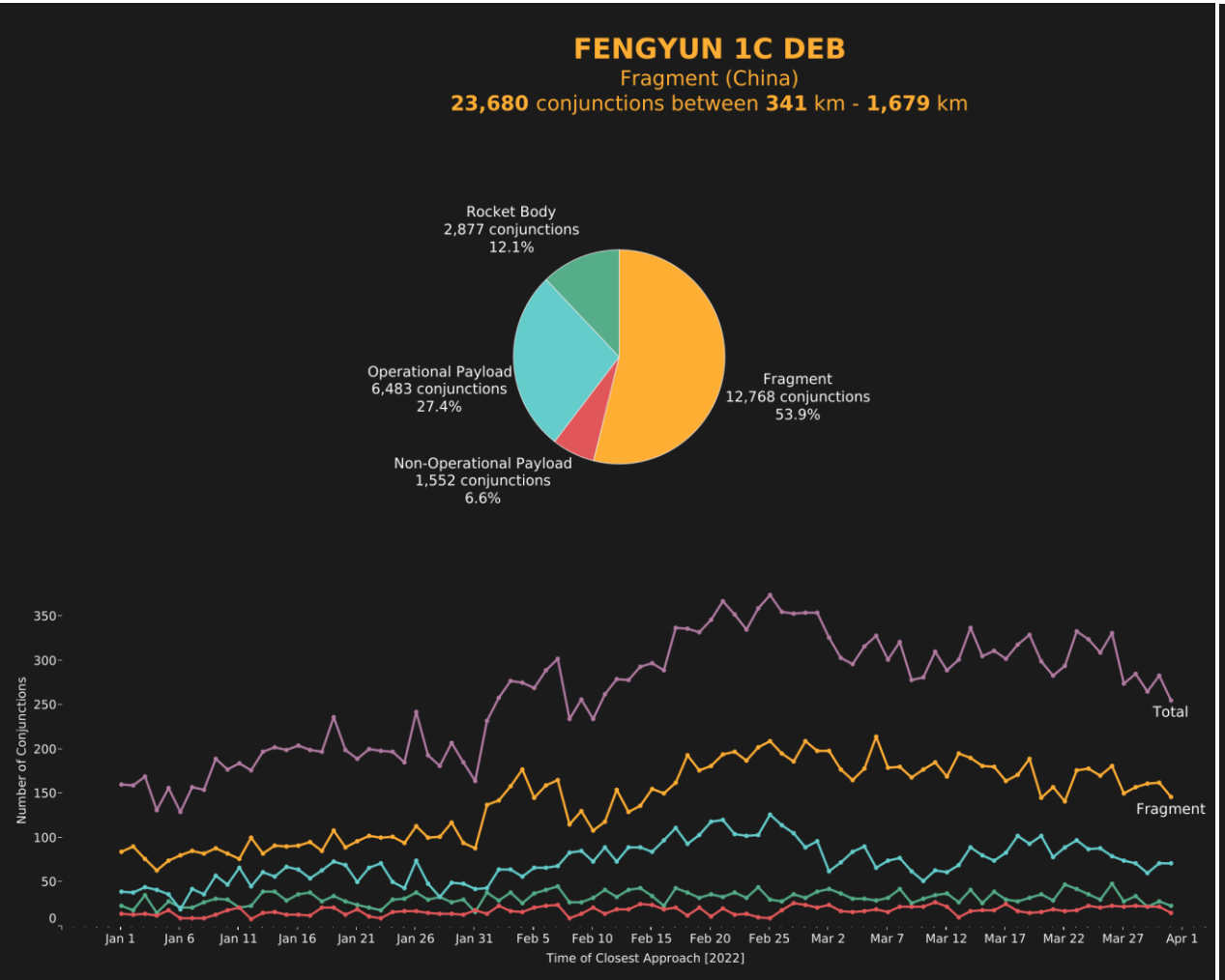
Space ecosystem evolution has a viable, logical, and repeatable pattern: do not fight the riptide - swim parallel to the coast

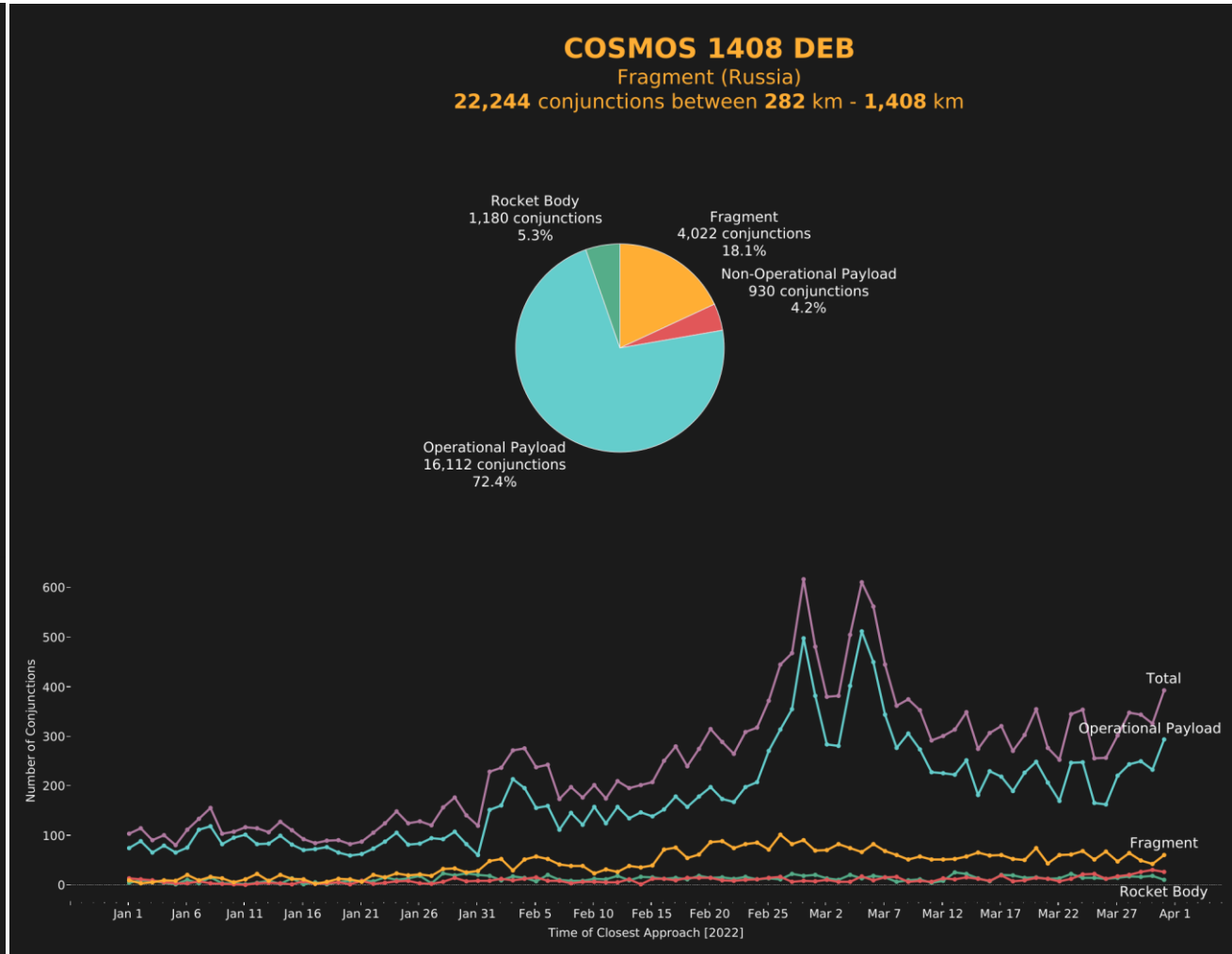
Government-sanctioned capabilities provide foundation for emerging scalable commercial offerings that augment "traditional" capabilities that in combination are better than either alone:

- Space-based Earth Imagery
- Space-based Ground Communications
- Space Launch Vehicles
- SSA/CA/RA Services
- ADR Services

Ban ASAT Tests…

- Two ASAT clouds account for 35% of all conjunctions with PC > 1E-6 in 2022
- Double number of fragments in orbit for Fengyun 1C cloud but nearly triple number of events with operational satellites for C1408 cloud

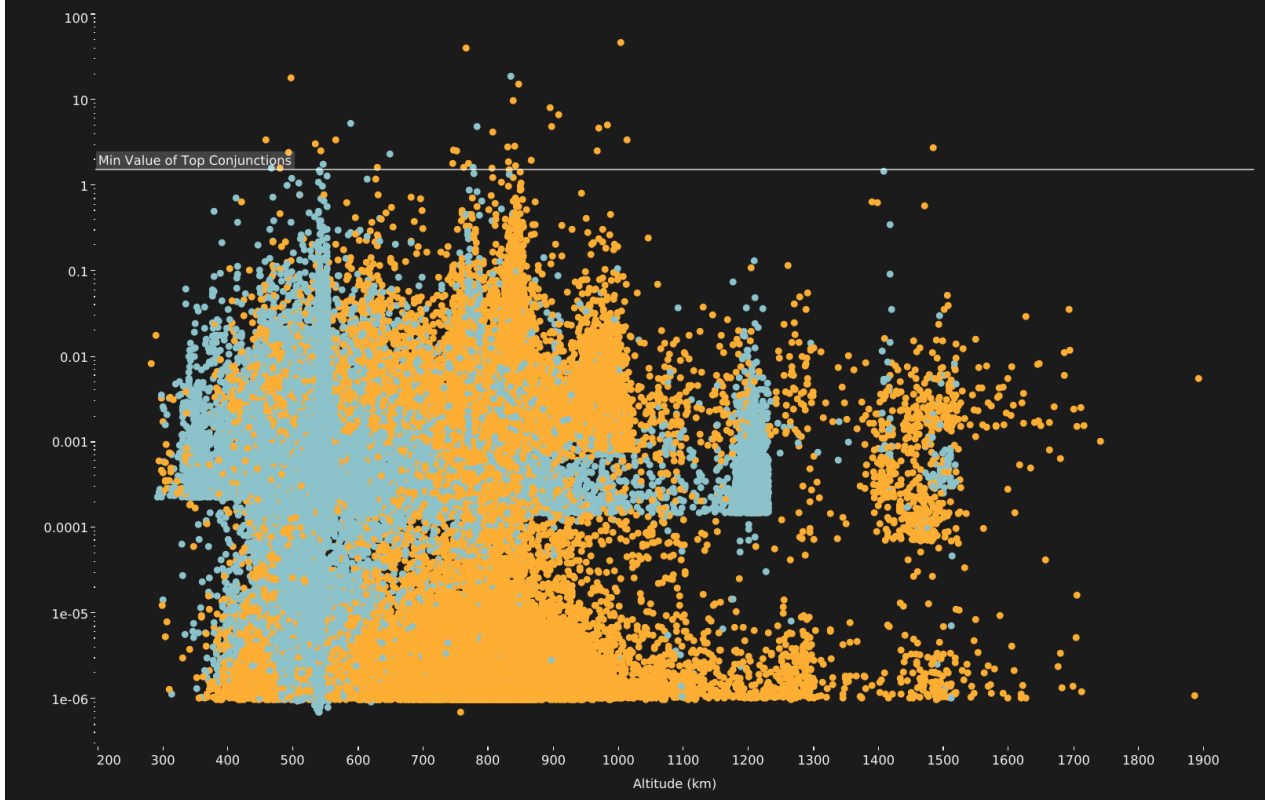




Risk = PC x Consequence (mass)

40,000/month with PC >1E-6

Top 40 Conjunctions by Risk (kg)



1	24304 (COSMOS 2334)	23603 (COSMOS 2315)	4.66e+01
2	11511 (SL-8 R/B)	44548 (CZ-2D R/B)	4.15e+01
3	118 (THOR ABLESTAR R/B)	43013 (NOAA 20)	1.93e+01
4	43067 (H-2A R/B)	42791 (VENTA 1)	1.83e+01
5	30288 (FENGYUN 1C DEB)	24298 (SL-16 R/B)	1.56e+01
6	20625 (SL-16 R/B)	22468 (SL-16 DEB)	9.78e+00
7	12457 (SL-3 R/B)	7363 (METEOR 1-18)	8.19e+00
8	20791 (CZ-4 R/B)	22367 (SL-16 DEB)	6.75e+00
9	49191 (ONEWEB-0321)	14780 (LANDSAT 5)	5.36e+00
10	18161 (SL-8 R/B)	28381 (SL-8 R/B)	5.06e+00
11	25415 (ORBCOMM FM 19)	13241 (COSMOS 1371)	5.02e+00
12	7715 (SL-3 R/B)	31686 (FENGYUN 1C DE..	4.92e+00
13	7477 (SL-8 R/B)	4615 (THORAD AGENA ..	4.74e+00
14	37215 (CZ-4C R/B)	21419 (SL-8 R/B)	4.28e+00
15	11062 (TIROS N DEB)	26474 (TITAN 4B R/B)	3.44e+00
16	49785 (COSMOS 1408 DE..	32290 (CZ-4C R/B)	3.43e+00
17	22888 (COSMOS 2266)	87271 (TBA - TO BE ASS..	3.42e+00
18	49700 (COSMOS 1408 DE..	40541 (SL-24 R/B)	3.07e+00
19	31793 (SL-16 R/B)	41281 (NOAA 16 DEB)	2.91e+00
20	22566 (SL-16 R/B)	29828 (FENGYUN 1C DE..	2.88e+00
21	10588 (COSMOS 981)	40303 (SL-24 R/B)	2.75e+00
22	16864 (SL-8 R/B)	47052 (COSMOS 2251 D..	2.66e+00
23	10137 (COSMOS 926)	14085 (SL-8 R/B)	2.58e+00
24	26474 (TITAN 4B R/B)	50736 (COSMOS 1408 D..	2.57e+00
25	20434 (SL-8 DEB)	5707 (SL-8 R/B)	2.54e+00
26	10517 (DELTA 1 R/B(1))	15889 (COSMOS 1666)	2.43e+00
27	716 (TIROS 8)	43484 (GAOFEN 6)	2.39e+00
28	17973 (COSMOS 1844)	30922 (FENGYUN 1C DE..	1.97e+00
29	7715 (SL-3 R/B)	16182 (SL-16 R/B)	1.90e+00
30	39261 (CZ-4C R/B)	34910 (COSMOS 2251 D..	1.84e+00
31	22491 (PEGASUS R/B)	24971 (IRS 1D)	1.82e+00
32	43067 (H-2A R/B)	43159 (JILIN-01-07)	1.79e+00
33	7715 (SL-3 R/B)	29909 (FENGYUN 1C DE..	1.72e+00
34	40239 (COSMOS 2251 DE..	42803 (IRIDIUM 113)	1.64e+00
35	23343 (SL-16 R/B)	115 (THOR ABLE DEB (Y..	1.64e+00
36	11870 (SL-8 R/B)	23345 (RESURS O1 DEB)	1.63e+00
37	39211 (CZ-4C R/B)	32435 (FENGYUN 1C DE..	1.58e+00
38	27432 (CZ-4B R/B)	22330 (SL-16 DEB)	1.58e+00
39	28647 (TITAN 4B R/B)	42016 (AL-FARABI 1)	1.58e+00
40	22220 (SL-16 R/B)	39984 (SL-14 DEB)	1.55e+00

Select:
- Probability of Collision
- Consequence (mass in kg)
- Risk (kg)
- Miss Distance (m)

Top N Conjunctions
40

Highlight Type of Conjunction

Time of Closest Approach
All values

Altitude (km)
All values

- Debris - Debris
- Operational Payload - All
- All Conjunctions

Number of Conjunctions in Top
0, 2, 4, 6, 8, 10

Debris - Debris

33
0.03% of Debris - Debris conjunctions in dataset

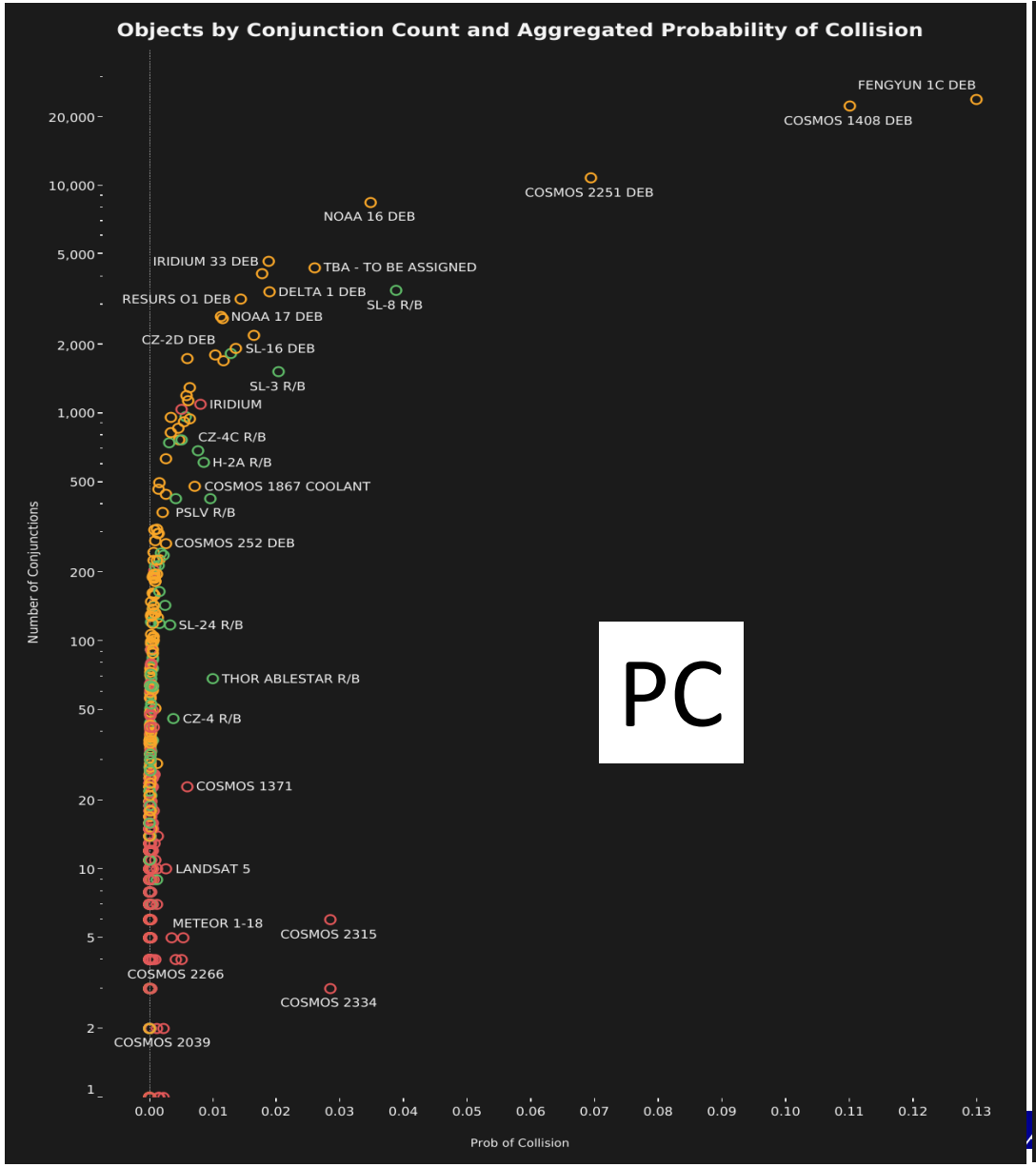
Operational Payload - All

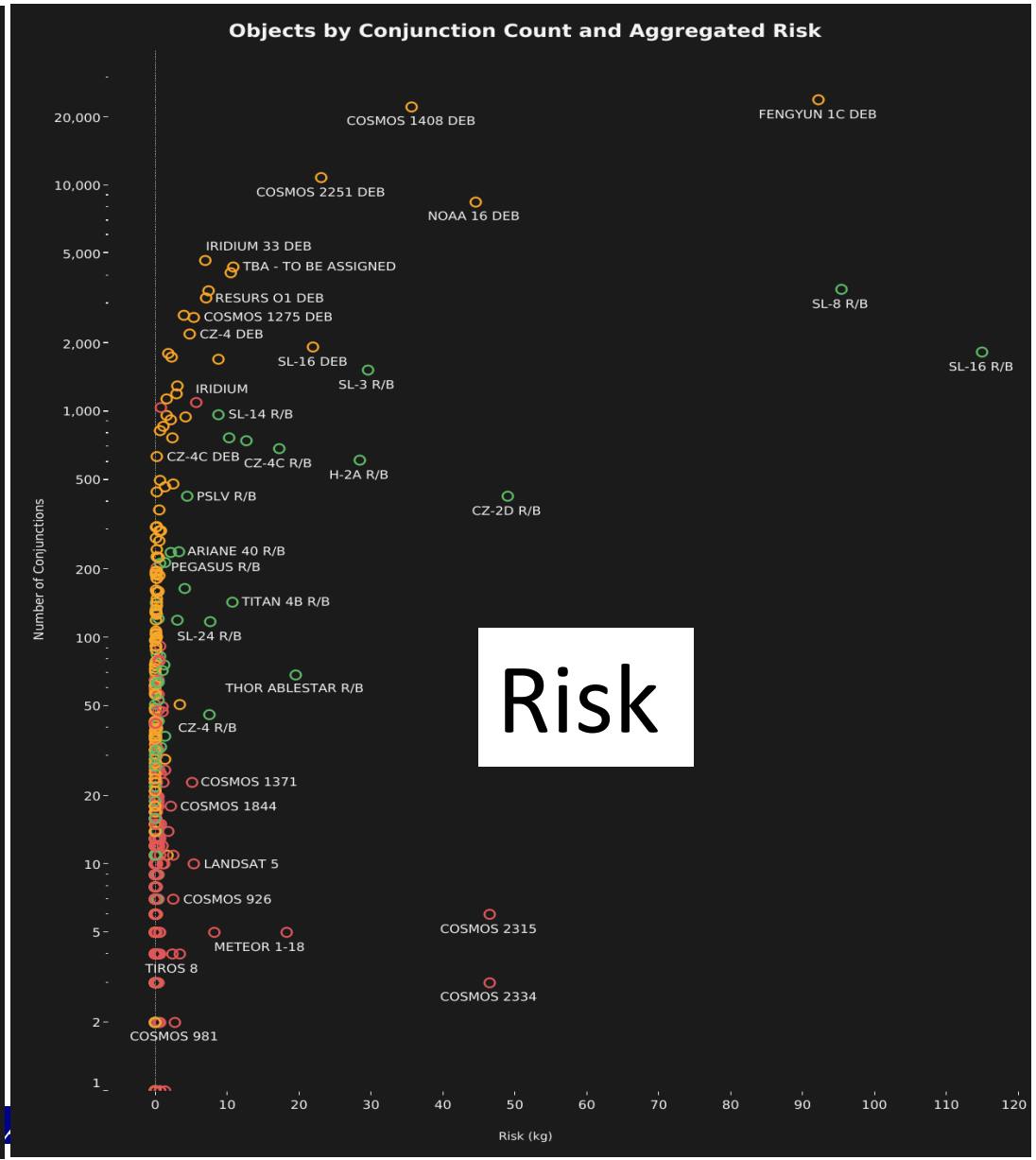
7
0.01% of Operational Payload - All conjunctions in dataset

All Conjunctions

40
0.03% of All conjunctions in dataset

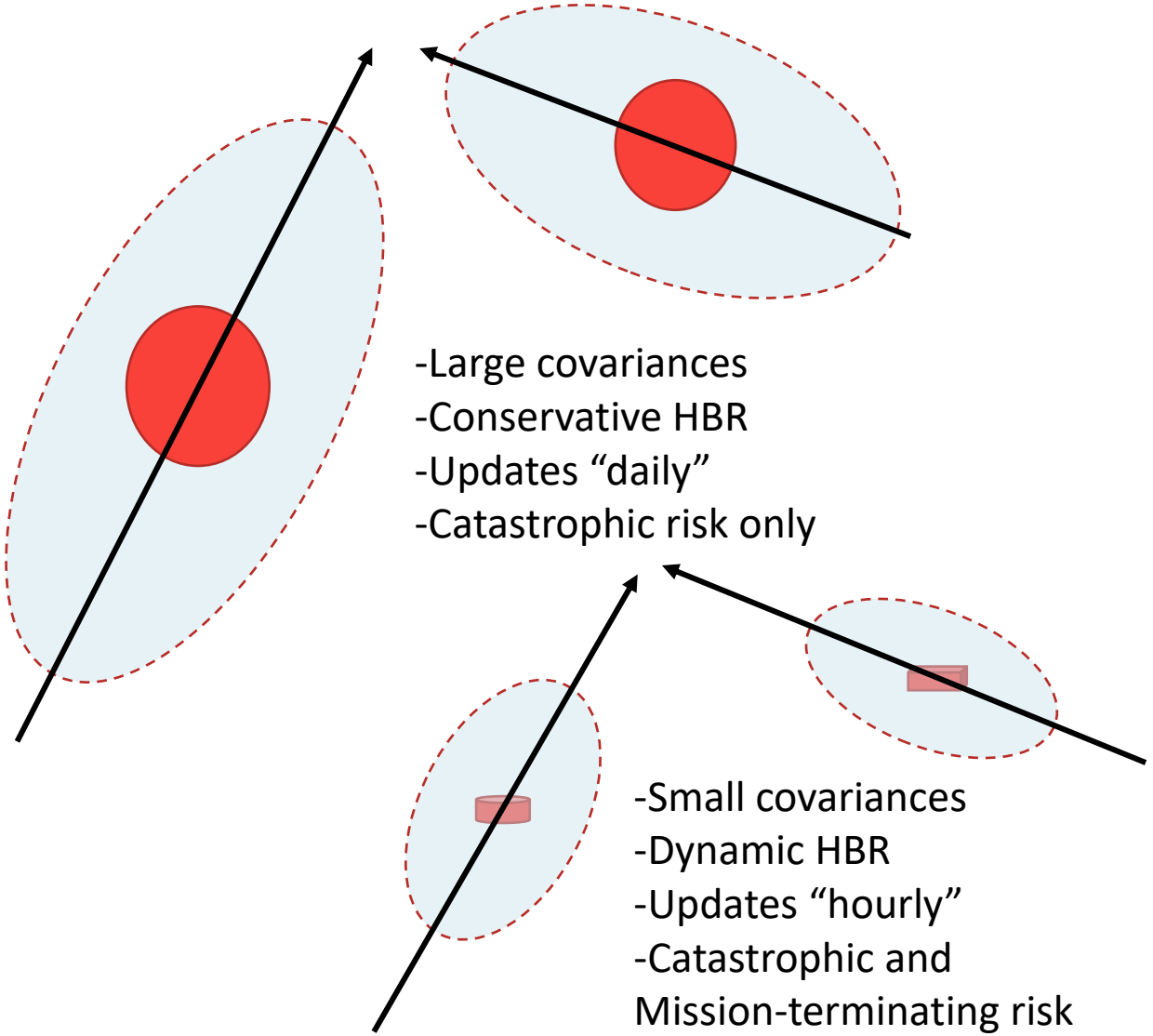
Aggregate PC vs Risk by "Derelict" Families





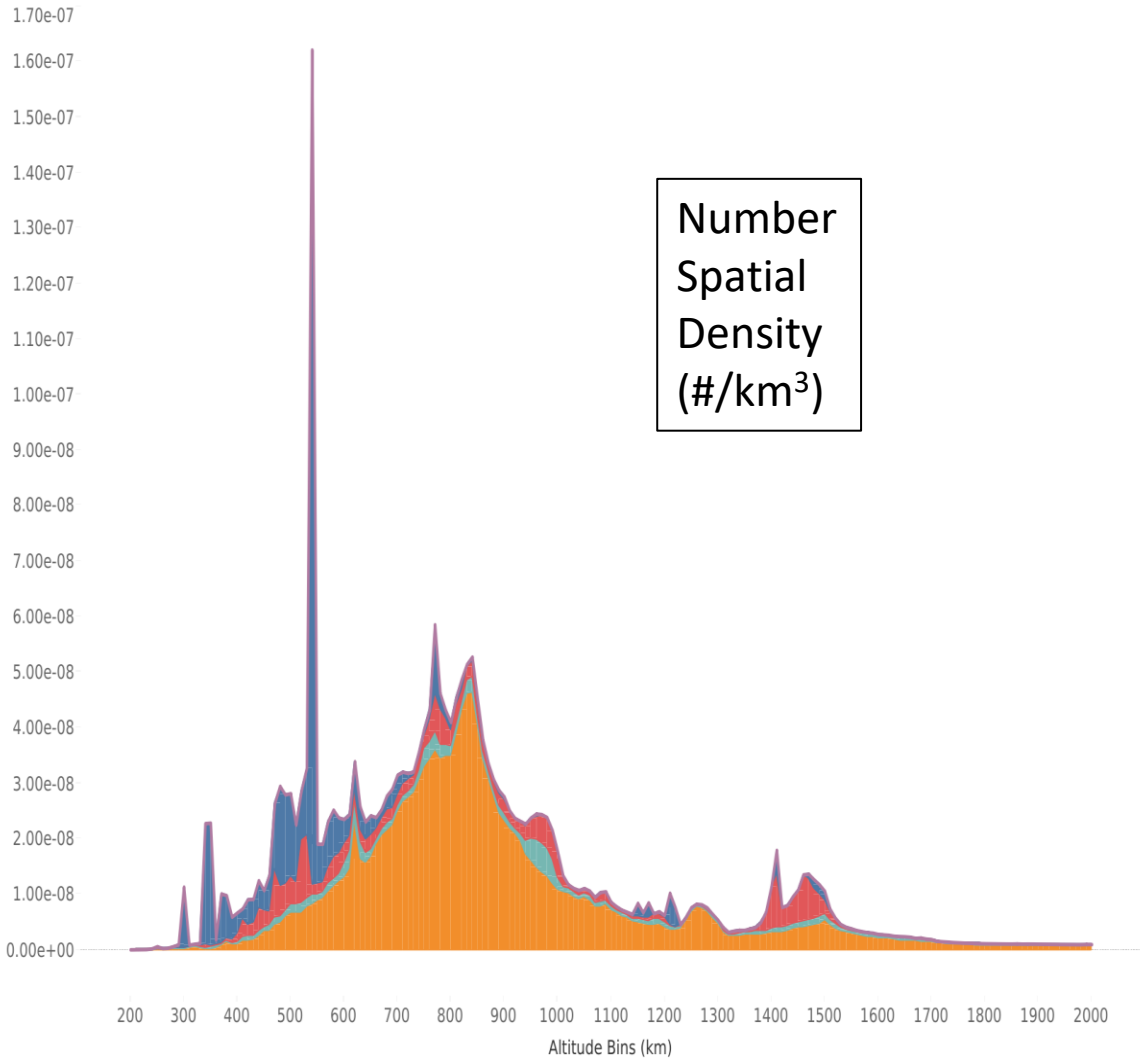
PC a Multi-Dimensional Value: Show Your Work

- Covariance Realism
  - Better math
  - More frequent obs
- HBR Realism
  - Avoid default values
  - Dynamic, physics-based
- Time is Safety
  - In minutes, not hours
  - Move closer to TCA
  - Fusion does not do this
- What you can't see, can kill you
  - Catalog LNT



Fewer and safer maneuvers

Current vs Future Collision Risk: Risk Realism

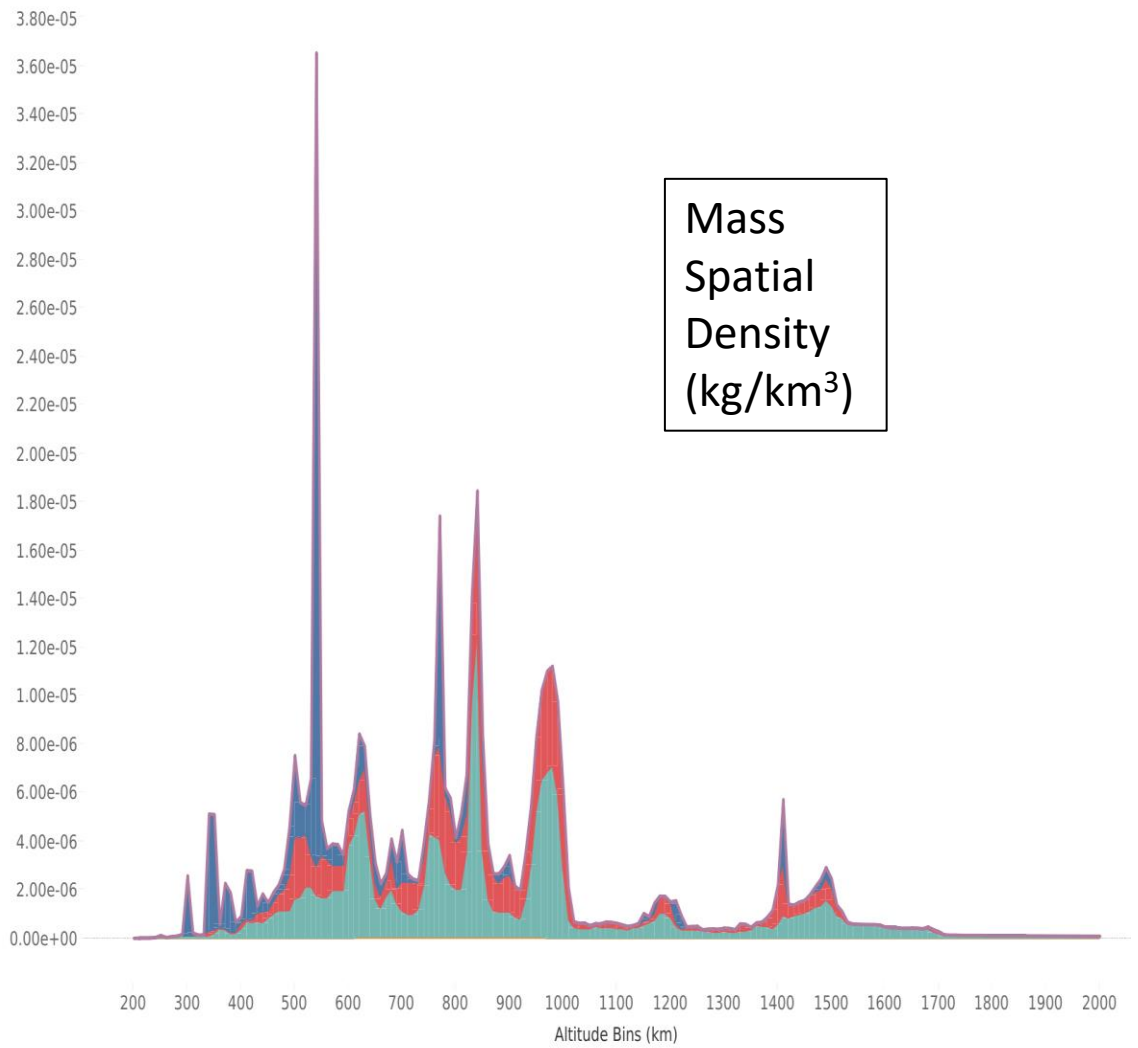


Object Type
Multiple values

Altitude Bins (km)
All values

Area or Line
Area
Line

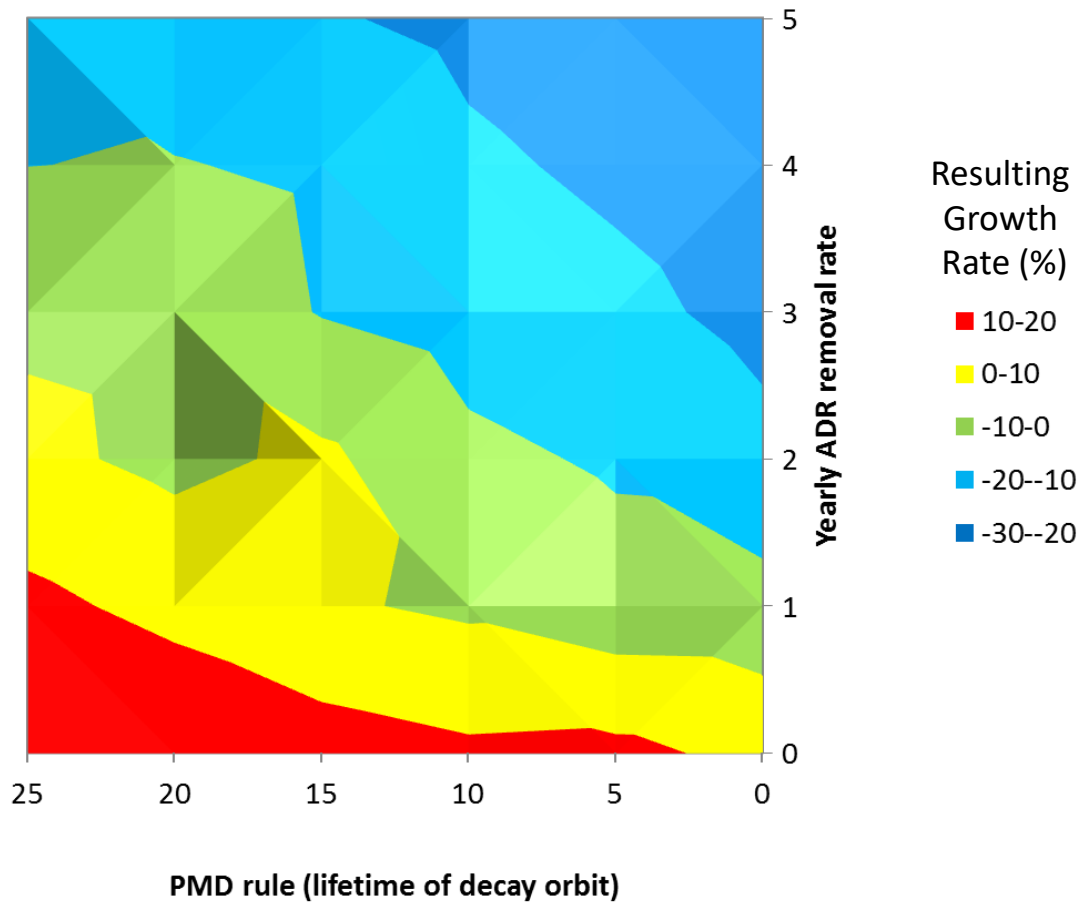
Object Type
Operational Payload
Non-Operational Payload
Rocket Body
Fragments



LEO LABS clearspace today AXA EPFL SECURE WORLD FOUNDATION

“Pay Me Now or Pay Me More Later…”

- Research by University of Southampton investigated tradeoff between tightening debris mitigation guidelines and ADR operations
  - ✓Reducing deorbit guideline to less than a year decreases ADR requirement from 5/year to around 1.5/year
  - ✓Reducing PMD threshold would be much less expensive than ADR but would have to pay NOW!
- THIS WAS FROM OVER TEN YEARS AGO – getting worse!!!



Compliments of Dr. Hugh Lewis, University of Southampton

Satellite Has Impact-Induced Anomaly? Call Darren

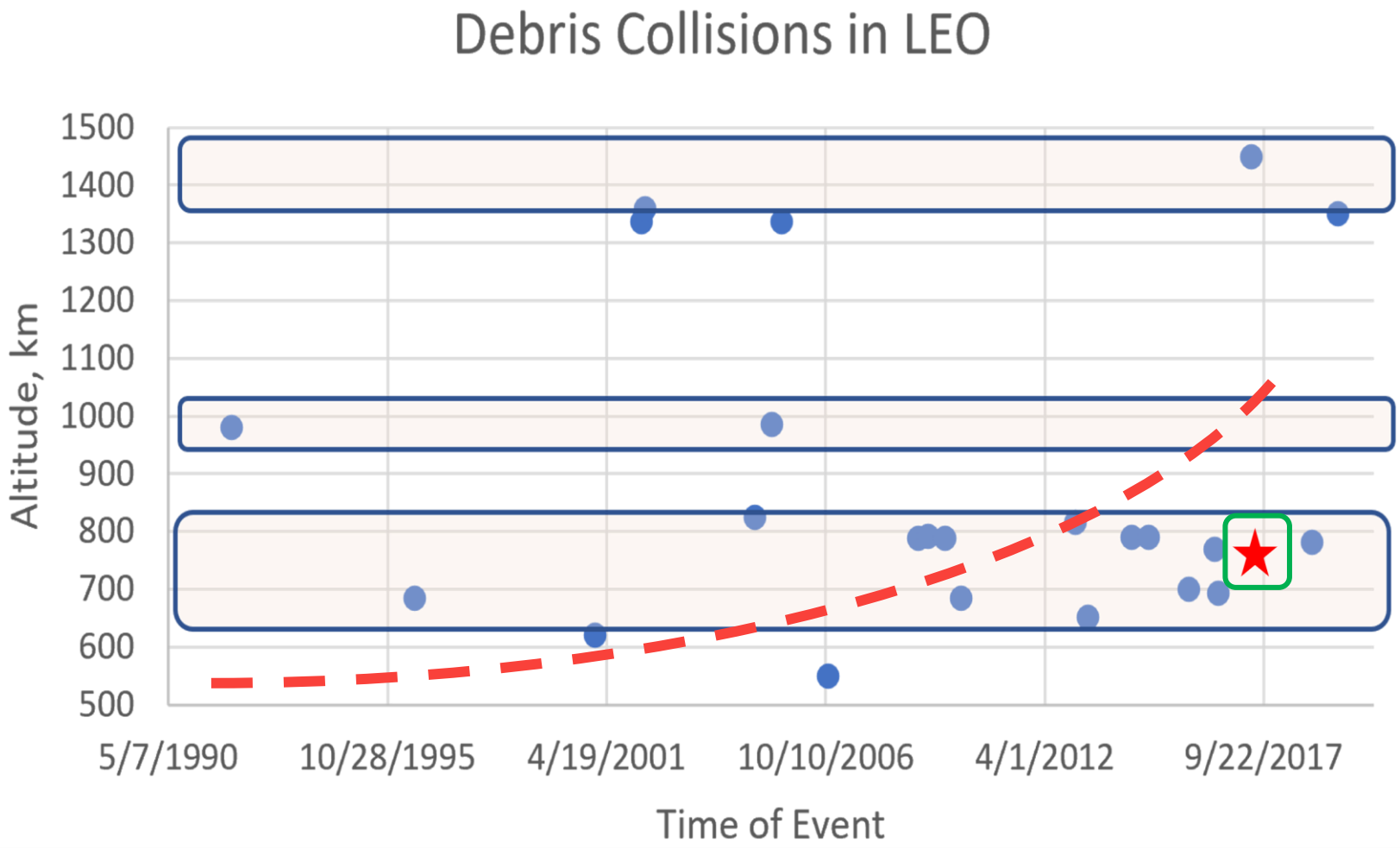


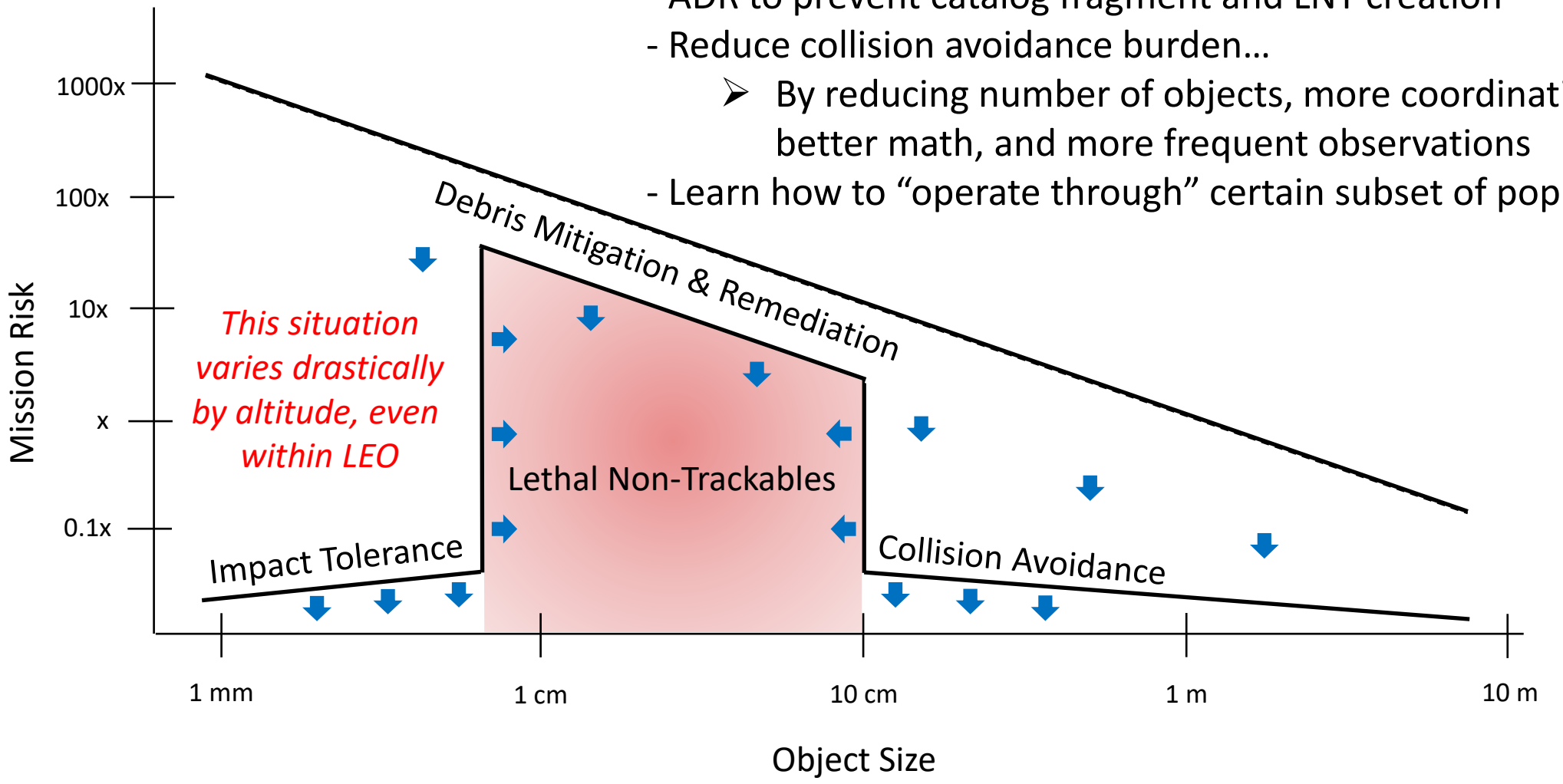
Figure 5. Debris collisions in LEO. Shaded rectangles indicate altitudes with high concentration of objects.

★ Reported March 2022 by South China Morning Post, Gaofen-3, SAR satellite lost 4% of solar power due to cm-sized impactor in 2016 near 750 km

LEO LABS clearspace today AXA EPFL SECURE WORLD FOUNDATION

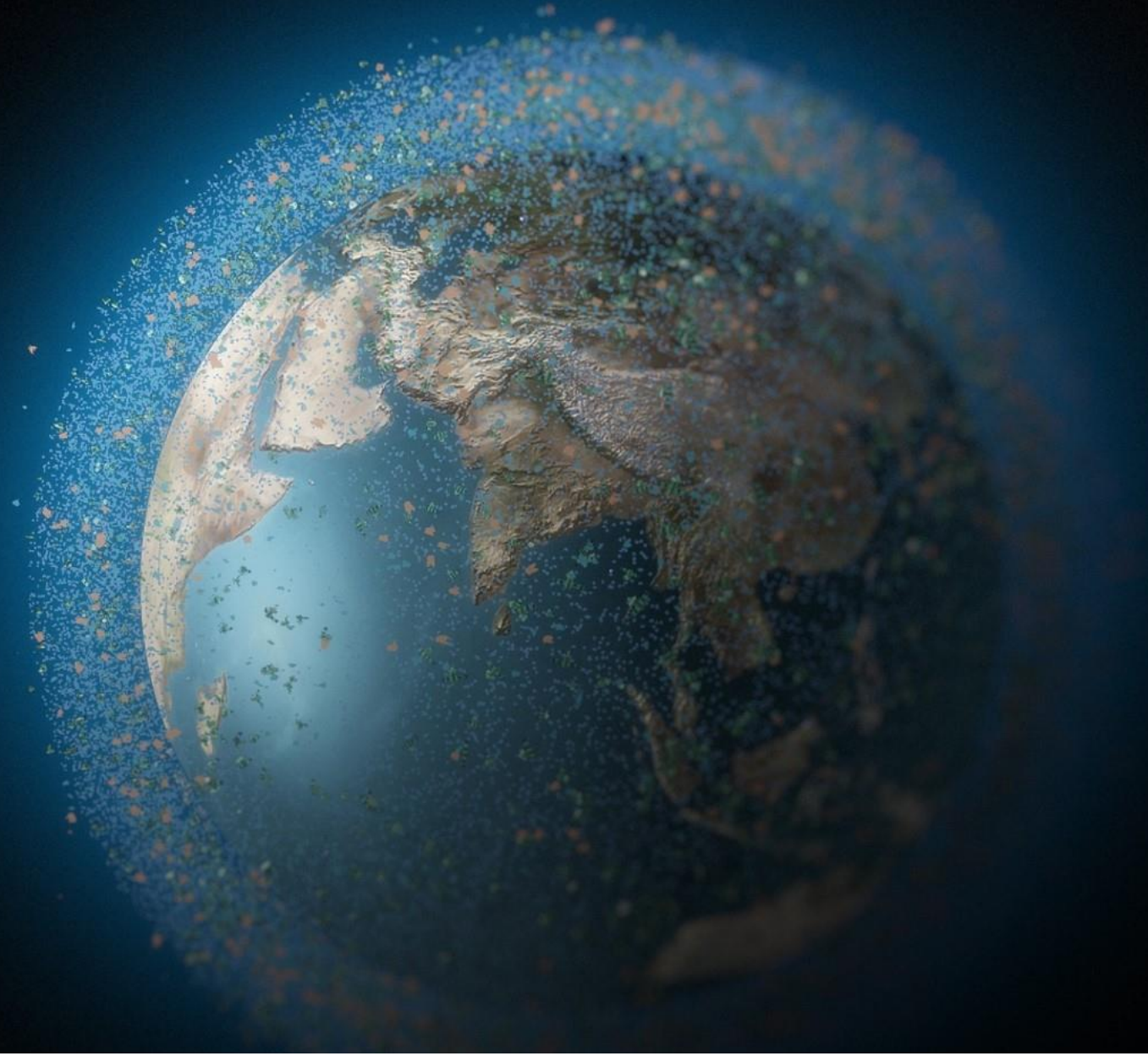
Reducing Collision Risk in LEO

- Prevention is easier than remediation
- ADR to prevent catalog fragment and LNT creation
- Reduce collision avoidance burden…
  - ➢ By reducing number of objects, more coordination, better math, and more frequent observations
- Learn how to "operate through" certain subset of population



LEO LABS clearspace today AXA EPFL SECURE WORLD FOUNDATION

THANK YOU



LEO LABS

clearspace today

AXA

EPFL

SECURE WORLD FOUNDATION