Space Debris in a nutshell

Long Term Sustainability of Space Operations

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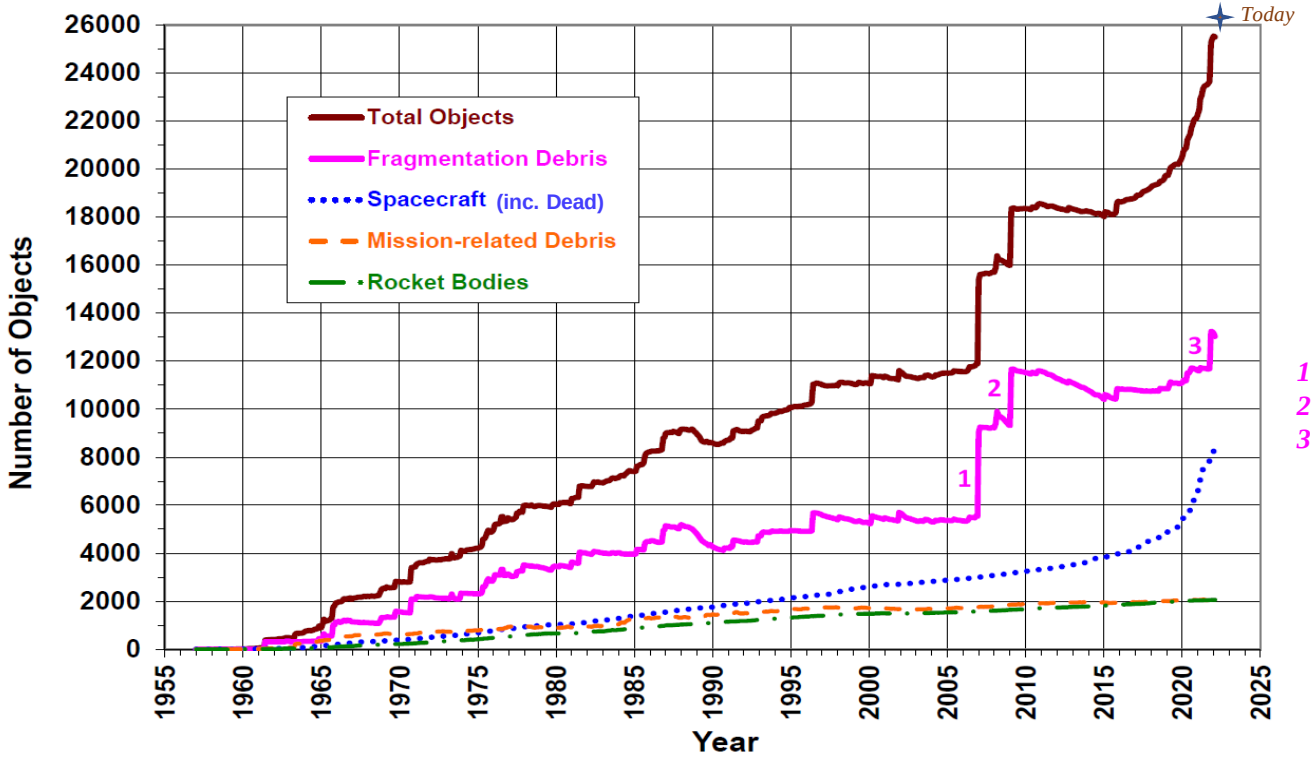
Orbital population

The number of cataloged objects has drastically increased these last years

- **Number of debris has doubled in 15 years**
- **Number of active satellites: 994 Jan. 1st, 2012 – 6,957 Oct. 17, 2022 (x7)**
- **Number of active satellites in Low Earth Orbit LEO: 469 Jan. 1st, 2012 – 5,846 Oct. 17, 2022 (x12)**



1 Feng Yun 1C ASAT
2 Iridium33 - K2251
3 K1804 ASAT

NASA Space Debris Quarterly News - https://orbitaldebris.jsc.nasa.gov/quarterly-news/

Orbital population

Sources of orbital objects are very unbalanced

Beware: all satellites, even dead: 6,957 active – 2,764 debris

↳ **USA + Russia + China =**

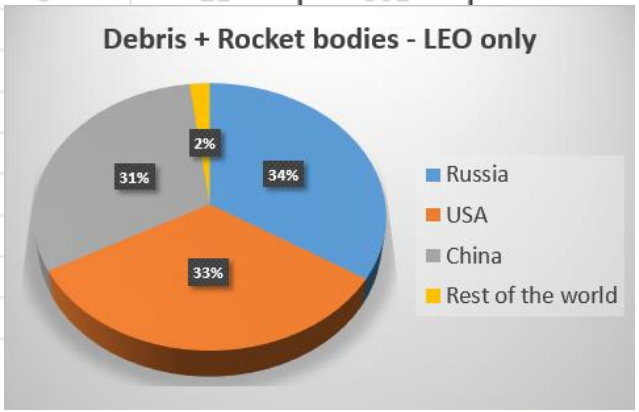
87% of the cataloged orbital population
95% of the cataloged orbital debris
97.5% of the debris in Low Earth Orbits

www.space-track.org

17.10.22	EN ORBITE				RENTRES				
Pays	SATELLITES	ETAGES	DEBRIS	TOTAL	SATELLITES	ETAGES	DEBRIS	TOTAL	TOTAL PAR PAYS
Total	9721	2313	14132	16166	4004	4065	19766	27835	54001
USA	5335	734	4469	10538	1529	742	4946	7217	17755
CIS Russie	1568	1050	5189	7807	2082	2898	11868	16848	24655
Chine	592	210	3750	4552	106	226	1312	1644	6196
France	84	167	349	600	11	82	671	764	1364
Royaume Uni	479	1	0	480	16	0	5	21	501
Japon	206	62	54	322	76	69			
Inde	107	40	71	218	14	25			
ESA	96	7	51	154	12	7			
Intelsat	91	0	1	92	1	0			
Allemagne	86	0	1	87	17	0			
Globalstar	84	0	1	85	0	0			
Canada	76	0	5	81	4	0			
Orb	58	0	14	72	1	0			
SES	58	0	0	58	1	0			

95%

87%

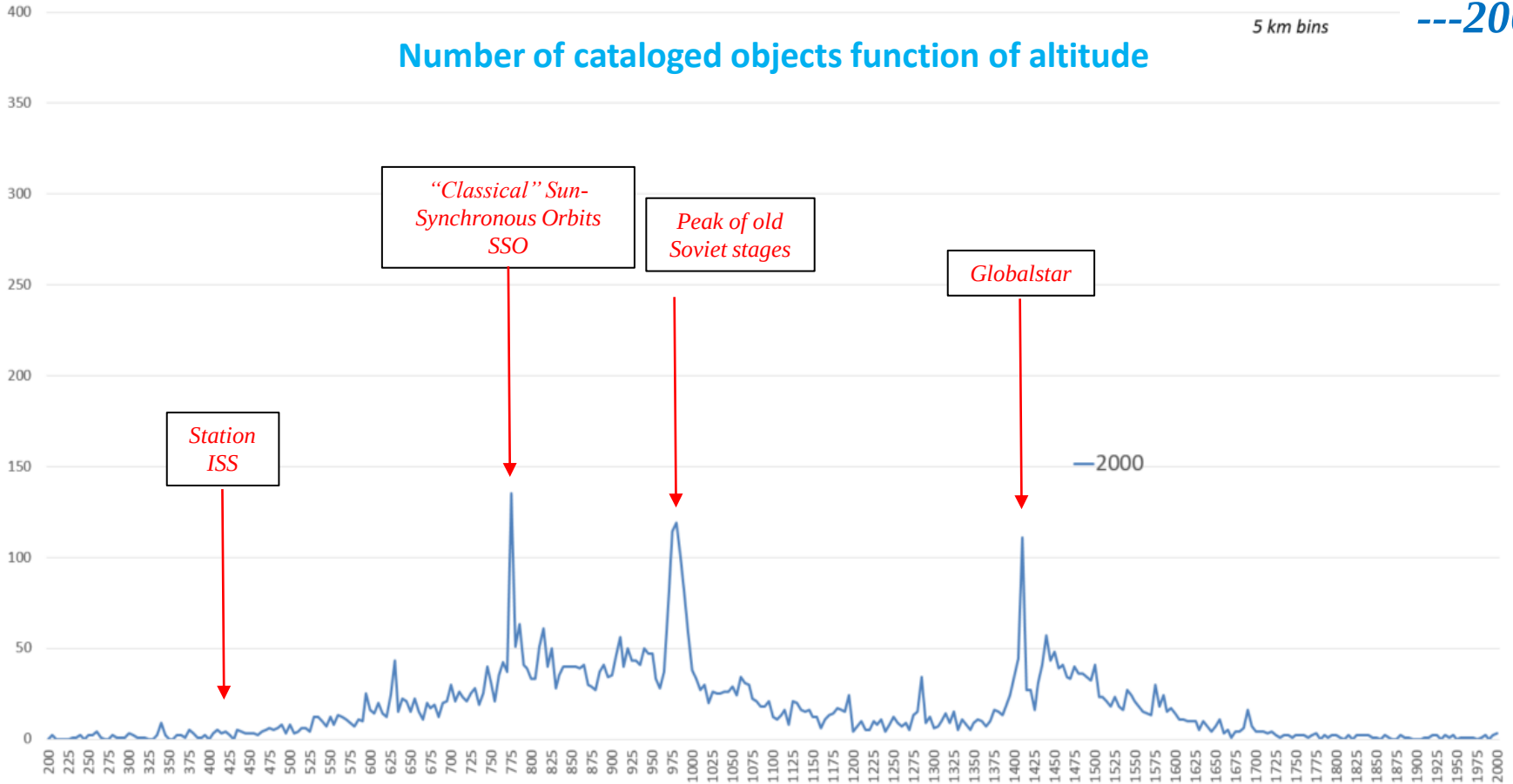


Time evolution of the orbital population

2000

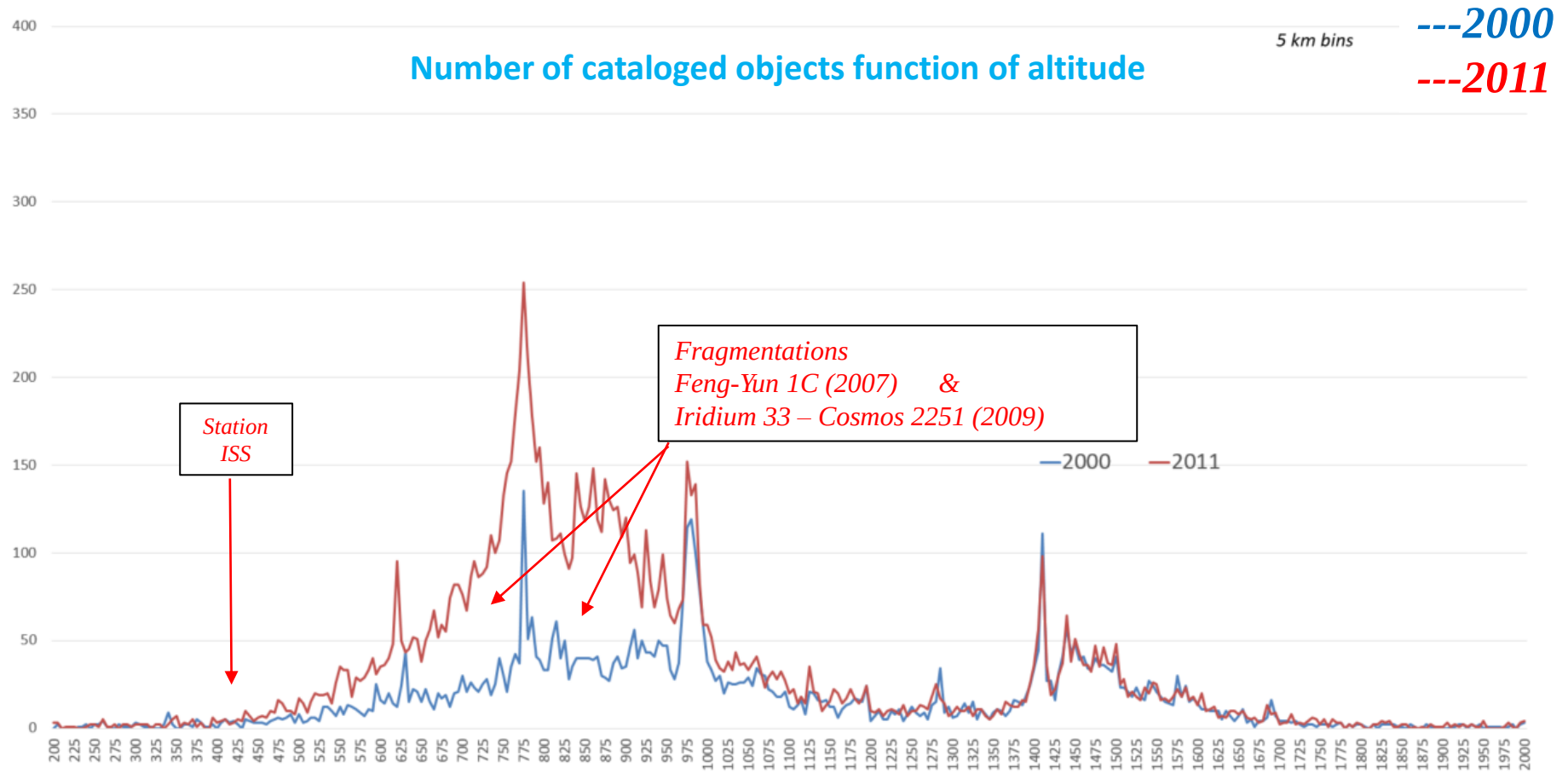
---2000

Number of cataloged objects function of altitude

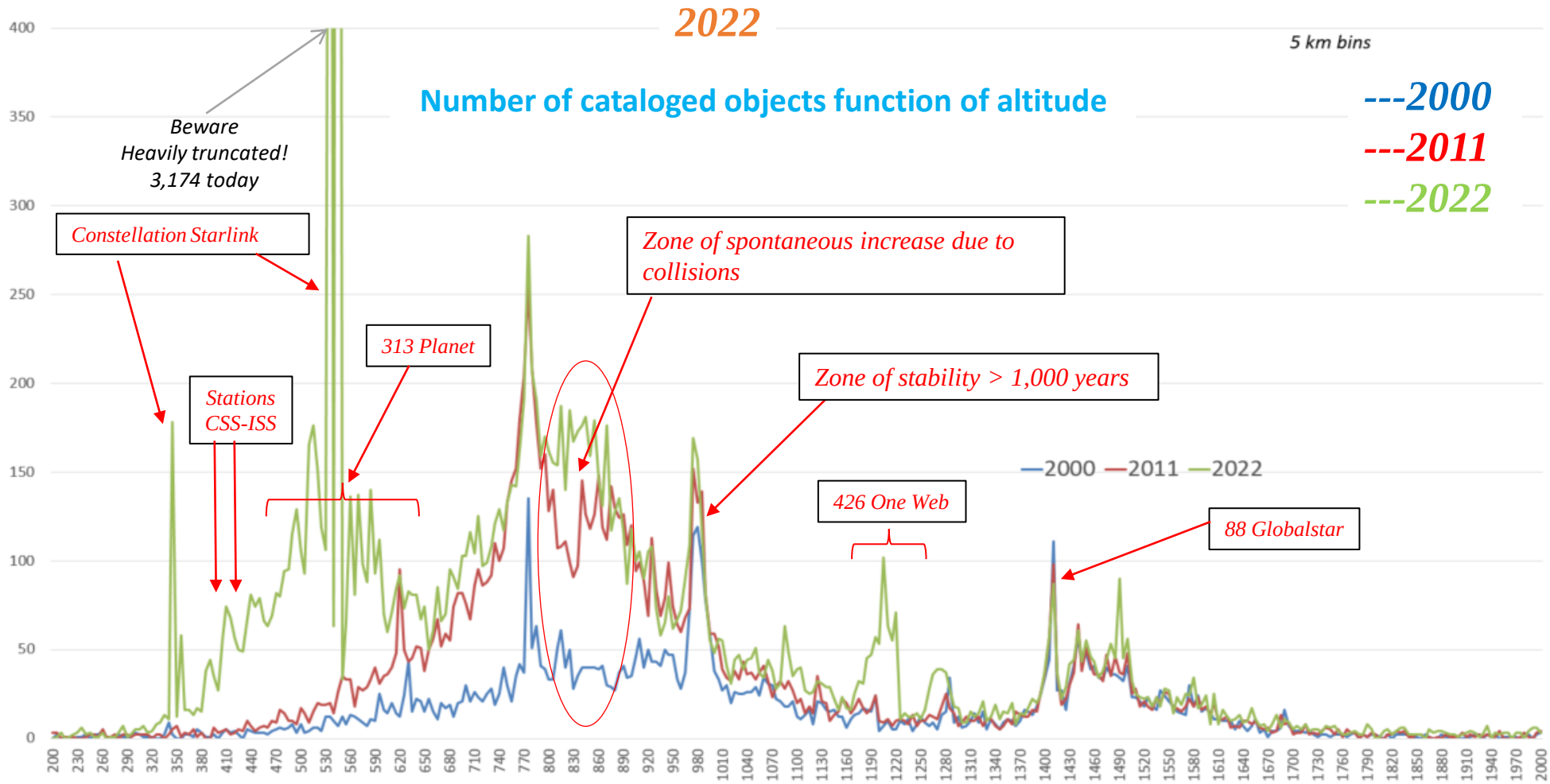


Time evolution of the orbital population

2011



Time evolution of the orbital population

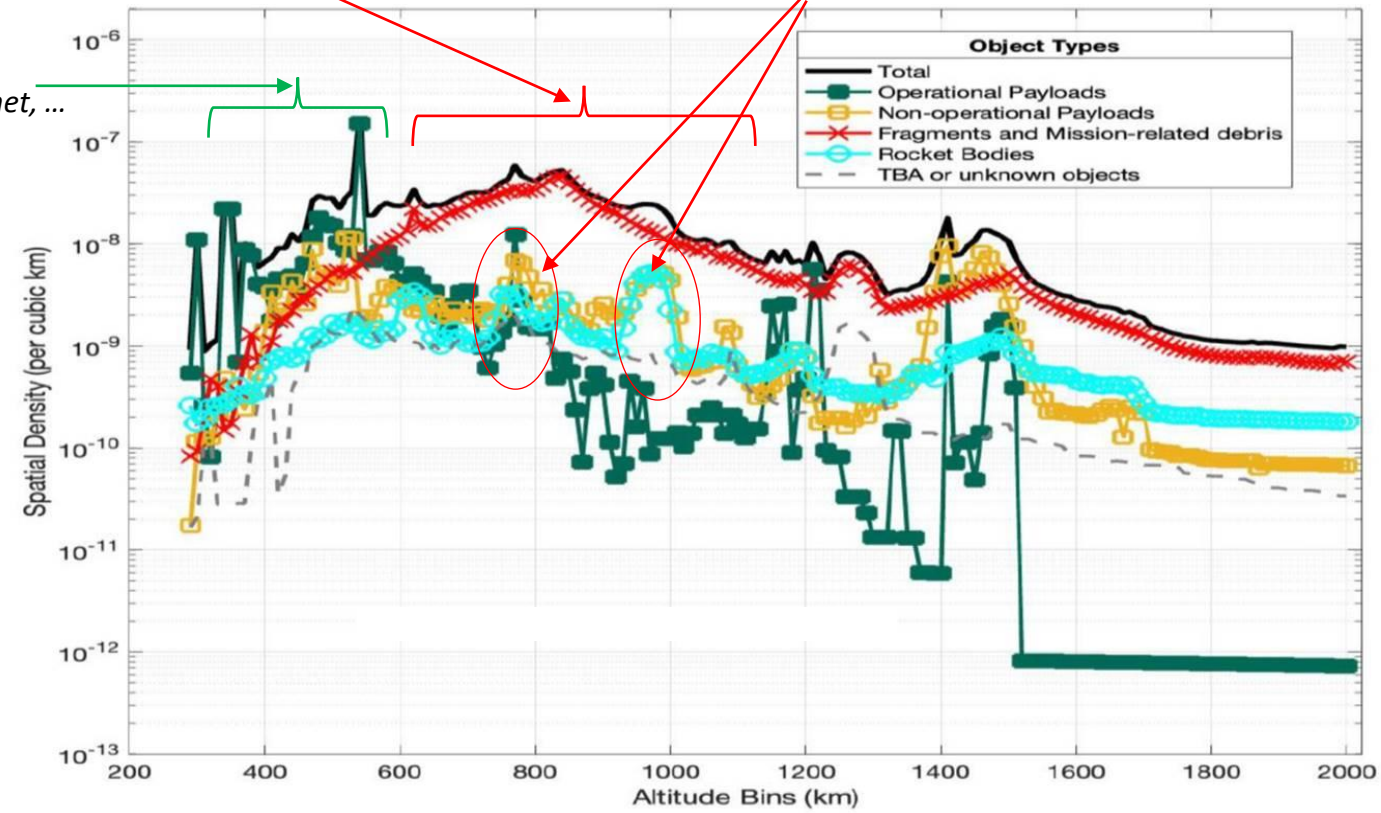


Typology of cataloged objects in Low Earth Orbits

10-100-1,000 times more debris than active satellites

Critical clusters of large debris

Starlink, Planet, …



M. Stevenson, D. Mc Knight, H. Lewis, C. Kunstadter, R. Bhatia, AMOS conference 2021

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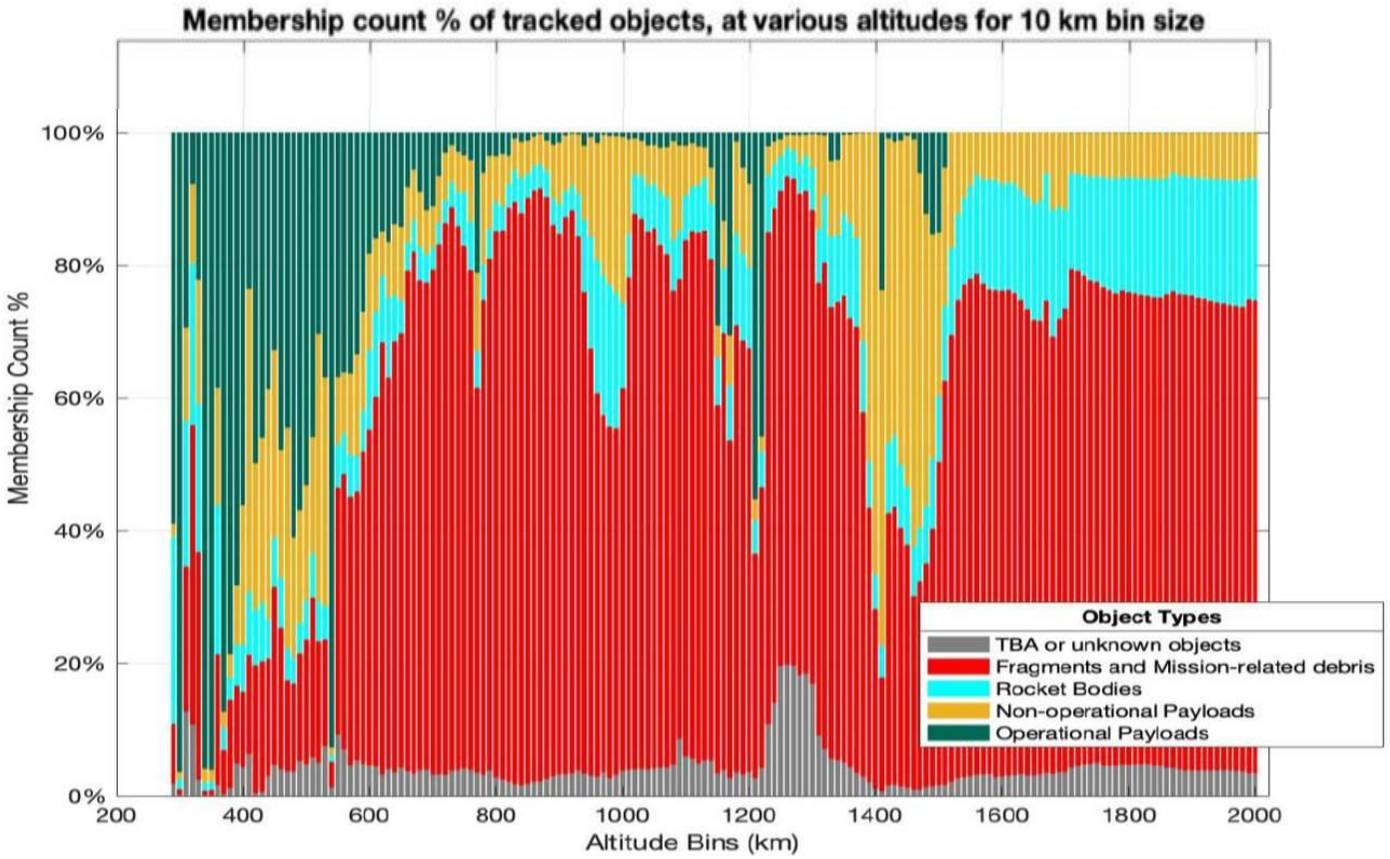

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Distribution of large debris in Low Earth Orbits

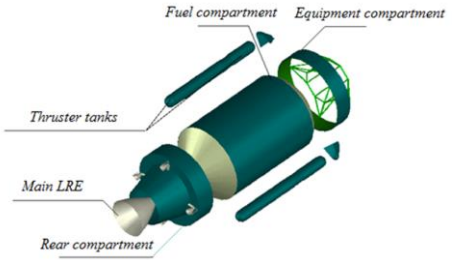
Large debris in LEO are essentially grouped into clusters, by altitude-inclination bands

- 2 Zenit SL-16 stages (8,3 tons, 9 meters) pass less than 100 m from each other once per month
- 205 Cosmos-3M SL-8 stages in 3 major Clusters
- According to our models, a front collision of 2 SL-16 stages would generate +18,000 new cataloged debris

Cluster	Cluster Member	Mass (kg)	Number	Apogee (km)	Perigee (km)	Inclination (deg)
C775	SL8 RB	1,434	44	793	733	74
	SL8 PL	850	44	802	742	74
C850	SL16 RB	8,300	18	860	814	71
	SL16 PL	3,250	18	868	823	71
C975	SL8 RB	1,434	144	1020	935	83
	SL8 PL	800	142	1024	934	83
	Other PL	1500	15	997	905	64
C1500	SL8 RB	1,434	17	1660	1330	74
	SL14 RB	1,407	24	1530	1363	83
	SL14 PL	2477	24	1507	1381	83
	TOTAL	**~756k**	**490**			27

D. McKnight

SL-16 Zenit Upper stage
Russian SpaceWeb Co.



SL-8 Cosmos 3M Upper stage
V. Trushlyakov

What can be done?

- **Wait, simply applying the current mitigation rules** ⇨ Not enough as no longer adapted today – Diverging
  - Update the 25-year rule ⇨ Discussions ongoing to propose 5 years
  - Update the probability of success of End of Life operations ⇨ 90% Not enough – Adopt 95 or 99%
  - Check effective compliance to current rules ⇨ Very poor level of compliance

    ↳ Even “No Future Launch” is diverging !

- **Avoid collisions implying maneuvering satellites** ⇨ “Space Traffic Coordination – Management” STC - STM
  - Fundamental, but not enough to guarantee Long Term Sustainability of Space Operations

    ↳ 60+% of collisions are between non-maneuvering orbital objects

- **Avoid collision between large debris** ⇨ “Just-in-time Collision Avoidance” JCA = Tactical operation
  - Numerous theoretical solutions are studied, but without market, i.e. impossible financing
  - Numerous associated problems, orbit accuracy, legal frame, insurances, duality ...

- **Retrieve the most dangerous debris** ⇨ “Active Debris Removal” ADR = Strategical operation
  - No technical problem a priori, but complex
  - Problem of the financing:
    - No positive business plan identified today
    - Several possibilities under study, mainly synergy with In-Orbit Servicing and Space-Tugs

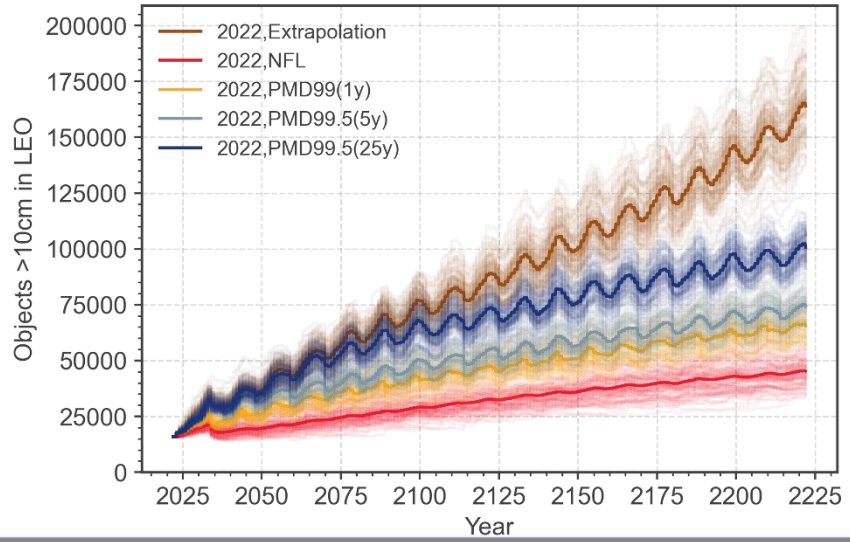
What can be done?

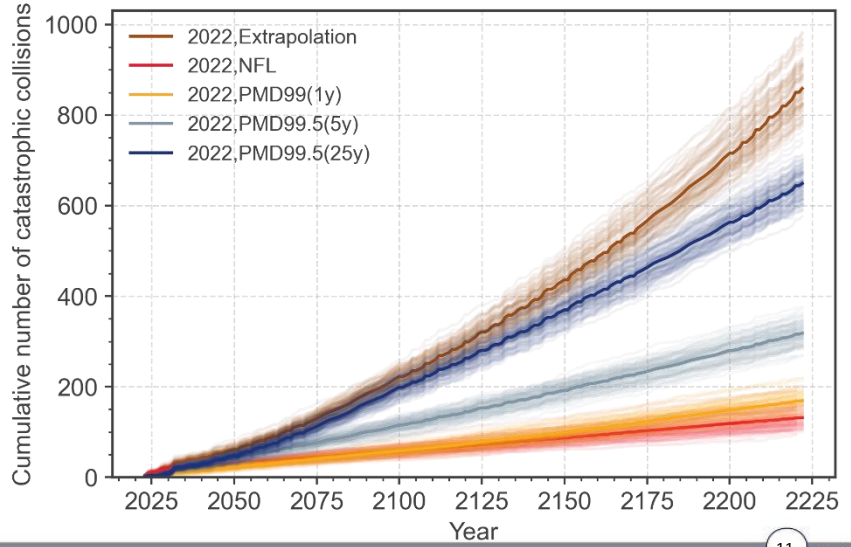
- **Mitigation Guidelines, whatever they are, are no longer sufficient**
  - Evolution of objects larger than 10 cm over time (lower left)
  - Cumulative number of catastrophic collisions (lower right)
  - Considering orbital lifetime limitation and Probability of successful disposal
  - Extreme cases:
    - Extrapolation = Business as Usual
    - NFL = No Future Launches

  ↳ **Even the "No Future Launches" is diverging…**

  ⇨ Need for Remediation = Active Debris Removal in some specific orbital zone

S. Lemmens, ESOC, 40th IADC, October 2022





Priorities

- **Deal with today's situation**
  - Consolidation of international regulations
    - **① We shall share the current regulations at international level, based on the 21 LTS COPUOS**
    - **② Consolidate our action at international level ECSS, IADC, ISO, COPUOS**
  - Specificities of "New-Space": a very high reactivity is mandatory in order not to be always "one war late"
    - **③ Very dynamic evolution of current regulations is compulsory: Current action at LOS level ongoing**

- **Mitigate the consequences from yesterday**
  - Kessler syndrome between 700 and 1,100 km altitude mainly linked to operations in the years 70-90
  - Necessity to retrieve largest and most dangerous debris, otherwise naturally diverging
  - No significant action ongoing today at international level
    - **④ It is fundamental to start as soon as possible Active Debris Removal operations**

- **Prepare for tomorrow**
  - Take all necessary actions to guarantee Long Term Sustainability, despite large constellations
  - Drastic improvement of Collision Avoidance processes: STC – STM
    - **⑤ It is fundamental to coordinate at international level to share the same rules (ECSS – ISO)**
  - Improvement of the knowledge of orbital environment: priority to Space Surveillance & Tracking (SST)
    - **⑥ It is mandatory to improve tracking and cataloging of orbital objects**
  - Preserve the "inhabitable" zone 380 – 430 km: density of objects there has increased by a factor 18 in 10 ans
    - **⑦ It is important (but hard to imagine…) to define a preserved zone for inhabited space stations**