

Space Debris – Risks and Mitigation

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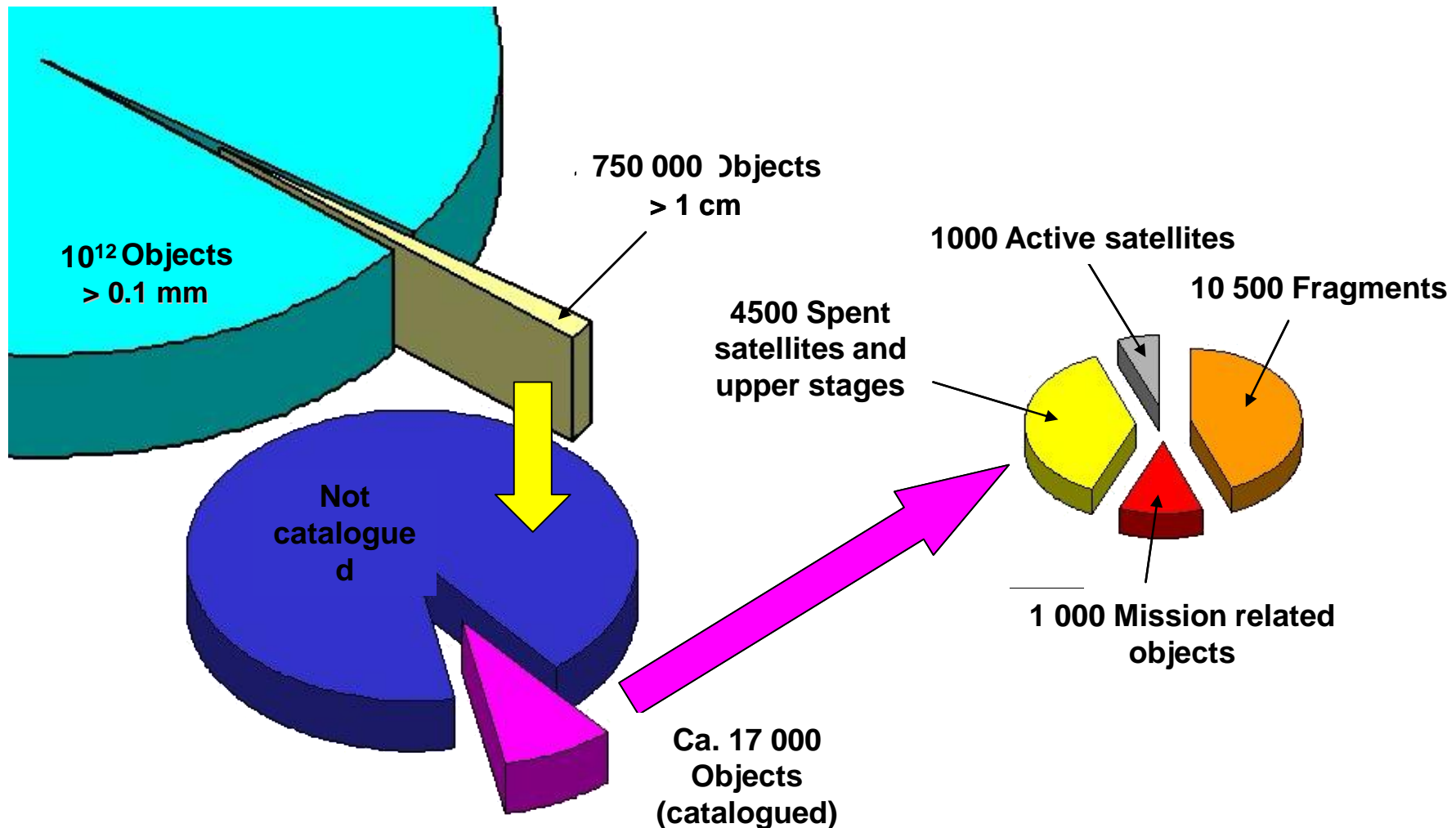
CLEANSAT WORKSHOP, ESTEC, March 18th 2015

Distribution of Catalogued Objects



2013

The overall population in space



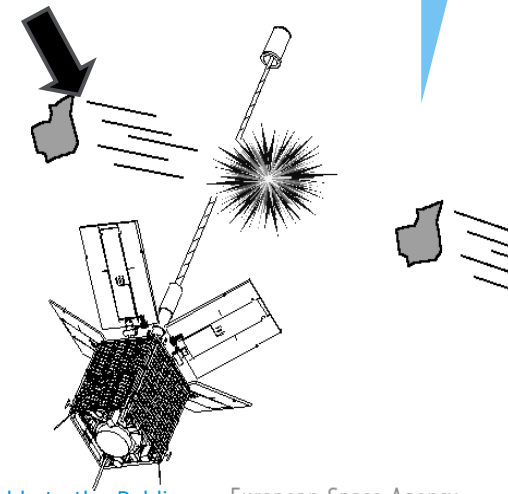
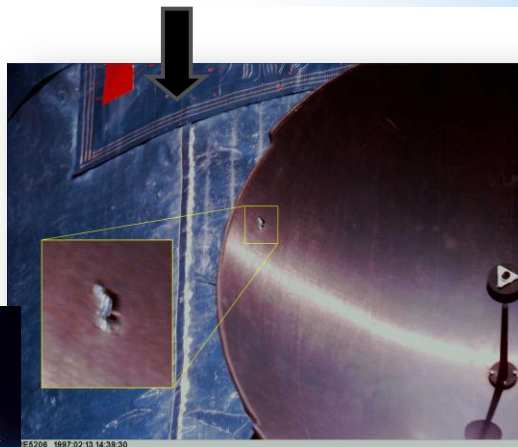
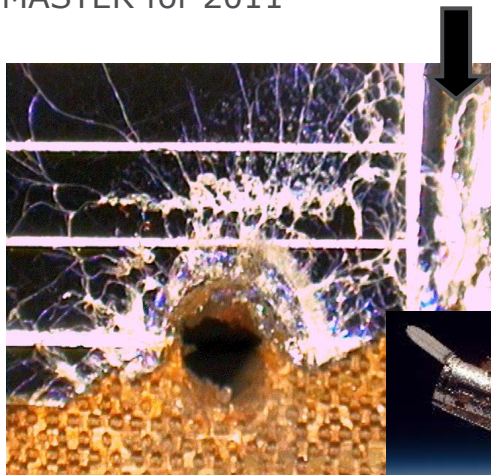
Impactor Diameter and Frequency

Mean time between two impacts on an orbiting cross-section of 30m²

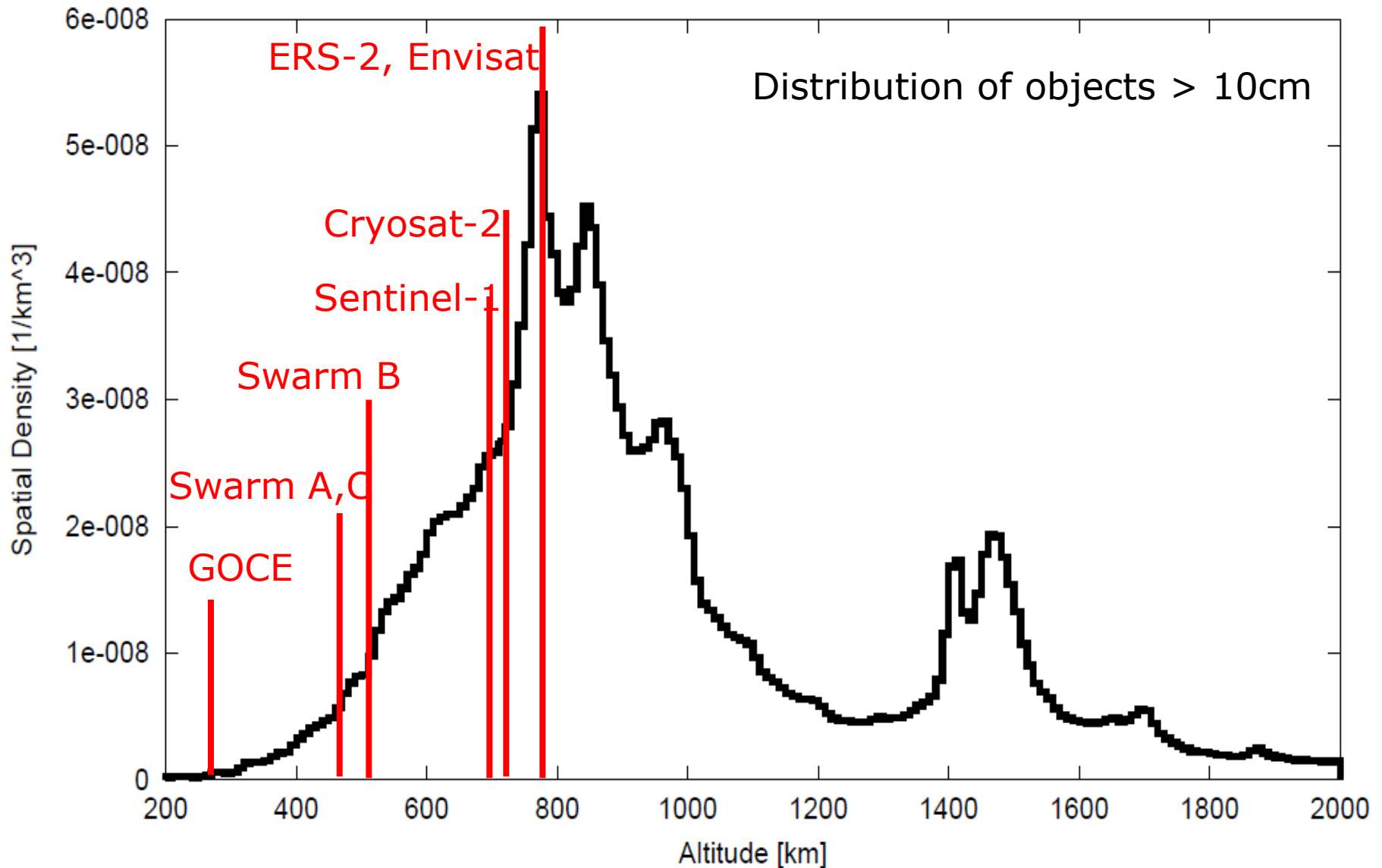
Altitude	>0.1mm	>1mm	>1cm	>10cm
400km	4,5 days	37 years	2,416 years	41.667 years
800km	0,1 days	2,9 years	133 years	2.483 years
GEO	17,3 days	556 years	128.205 years	1.488.095 years

Detectivity

ESA-MASTER for 2011



Collision Avoidance



Envisat Conjunction Jan. 21st, 2010



Envisat upper stage

02:53:18.00
2010/01/21

Business As Usual



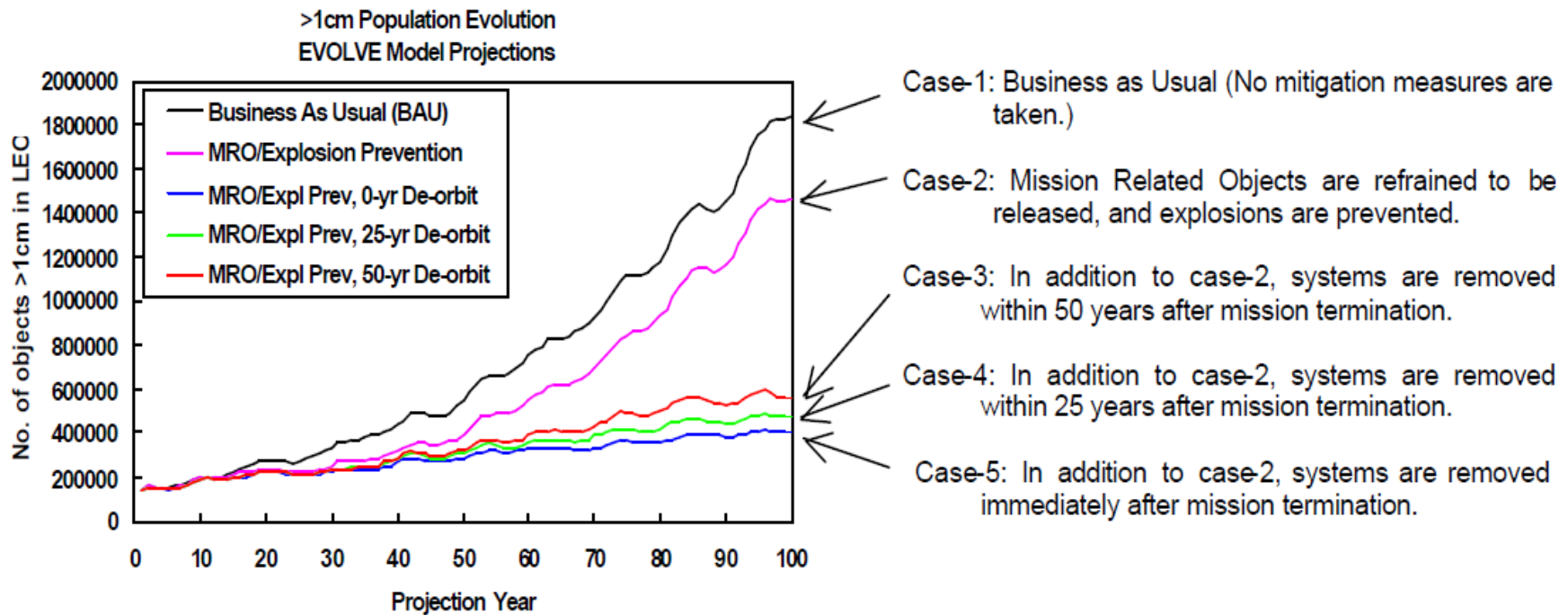
**business
as usual**

**object
count**

time

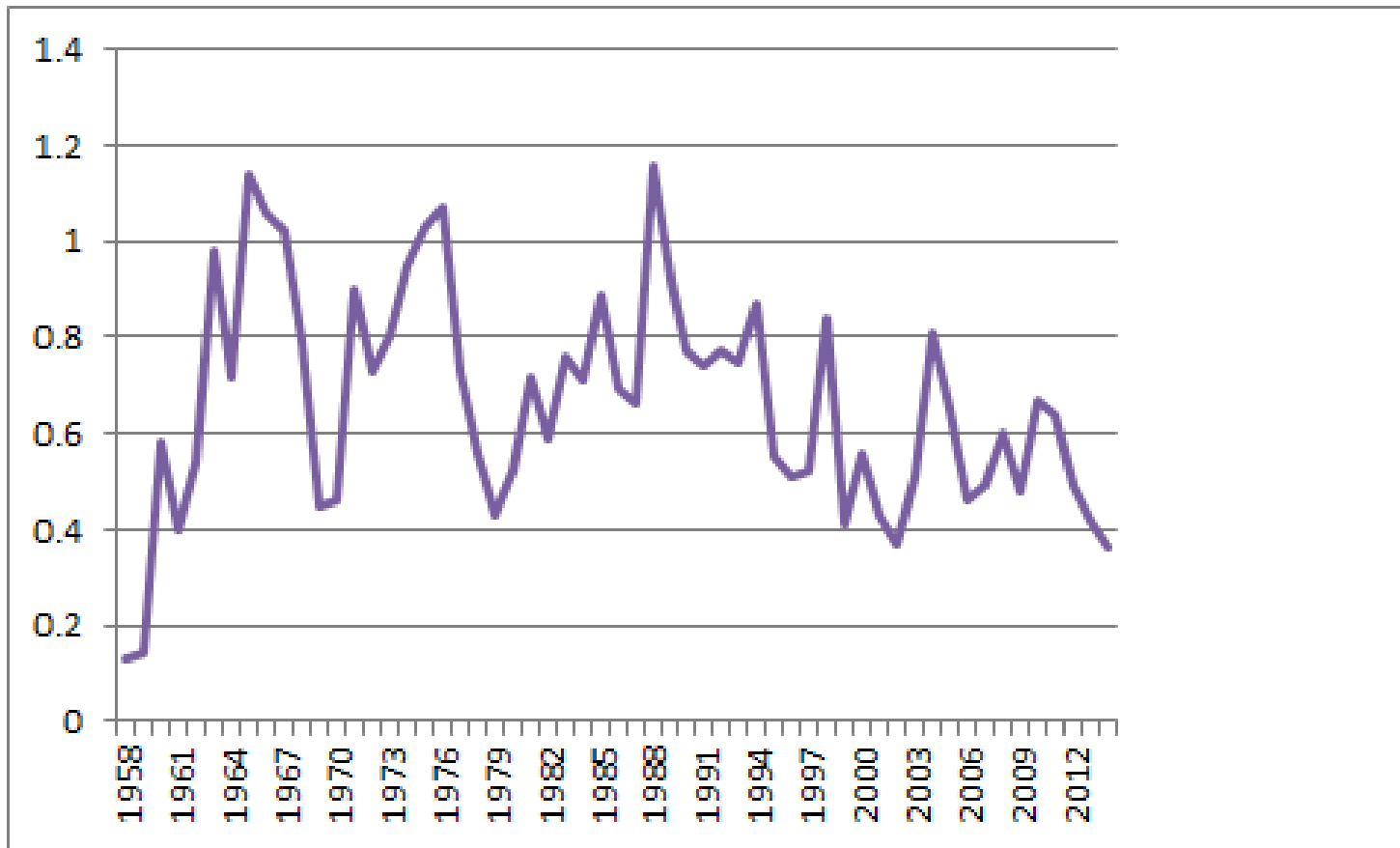
2010

IADC Analysis for LEO orbital lifetime limitation

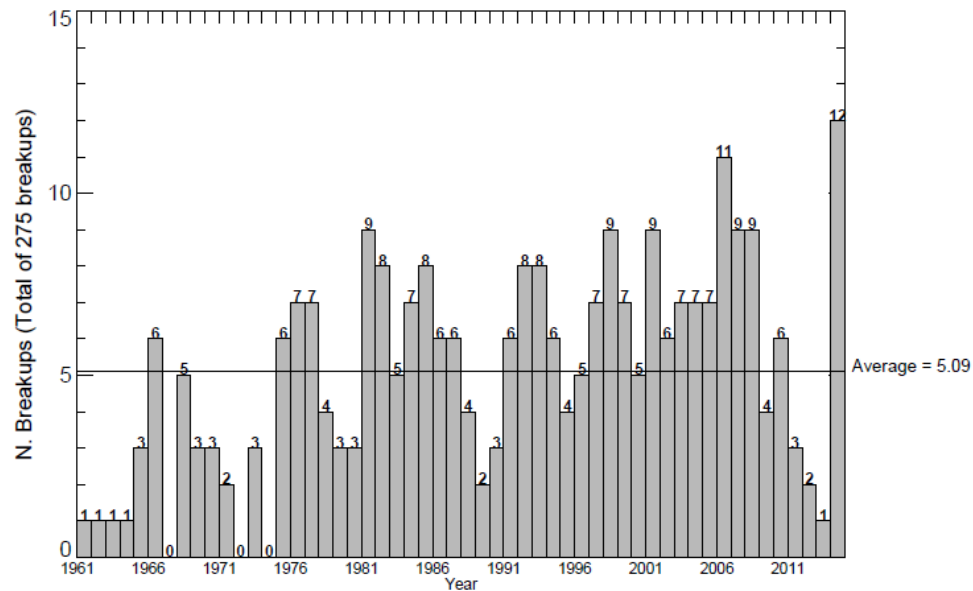


(IADC Support Document to Guidelines)

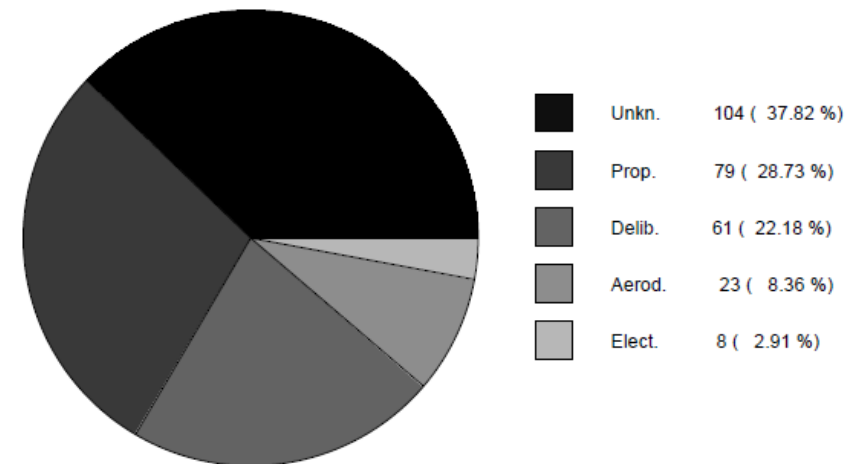
(global) average number released per launch (launcher elements only)



Number of break-ups per year

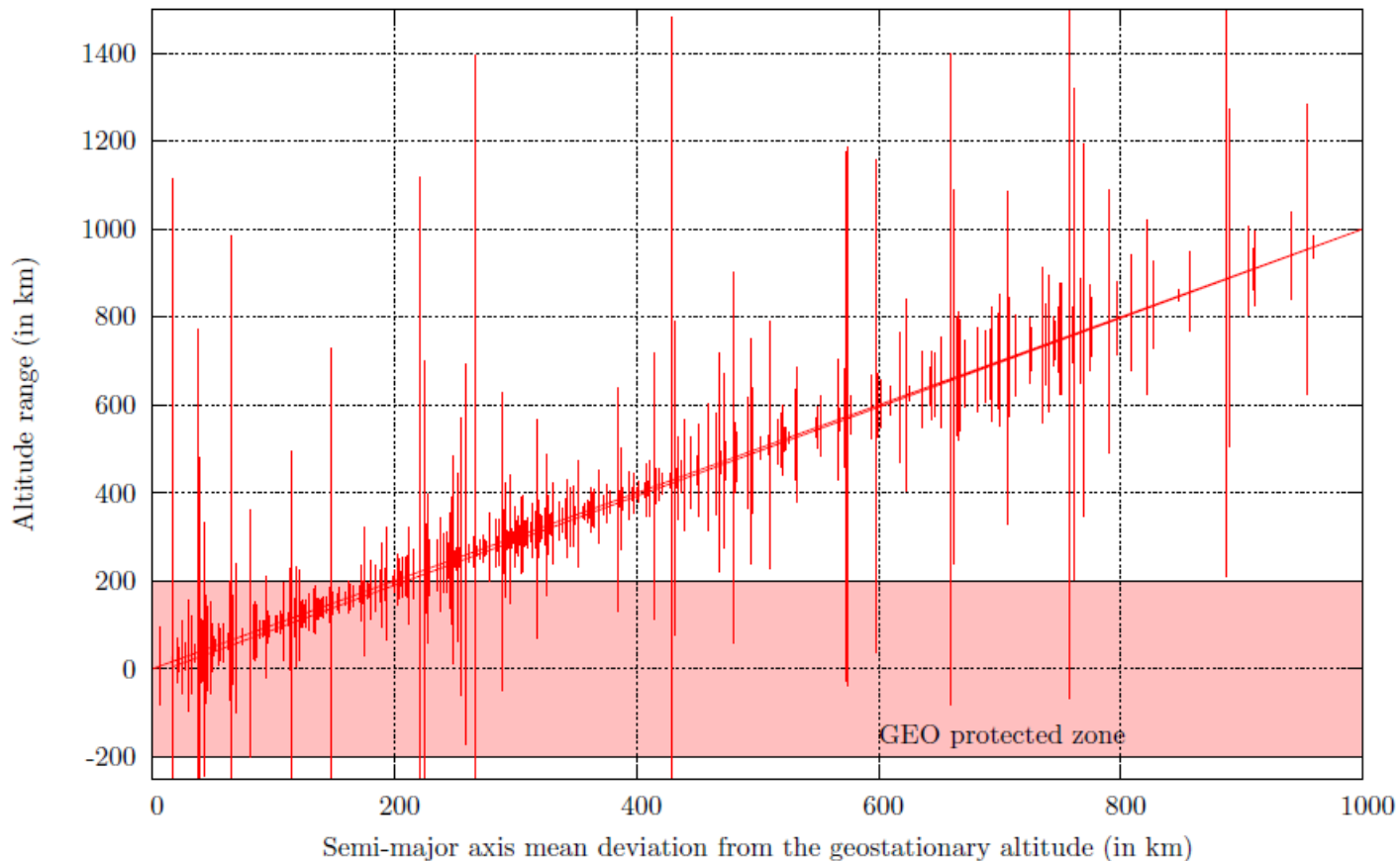


Break-up cause



Objects in drift orbit

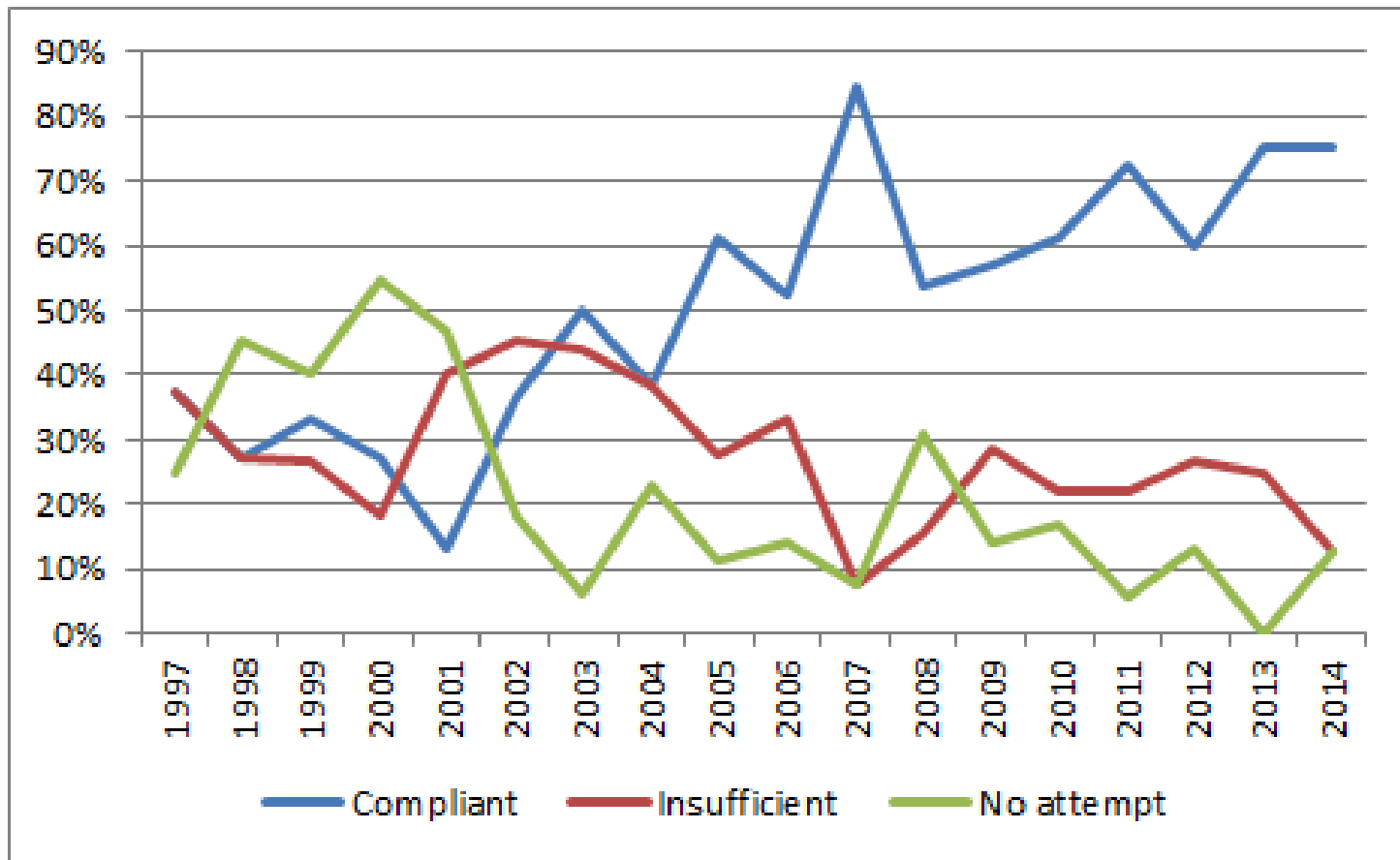
Status: 26-JAN-15



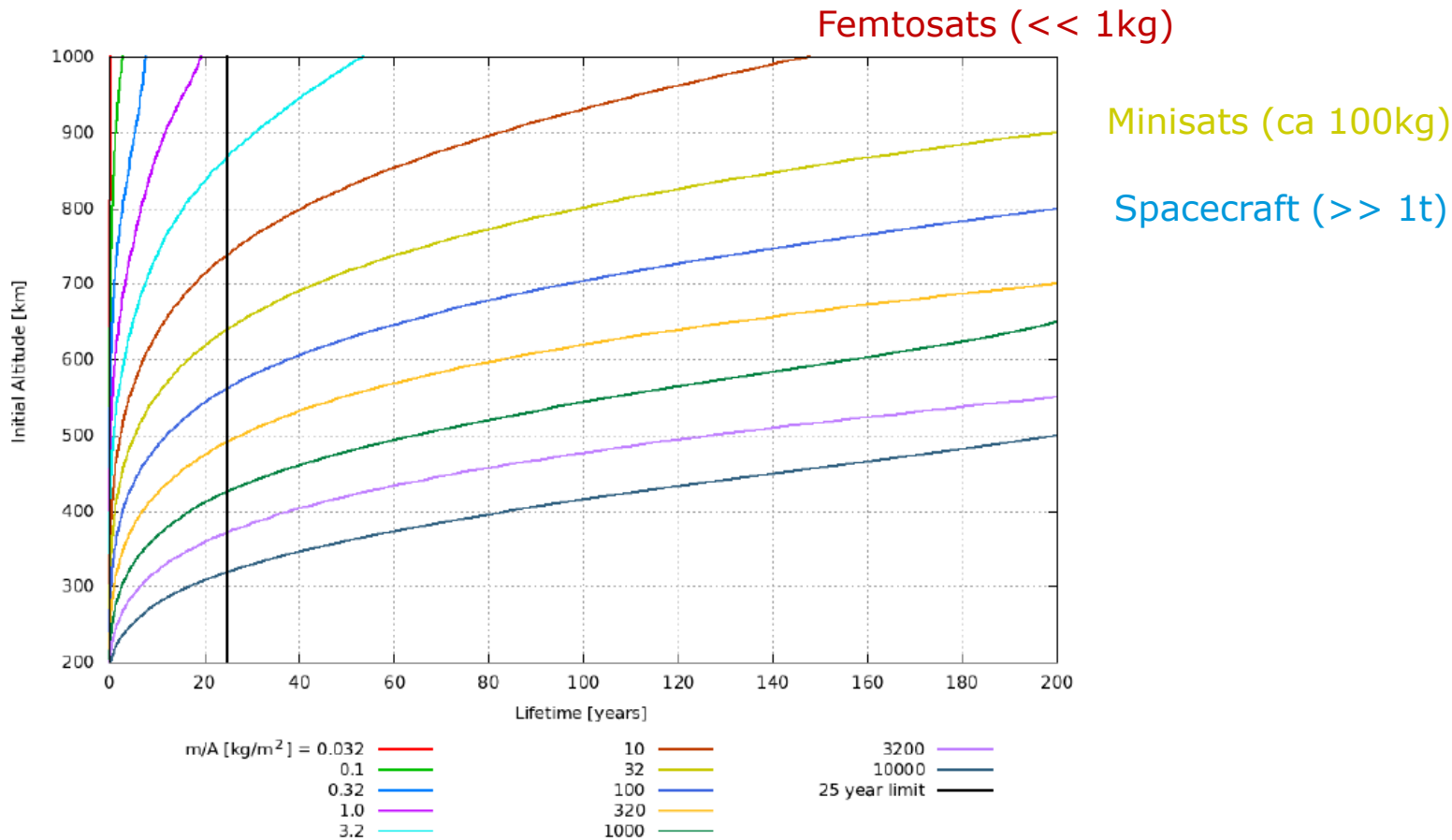
GEO protected zone: EoL Statistics



- Average of 16 annual disposals (results for 2014 still under consolidation)
- based on Surveillance data and (where available) operator confirmation



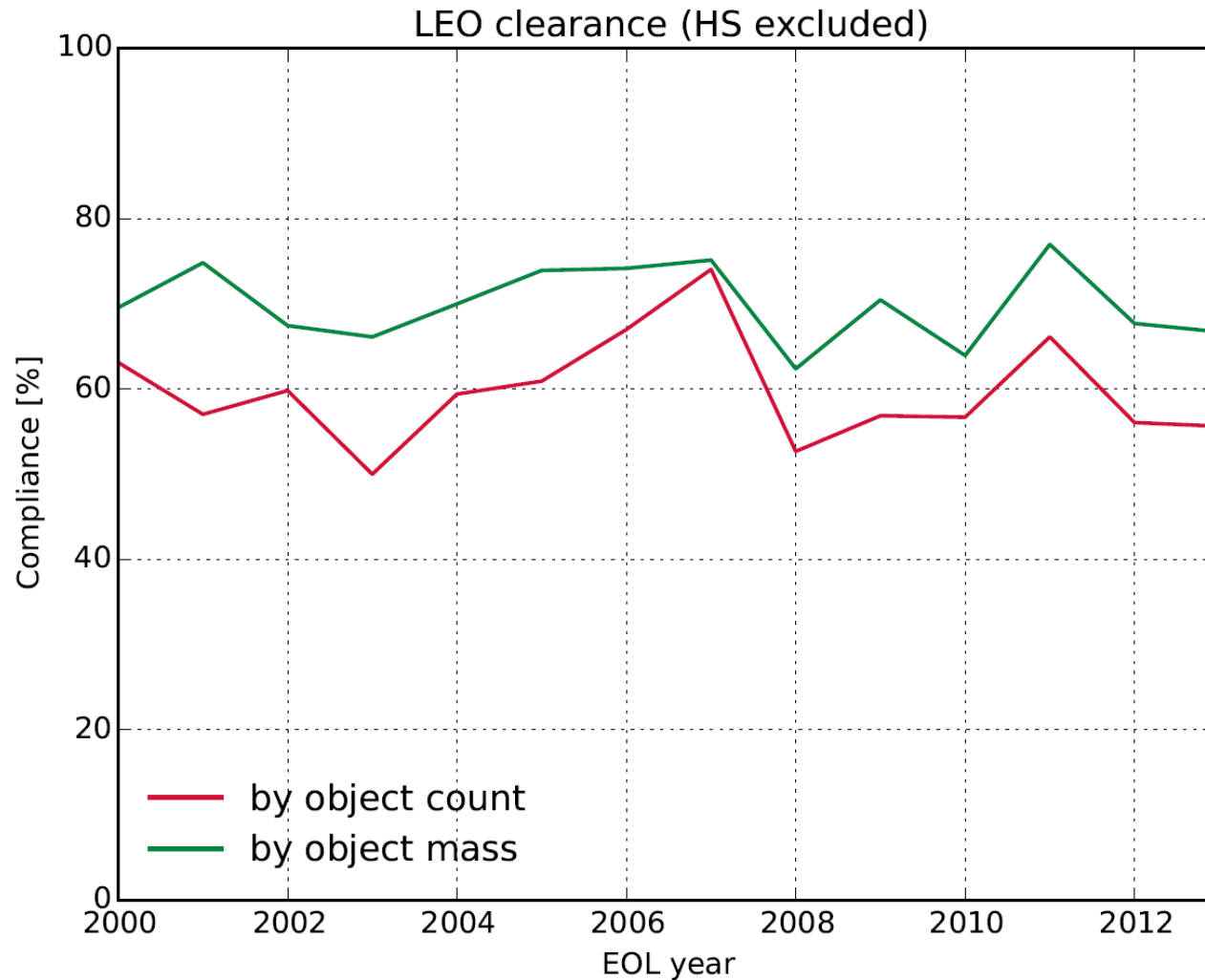
Circular Disposal Orbit Selection



History of object numbers and accumulated mass per year

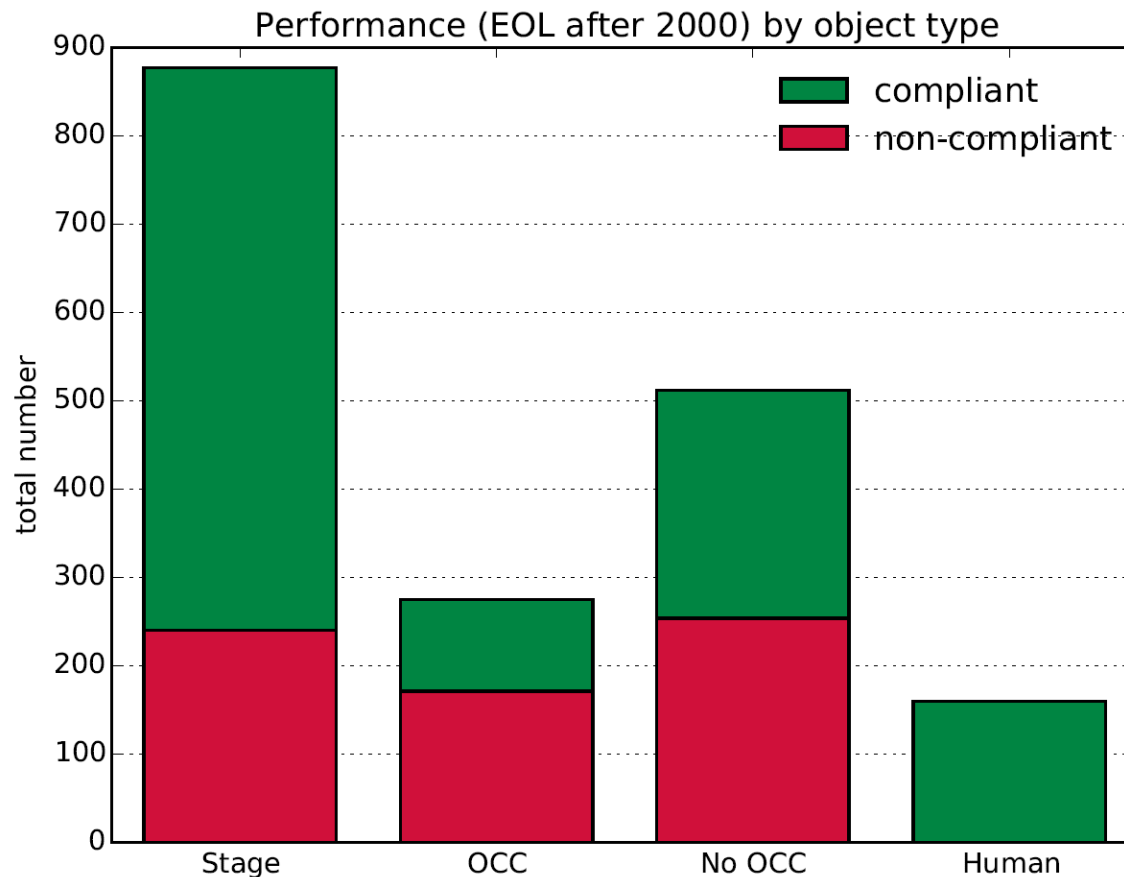


Trends in Successfully Clearing LEO

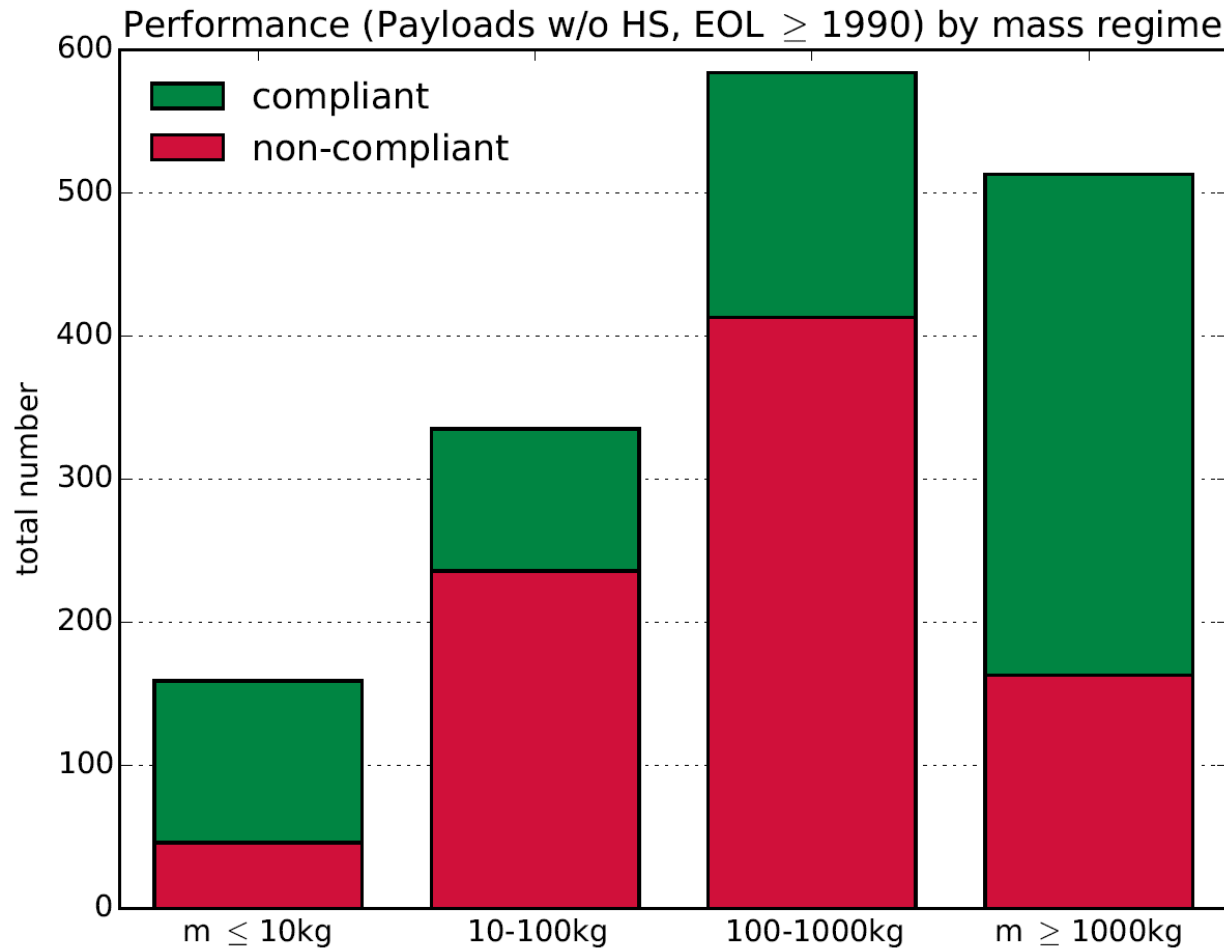


LEO Clearance 2000-2012 by Type

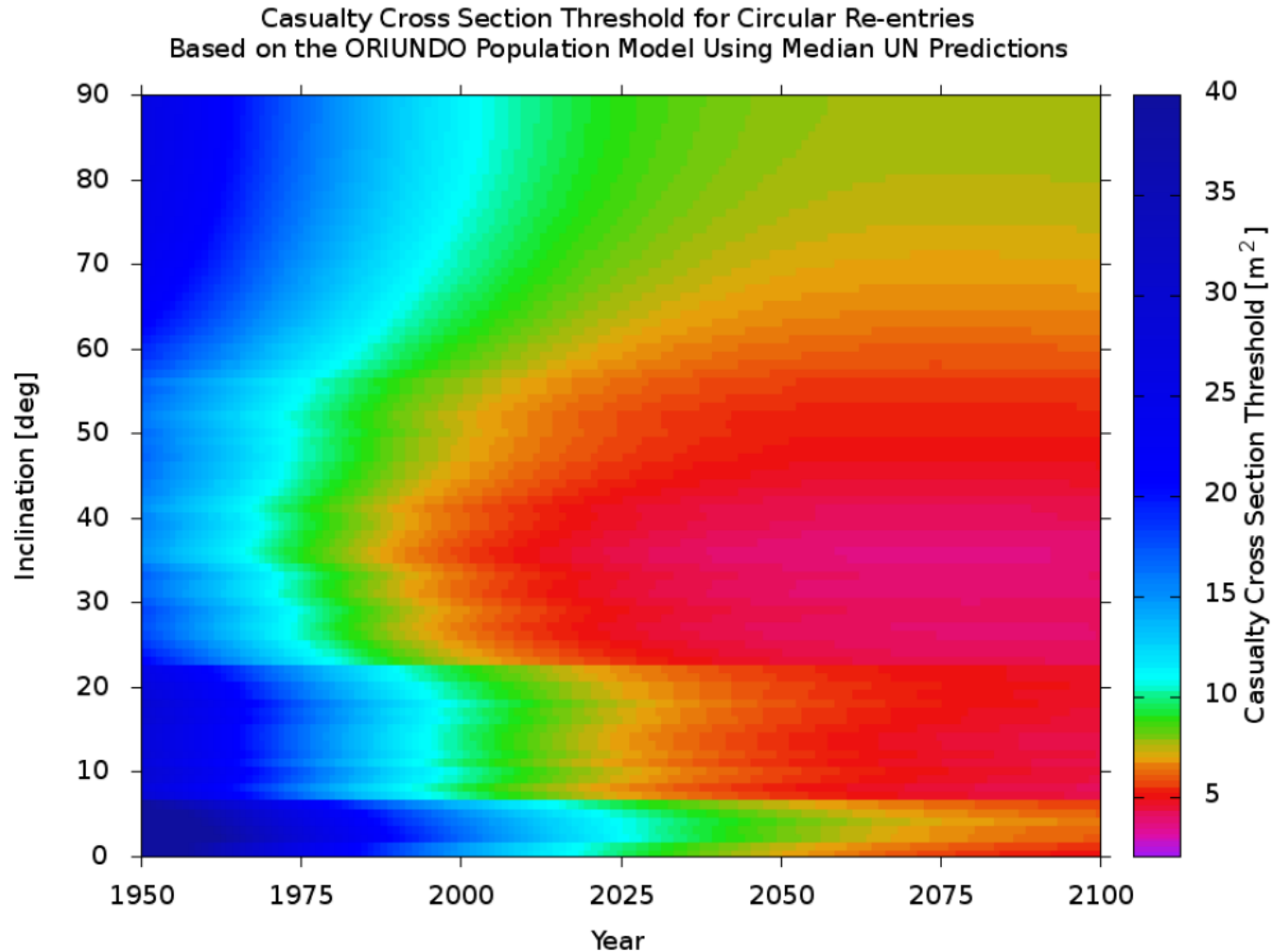
OCC = Orbit Control Capacity



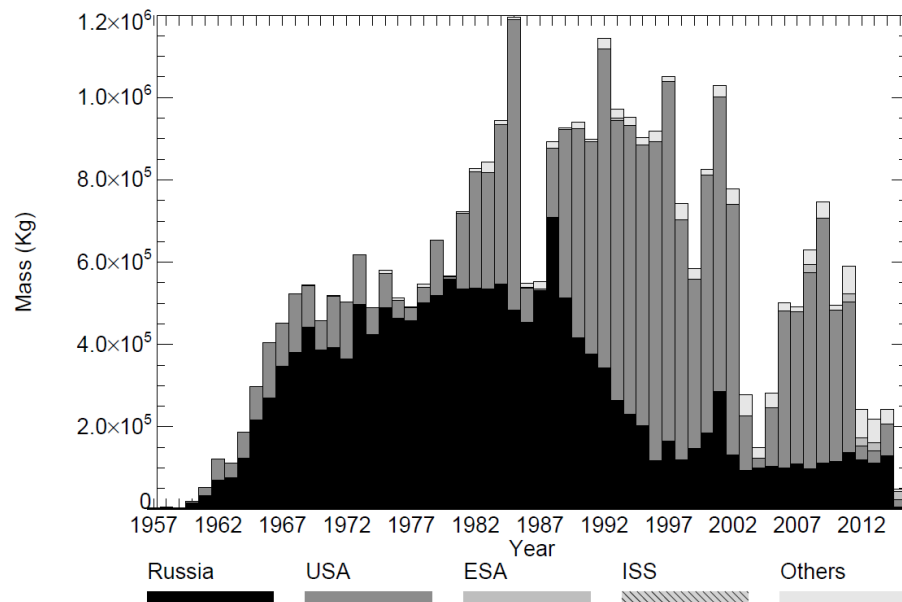
LEO Clearance 2000-2012 by Mass



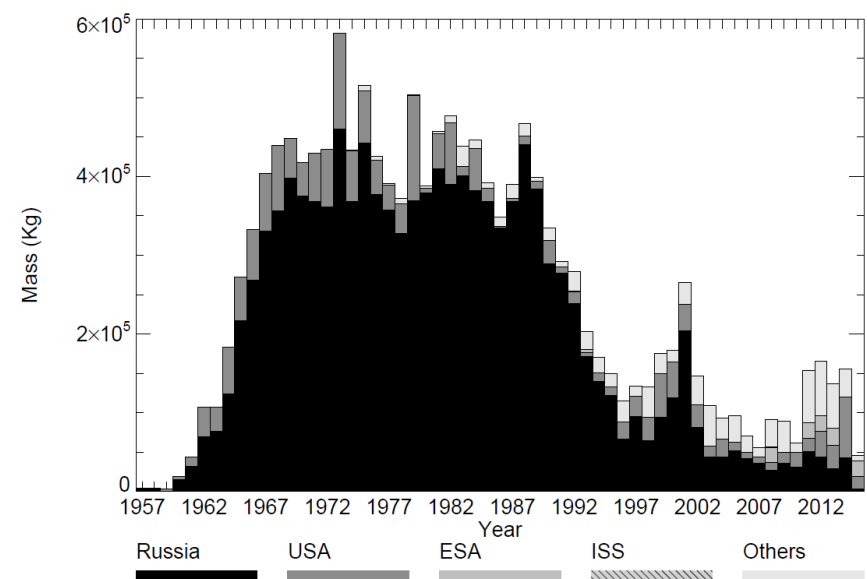
Dependency on Epoch and Inclination



All re-entries



Uncontrolled re-entries



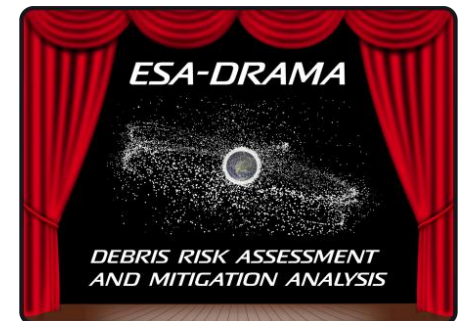
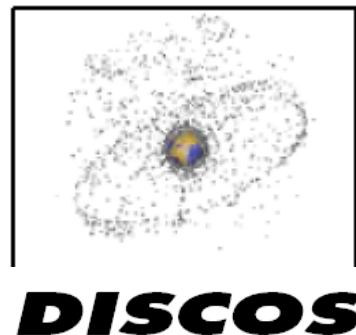
...i.e. HS vehicles excluded...

Thank You!!



Download ESA space debris tools from:

- <https://sdup.esoc.esa.int>





ARES: Assessment of Risk Event Statistics:
To consider the possible requirements for collision avoidance manoeuvres during a mission.



MIDAS: MASTER (-based) Impact Flux and Damage Assessment Software: To model the collision flux and damage statistics for a mission.



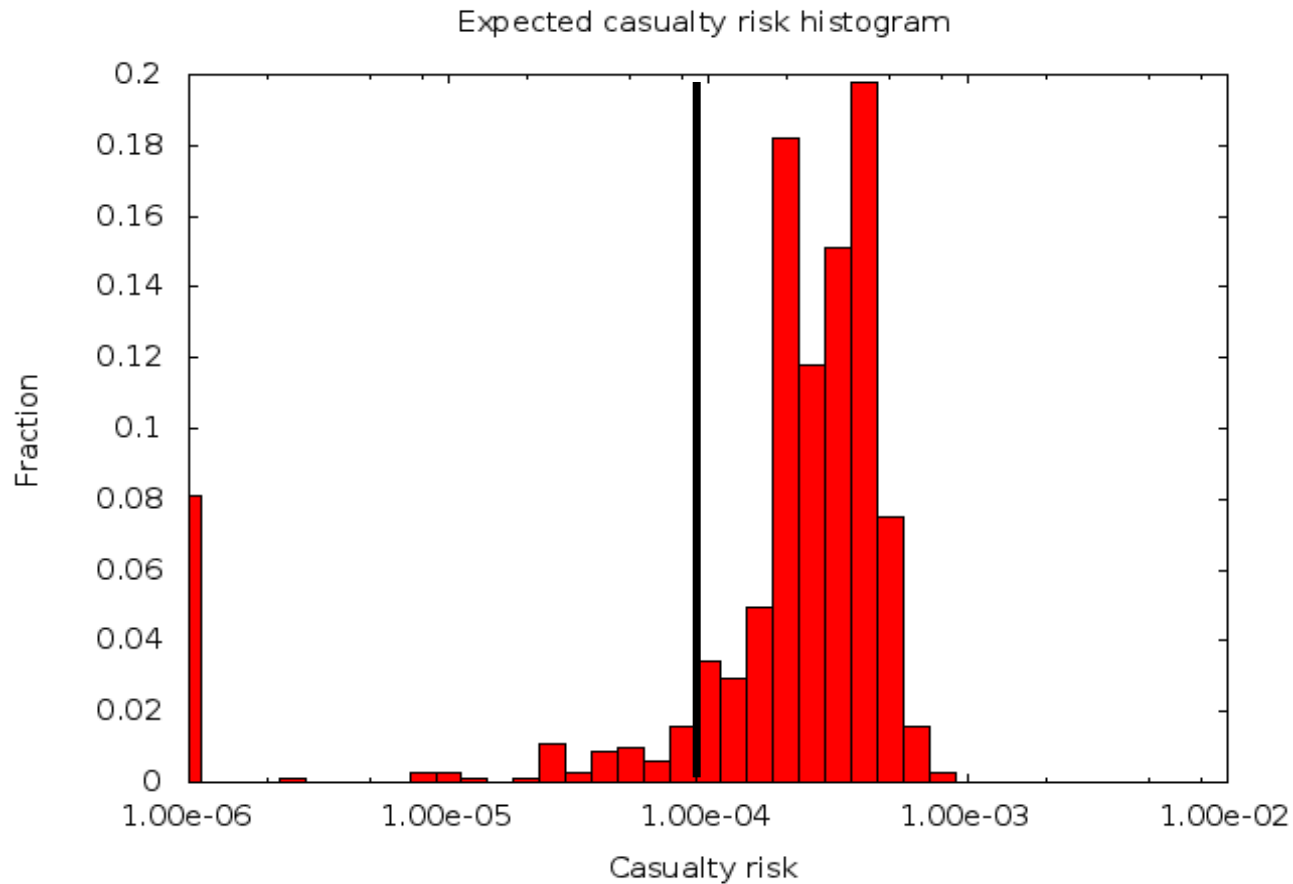
OSCAR: Orbital Spacecraft Active Removal: To analyse the disposal manoeuvre performed by a space system at the end of its useful lifetime.



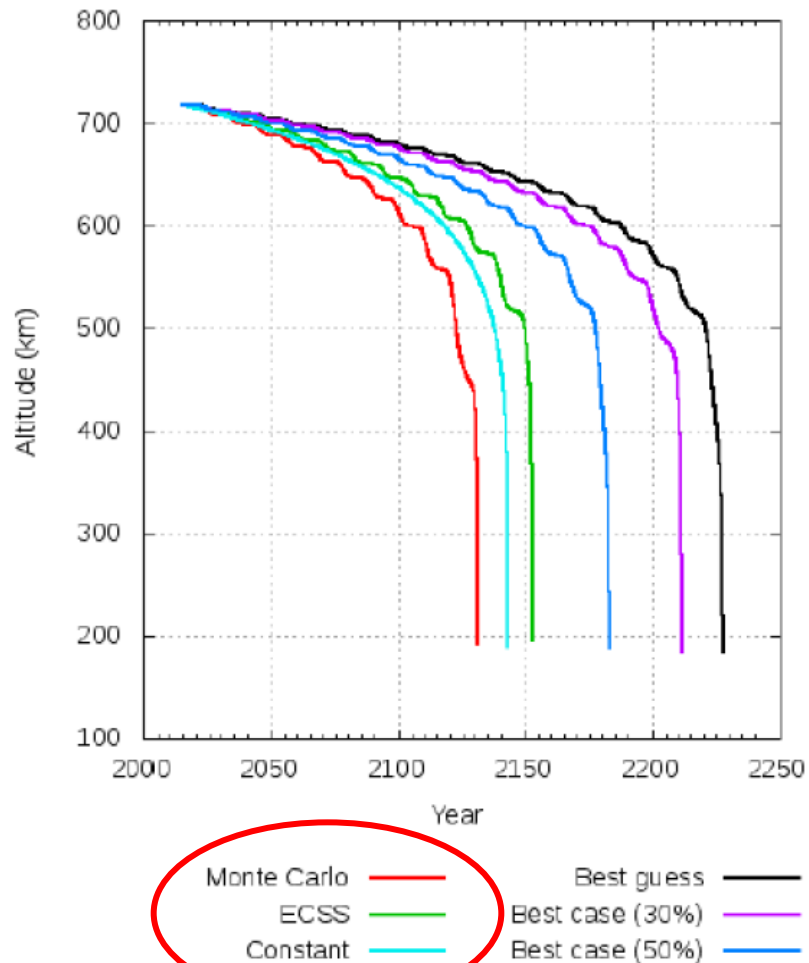
CROC: Compute projected cross-sectional areas of complex bodies



SARA: Spacecraft Entry Survival Analysis Module (SESAM):
To model the re-entry of a space system into the Earth's atmosphere.
Spacecraft Entry Risk Analysis Module (SERAM):
To assess the risk on-ground of objects surviving re-entry.



Solar Activity Forecasting Schemes



Example:

- initial orbit of 710 km x 726 km,
- 92° inclination,
- epoch 01/01/2015,
- cross-section 3.4 m²

Destination orbits of spacecraft

