

Space Debris – Risks and Mitigation

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Distribution of Catalogued Objects





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ESA UNCLASSIFIED – Releasable to the Public European Space Agency

The overall population in space







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

Altitude	>0.1mm	>1mm	>1cm	>10cm	Detectivity
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	

ESA-MASTER for 2011



Collision Avoidance





Envisat Conjunction Jan. 21st, 2010





Business As Usual





IADC Analysis for LEO orbital lifetime limitation eSa



(IADC Support Document to Guidelines)

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



Break-Up Events

Number of break-ups per year







Break-up cause

GEO: Current Status (objects with TLEs)





Objects in drift orbit

Semi-major axis mean deviation from the geostationary altitude (in km)

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





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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





Dependency on Dry Mass



Casualty cross-section of selected ESA spacecraft The plot contains results of parameter variations on some re-entry objects Results contain all objects including re-entry from Lagrange Points Note that the casualty cross-section is independent of the re-entry epoch + Cases analysed with SCARAB 1000 × Cases analysed with DRAMA $f(x) = 5.6 \times x \times (1/4) - 15$ 100 + +

Casualty cross-section [m**2] 10 100 1000 10000 Re-entering mass [kg]

Re-entering Mass per year



Others

All re-entries Uncontrolled re-entries 1.2×10⁶ 6×10⁵ 1.0×10⁶ 4×10⁵ 8.0×10⁵ Mass (Kg) Mass (Kg) 6.0×10⁵ 2×10⁵ 4.0×10⁵ 2.0×10⁵ 1962 1967 1972 1977 1982 1987 1992 1997 2002 2007 2012 1957 1957 1962 1967 1972 1977 1982 1987 1992 1997 2002 2007 2012 Year Year Russia USA ESA ISS Russia USA ESA ISS Others

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



Download ESA space debris tools from:

https://sdup.esoc.esa.int











DRAMA2 (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): Workshop| Krag | 18 March 2015 | Pag. 22 To assess the risk on-ground of objects surviving re-entry. Exa UNCLASSIFIED - Releasable to the Public Exa UNCLASSIFIED - Releasable to the Public European Space Agency

Cumulative on-ground risk





Expected casualty risk histogram

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



