Effect of Mitigation Measures on the Long-Term Evolution of the Debris Population

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SDM Version 2.0

- New version of the Space Debris Mitigation (SDM) long-term analysis software, developed under ESA/ESOC contract
- Inclusion of new traffic model and end of life disposal options

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Simulation Assumptions

- Simulation Time Span: 100 years
- Monte Carlo runs: 20 per each scenario
- Initial Population: CODRM-99
- Altitude Range: 0 - 40,000 km
- Mitigation Scenarios: 7 + 1
- Total Number of Runs: 140 + 20

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Traffic Model

- Routine Traffic: 80 launches per year
- Satellite Operational Lifetime: 10 years
- Explosion Events: 5.5 per year
- Constellations in LEO: 5

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Results up to 40,000 km

- The main conclusions are the same valid for LEO
- An important difference is represented by the much higher relative importance of the suppression of mission related objects, that simply accumulate at high altitude
- Due to the very low debris density, a negligible number of collisions occurred above 2000 km, between objects larger than 1 cm

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Results in GEO

- In the BAU case there is a steady increment of satellites and apogee kick motors, but a very limited growth of centimeter sized debris
- The adoption of satellite end of life re-orbiting, as proposed by IADC, is quite effective in stabilizing the number of both satellites and debris
- No collision occurred in the simulation period

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Conclusions [1]

- **Explosion avoidance is quite effective and should be strictly pursued; however, it will not be sufficient to decrease or stabilize the collision rate**

- **Some form of de-orbiting – or re-orbiting, for high altitude orbits – will be needed. The LEO environment deserves the most urgent actions, while above 2000 km, including the GEO regime, the collision probability will remain very low in the next century, even in the business as usual case**

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Conclusions [2]

- In LEO, immediate controlled reentry is desirable, but a certain delay, by de-orbiting in disposal orbits with residual lifetimes of 25 or 50 years, may involve acceptable long-term results, with not negligible operational advantages

- Elliptical vs. circular disposal orbits: no long-term adverse effect observed, but elliptical disposal orbits might be unacceptable for operational and/or political reasons (e.g. interference with ISS)

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Constellations in LEO

Year of Launch	Altitude (km)	Inc. (deg)	S/C In Orbit	S/C Area (m^2)	S/C Mass (kg)
2002	1375	85	324	12	1400
1998	780	86	72	9	700
1999	1414	52	56	10	450
1998	775	45	28	9.6	42
2002	1457	55	80	12	800