Space Debris Mitigation Activities at ESA

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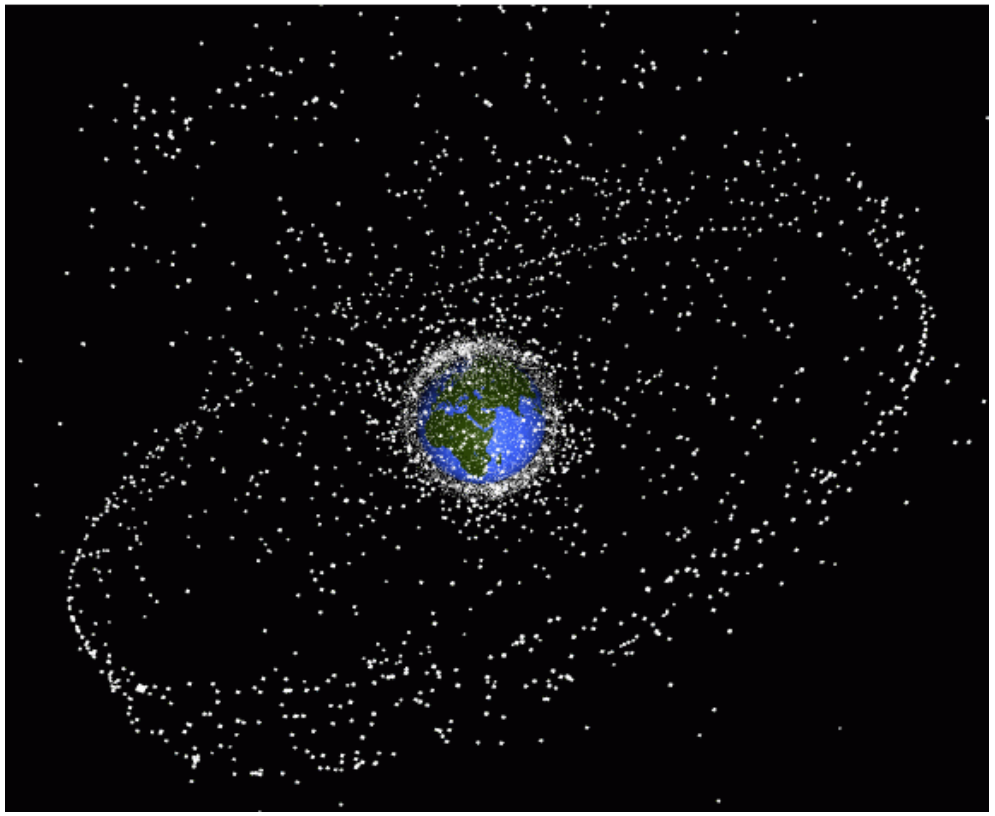
Overview

- *the current, observable space debris environment*
- *recent fragmentation events*
- *collision avoidance activities for ESA satellites*
- *status of objects in the geostationary orbit environment*
- *requirements on space debris mitigation for ESA projects*
- *conclusions*

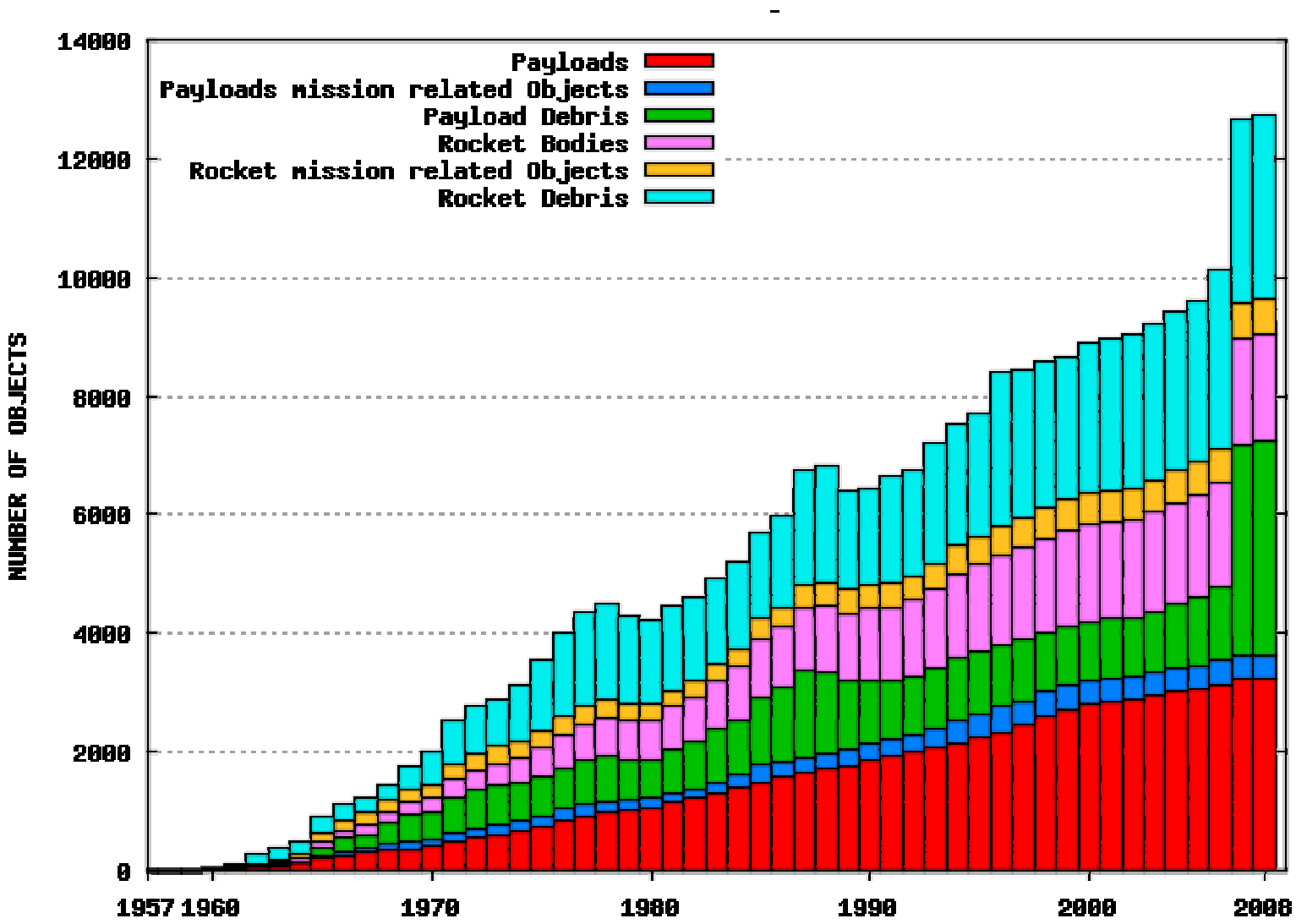
Status of the Orbital Debris Environment

- *4,547 launches and ~200 fragmentations have led to 12,500 US SSN catalog objects by end 2007*
- *ASAT test on 11-Jan-2007 ⇨ catalog increase by ~24% (~2400 fragments)*
- *Breeze-M explosion on 19-Feb-2007 ⇨ ~1,100 fragments (23 cataloged)*



- *catalog composition at end 2007: 25% payloads (6% thereof operational), 14% rocket bodies, 8% mission-related objects, and 53% fragments (41% before the ASAT test)*

Evolution of the Space Object Population



Collision Avoidance Activities

- *baseline of ESA's conjunction event assessments:*
  - *conjunction analysis and collision avoidance service provided for ERS-2 (2.2 tons) and Envisat (8 tons), both on sun-synchronous, near-polar orbits of 780 km altitude*
  - *conjunction event screening performed with catalog orbit data of the US SSN*
  - *forecasts and notifications are issued automatically, each day, for 7 days ahead*
  - *high-risk events are verified with own orbit determinations from European radar data*
  - *max. accepted collision probability: 1 in 1,000 per event (else ⇨ evasive maneuver)*
- *near-miss of Envisat with Cosmos 1624 and Cosmos 1371*
  - *Cosmos 1624 and 1371: 750 kg spacecraft on a 785 km, high-inclination orbit*
  - *potential collision geometry: near head-on approach at 14.8 km/s (53,000 km/h)*
  - *Cosmos 1624: near-miss event on Jan. 9, 2008, 19:00 UTC, at 282 m distance*
  - *Cosmos 1371: near-miss event on Jan. 13, 2008, 18:58 UTC, at 145 m distance*
  - *based on ESA orbit determinations from German FGAN radar data the assessed collision risk was negligible for both events ⇨ no avoidance maneuvers performed*
  - *Envisat near-miss events in 2007 : 13 at < 500 m, 8 at < 300 m, 3 at < 100 m*
  - *frequent re-visits by some objects: 27 conjunctions of Envisat with Kosmos 783*
  - *15% of all Envisat near-miss events in 2007 were due to Fengyun 1C fragments*

GEO Satellite Retirements in 2007

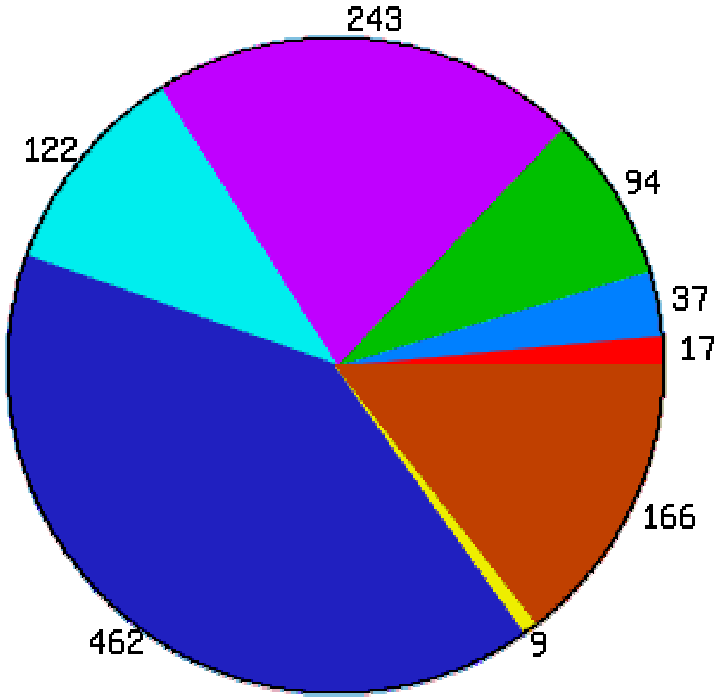
- 8 disposals according to the IADC Guideline (re-orbit by >275 km)
  - NATO IV A (91-001A) ⇨ disposal orbit 530 km x 600 km above GEO
  - Meteosat 5 (91-015B, EUMETSAT) ⇨ disposal orbit 490 km x 550 km above GEO
  - Satcom C4 (92-057A, UK) ⇨ disposal orbit 340 km x 370 km above GEO
  - DirecTV 2 (94-047A, USA) ⇨ disposal orbit 410 km x 520 km above GEO
  - GOES 9 (95-025A, USA) ⇨ disposal orbit 410 km x 430 km above GEO
  - Fengyun-2 1R (97-029A, PR China) ⇨ disposal orbit 800 km x 1650 km above GEO
  - BSAT 1B (98-024B, Japan) ⇨ disposal orbit 295 km x 340 km above GEO
  - Thuraya (00-066A, Emirates) ⇨ disposal orbit 330 km x 400 km above GEO
- 3 disposals with > 200 years clearance of the protected GEO region
  - Hot Bird 1 (95-016B, EUTELSAT) ⇨ disposal orbit 258 km x 283 km above GEO
  - JC Sat 3 (95-043A, Japan) ⇨ disposal orbit 265 km x 372 km above GEO
  - N-Star 2 (96-007A, Japan) ⇨ disposal orbit 255 km x 318 km above GEO
- 2 satellites left in the GEO protected region (GEO ± 200 km)
  - Gorizont 26 (92-043A, Russia) ⇨ too low disposal orbit 160 km x 420 km above GEO
  - Raduga 30 (93-062A, Russia) ⇨ left in libration around eastern stable longitude

End-of-Life Disposal History of GEO Satellites

	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	Total
● Left at L_1	1	7	5	3	5	1	–	2	1	2	1	28
● Left at L_2	2	3	1	1	1	1	1	1	1	1	–	13
● Left at L_1/L_2	–	–	–	2	–	–	–	–	1	–	–	3
● Drift orbit (too low)	6	6	4	2	6	5	7	5	5	7	1	54
● Drift orbit (compliant)	–	–	1	–	–	1	2	–	3	–	3	10
● Drift orbit (> 275 km)	6	6	4	3	2	3	6	5	8	9	8	60
Annual Total	15	22	15	11	14	11	16	13	19	19	13	168

- *the compliance with GEO end-of-life re-orbiting guidelines has improved considerably over the past 10 years*

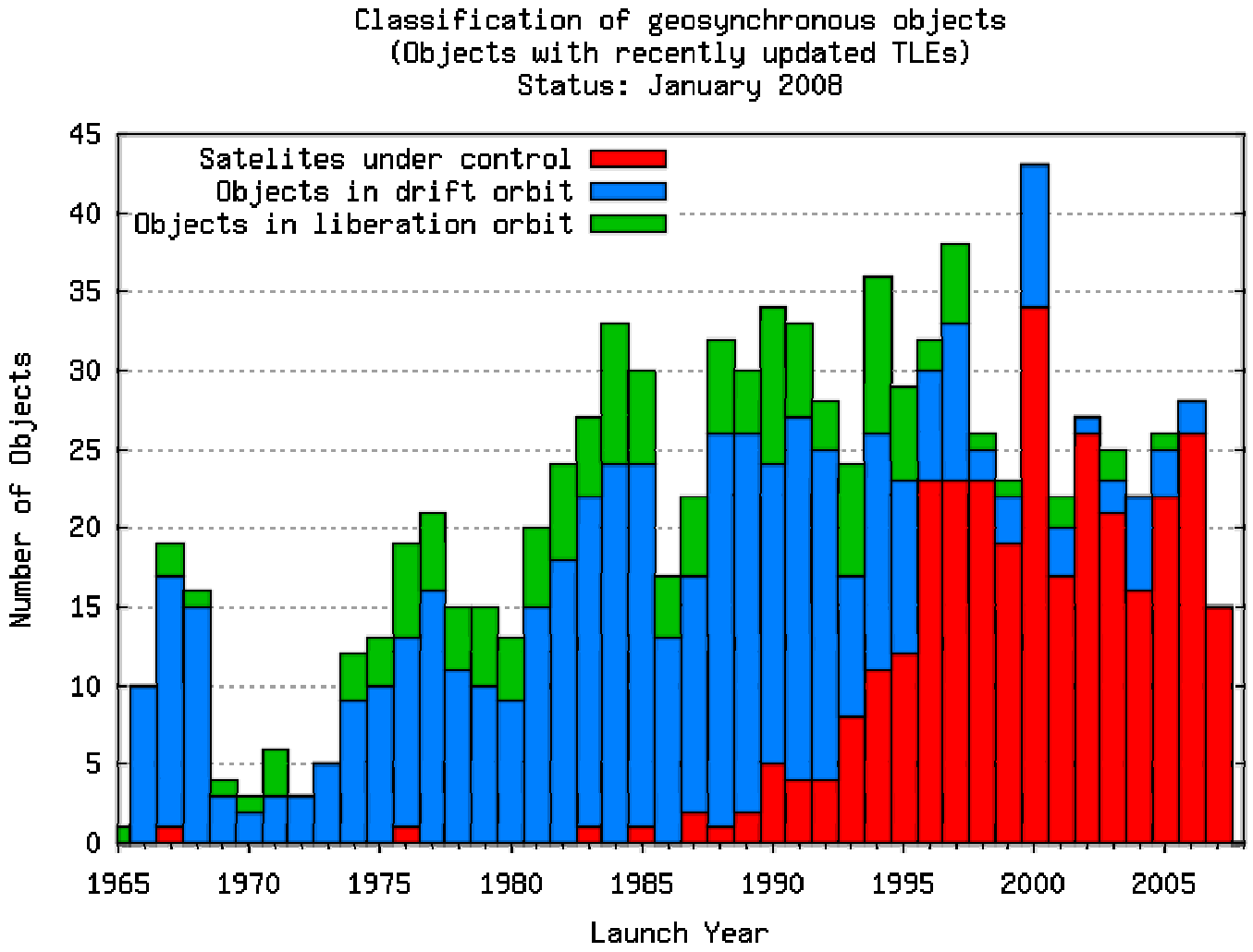
Orbit Control Status of GEO Objects in 2007



Libration around 2 points:	17	Controlled :	122
Libration around 105 W:	37	Drift :	462
Libration around 75 E:	94	Indeterminate :	9
Controlled (E-W and N-S):	243	Uncontrolled (no TLEs):	166

- *934 objects were in or near the GEO ring in 2007; of these,13 satellites were retired, and 22 satellites and 2 orbit stages were newly inserted*

Orbit Control Status vs. Age of GEO Objects



ESA Requirements on Space Debris Mitigation

- *scope of Requirements on Space Debris Mitigation for ESA Projects*
  - *based on European Code of Conduct on Space Debris Mitigation (issue 1, rev.0, June 28, 2004), as signed by ESA*
  - *compliant with IADC Guidelines (Nov. 2002) and UN Guidelines (Jan.10, 2008)*
  - *to become applicable for all future ESA projects as an ESA Instruction*
- *tracing of ESA Requirements against UN and IADC Guidelines*
  - *limit debris released during normal operations (UN, IADC, ESA)*
  - *minimize the potential of break-ups during operational phase (UN, IADC, ESA)*
  - *limit the probability or accidental collisions in orbit (UN, IADC, ESA [1])*
  - *avoid intentional destruction and other harmful activities (UN, IADC, ESA)*
  - *minimize the potential for post-mission break-ups resulting from stored energy (UN, IADC, ESA)*
  - *limit the long-term presence of S/C and L/V orbital stages in LEO after their end of mission (UN, IADC, ESA)*
  - *limit the long-term interference of S/C and L/V orbital stages with GEO after their end of mission (UN, IADC, ESA)*

[1] adopted as a guideline, but not as a requirement, due to lack of guaranteed data

Conclusions

- *the frequency of near-miss events in some low earth orbits is high*
- *debris concentrations at some altitudes have reached critical levels*
- *debris mitigation measures must consistently be applied in low earth orbits to reach a stable environment*
- *debris remediation measures may be necessary to safeguard a stable low earth orbit environment in the long-term future*
- *space debris mitigation measures have been progressively applied for the disposal of GEO spacecraft during the past 10 years [1]*

[1] see "Classification of Geosynchronous Objects", issue 10, Feb.2008 (electronic copies can be requested from Ruediger.Jehn@esa.int)