Space Debris Mitigation Activities at ESA

Heiner Klinkrad

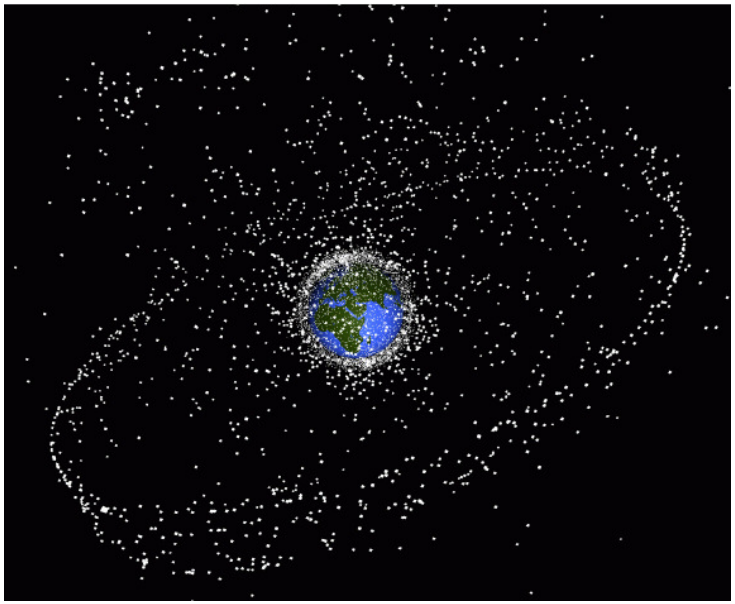
ESA Space Debris Office

Overview

- the current, observable space debris environment
- the mission of ATV Jules Verne
- collision avoidance activities for ESA satellites
- status of objects in the geostationary orbit
- ESA debris mitigation requirements
- European space situational awareness program
- conclusions

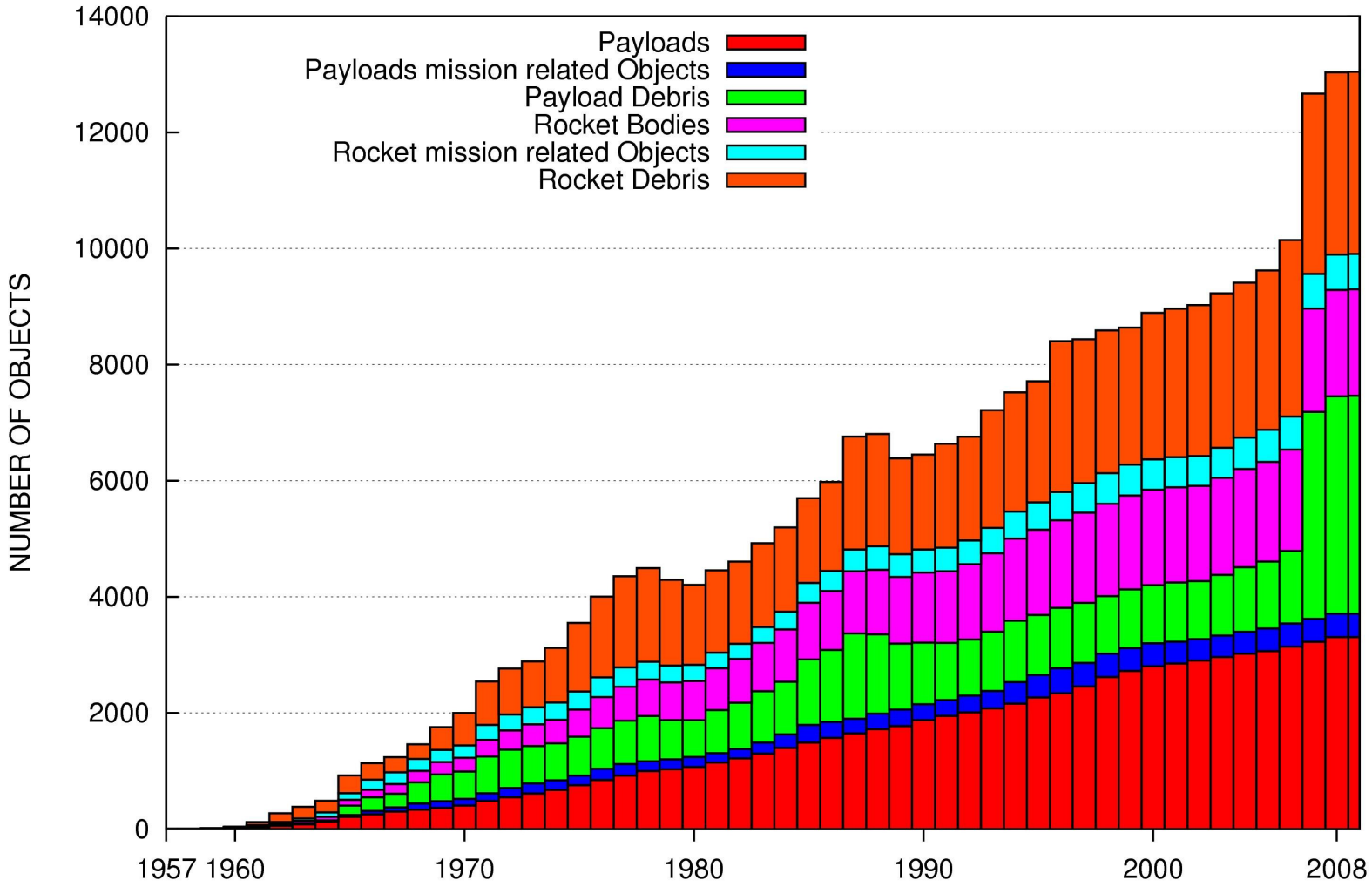
Status of the Space Debris Environment in 2008

- 4,616 launches and 245 on-orbit break-ups led to 12,500 catalog objects of the United States‘ Space Surveillance Network by Dec. 2008
- launches in 2008 ⇨ 67
- mass on orbit ⇨ 6,300 tons
- catalog orbital distribution:
  low Earth orbits ⇨ 73%;
  near-geostationary orbits ⇨ 8%;
  highly eccentric orbits ⇨ 10%;
  other orbits (incl. GNSS) ⇨ 9%



- catalog composition: satellites ⇨ 25% (only 7% operational), 14% rocket bodies, 8% mission-related objects, and 53% fragments (41% before FengYun 1C ASAT test)
- consequences of satellite engagements (as of Dec. 2008):
  FengYun 1C (11 Jan. 2007) ⇨ 2,318 cataloged fragments in orbit;
  USA-193 (21 Feb. 2008) ⇨ no cataloged fragments left in orbit

Evolution of the Space Object Population



The ATV Servicing Mission and Its Re-Entry

- ATV Jules Verne: a 20-ton ESA servicing vehicle for ISS launched from Kourou on Ariane 5 on March 9, 2008; ISS docking on April 3
- on Aug. 27, ATV lowered the orbit of the 240-ton ISS by 1.8 km to avoid a potential collision with a fragment of Cosmos-2421
- on Sep. 5, ATV was de-docked from the ISS; on Sep. 29, ATV was de-orbited into an un-inhabited area of the south Pacific Ocean
- the ATV re-entry (right image) was observed from two aircraft and from the ISS by 23 instruments of 38 researchers; post-flight data analysis will improve the understanding of re-entry phenomena

Collision Avoidance Statistics for 2008

ESA's conjunction event assessment service

- 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
- accepted collision probability: 1 in 1,000 per event (else ⇨ avoidance maneuver)

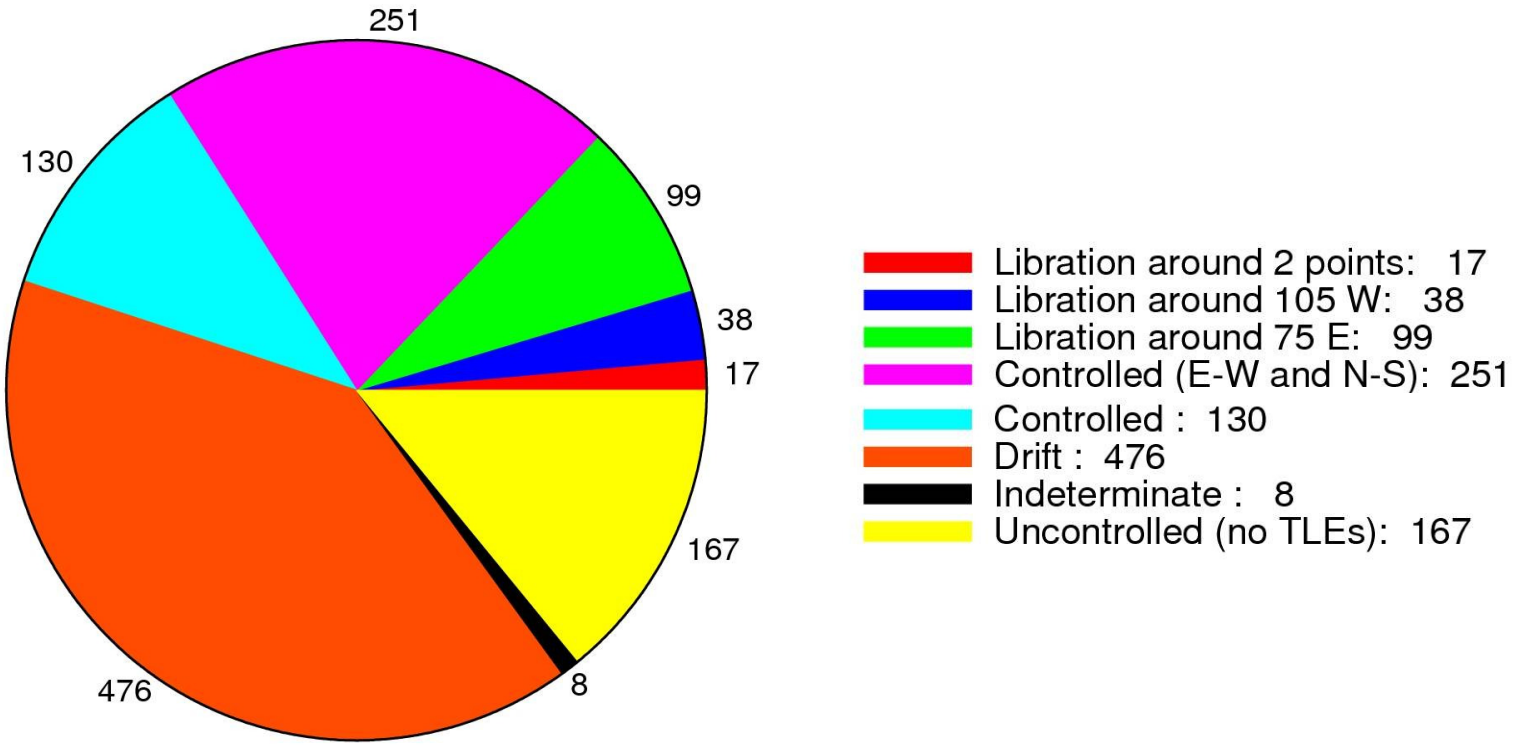
conjunction event statistics for the year 2008

- 4 events exceeded a collision probability of 1 in 1,000 (all for Envisat);
  18 events exceeded a collision probability of 1 in 10,000 (15 for Envisat; 3 for ERS-2);
  near-miss events: 7 at < 200m, 11 at < 300m, 19 at < 400m, and 27 at < 500m
- conjunction objects: 23% FengYun 1C fragments, 23% spacecraft, 13% orbital stages, 36% fragmentation debris, and 5% mission-related objects
- frequent re-visits: 7 conjunctions of Envisat with Cosmos 841; 10 conjunctions of ERS-2 with a Cosmos-3M 2nd stage
- 4 events required tracking campaigns (4 passes each) to determine improved orbits
- no avoidance maneuver was necessary as result of the improved orbit knowledge
- the collision of Iridium 33 with Cosmos 2251 on Feb.10, 2009, 16:56 UTC will significantly increase the collision risk for ESA's ERS-2 and Envisat satellites

GEO Satellite Retirements in 2008

- 7 satellites re-orbited according to IADC Guidelines
  - Marisat 3 (76-101A, USA) ⇨ disposal orbit 330 km x 1,205 km above GEO
  - Optus A3 (87-078A, AUS) ⇨ disposal orbit 350 km x 425 km above GEO
  - Optus B1 (92-054A, AUS) ⇨ disposal orbit 275 km x 330 km above GEO
  - Superbird A1 (92-084A, Japan) ⇨ disposal orbit 290 km x 365 km above GEO
  - Orion 1 (94-079A, USA) ⇨ disposal orbit 390 km x 570 km above GEO
  - Skynet 4D (98-002A, UK) ⇨ disposal orbit 305 km x 330 km above GEO
  - PAS 6B (98-075A, USA) ⇨ disposal orbit 241 km x 393 km above GEO
- 1 satellite re-orbited too low
  - Galaxy 10R (00-002A, USA) ⇨ disposal orbit 170 km x 190 km above GEO
- 4 satellites left in GEO protected region (GEO ± 200 km)
  - Gorizont 28 (93-069A, Russia) ⇨ left in libration around L1
  - Echostar 2 (96-055A, USA) ⇨ left in libration around L2
  - Gorizont 33 (00-029A, Russia) ⇨ left in libration around L1 and L2
  - Xinnuo 2 (06-048A, PR China) ⇨ left in libration around L1

Orbit Control Status of GEO Objects in 2008



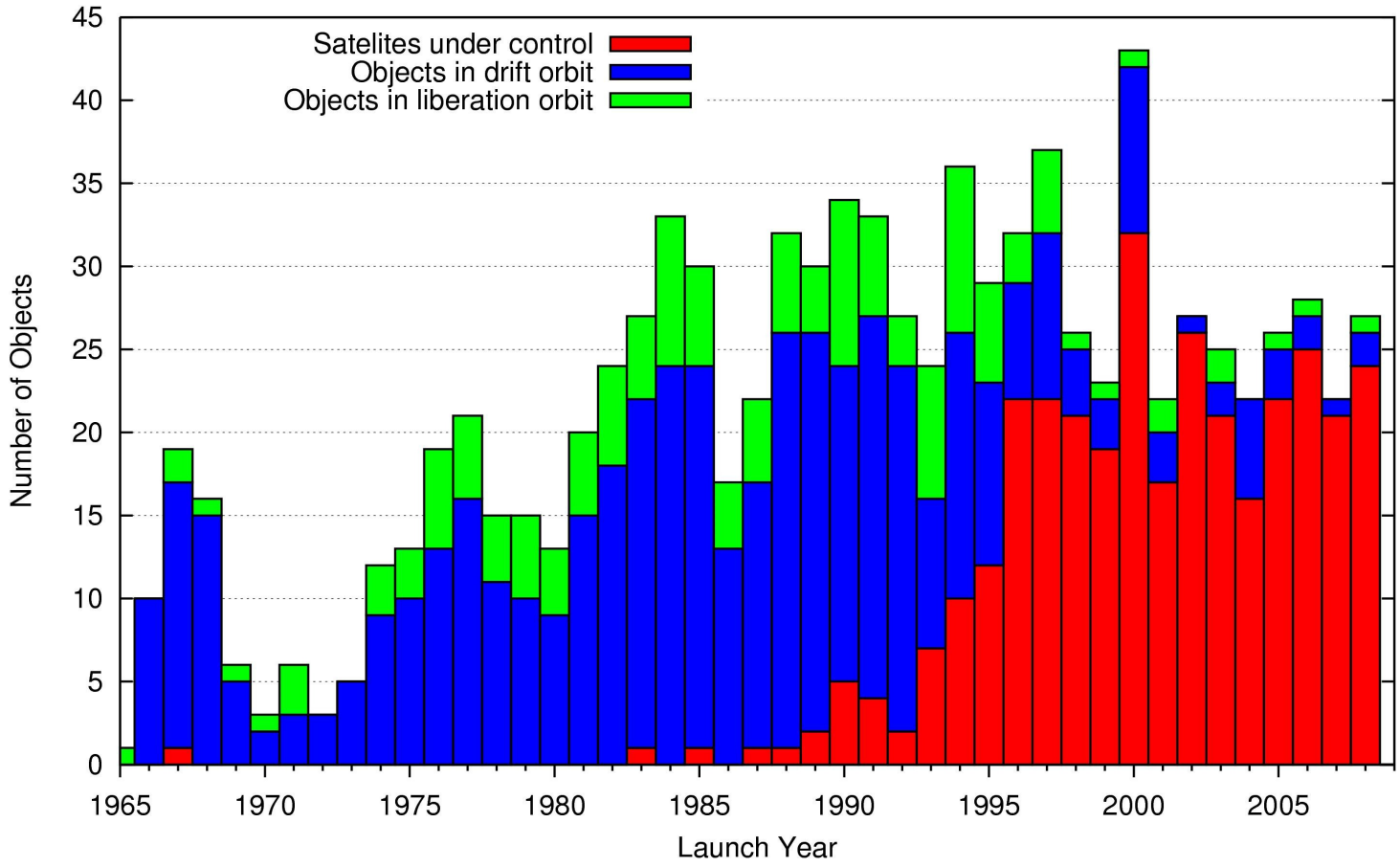
- 1,186 objects were in or near the GEO ring in 2008
- 12 satellites were retired; 28 satellites / 4 stages were inserted
- 381 satellites are controlled (251 of them in E-W and N-S)

End-of-Life Disposal History of GEO Satellites

	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	Total	
• Left at L_1	7	5	3	5	1	–	2	1	2	1	2	29	(18%)
• Left at L_2	3	1	1	1	1	1	1	1	1	–	1	12	(7%)
• Left at L_1/L_2	–	–	2	–	–	–	–	1	–	–	1	4	(2%)
• Drift orbit (too low)	6	4	2	6	5	7	5	5	7	1	1	49	(30%)
• Drift orbit (compliant)	6	5	3	2	4	8	5	11	9	11	7	71	(43%)
Annual Total	22	15	11	14	11	16	13	19	19	13	12	165	(100%)

- compliance with GEO end-of-life re-orbiting guidelines has improved during the past 11 years
- averaged over 11 years, 43% of the retired GEO spacecraft were properly re-orbited, 30% were insufficiently re-orbited, and 27% were abandonned in the GEO ring

Orbit Control Status vs. Age of GEO Satellites



see "Classification of Geosynchronous Objects", Issue 11, Feb.2009
(electronic copies can be requested from Ruediger.Jehn@esa.int)

Other Debris-Associated Activities of ESA

- **ESA Requirements on Space Debris Mitigation**
  - ESA/ADMIN/IPOL(2008)2 ⇨ binding set of management, design and operational requirements for new ESA projects as of April 1, 2008
  - based on the European Code of Conduct on Space Debris Mitigation (2004)
  - compliant with IADC Guidelines (Nov. 2002) and UN Guidelines (Jan. 2008)
- **Space Situational Awareness (SSA) Program**
  - Nov. 26, 2008 ⇨ Program Declaration subscribed by ESA Member States
  - SSA Preparatory Program (2009 – 2011) ⇨ [1] space surveillance & tracking, [2] governance, data policy & data centers, [3] space weather & near-Earth objects, [4] radar system analyses
  - short-term objectives ⇨ availability of SSA precursor services by 2012
  - long-term objectives ⇨ provide Europe with an autonomous capability for [1] accurate, timely, and complete space situational awareness information, [2] secure and safe operations of its space activities and services, [3] protection of its population in case of re-entries and NEO approaches, [4] verification of compliance with international treaties and codes of conduct to support the peaceful uses of outer space

Conclusions

- the collision of Iridium 33 with Cosmos 2251 on Feb. 10, 2009, is consistent with assessments by researchers that space debris concentrations at some altitudes have reached critical levels
- debris mitigation measures must be consistently applied today to conserve the environment
- debris remediation (active mass removal) will ultimately be required to maintain a safe orbit environment in the long-term future
- European space situational awareness data will contribute to the improvement of safety on orbit and for the population on ground
- ESA is committed to play an active role in space debris control