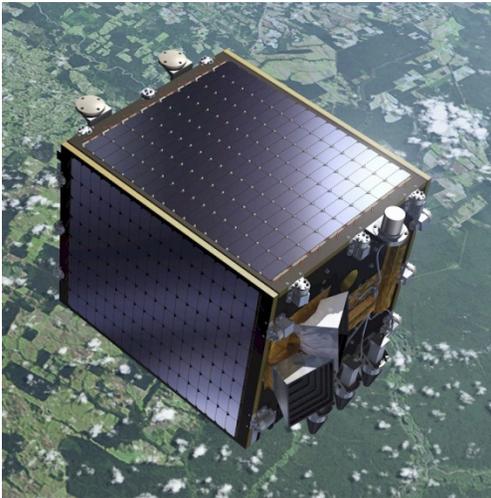
A background illustration showing a central Earth globe surrounded by a dense field of small grey dots representing space debris in various orbital paths.

# Space Debris Mitigation Activities at ESA in 2013

**Heiner Klinkrad**  
**ESA Space Debris Office**

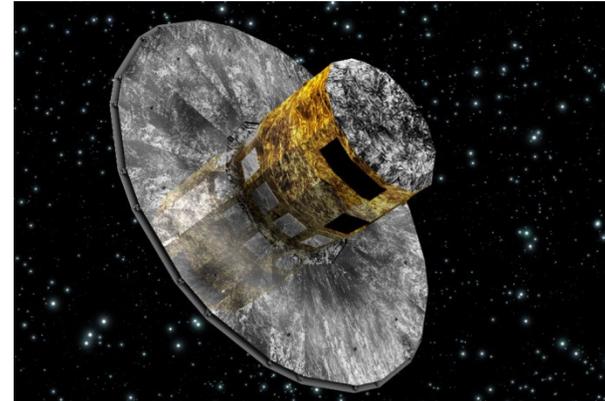


## ■ PROBA-V (2013-021A)

- launch ⇒ May 7, from CSG/Kourou on VEGA; mass ⇒ 160kg  
orbit ⇒ 813km x 819km @ 98.71°
- mission objectives ⇒ crop and biosphere monitoring

## ■ ATV-4 "Albert Einstein" (2013-027A)

- launch ⇒ June 5, from CSG/Kourou, on Ariane-5 ES; mass ⇒ 20,200kg  
events ⇒ ISS docking/undocking/entry on June 15/Oct. 28/Nov. 2



## ■ Swarm A-C (2013-067A, B, C)

- launch  $\Rightarrow$  Nov. 22, from Plesetsk on Rokot/Briz; mass  $\Rightarrow$  470kg each  
orbit Swarm A  $\Rightarrow$  481km x 486km @ 87.48°  
orbit Swarm B, C  $\Rightarrow$  491km x 497km @ 87.55°
- mission objectives  $\Rightarrow$  Earth core dynamics & core/mantle interaction; magnetosphere, ionosphere & atmosphere monitoring

## ■ GAIA (2013-074A)

- launch  $\Rightarrow$  Dec. 19, from CSG/Kourou on Soyuz/Fregat; mass  $\Rightarrow$  2,000kg  
orbit  $\Rightarrow$  Sun-Earth L2 Lissajous orbit
- mission objectives  $\Rightarrow$  high-precision astrometry of  $>10^{+9}$  stars

# ESA Debris Mitigation Actions in 2013



## ■ **Herschel (2009-026A)**

- mission ⇒ IR astronomy from a Sun-Earth L2 Lissajous orbit
- April 29 ⇒ depletion of superfluid Helium and end of mission
- May 13 ⇒ final insertion maneuver into a heliocentric disposal orbit
- June 17 ⇒ spacecraft switch-off

## ■ **Planck (2009-026B)**

- mission ⇒ IR &  $\mu$ -wave astronomy from a Sun-Earth L2 Lissajous orbit
- Oct. 9-11 ⇒ final insertion maneuver into a heliocentric disposal orbit
- Oct. 22-23 ⇒ fuel depletion, passivation, and spacecraft switch-off

## ■ **ATV-4 "Albert Einstein" (2013-027A)**

- mission ⇒ delivery of consumables and supplies to the ISS
- Nov. 2 ⇒ controlled re-entry over the South Pacific

## ■ **GOCE (2009-013A)**

- mission ⇒ high-resolution gravity field determination
- Oct. 21 ⇒ fuel depletion and end of "drag-free" orbit control
- Nov. 11 ⇒ re-entry over the South Atlantic at 00:16 UTC (~80km)

# The Re-Entry of GOCE



## ■ GOCE re-entry observations:

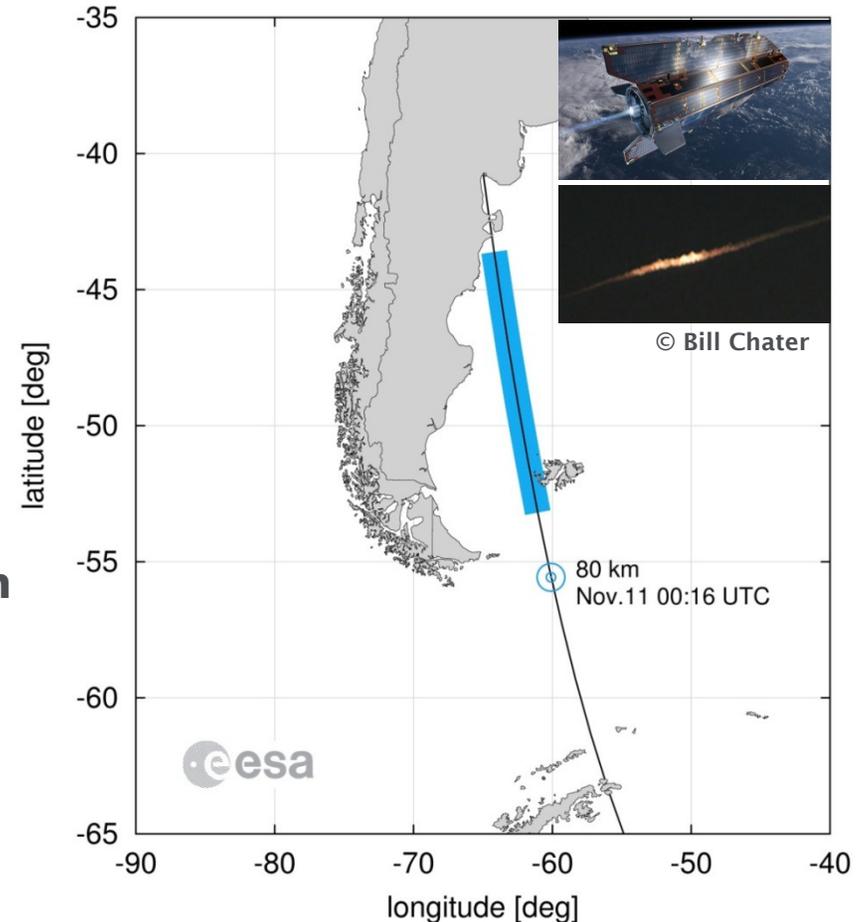
- last contact via Troll station ⇒ Nov.10 22:44 UTC (at t-1.5h)
- JSpOC ⇒ Nov.11 00:16 UTC (at 80km, 60° W/56° S)
- observer from the Falklands ⇒ Nov.11 00:20 UTC (see image)

## ■ IADC reference entry location & time:

- IADC ⇒ Nov.11 00:23 UTC (at 10km, 65° W/41° S)
- ESA distributed re-entry prediction bulletins to national and EU PoC's, and to IADC Members

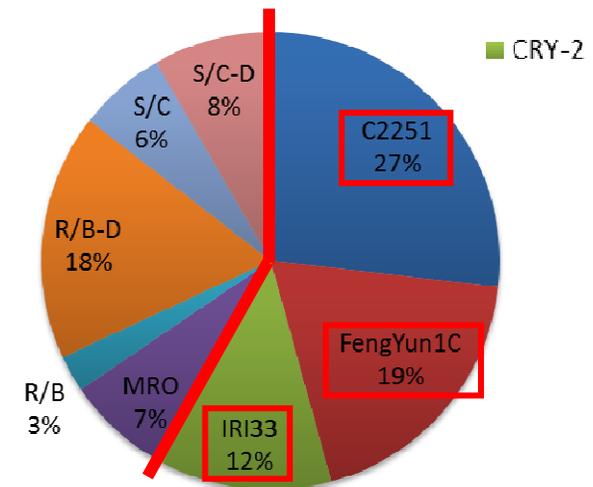
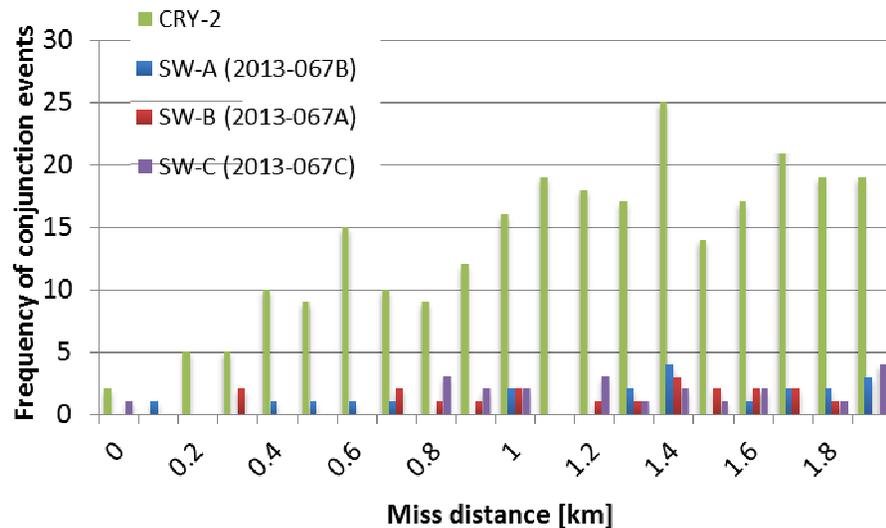
## ■ GOCE impact ground swath:

- the impact ground swath ended before the Argentinian coast line
- there were no reports on impacts



- **6<sup>th</sup> European Conference on Space Debris (22-25 April 2013):**
  - confirmed its status as largest dedicated conference on Space Debris, with 355 participants from 26 countries, and 115 oral presentations
  - key message: space debris mitigation measures should be rigorously implemented, supported by active mass removal in the near future
- **31<sup>st</sup> IADC Meeting (17-19 April 2013):**
  - held at ESA/ESOC, with 100 participants from 12 Member Agencies
  - ESA's GOCE satellite was adopted for the IADC re-entry test campaign 2013; the campaign started on Oct.21 (it ended on Nov.11)
- **ESA CleanSpace initiative:**
  - integral part of ESA's Agenda 2015 ("sustainable access to space")
  - development of technologies on debris mitigation, mass removal from orbit, and design for demise on re-entry
  - several Phase-A industrial studies for active removal (controlled de-orbit) of an ESA satellite are in progress

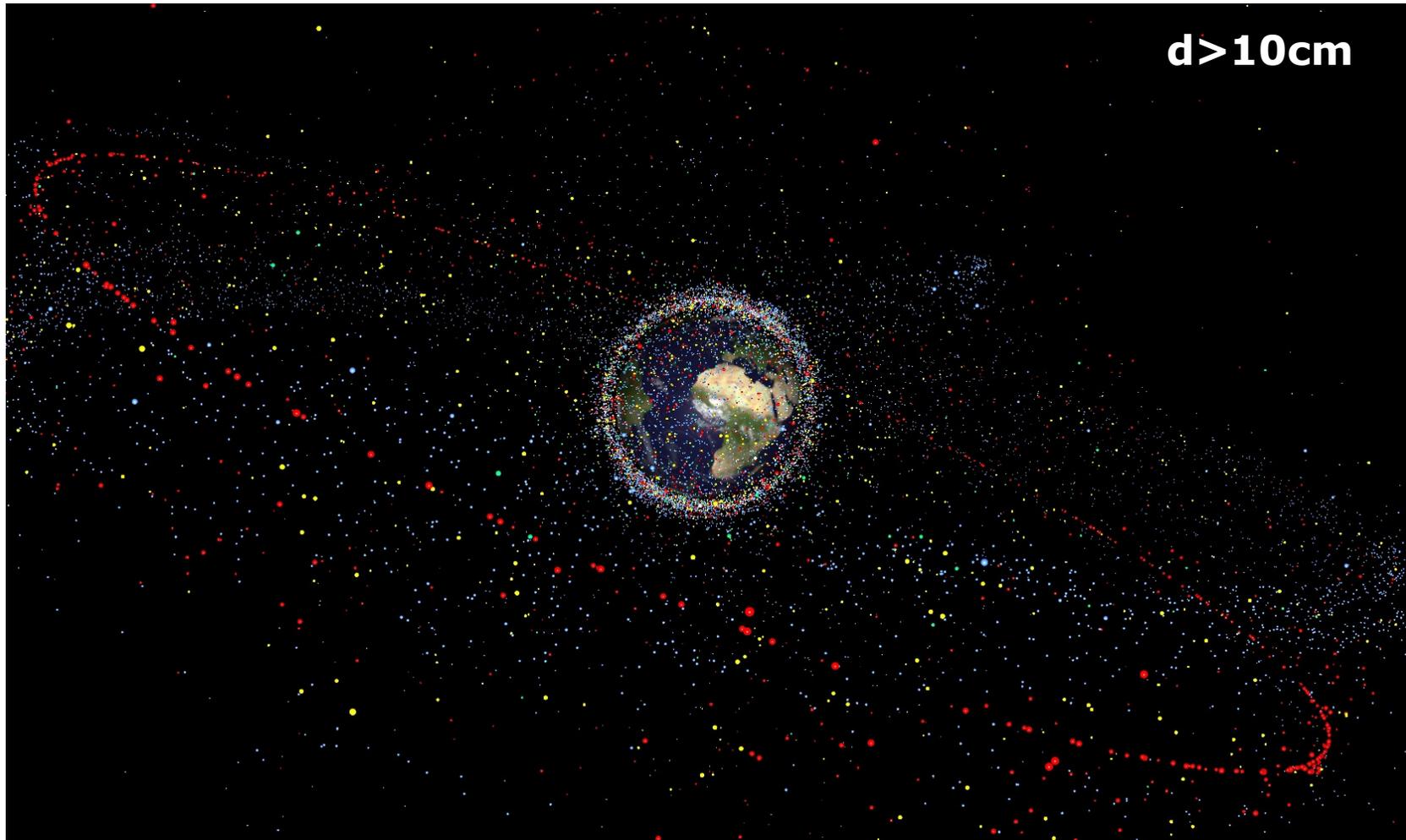
# Collision Avoidance for ESA Satellites



## ■ conjunction statistics in 2013:

- CryoSat-2 ⇒ 7 conjunctions within 300m; 2 evasive maneuvers:
  - 2013-Oct-11 (JSpOC alert): conjunction at ~340m (53m radial)
  - 2013-Oct-15 (JSpOC alert): conjunction at ~205m (200m radial)
- Swarm A+C, PROBA, PROBA-2, and PROBA-V ⇒ 10 conjunctions within 300m; no evasive maneuvers performed
- 24% to 58% of all conjunction events with ESA satellites were related to Iridium-33/C-2251 and FengYun-1C collision fragments

# Snapshot of Cataloged Space Objects in 2013



## ■ background:

- **ESA's report on the "Classification of GEO Objects" (issue 16, 2014) describes the orbital and operational status of tracked objects in or near GEO (for orbits with  $e < 0.2$ ,  $i < 70^\circ$ ,  $0.9 < n < 1.1$  revs/d)**
- **orbit data are based on information from the USA (USAF/SpaceTrack) and from Russia (KIAM)**
- **the information is merged & processed by ESA's DISCOS database**

## ■ GEO end-of-life disposals:

- **based on orbit time histories and the termination of associated orbit/longitude maintenance maneuvers, spacecraft retirements are identified, and end-of-life disposal maneuvers are analyzed**
- **verification of the disposal status is done with spacecraft operators and orbit data providers**

## ■ Availability of "Classification of GEO Objects" (issue 16, 2014):

- **please send your e-mail request to ESA, c/o Dr. Tim Flohrer, ESA Space Debris Office (*Tim.Flohrer@esa.int*)**

# GEO Satellite Retirements in 2013 (part 1)



## ■ 15 spacecraft were re-orbited above GEO+250km (IADC conformant):

- Inmarsat 2-F1 (90-093A, INMARSAT) ⇒ 385 km × 408 km
- Solidaridad 2 (94-065A, Mexico) ⇒ 280 km × 515 km
- MEASAT 1 (96-002B, Malaysia) ⇒ 336 km × 350 km
- Intelsat VII F-6 (96-035A, INTELSAT) ⇒ 280 km × 337 km
- Intelsat VIII F-1 (97-009A, INTELSAT) ⇒ 394 km × 480 km
- Thor II (97-025A, Norway) ⇒ 359 km × 379 km
- NileSat 101 (98-024A, Egypt) ⇒ 731 km × 923 km
- BSAT-1B (98-024B, Japan) ⇒ 313 km × 340 km
- ZX 5B (ChinaSat 5B) (98-044A, PR China) ⇒ 278 km × 342 km
- ST-1 (98-049A, INTELSAT) ⇒ 411 km × 455 km
- Hot Bird 5 (98-057A, EUTELSAT) ⇒ 491 km × 543 km
- GOES 12 (01-031A, USA) ⇒ 297 km × 346 km
- BSAT-2C (03-028A, Japan) ⇒ 283 km × 325 km
- Ekspress AM-1 (04-043A, Russia) ⇒ 281 km × 328 km
- Ekspress MD-1 (09-007B, Russia) ⇒ 306 km × 352 km

# GEO Satellite Retirements in 2013

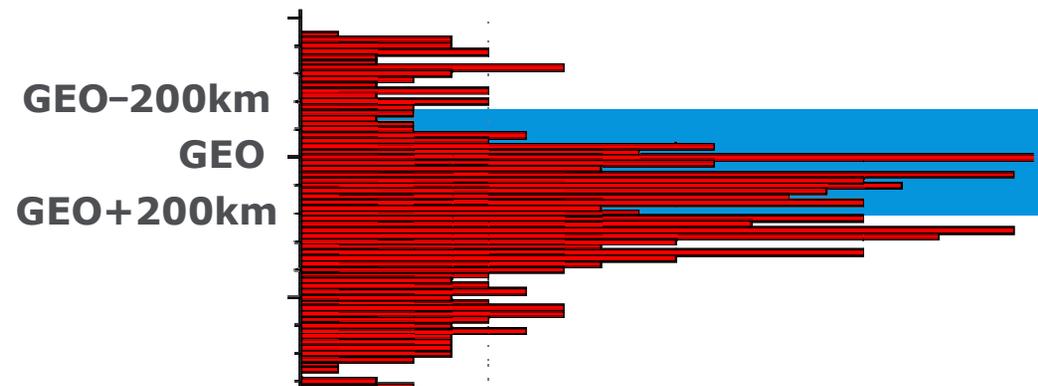


## ■ 3 spacecraft were re-orbited too low :

- Intelsat VIIA F-2 (96-015A, INTELSAT)  $\Rightarrow$  224 km  $\times$  795 km
- Arabsat 2B (96-063A, Saudi Arabia)  $\Rightarrow$  227 km  $\times$  259 km
- Cosmos-2434/Raduga-1M1 (07-058A, Russia)  $\Rightarrow$  238 km  $\times$  256 km

## ■ 2 spacecraft retirements did not comply with IADC Guidelines :

- USA 8 (85-010B, USA)  $\Rightarrow$  -434 km  $\times$  696 km
- USA 48 (89-090B, USA)  $\Rightarrow$  -1305 km  $\times$  1050 km



post-mission re-orbiting practices are discernible in their attained perigee altitude with respect to the protected GEO zone

# GEO Satellite Retirement Statistics



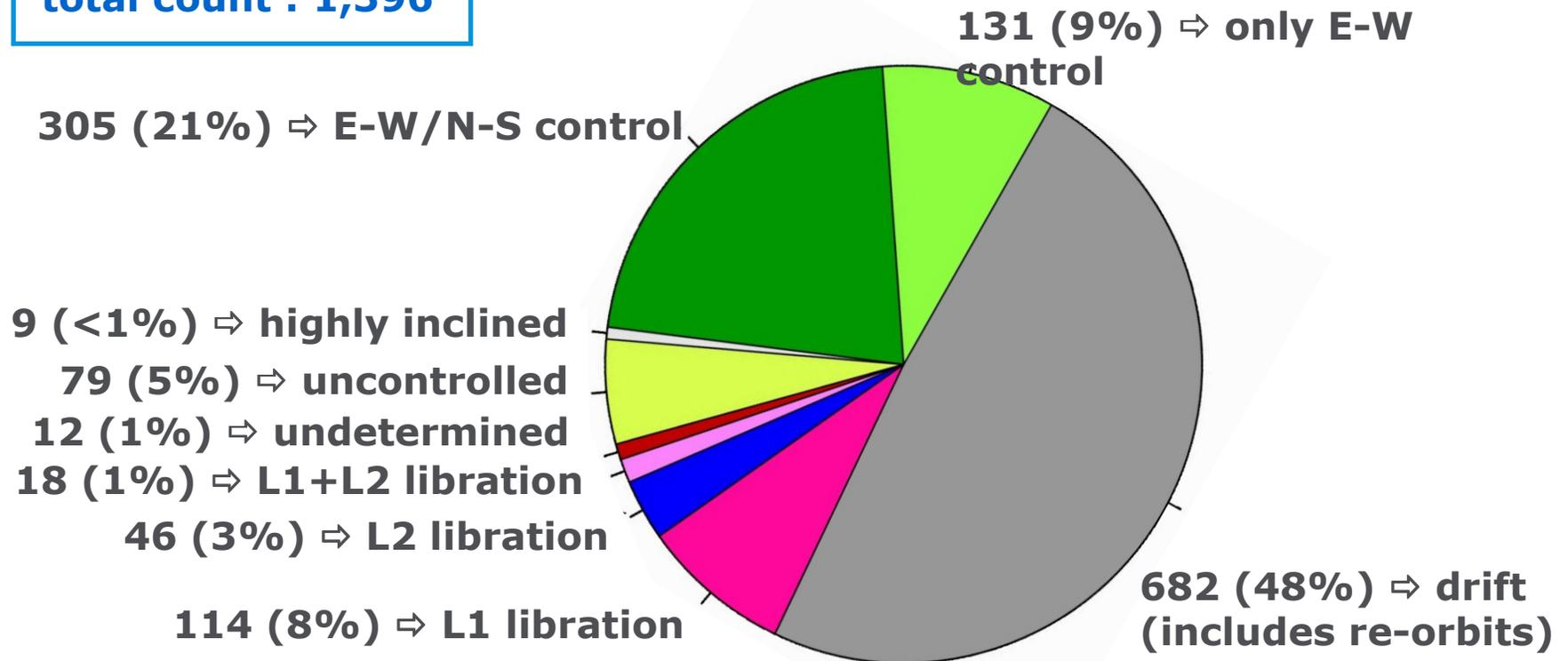
	'99-'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	Total
● Left at L <sub>1</sub>	14	2	1	2	1	2	3	1	–	1	–	27 (11.8%)
● Left at L <sub>2</sub>	5	1	1	1	–	1	–	–	–	–	–	9 (3.9%)
● Left at L <sub>1</sub> /L <sub>2</sub>	2	–	1	–	–	1	–	–	–	–	–	4 (1.7%)
● Drift orbit (too low)	24	5	5	7	1	1	6	4	3	4	5	65 (28.4%)
● Drift orbit (compliant)	22	5	11	9	11	6	12	11	12	10	15	124 (54.2%)
<b>Annual Total</b>	<b>67</b>	<b>13</b>	<b>19</b>	<b>19</b>	<b>13</b>	<b>11</b>	<b>21</b>	<b>16</b>	<b>15</b>	<b>15</b>	<b>20</b>	<b>229 (100%)</b>

- compliance with GEO end-of-life re-orbit guidelines in the past 10 years has improved by about 25% as compared with pre-2003 disposals
- end-of-life abandonment of GEO satellites in the past 10 years was reduced by about 30% as compared with pre-2003 disposals

# Orbit Control Status of GEO Objects in 2013

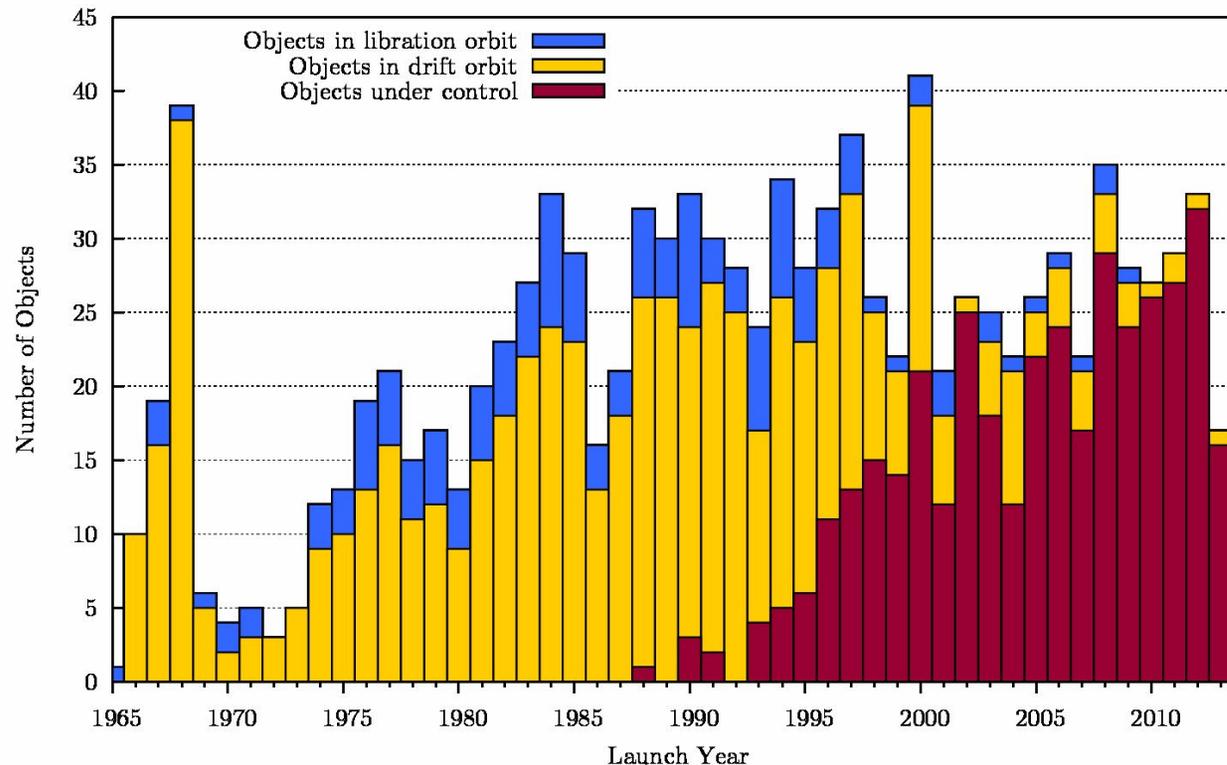


**total count : 1,396**



- 1,142 TLE catalog objects met „near GEO“ criteria ( $e < 0.2$ ,  $0.9 < n < 1.1$  rev/d,  $i < 70^\circ$ ); 254 more objects are known to be in this area
- controlled  $\Rightarrow$  436 (305 thereof E-W/N-S); uncontrolled  $\Rightarrow$  960

# Status of GEO Objects vs. Launch Year



- 26 new GEO objects were injected in 2013 (25 payloads + 1 rocket body)
- typical operational lifetimes of GEO satellites are about 15 years; the share of abandoned satellites keeps decreasing since the late 1990s

- **the 6<sup>th</sup> European Conference on Space Debris and the 31<sup>st</sup> gathering of the Inter-Agency Space Debris Coordination Committee (IADC) have concluded that, in order to stabilize the orbital environment ...**
  - **space debris mitigation is a necessary, but insufficient step that must be accompanied by active mass removal**
- **ESA supports related initiatives, e.g., at the LTSSA WG of UNCOPUOS, and in ESA's "CleanSpace" programme**
- **ESA is committed to debris mitigation and environment remediation in close cooperation and coordination with international partners**