

Space Debris Mitigation Activities at ESA in 2015

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European Space Agency

ESA Launches in 2015

Sentinel-2A (with EC)

- Launch: June 23rd, 2015 from CSG/Kourou (Vega), 790km x 788km @ 100.6°
- Mission: Multispectral optical imagery



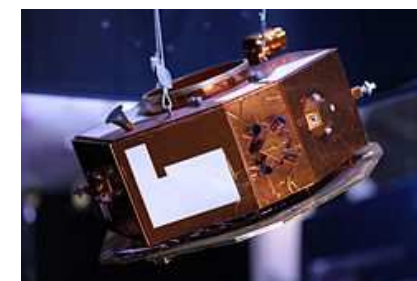
Galileo 7, 8, 9, 10, 11, 12 (with EC)

- Launches: (7, 8) March 27th, (9, 10) Sep. 11th, (11, 12) Dec. 17th, 2015 from CSG/Kourou (Soyuz),
- 23235km x 23212km @55deg



Lisa Pathfinder

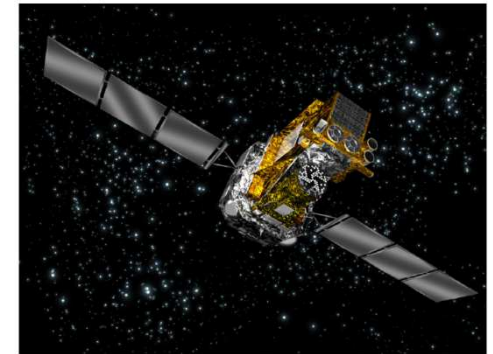
- Launch: Dec 3rd, 2015 from CSG/Kourou (Vega)
- Earth-Sun Lagrange Point 1
- Mission: Technology demonstration for gravitational wave measurements



Debris Mitigation Efforts by ESA in 2015

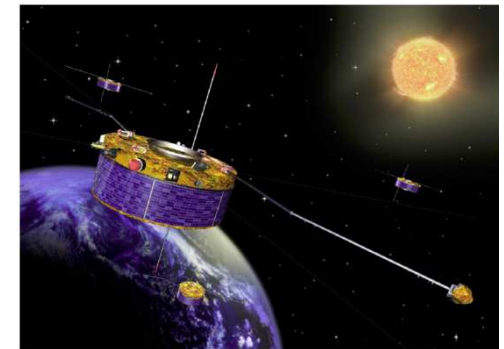
Integral, launched 2002

- Orbit: 140,000km x 9,500km @ 52.2°, 3320kg dry-mass
- Mission: Gamma-ray observations
- 4 Disposal manoeuvres in Jan/Feb 2015 to force re-entry in 2029 with on-ground risk $< 10^{-4}$
- Without disposal: no re-entry in 200 years, periodic penetrations of LEO and GEO protected zones



Cluster-II, S/C 1 (Rumba), launched 2000

- Orbit: 105,000km x 27,000km @ 132°, 550kg dry-mass
- Mission: interaction between solar wind and magnetosphere
- 4 Disposal manoeuvres in March 2015 to force re-entry in 2025 with on-ground risk $< 10^{-4}$
- Without disposal: re-entry in 2038 with on-ground risk $> 10^{-4}$



- **Both missions will continue to operate while flying on their fail-safe disposal orbits!**

ESA's Space Debris Risk Analysis Tools

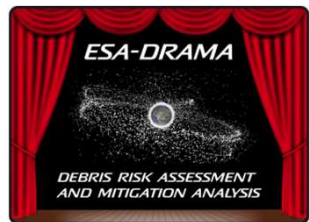


<https://sdup.esoc.esa.int>



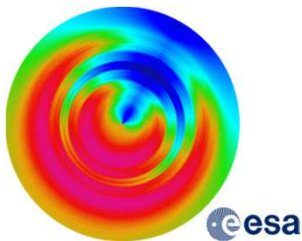
MASTER (**M**eteoroid **a**nd **S**pace Debris **T**errestrial **E**nvironment **R**eference)

- assess the debris or meteoroid flux imparted on a spacecraft on an arbitrary earth orbit



DRAMA (**D**ebris **R**isk **A**ssessment and **M**itigation **A**nalysis):

- Vulnerability assessments in response to debris and meteoroid impact flux
- Collision avoidance manoeuvre frequencies for a given spacecraft and a project-specific accepted risk level
- Re-orbit and de-orbit fuel requirements for a given initial orbit and disposal scenario
- Geometric cross-section computations
- Re-entry survival predictions for a given object of user-defined components and associated risk on ground

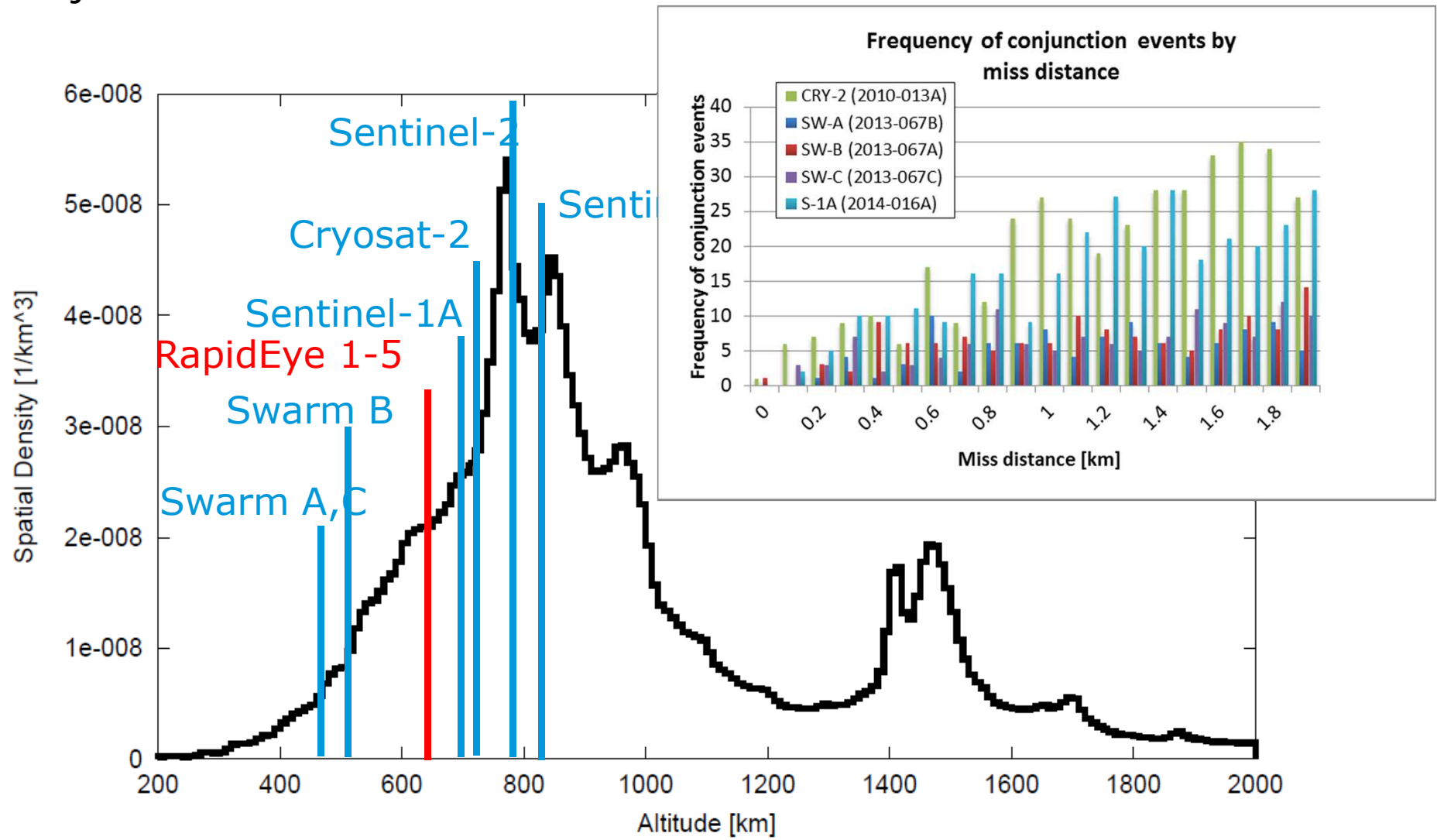


ORIUNDO (**O**n-ground **R**isk estimation for **UN**controlled **D**e re-entries **tOol**)
front-end for population model (UN World Population Prospect)

Critical Orbital Regions and Mission Risk

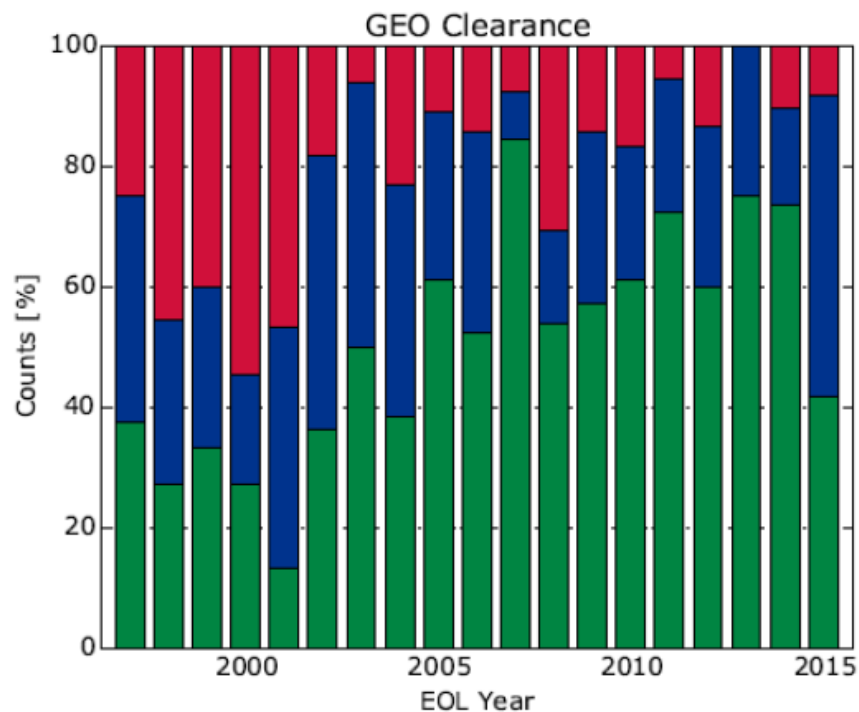


Objects > 10cm






Statistics on Global Adherence to UN Guidelines: GEO

GEO Clearance (16 satellites p.a.)



End of 2015 (tentative results, TLEs only):

- 40 new objects (at least) 35 payloads
- 3 rocket bodies
- 2 mission related objects
- 12 objects reaching EOL 5 are compliant
- 6 insufficient maneuvers
- 1 RB left crossing GEO

 No attempt
 Insufficient
 Compliant

Statistics on Global Adherence to UN Guidelines: LEO

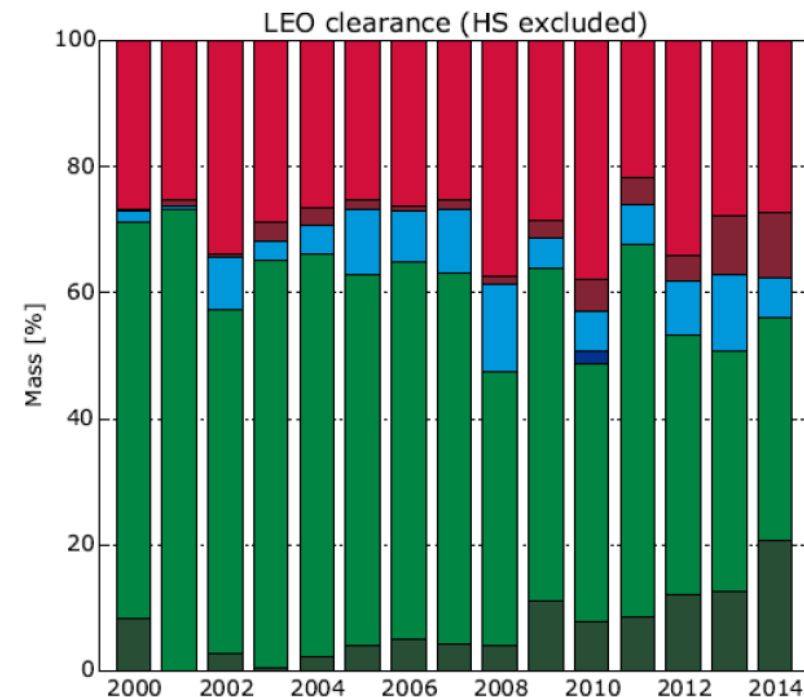
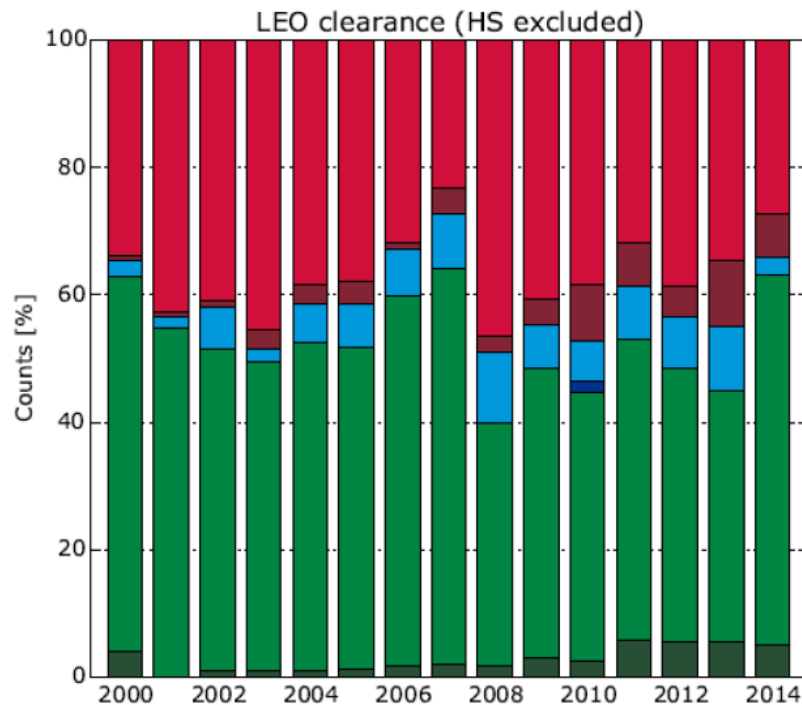


LEO Clearance

By number

(114 satellites p.a.)

By mass



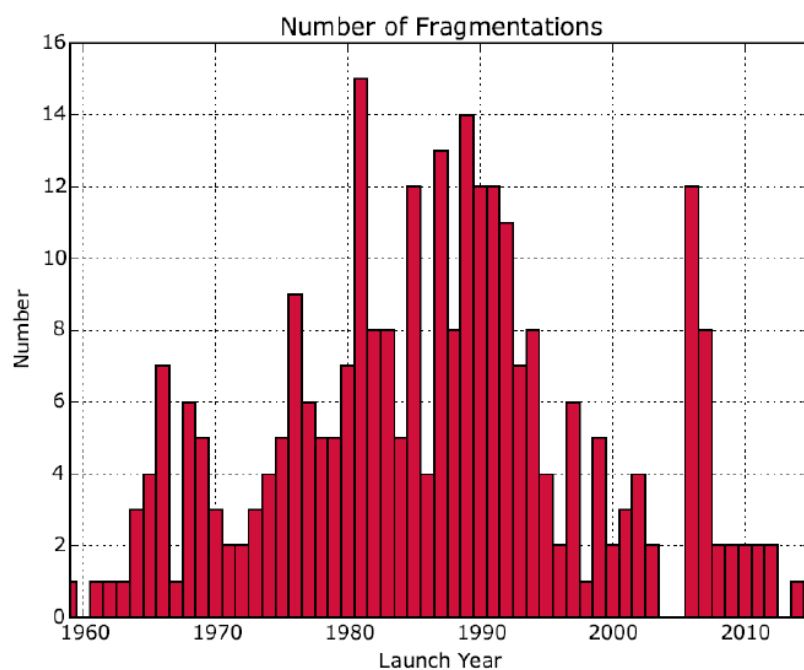
■ Non-compliant, without maneuver
■ Non-compliant, with maneuver
■ Compliant, with maneuver, true before

■ Compliant, with maneuver, false before
■ Compliant, without maneuver
■ Compliant, with direct re-entry

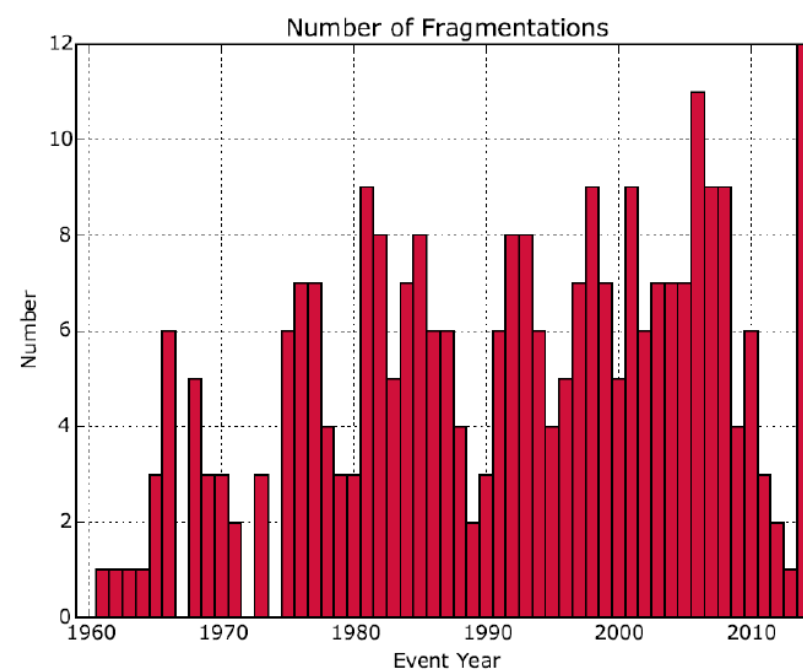


On-Orbit Break-Ups

Launch year

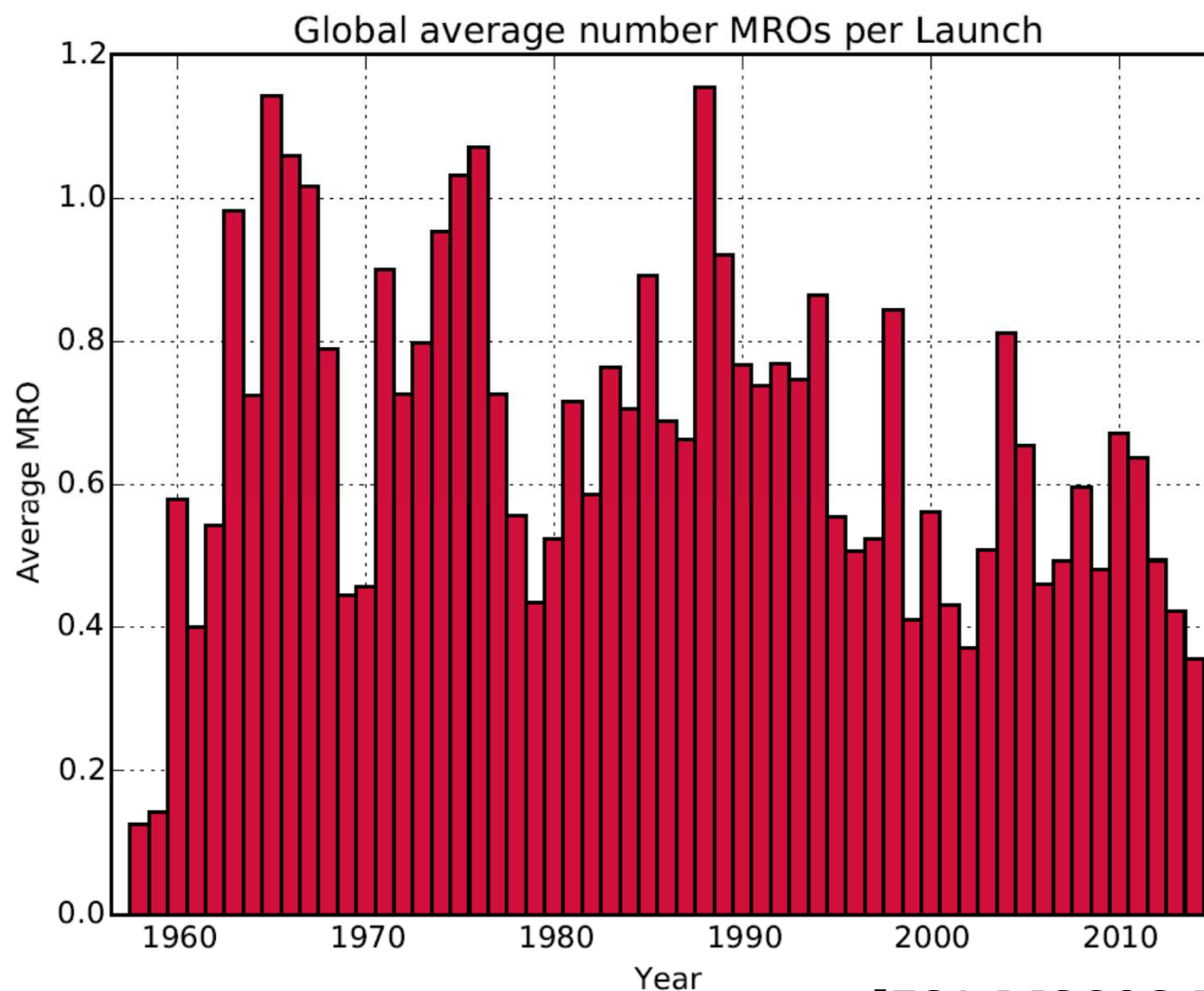


Year of break-up



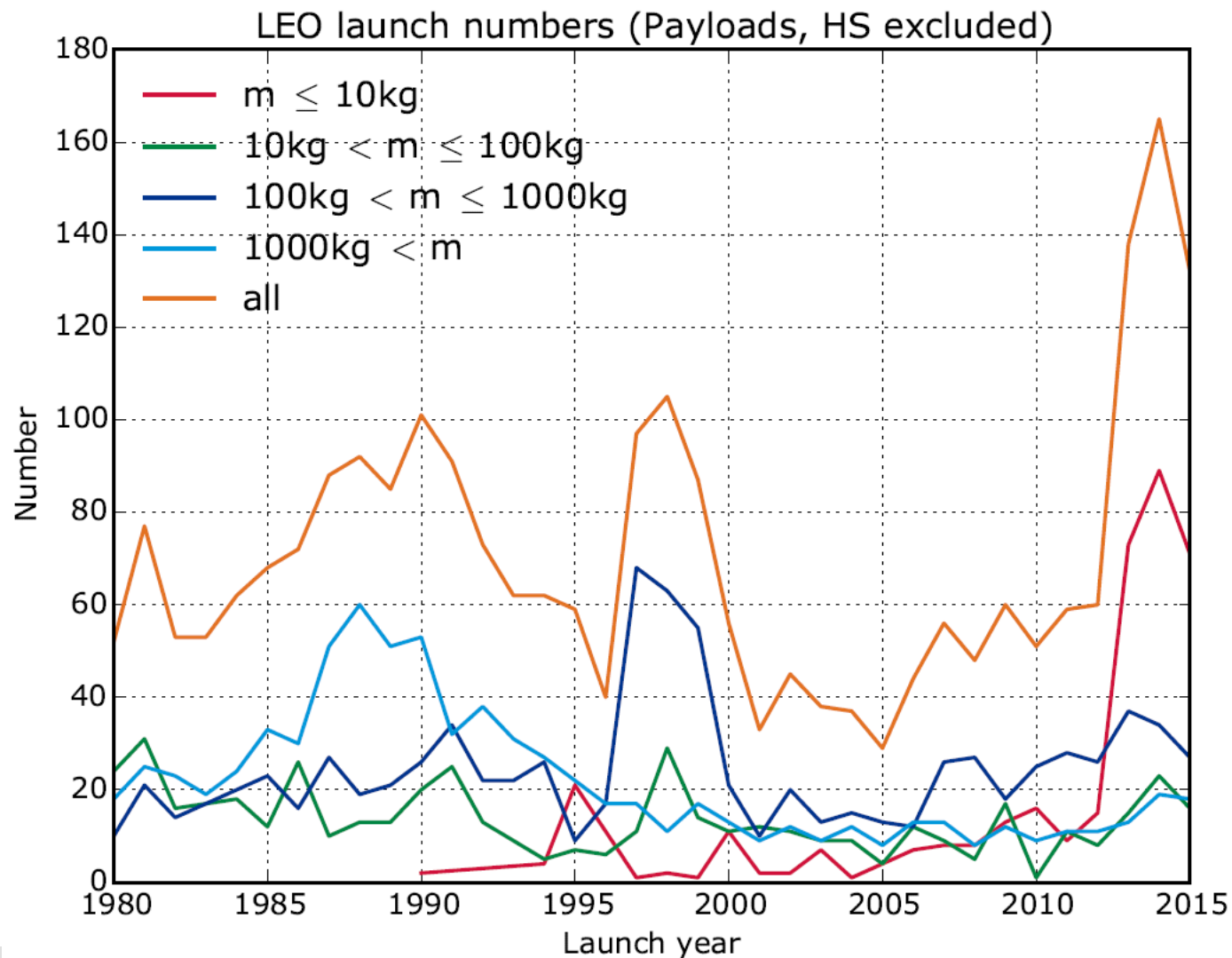
[ESA DISCOS Database]

Mission Related Object Release



[ESA DISCOS Database]

Recent Changes to the Space Traffic



Future Mega-Constellations

- Announced LEO telecommunication constellations with > 100 satellites:



Constellation Name	Number of satellites	Orbital altitude [km]
Samsung	4600	1400
SpaceX	4000	1100
Oneweb	650	1200
Leosat LLC	140	1800
Yalini	135	600

Source: Various News Articles

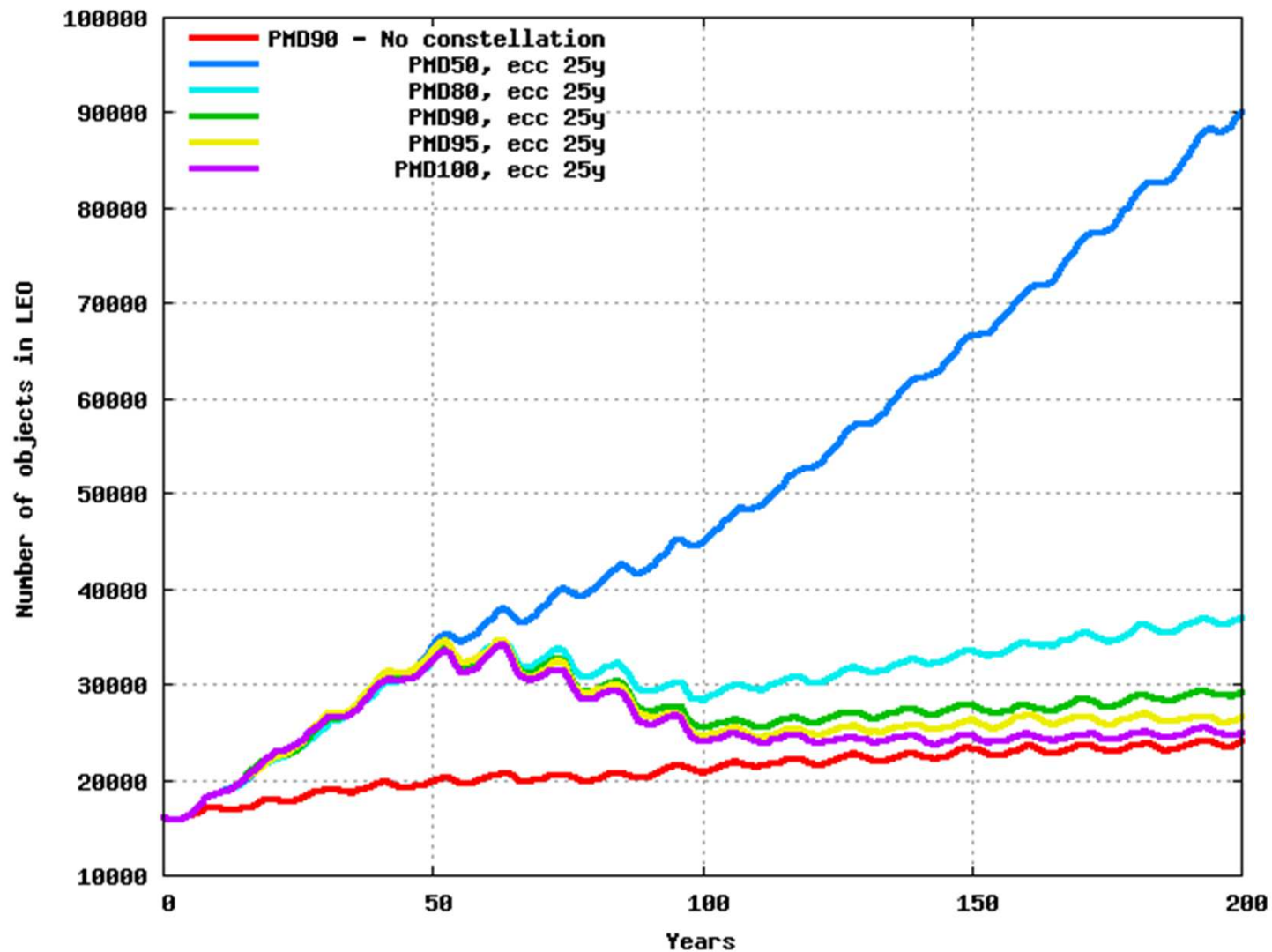
- “Synthetic” Constellation Study Case



Constellation	1080 satellites 1100km altitude 20 orbital planes 85deg inclination
Mission	Jan 2021 to Jan 2071
Satellite	200kg mass 1m ² effective cross-section 5 years of mission lifetime
Constellation build-up	2018-2010 20 launches per year 18 satellites per launch
Constellation maintenance	2021-2071 18 objects per launch 12 launches per year
Mitigation behaviour	Launcher stages perform a direct re-entry No mission-related objects are released

- Background: continuation of current traffic, excellent application of mitigation guidelines

Mega Constellations and Post Mission Disposal Rates



Technologies



Passivation



Design for demise

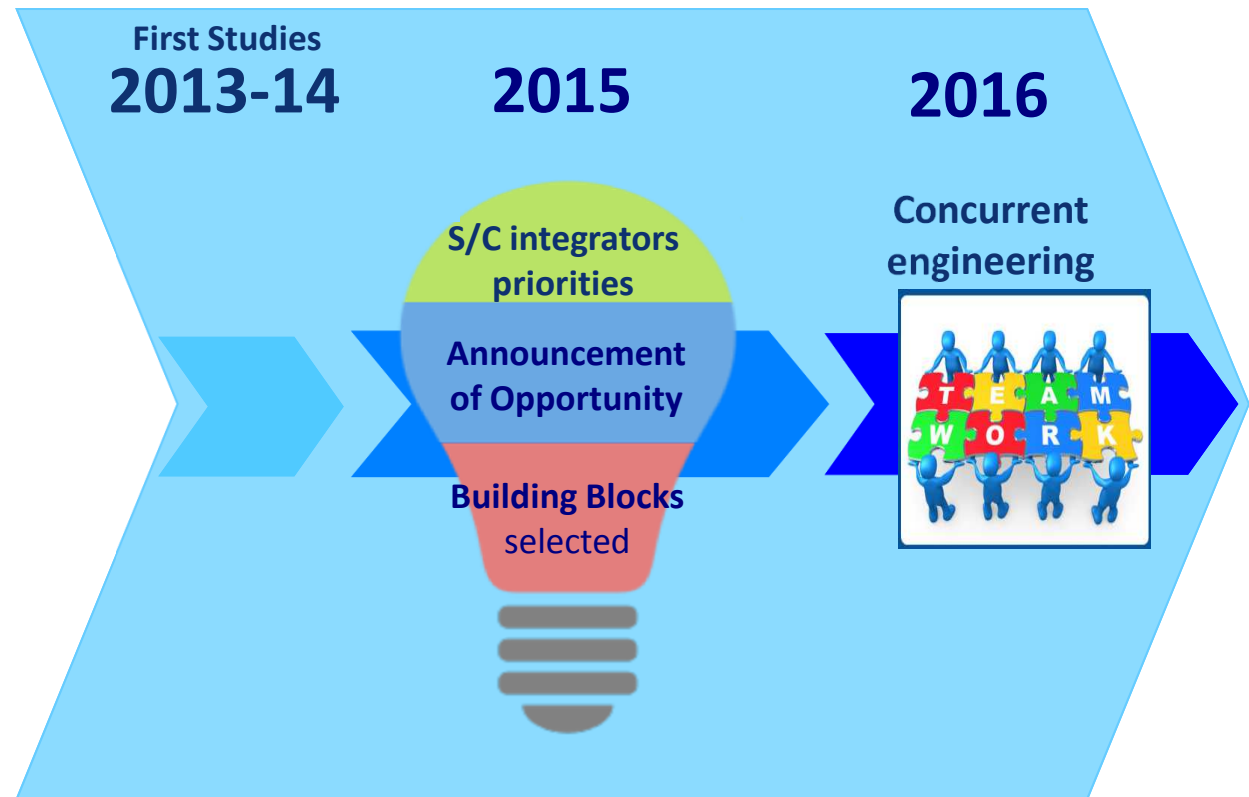


Deorbiting systems



Design for servicing

Roadmap



Summary

- ESA has launched 8 spacecraft in 2015 in compliance to UN guidelines
- ESA has implemented mitigation measures for 2 spacecraft (launched prior to the appearance of guidelines)
- ESA has put its space debris risk analysis tools online and has the permission for worldwide licensing
- Global performance in mitigating debris:
 - a clear and positive trend in GEO
 - Poor in critical LEO altitudes, no apparent trends
- The operation of a mega constellation means a step increase in launch traffic
- The level of adherence to the post mission disposal guidelines is the absolute key driver for the environmental impact.
- Historical behaviour (of all objects) in this regard shows that post mission disposal is a technological and operational challenge in reality
- ESA invests into technology to support mitigation actions