

# Space Debris Mitigation Activities at ESA in 2016

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# ESA Launches and Mitigation Efforts in 2016 (1/2)



## Sentinel-3A (with EC)

- Launch: February 16<sup>th</sup>, 2016 from Plesetsk (Rokot), 804km x 802km @ 100.9°
- Mission: Ocean and land temperature and colour
- Briz stage lowered its orbit after insertion to 400 x 800km



## Exomars

- Launch: March 14<sup>th</sup>, 2016 from Baikonour (Proton), in Mars orbit
- Mission: Trace gases in the Martian atmosphere
- Briz stage escaped
- External Briz tank will re-enter within 25 years



# Debris Mitigation Efforts by ESA in 2016 (2/2)

## Sentinel-1B (with EC)

- Launch: April 25<sup>th</sup>, 2016 from CSG/Kourou (Soyuz), 697km x 695km @ 98.2°
- Mission: SAR land and sea monitoring
- Fregat stage performed a controlled re-entry



## Galileo 13,14,15,16,17,18 (with EC)

- Launches: (13, 14) May 24, (15 - 18) Nov. 17th
- 23235km x 23212km @55deg
- Fregat and Ariane 5 EPS stages moved to graveyard orbit



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### SPACE DEBRIS USER PORTAL > HOME

This portal addresses the user community of ESA's Space Debris Software. It serves as entry gate for software license applications and for the retrieval of the software. Registered users may retrieve updated data and software patches and may raise support requests.

### THE FOLLOWING ESA SPACE DEBRIS TOOLS CAN BE REQUESTED:

#### MASTER

MASTER (Meteoroid and Space Debris Terrestrial Environment Reference) allows to assess the debris or meteoroid flux imparted on a spacecraft on an arbitrary earth orbit. MASTER also provides the necessary computational and data reference for DRAMA and needs to be installed before DRAMA is installed.



#### DRAMA

DRAMA (Debris Risk Assessment and Mitigation Analysis) is a comprehensive tool for the compliance analysis of a space mission with space debris mitigation standards. For a given space mission, DRAMA allows analysis of:

- Debris and meteoroid impact flux levels (at user-defined size regimes)
- 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
- The associated risk on ground for at the resulting impact ground swath



*Please beware that the installation of MASTER is a necessary pre-condition for the successful operation of the DRAMA suite. MASTER provides the necessary computational and data reference for DRAMA and needs to be installed before DRAMA is installed.*

#### DISCOSWEB

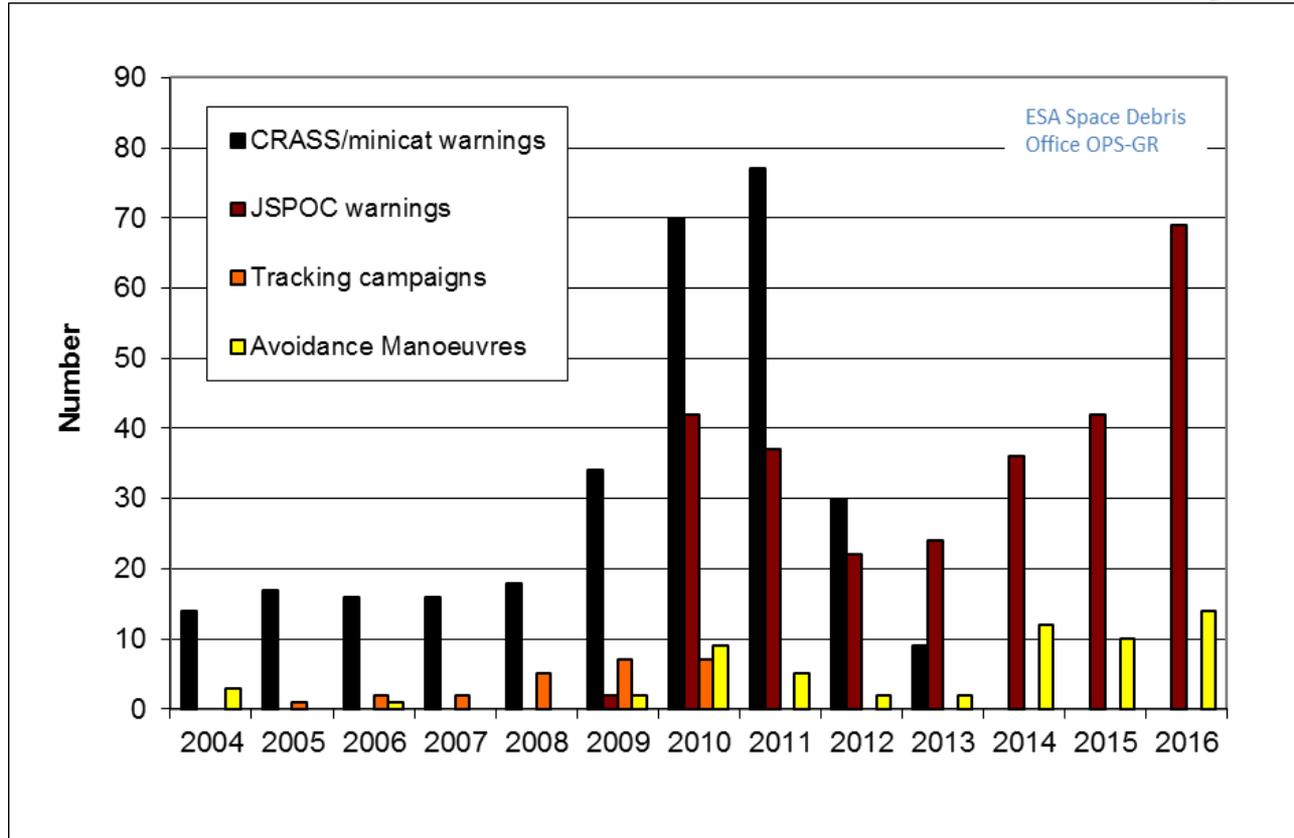
DISCOS (Database and Information System Characterising Objects in Space) serves as a single-source reference for launch information, object registration details, launch vehicle descriptions, spacecraft information (e.g. size, mass, shape, mission objectives, owner), as well as orbital data histories for all trackable, unclassified objects which sum up to more than 40000 objects. Today, DISCOS not only plays an essential role in the various daily activities at the ESA's Space Debris Office, and it is the basis for operational processes in collision avoidance, re-entry analyses, and for contingency support. DISCOS also provides input to numerous and very differently scoped engineering activities, within ESA and throughout academia and industry. DISCOS-based routine activities also comprise the maintenance of a Re-entry Events Database to



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

# Collision Avoidance

- 16 spacecraft monitored



# User / Operator Front-End



## Mission: Sentinel 1A

Thursday, April 2nd 2015, 1:44:07 pm

**Highest Collision Probability**

**1.254e<sup>-4</sup>**  
Worst Case 1.254e<sup>-4</sup>

**Closest Encounter**

**642.00 m**  
Worst Case 293.00 m

**Closest Radial Encounter**

**0.10 m**  
Worst Case 0.10 m

**Escalated Events**

**Event: 41297**  
Collision Probability: 1.254e-4  
Miss Distance: 642.00 m  
Radial Distance: 230.40 m

**Cumulative Risk**

**1.617e<sup>-4</sup>**

**Number of Foreseen Events**

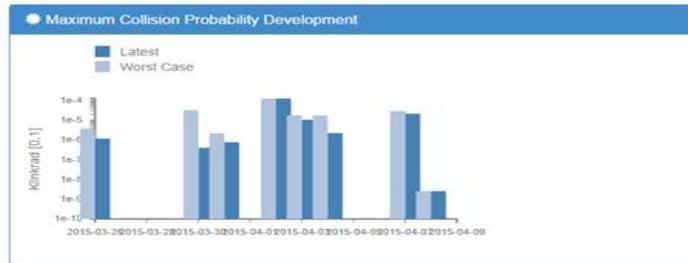
**44**

**Foreseen Events above Risk Threshold**

**3**  
Risk Threshold: 1e-5

**10 Most Risky Events**

1.254e-4	1999-025BEF
2.137e-5	1983-109E
1.053e-5	1997-051MB
2.229e-6	1997-051MB
1.074e-6	1997-051MB
1.074e-6	1997-051MB
1.489e-8	1997-051MB
5.912e-9	1997-051MB
2.562e-9	1976-126E
7.687e-12	1999-025BEF



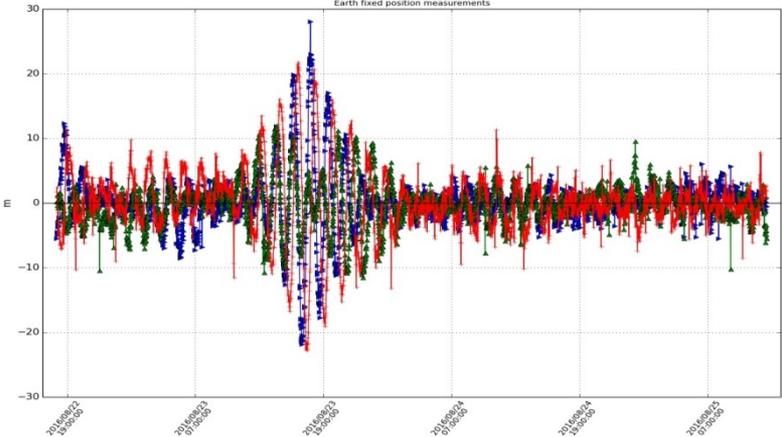
**10 Closest Encounters**

**10 Worst Cases**



# Sentinel-1A Impact 2016/08/23

Residual Plot File ROUTINE OD  
Earth fixed position measurements



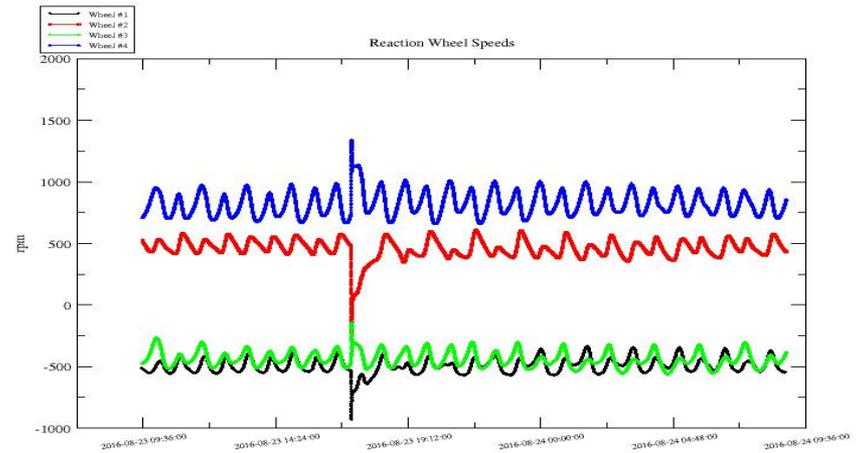
— At around 17:07 UTC:

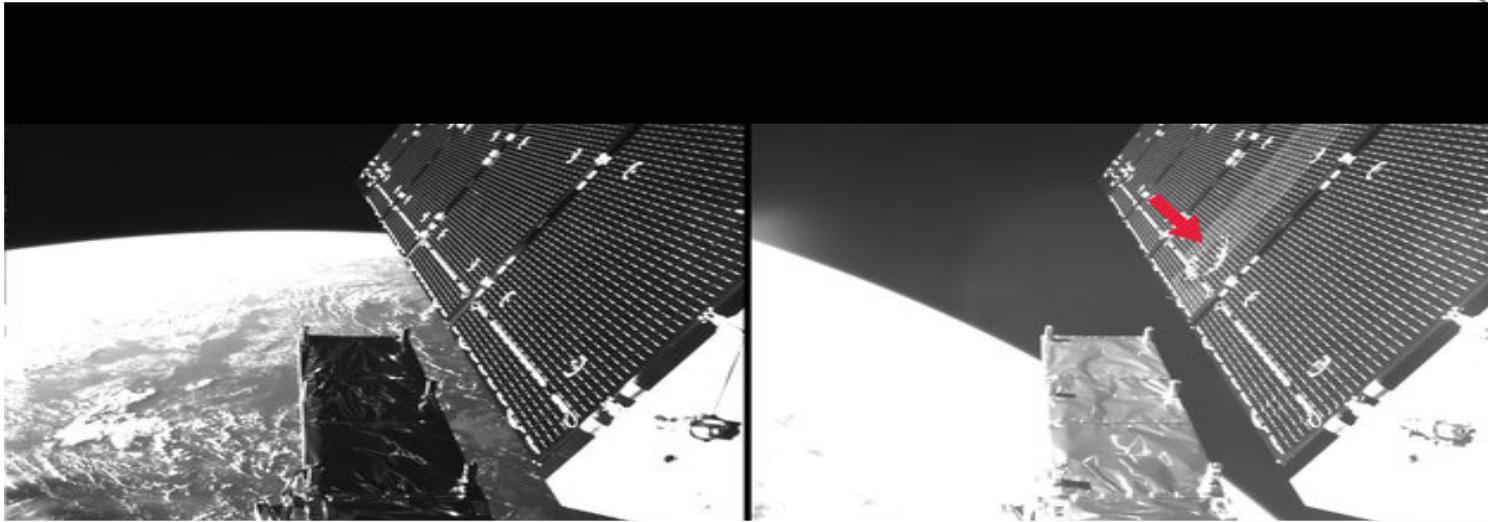
- SENT1A Pos.EF. X (m)
- SENT1A Pos.EF. Y (m)
- SENT1A Pos.EF. Z (m)

At around 17:07 UTC:

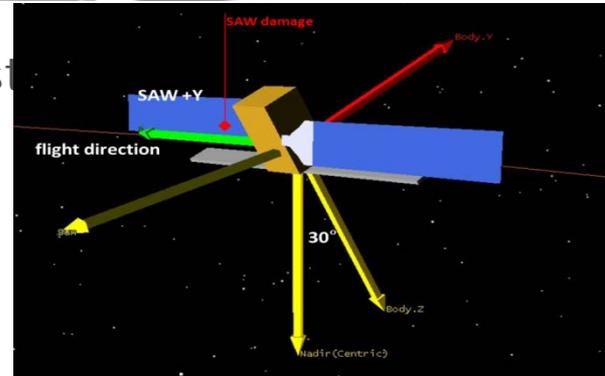
- Inconsistency in the GPS-based orbit solution
- Ad-hoc change in the wheel rates
- The output power of the SAW+Y Solar array dropped by 280W from a nominal 6000W on 2016/08/23 17:07:47 UTC

- After analysis:
  - Loss of about 5% solar array
  - Orbit change by 0.7mm/s
  - Attitude changed by a few degree
  - USSTRATCOM tracks 8 fragments



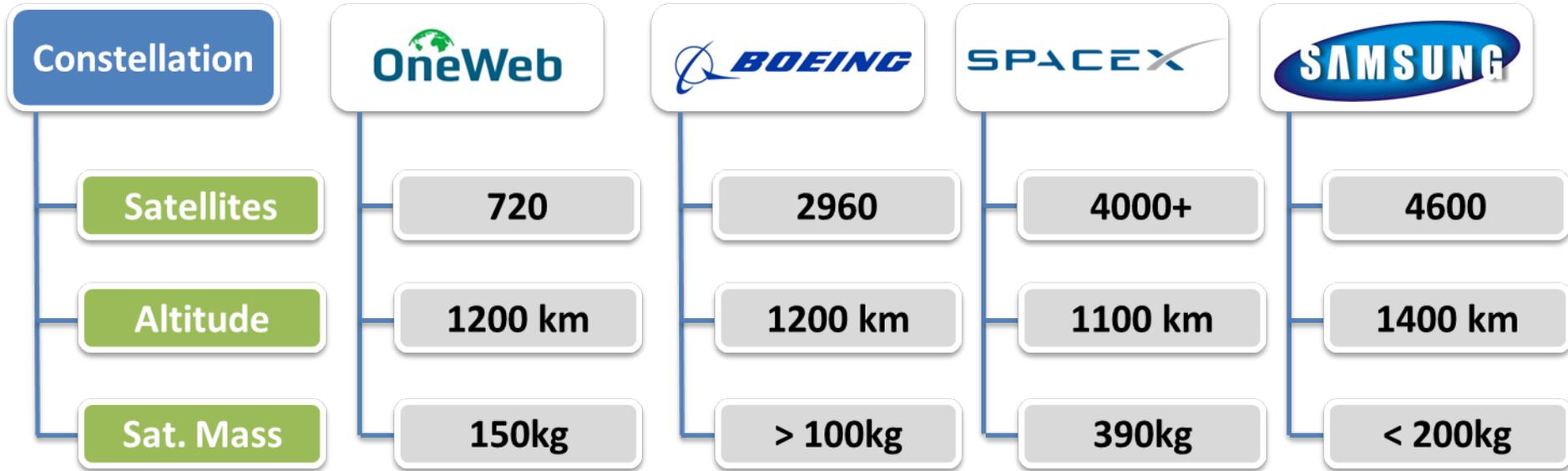


- The impactor was a man-made piece of debris (most likely an explosion or collision fragment) of 0.2g mass and approximately 1cm size
- It approached with about 11km/s

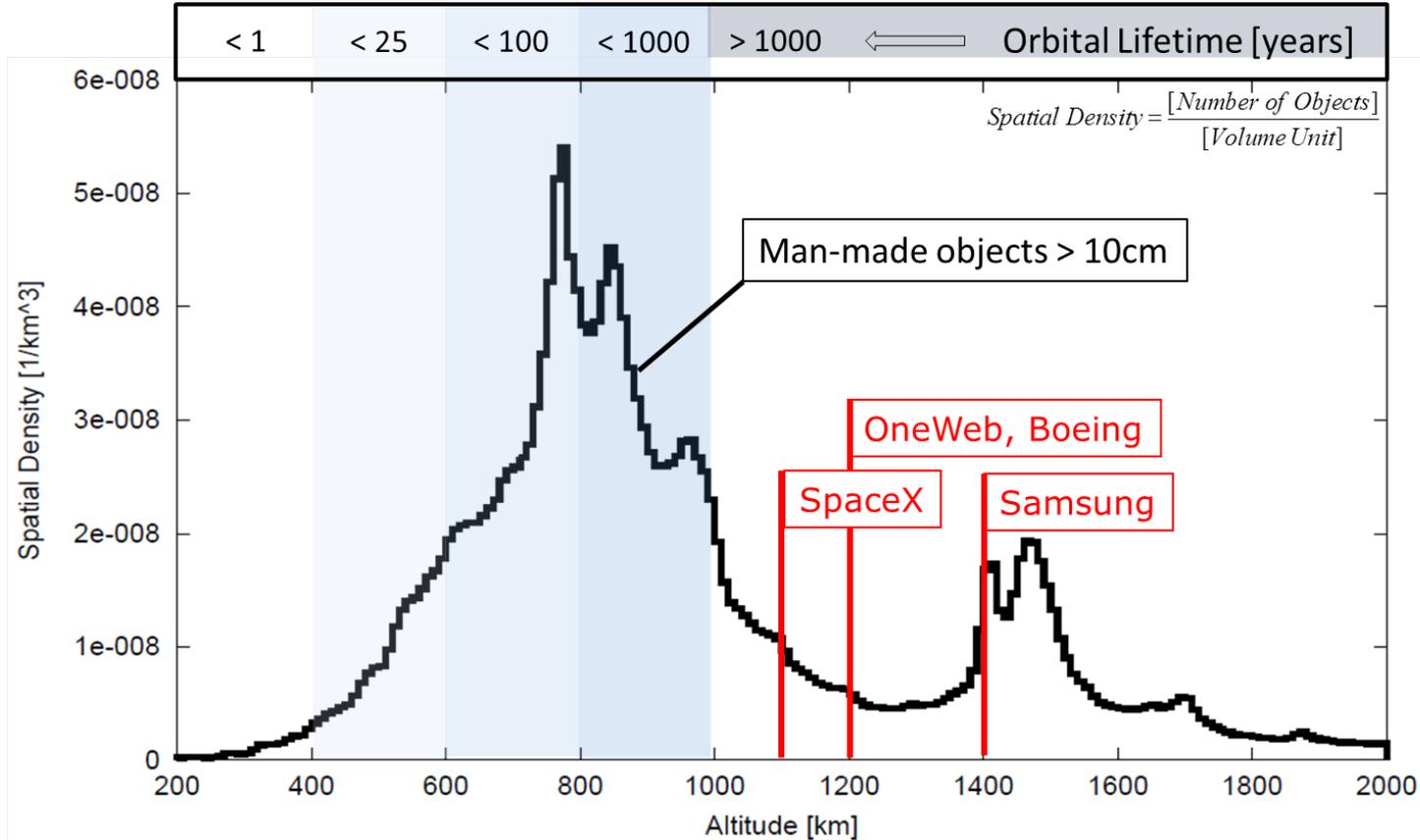


# Megaconstellations - planned

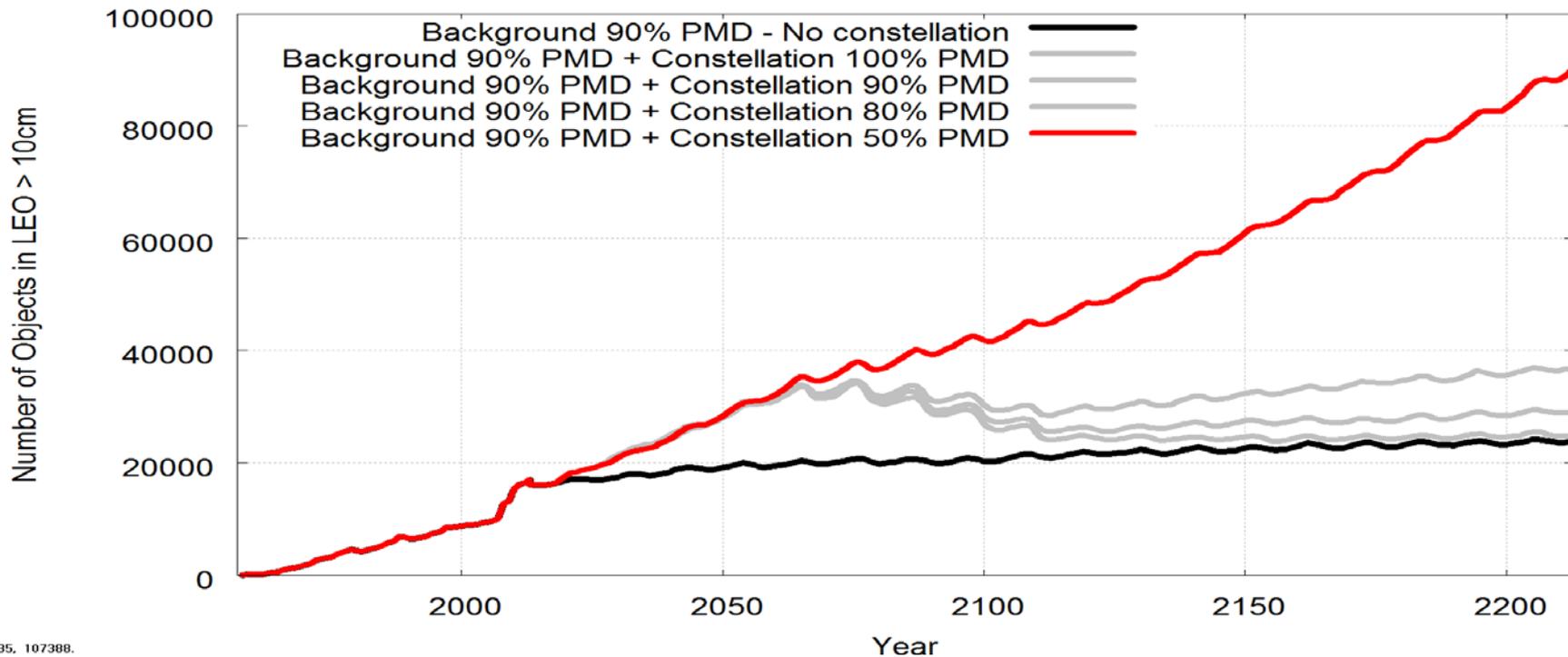
- Selected proposals from the last FCC (Federal Communications Commission) round



# Megaconstellations – and the current environment

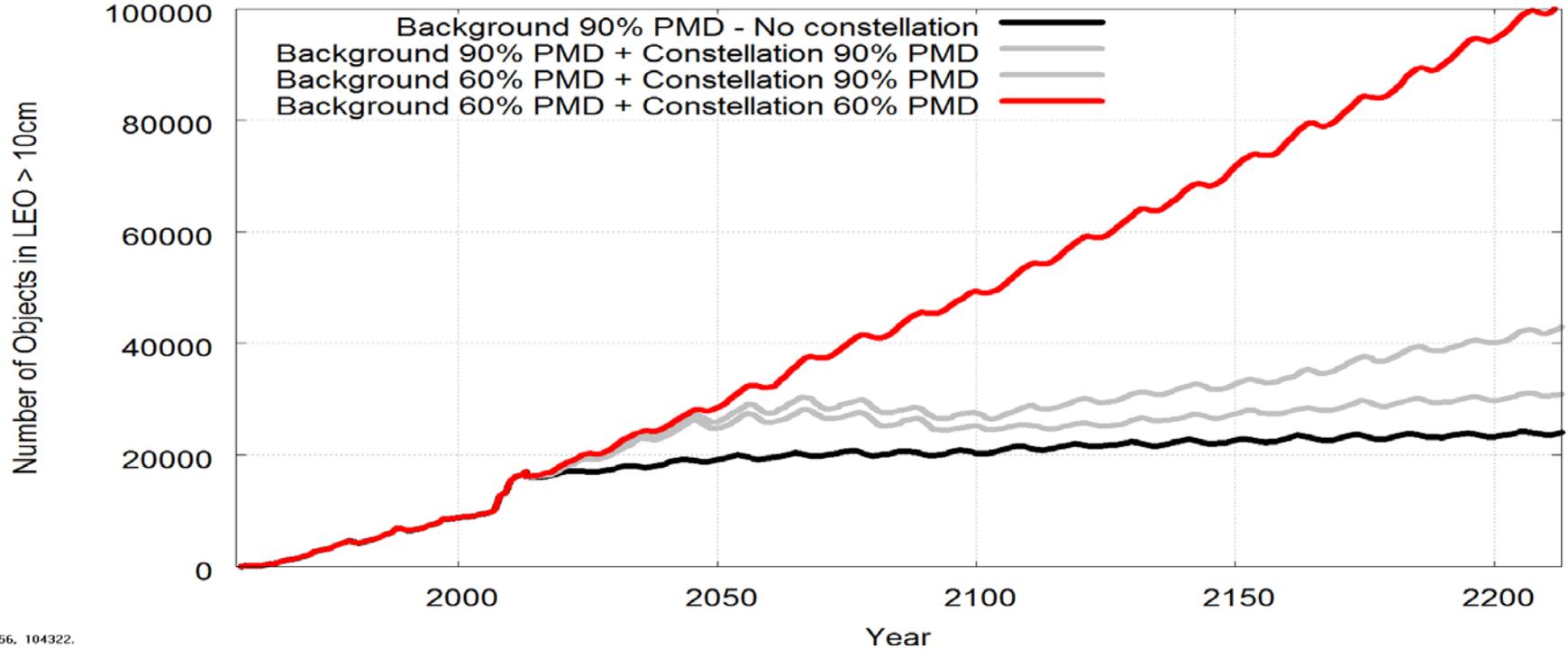


# Environmental Effects of a Large Constellation



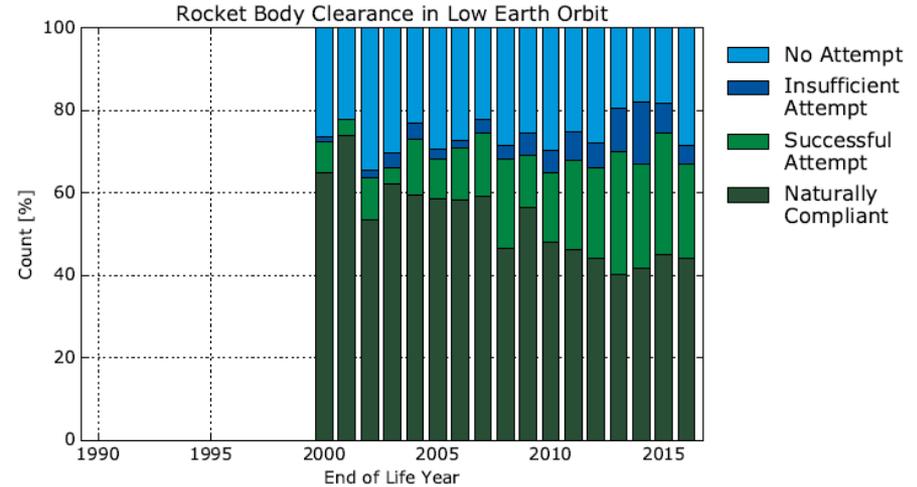
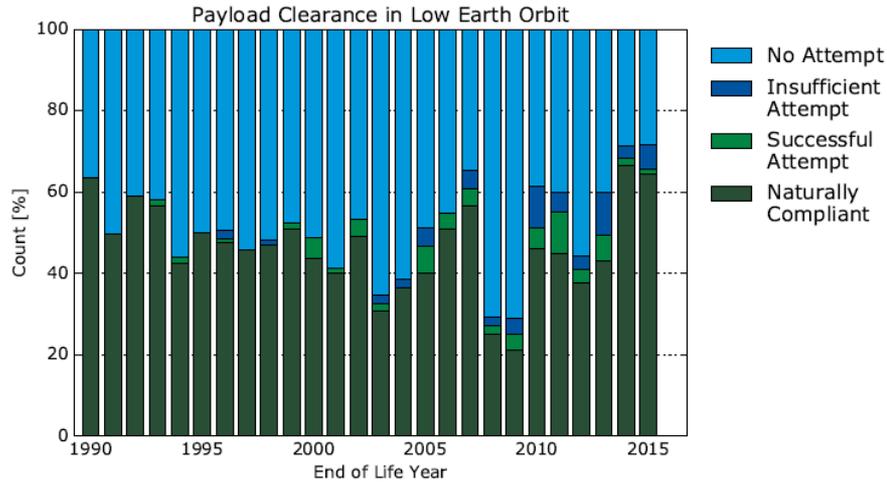
2076.35, 107388.

# Extrapolation of Trends

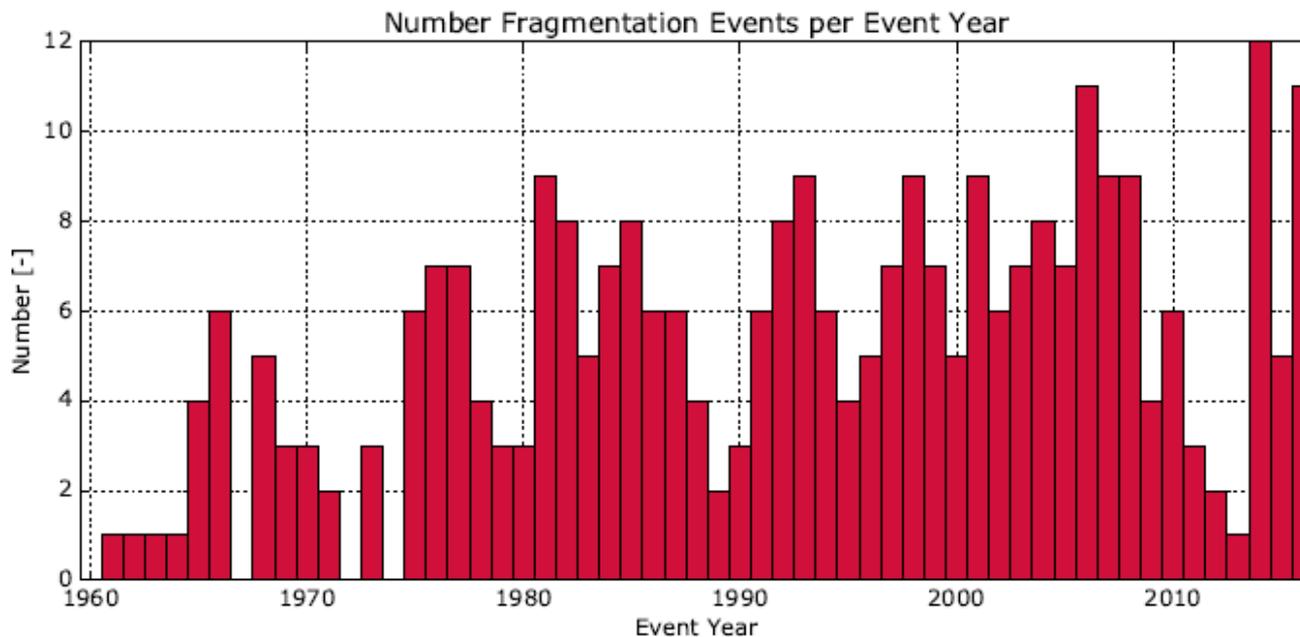


2060.56. 104322.

# Annual Mitigation Compliance Review – Clearing Protected Zones



# Annual Mitigation Compliance Review – Fragmentations



# 7<sup>th</sup> European Space Debris Conference



18-21 April, 2017

ESOC, Darmstadt

<https://conference.sdo.esoc.esa.int/>



**7<sup>th</sup> European Conference on Space Debris**

→ ESOC, Darmstadt/Germany  
18 – 21 April 2017  
organised by the  
European Space Agency

→ registration website  
[www.esa.int/???](http://www.esa.int/???)

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European Space Agency

# Summary



- ESA has launched 9 spacecraft in 2016 in compliance to UN guidelines
- ESA has put its space debris risk analysis tools online and has the permission for worldwide licensing
- Global performance in mitigating debris still shows apparent trend in LEO
- The operation of a mega constellation requires dramatic improvements in technical reliability and operational paradigms to successfully execute post mission disposal

