OVERVIEW ON 2016 SPACE DEBRIS ACTIVITIES IN FRANCE

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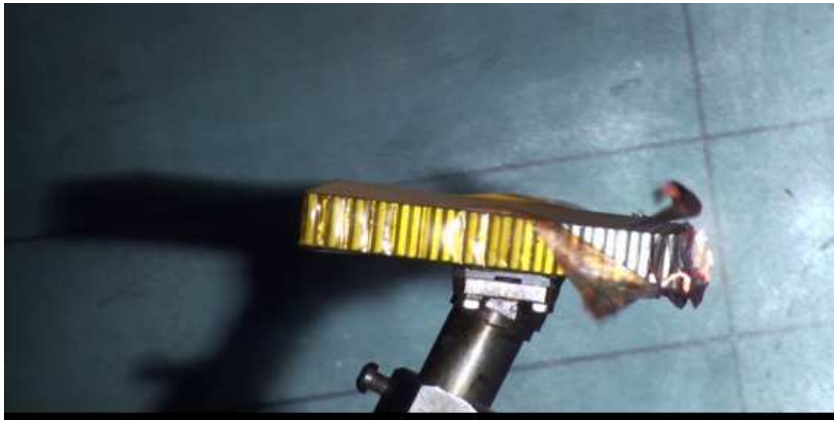
CONTENT

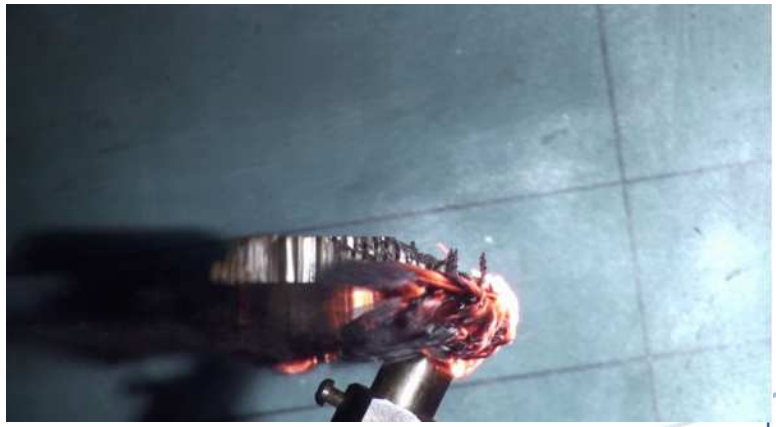
- **Main studies :**
  - Reentry risk analysis,
  - Use of TAROT during Galileo launch,
  - Debris mitigation rules compliance results,
  - Space debris population evolution with more realistic hypotheses,
  - Space debris population evolution with a constellation.
- **Operational activities :**
  - Collision risk monitoring,
  - Atmospheric reentries predictions.
- **Regulatory activities**
- **National Register of Space Objects**
- **Workshops and meetings**

MAIN STUDIES : Reentry risk analysis

- Tests with reentry conditions on the behavior of structural panels composed of aluminium honeycomb between 2 plates to improve, with the results, the representativeness of DEBRISK tool (tests in TsAGI facility) :

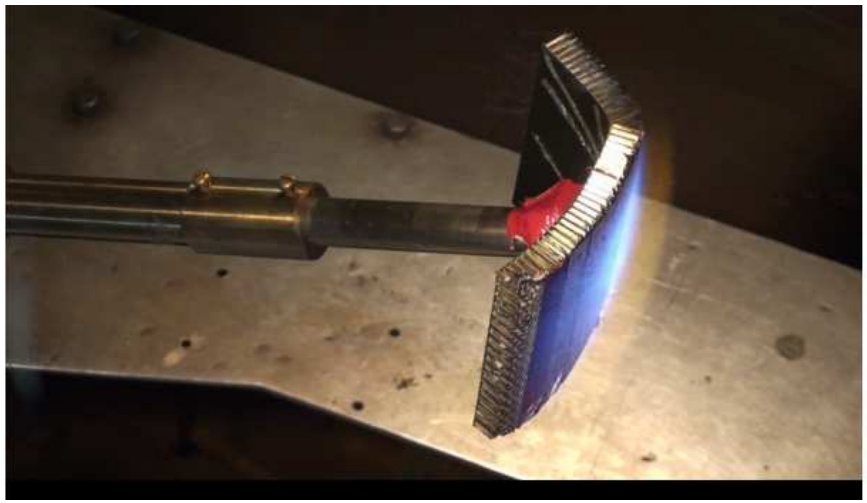
- Images of honeycomb panels with aluminium plates behavior

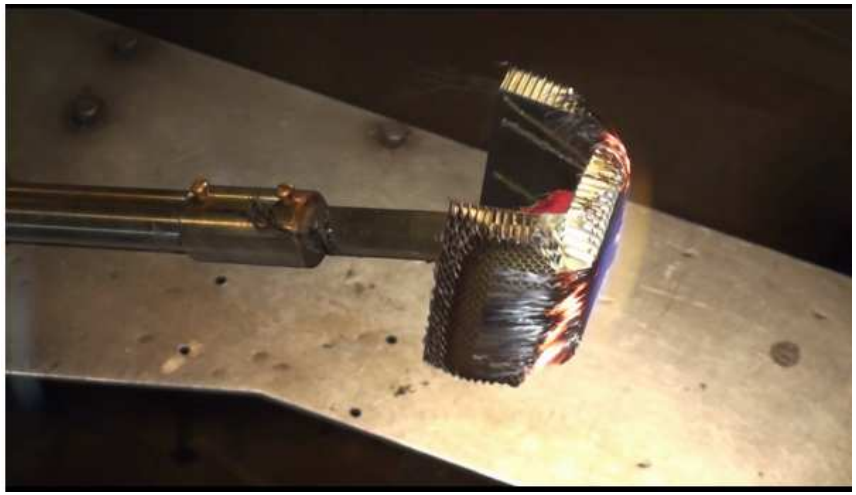




MAIN STUDIES : Reentry risk analysis

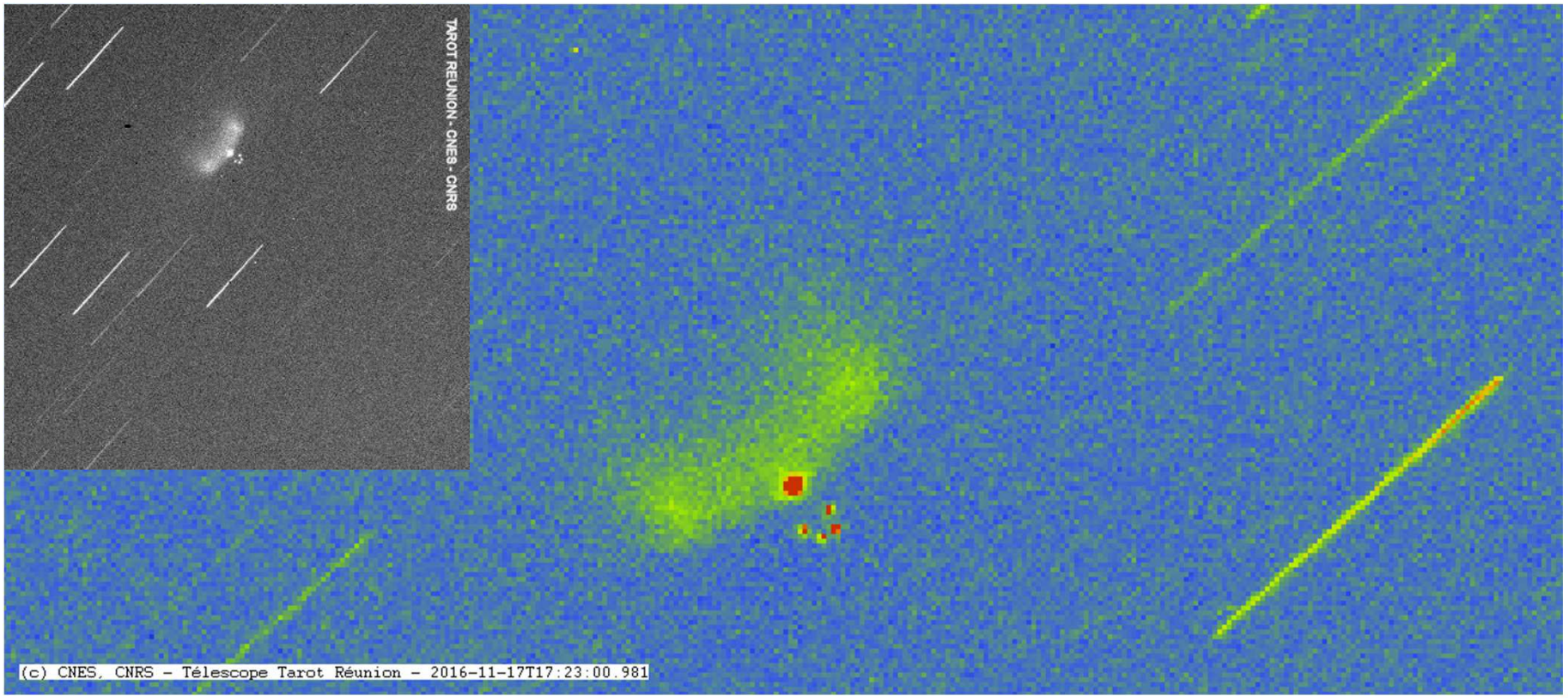
- Images of honeycomb panels with CFRP (Carbon Fiber Reinforced Polymere) plates behavior





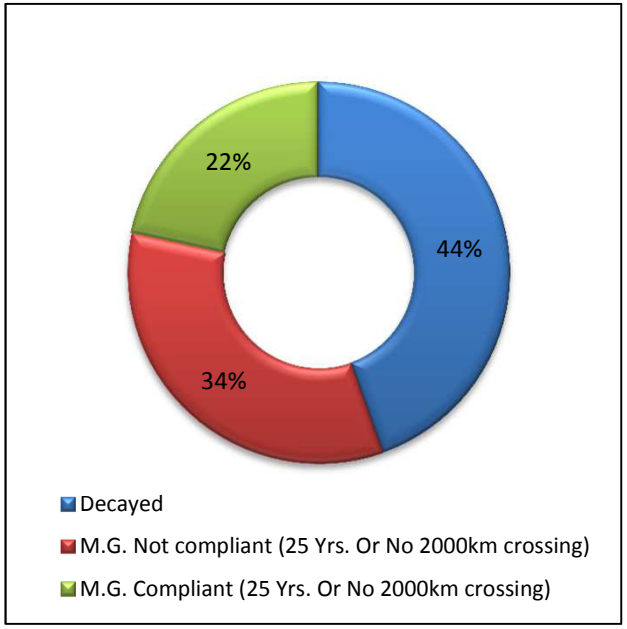
MAIN STUDIES : Use of TAROT during Galileo launch

- Image from the TAROT telescope located in La Reunion used to follow the separation of the 4 Galileo satellite from the Ariane 5 upper stage (launch on November 17)

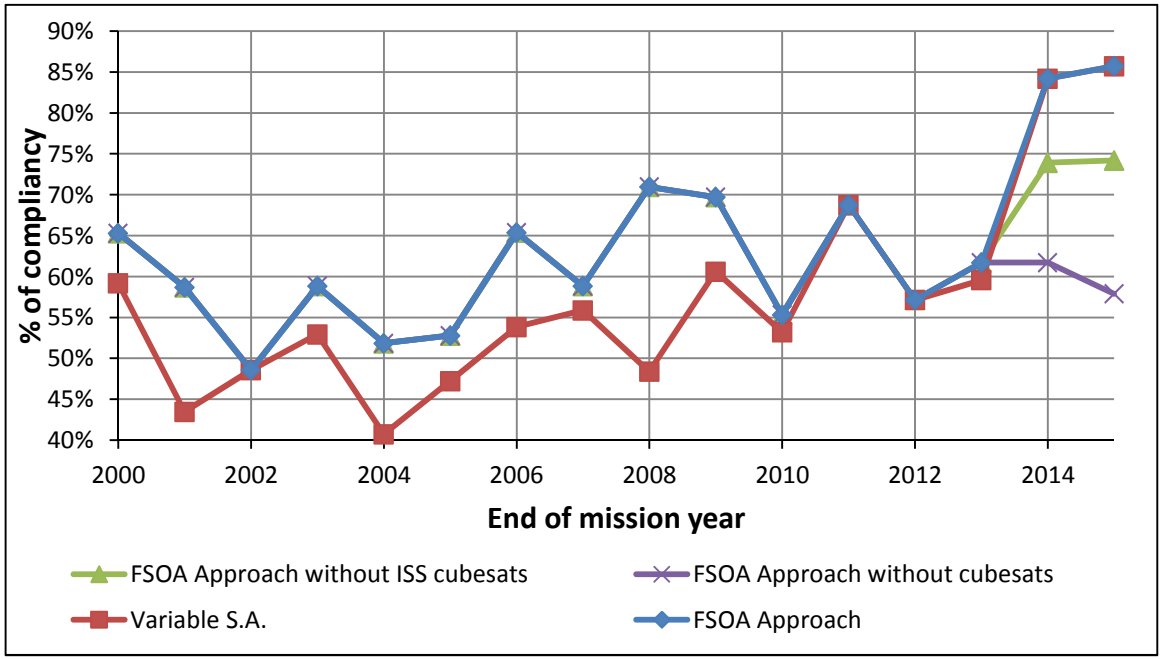


MAIN STUDIES : Debris mitigation rules compliance results

- **Analysis of the results of the past (2000 to 2015) in Low Earth Orbit for satellites post mission disposal**



Global statistics for all objects between 2000 - 2015

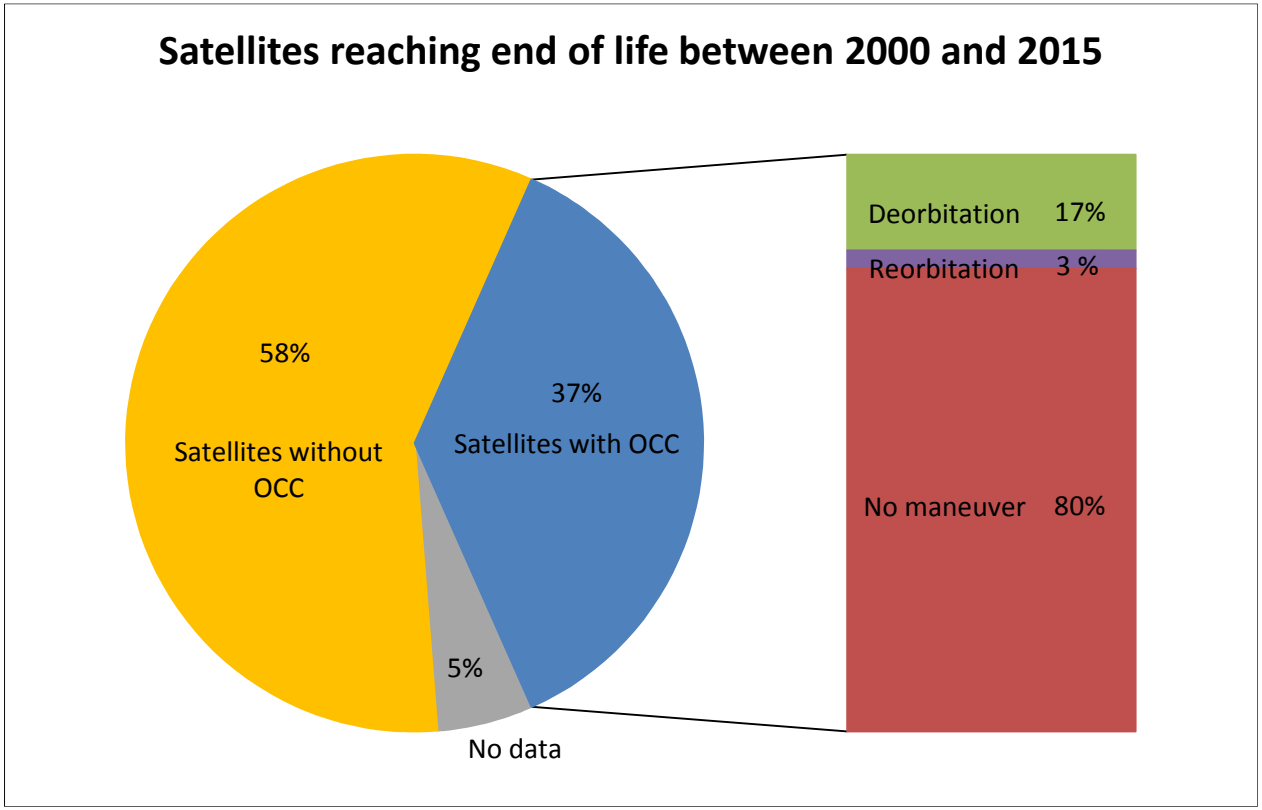


Yearly statistics for all objects between 2000 - 2015

- **For post mission disposal, the compliance with the mitigations guidelines is around 66% with a small improvement coming from the cubesats released from the ISS.**

MAIN STUDIES : Debris mitigation rules compliance results

- **Analysis of the results of the past (2000 to 2015) in Low Earth Orbit for post mission disposal of satellites having a maneuver capability (OCC) : Only 20% of the satellites are performing a maneuver.**



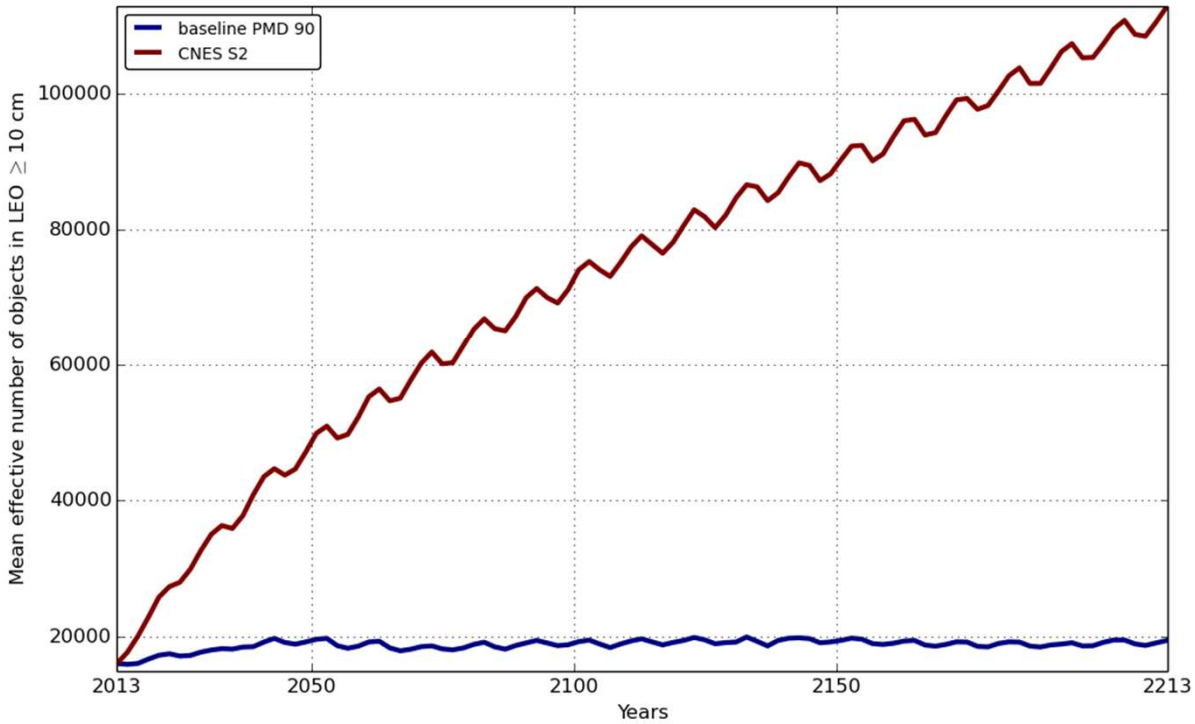
MAIN STUDIES : Space debris population evolution with more realistic hypotheses

- **Fragmentations information :**
  - **12 detected in 2014 with a number of detected debris from 3 to 70.** (from NASA STSC 2015 presentation)
  - **6 detected in 2015 with a number of detected debris from 9 to 164.** (from NASA STSC 2016 presentation)
  - **~ 10 (TBC) detected in 2016 with a number of detected debris from 6 to 344.**

- **Scenarios for population evolution simulations :**
  - **Baseline PMD 90 : 90% of space vehicles compliant with post mission disposal rules – no fragmentation.**
  - **CNES S2 : 20% of space vehicles compliant with post mission disposal rules at the beginning (result of the previous chart) and linear increase up to 90% in 2050 – between 5 and 12 fragmentations per year (randomly) generating more than 5 debris (randomly) with a maximum of 500; there is no fragmentation for objects launched after 2020.**
  - **Constellation 1 : 1080 satellites with an orbit altitude of 1100 km and inclination of 85°, operational mission 5 years, for 90% of the satellites reentry 2 years after end of mission.**

MAIN STUDIES : Space debris population evolution with more realistic hypotheses

- **Use of MEDEE with the previous hypothesis :**

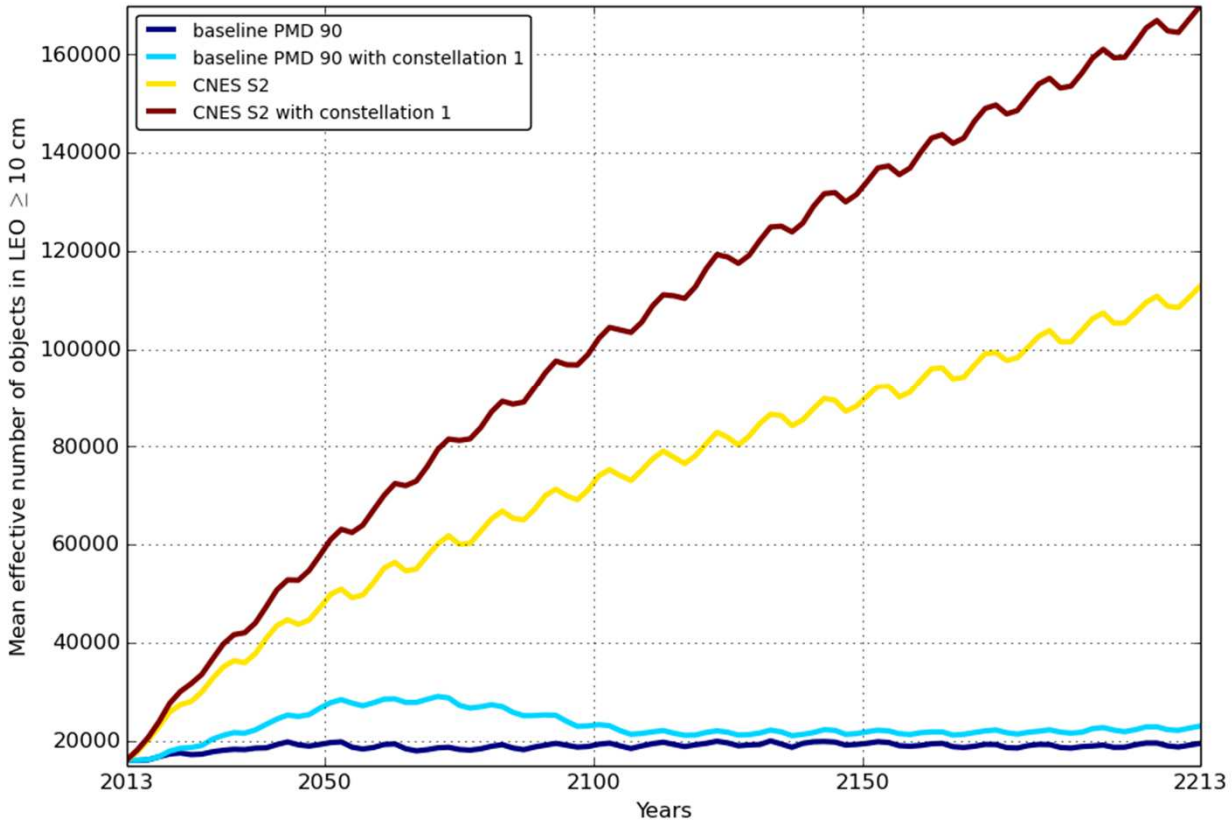


- **With the hypothesis of the situation that we see today, we have a dramatic increase of the space population compared to a situation with a strict application of the mitigation guidelines :**

It is time to enforce
the application of the space debris mitigation guidelines

MAIN STUDIES : Space debris population evolution with a constellation

- **Use of MEDEE with the previous hypothesis and a perfect constellation :**



- **The effect of a perfect constellation is depending on the behavior of the population already in space.**

OPERATIONAL ACTIVITIES : collision risk monitoring

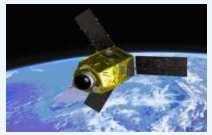
- **CNES operational service called CAESAR (Conjunction Analysis and Evaluation, Assessment and Recommendations) :**
  - **Analysis of all CDMs (Conjunction Data Messages) available corresponding to a conjunction,**
  - **Risk evaluation and avoidance maneuver recommendations.**

LEO

Hélios 2a
Hélios 2b

Calipso

Pléiades 1A
Pléiades 1B



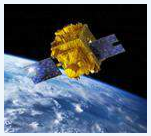
Smos

Jason 2
Jason 3

Elisa x 4

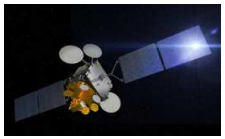
Metop A
Metop B

Microscope

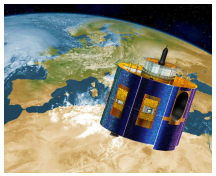


GEO

Syracuse 3A
Syracuse 3B



Athena-Fidus



Meteosat 7, 8, 9, 10, 11

	LEO 2016	GEO 2016
Satellites monitored	15	8
Conjunction messages handled	~ 1 000 000	~ 30 000
Close approach analyzed	~ 57 000	~ 11 000
Additional tracking request	16	3
Effective collision avoidance maneuvers	17	0

OPERATIONAL ACTIVITIES : atmospheric reentries predictions

- **Objects monitored:**
  - «French» objects that could fall on foreign countries (Launching State responsibility) :
    - satellites and launcher stages registered by France,
    - launcher stages registered by ESA.
  - « foreign » objects that could fall on the national territory :
    - Potentially dangerous objects registered by other countries :
      -Mass > 5T,
      -dangerous materials.
- **Particular cases**
  IADC or governmental requests.
- **« debris » objects not considered**
- **15 reentries monitored in 2016**

REGULATORY ACTIVITIES

- French Space Act applicable since December 2010
- Technical compliance is checked by CNES for the French Space Ministry before launch or critical operations
- Authorization given in 2016:
  - ROBUSTA 1B
  - MICROSCOPE
  - EUTELSAT 8 WEST B,
  - EUTELSAT 65 WEST A
- Authorization given for in orbit delivery
  - TELCOM 3S

REGULATORY ACTIVITIES

2016 : authorized end of life operations

- **EUTELSAT**
  - **EUTELSAT 33D**
    - **Emergency end of life,**
    - **Final orbit ~300 km above geostationary orbit in compliance with French Space Act Technical Regulation and international guidelines,**
    - **The satellite will stay outside the GEO protected region.**

NATIONAL REGISTER OF SPACE OBJECTS

French registered objects launched in 2016

- **3 satellites:**

Date	Name	Launcher	Launch base
January 29	EUTELSAT 9 B	Proton-M	Baïkonour
March 9	EUTELSAT 65 West A	Ariane 5	Kourou
April 25	Microscope	Soyouz-ST	Kourou

- **7 Ariane 5 upper stages**
- **4 Sylda**
- **1 Fregat (upper stage of Soyouz)**
- **1 Avum (upper stage of Vega)**

NATIONAL REGISTER OF SPACE OBJECTS

French registered objects decayed in 2016

International number	Name	US number	Launch date	Decay date
1990-091C	ARIANE 44L R/B	20874	12/10/1990	20/09/2016
2006-054C	ARIANE 5 DEB (Sylda)	29645	08/12/2006	24/07/2016
2009-035B	ARIANE 5 R/B	35497	01/07/2009	31/10/2016
2012-062D	ARIANE 5 DEB (Sylda)	38994	10/11/2012	08/11/2016

MEETINGS AND WORKSHOPS

- **Meetings and workshops are regularly organized:**
  - **To inform all partners (industry, operators, research organizations, governmental bodies,…) on space debris activities at national and international levels**
  - **To get their feedbacks and needs relative to mitigation rules and to research activities**

- **Main meetings:**
  - **January 28, 2016 : satellites end of life workshop (Paris)**
  - **June 6 – 8, 2016 : 4th International Workshop on Modeling and Remediation (Paris)**
  - **June 28, 2016: annual national meeting on space debris : Space Debris Synthesis Group (Toulouse)**