OVERVIEW ON 2013 SPACE DEBRIS ACTIVITIES IN FRANCE

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  - Reentry risk analysis
  - Long term evolution of the space debris population
- Operational activities:
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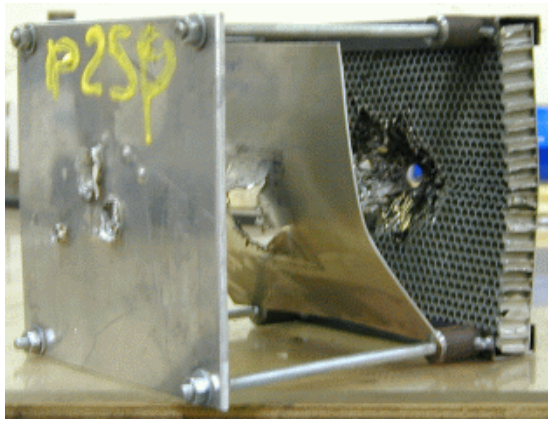
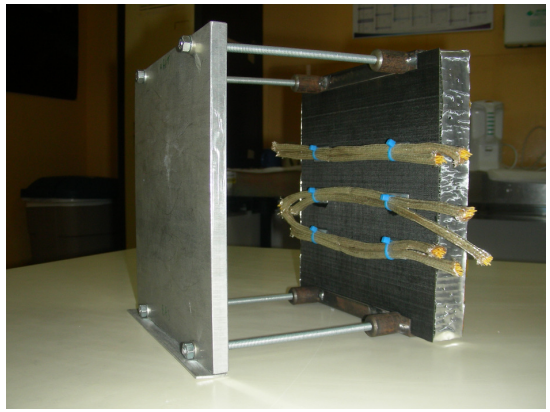
  - Atmospheric reentries predictions
  - End of life operations
- Regulatory activities
- National Register of Space Objects
- Workshops and meetings

MAIN STUDIES



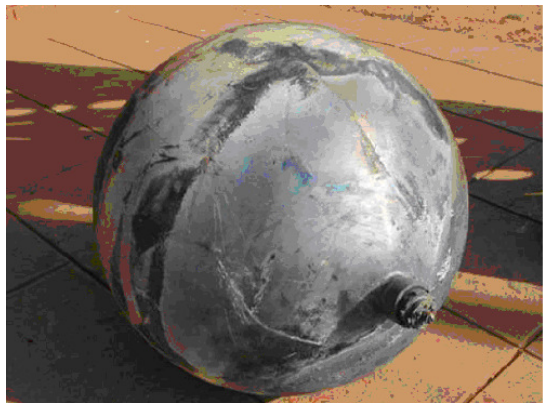
Hypervelocity impact studies

- **Impacts by small particles may damage satellites**
- **Need to assess risk level and vulnerability**
- **3 steps**
  - Perforation law of the walls (ballistic equations)
  - Propagation of debris cloud inside the spacecraft
  - Effect inside a satellite: equipment, tanks, harness
- **Main difficulties**
  - Poor knowledge of small particles debris flux
  - Angle of attack, faces of the satellite
  - Influence of hypothesis: spherical shape and average density of the projectile, temperature
  - Limitation of on-ground test facilities



MAIN STUDIES

Reentry risk analysis



- **Need for casualty risk evaluation**
- **Tools supporting the implementation of French Space Act and reentries operational monitoring: Debrisk and Electra**
- **3 steps:**
  - Fragmentation
  - Survivability of debris
  - Casualty area, population model, risk level
- **Analysis of debris recovered on ground after reentry**
  - Surface analysis, damage evaluation, mass loss, materials properties changes
  - Comparison with survivability models (aerothermal effects, fragmentation)

MAIN STUDIES

MEDEE – Modeling the Evolution of Debris on Earth's Environment

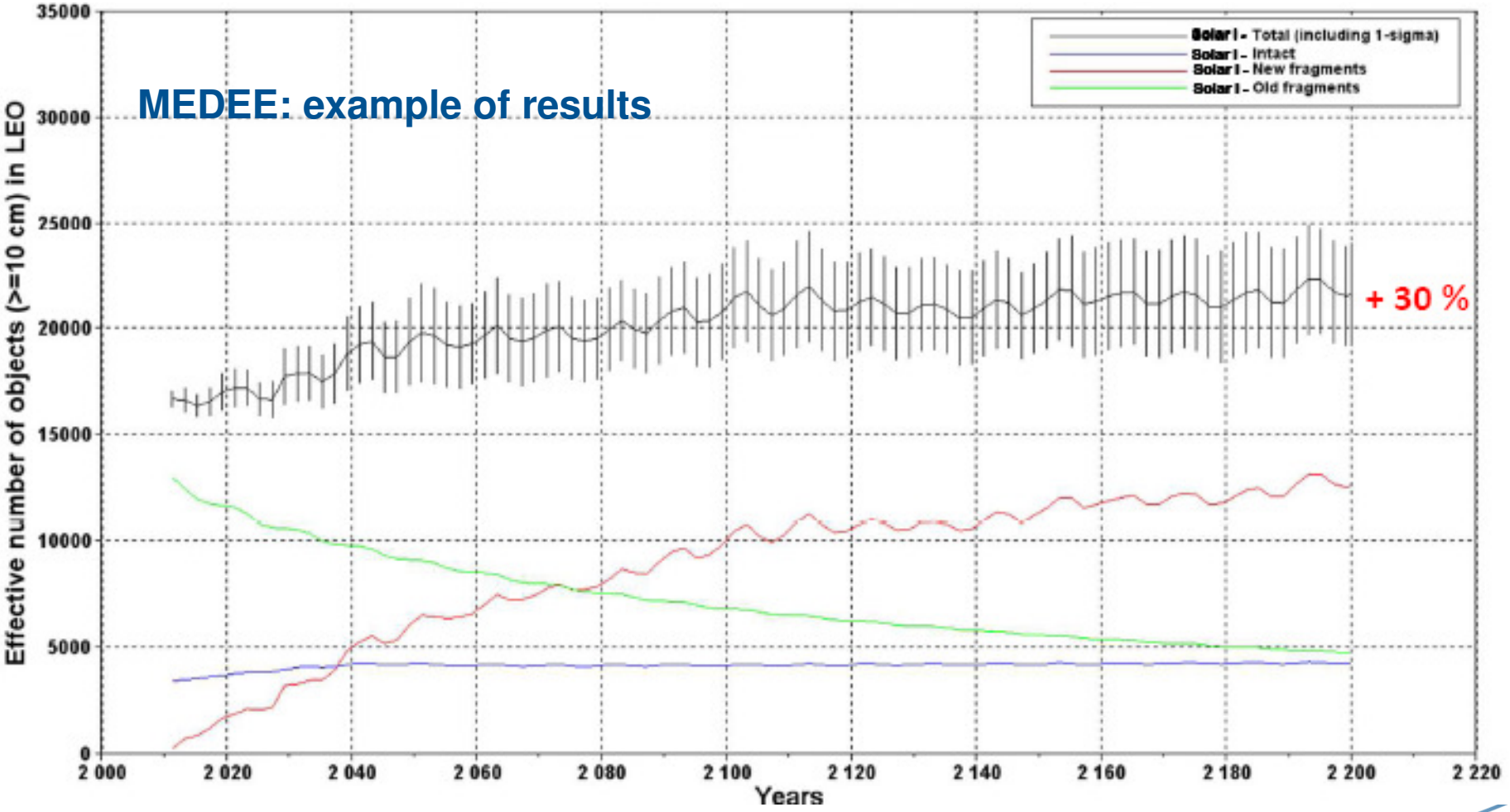
- **Objectives:**
  - Long term evolution of the space debris population (200 years)
  - To analyze the influence of launch rate and mitigation effectiveness
  - To confirm or not the need for active debris removal

- **Preliminary findings: unstability of the results, high influence of several inputs:**
  - Solar activity, atmospheric model
  - Traffic model
  - Fragmentation model
  - End of life disposal

- **Need for additional cooperation with the other space agencies**

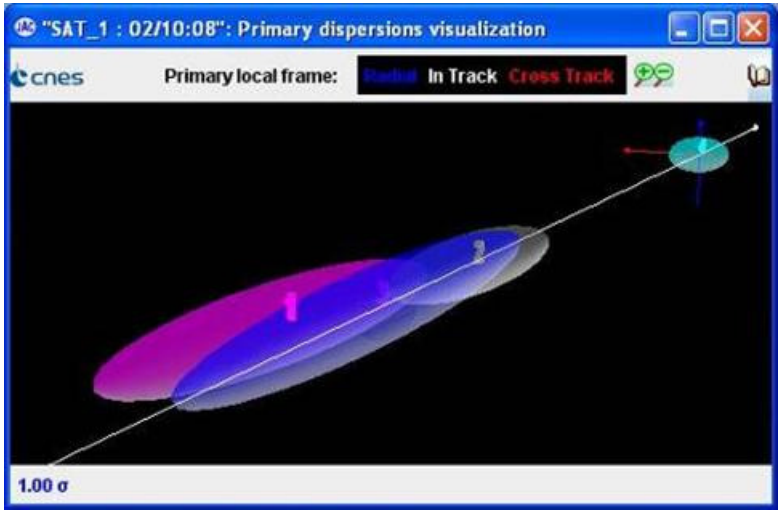
MAIN STUDIES

MEDEE: example of results



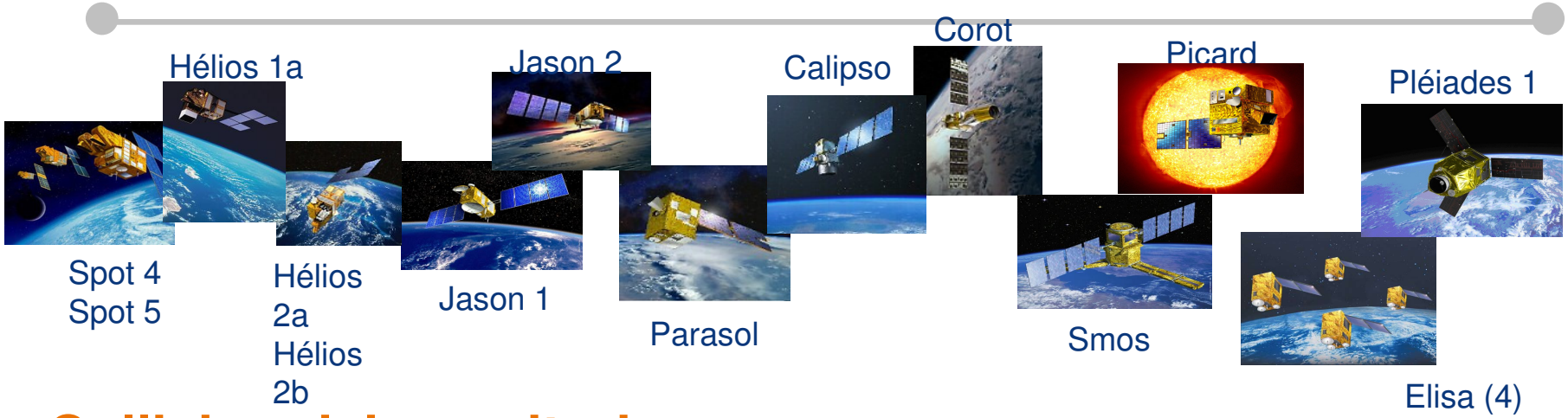
OPERATIONAL ACTIVITIES

Collision risk monitoring



- **Available information:**
  - Conjunction Summary Messages (CSM) issued by the US SSN
  - Space Surveillance Data from the Graves radar
  - Tracking measurements by several radars and telescopes
- **Main difficulties:**
  - Many alerts (CSM) received for a given close approach
  - Uncertainties on positions/velocities of both objects
- **Expertise and dedicated tools necessary to analyze the situation**

OPERATIONAL ACTIVITIES



Collision risk monitoring

- **Operational service called CAESAR (Conjunction Analysis and Evaluation, Assessment and Recommendations)**
  - ✦Analysis of all CSMs available corresponding to a conjunction
  - ✦Risk evaluation and avoidance recommendations
- **Open to:**
  - ✦Satellites controlled by CNES
  - ✦External customers

	2012	2013
Satellites monitored	18	17
Support requests	9	23
Avoidance manoeuvres	13	19

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**
- **10 reentries monitored in 2013**

OPERATIONAL ACTIVITIES

Post mission disposals

- **21 June 2013: JASON-1 (NASA-CNES)**
  - Altimetry, oceanography
  - Launched 7 December 2001
  - Final orbit 1332 x 1319 km, passivation

- **29 June 2013: SPOT 4**
  - Earth observation
  - Launched 24 March 1998
  - Final orbit 727 x 706 km
  - Emptying of tanks, electrical passivation

- **18 December 2013: PARASOL**
  - Analysis of aerosols in the Earth atmosphere (Aqua-Train)
  - Launched 18 December 2004
  - Final orbit 681 x 660 km, passivation

- **December 2013-January 2014: COROT**
  - Exo-planetary research
  - Launched 27 December 2006
  - Final orbit: on-going operations

REGULATORY ACTIVITIES

- **French Space Act applicable since December 2010**
- **Technical compliance is checked by CNES before launch or critical operations**
- **Authorization given in 2012-2013:**
  - 5 satellites Eutelsat
  - 6 satellites Globalstar to complete the 24 satellites constellation,
  - AstroTerra/Spot6 (Astrium)
  - Robusta (University of Montpellier)
  - Pleiades 1B (CNES)
- **Authorization given for in orbit delivery**
  - YAHSAT 1B, VNREDSAT
- **Conformance status for ESA:** ATV-4

REGULATORY ACTIVITIES

2012-2013: authorized end of life operations

- **EUTELSAT**
  - EUTELSAT 4A
  - EUTELSAT 4B

- **CNES**
  - Jason-1
  - SPOT 4
  - PARASOL
  - TELECOM 2D
  - COROT

- **ESA**
  - ATV-4 controlled re-entry

NATIONAL REGISTER OF SPACE OBJECTS

French registered objects launched in 2013

- **2 satellites:**

Date	Name	Launcher	Launch base
14 May	EUTELSAT 3D	Proton	Tyuratam
29 August	EUTELSAT 25B	Ariane 5	Kourou

- **4 Ariane 5 upper stages**
- **3 Sylda**

NATIONAL REGISTER OF SPACE OBJECTS

French registered objects decayed in 2013

US number	Name	International number	Launch date	Decay date
17324	ARIANE 1 DEB	1986-019DG	22/2/1986	1/10/2013
25640	ARIANE 44L R/B	1999-009C	26/2/1999	11/2/2013
26805	ARIANE 3 DEB	1986-026H	28/3/1986	17/8/2013
30796	ARIANE 5 SYLDA	2007-007D	11/3/2007	6/4/2013
32296	ARIANE 5 SYLDA	2007-056D	14/11/2007	20/9/2013
37608	ARIANE 5 SYLDA	2011-022D	20/5/2011	21/1/2013
39176	ARIANE 5 R/B	2013-027B	5/6/2013	6/6/2013

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:

- 28 January 2014: satellites end of life workshop (Paris)
- 16-18 June 2014: 3rd European workshop on Space Debris Modeling and Remediation (Paris)
- 27 June 2013: annual national meeting on space debris
  Space Debris Synthesis Group (Toulouse)