

# OVERVIEW ON 2014 SPACE DEBRIS ACTIVITIES IN FRANCE

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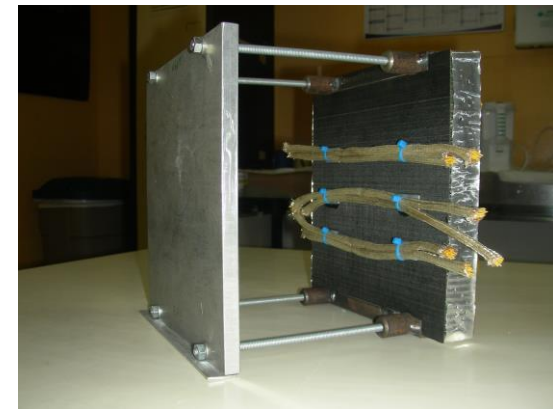
**COPUOS STSC**  
**2-13 February 2015**

- **Main studies :**
  - ◆ Hypervelocity impacts,
  - ◆ Reentry risk analysis,
  - ◆ Long term evolution of the space debris population.
  
- **Operational activities::**
  - ◆ Collision risk monitoring,
  - ◆ Atmospheric reentries predictions,
  - ◆ End of life operations.
  
- **Regulatory activities**
  
- **National Register of Space Objects**
  
- **Workshops and meetings**

# MAIN STUDIES

## Hypervelocity impact studies

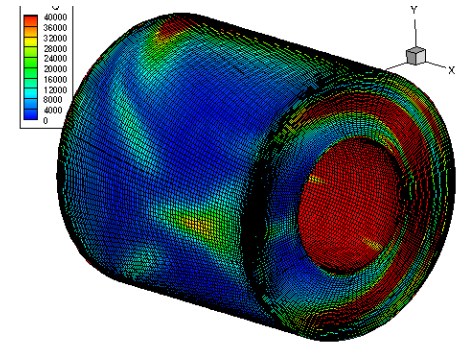
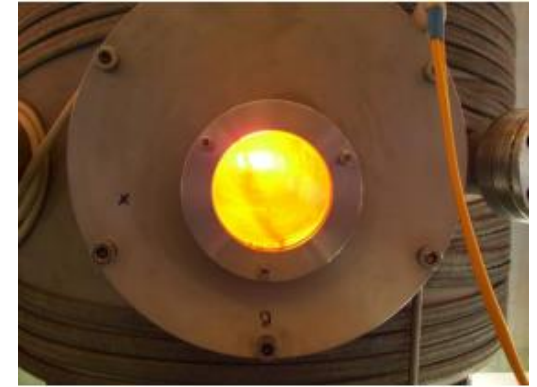
- Impacts by small particles may damage satellites
- Need to assess risk level and vulnerability
- 3 steps
  - ◆ Perforation law of the walls (ballistic equations),
  - ◆ Propagation of debris cloud inside the spacecraft,
  - ◆ Effect inside a satellite: equipment, tanks, harness.
- Main difficulties
  - ◆ 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

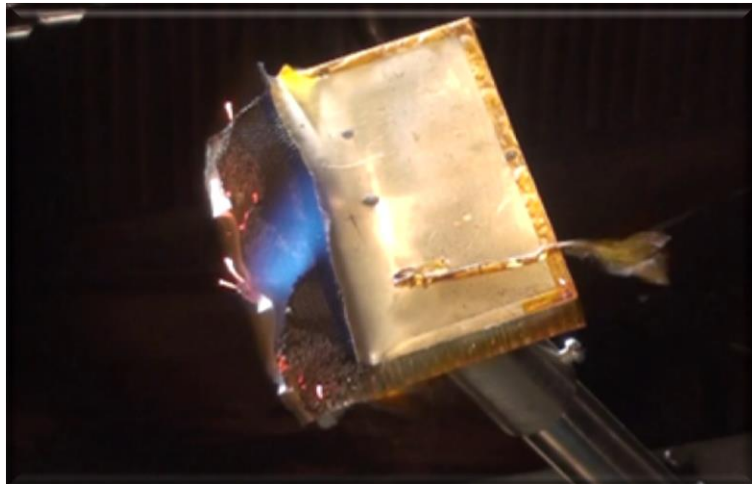
**Reentry risk analysis** : Improvement of the knowledge and margins of Tools supporting the implementation of French Space Act and reentries operational monitoring : Debrisk and Electra.

- Material characterization in solar furnace : measurement of emissivity, calorific capacity, oxidation enthalpy parameters.
- Use of Computational Fluid Dynamics codes to consolidate drag and heat fluxes coefficients.



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- Wind tunnel tests at high Mach number to :
  - measure drag and fluxes,
  - analyze the destructive process for spacecraft composite materials.



# MAIN STUDIES : MEDEE

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

- Objectives :

- ◆ To analyze the long term evolution of the space debris population (typically 200 years),
- ◆ To study the sensitivity of the results to the uncertainties (e.g. solar activities) and to simulation hypothesis (e.g. launch rate and mitigation effectiveness),
- ◆ To analyze the mitigation and remediation measures which could be needed to guarantee the long term sustainability of space activities.

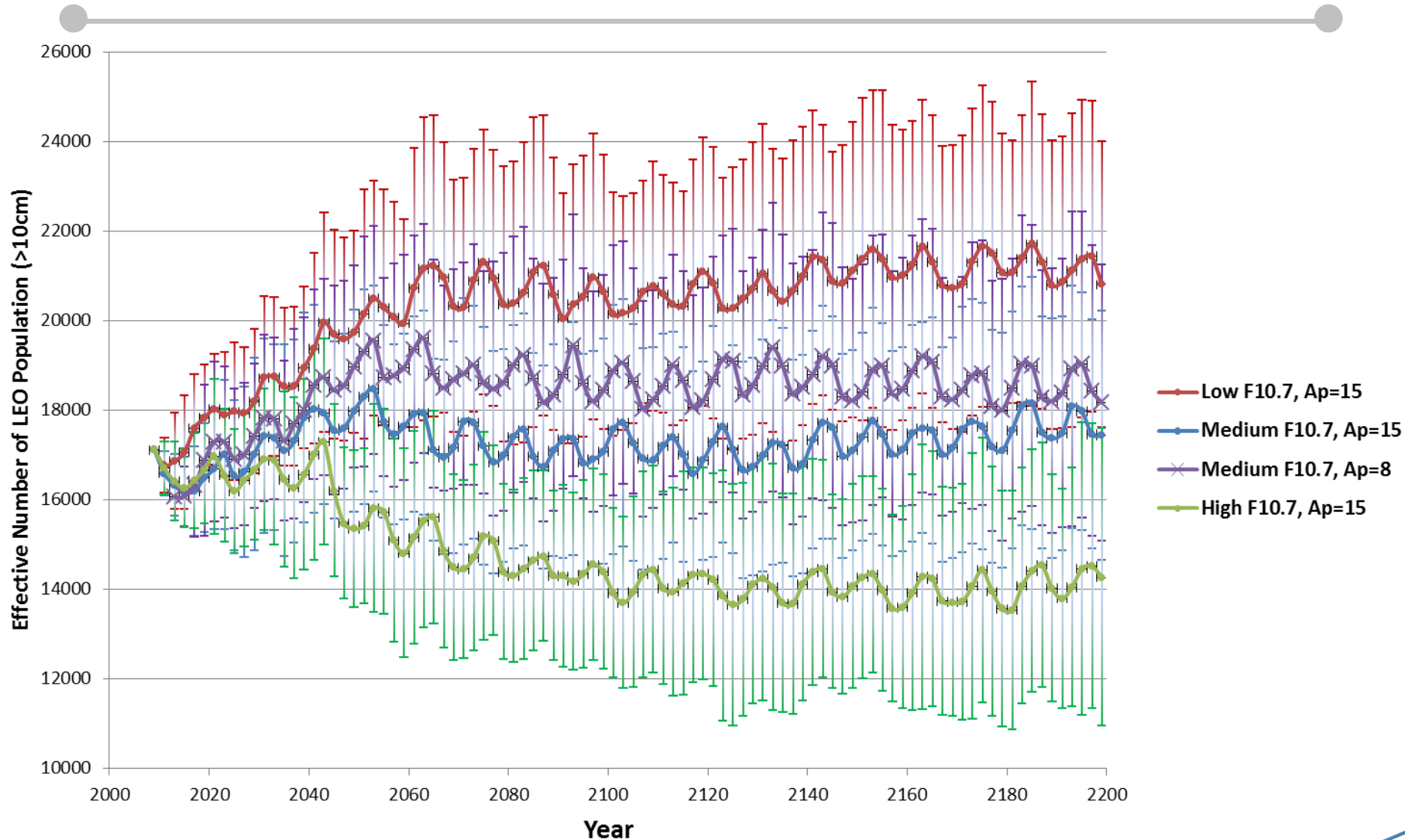
- Preliminary findings: sensitivity of the results, high influence of several uncertain parameters, in particular the solar activity.

- Further work :

- ◆ To continue the sensitivity analysis of the long-term evolution of the environment to uncertain parameters,
- ◆ To identify the critical parameters and define a way to take such uncertainty into account on the simulation,
- ◆ To perform realistic scenario simulations (e.g. future launch rate, cubesats, real PMD compliance, ...) and analyze the long term evolution of the population under such hypothesis.

- Need to continue cooperation and research with the other space agencies.





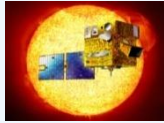
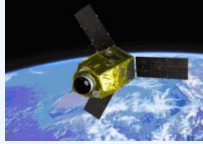





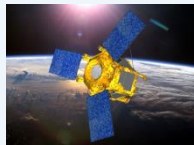

# MAIN STUDIES : MEDEE - example of results



Low Earth Orbit evolution for various solar activity hypotheses

# OPERATIONAL ACTIVITIES : collision risk monitoring

**LEO**

 Spot 4 (2013) Spot 5	 Hélios 2a Hélios 2b	 Parasol (2013)	 Corot	 Picard	 Pléiades 1A Pléiades 1B	 Syracuse 3A Syracuse 3B <b>GEO</b>
	 Jason 1 (2013) Jason 2	 Calipso	 Smos	 Elisa x 4	 Spot 6 Spot 7 (2014)	 Athena-Fidus

- **Available information :**

- ◆ **Conjunction Summary Messages (CSM) / Conjunction Data Message (CDM) issued by the US Space Surveillance Network,**
- ◆ **Space Surveillance Data from the Graves radar,**
- ◆ **Tracking measurements by several radars and telescopes.**

- **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/CDMs available corresponding to a conjunction,
  - ◆ Risk evaluation and avoidance recommendations.
- Open to:
  - ◆ Satellites controlled by CNES,
  - ◆ External customers.

	LEO 2013	LEO 2014	MEO 2014 (LEOP GALILEO)	GEO 2014
Satellites monitored	18	16	2	3
Conjunction messages handled	~ 400 000	~ 165 500	2	~ 12 500
High level collision risk alert to operator, avoidance action prepared	48	72	0	1
Additional tracking request	25	12	0	3
Effective collision avoidance maneuvers	20	17	0	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.

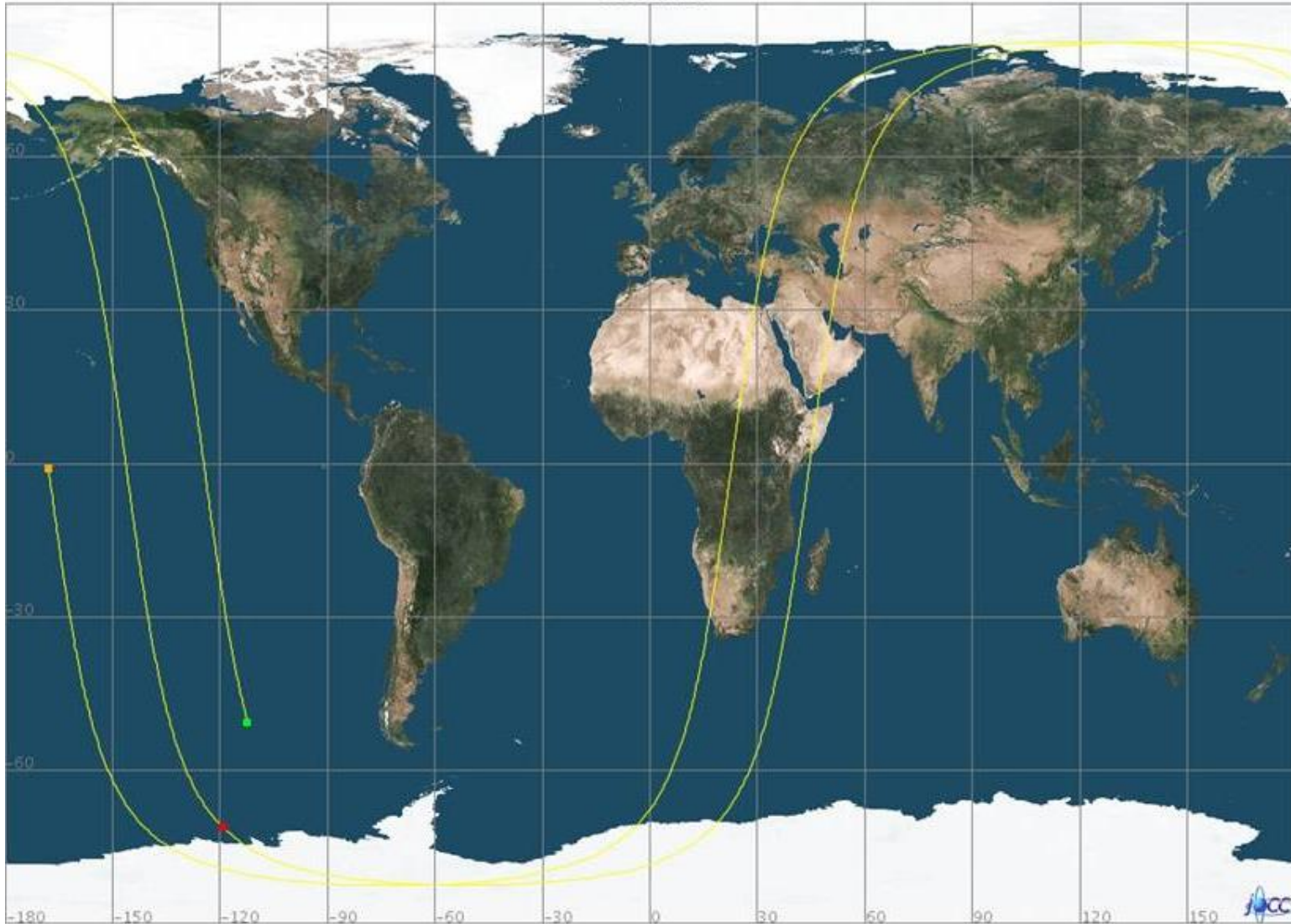
### ● « debris » objects not considered

### ● 10 reentries monitored in 2014



# OPERATIONAL ACTIVITIES : atmospheric reentry predictions

## Example of uncertainty for a prediction 12 hours before reentry

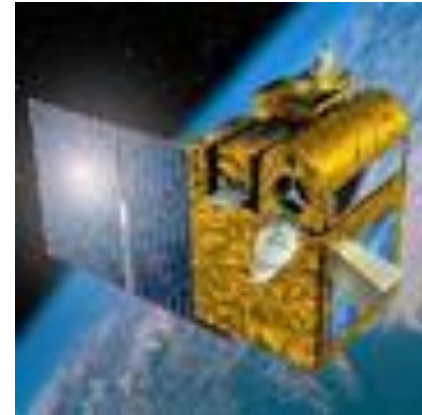


# OPERATIONAL ACTIVITIES

## Post mission disposals

### ● 4 June 2014: PICARD

- ◆ Study of solar variability,
- ◆ Launched 15 June 2010,
- ◆ Final orbit 732 x 715 km, passivation.



### ● 17 June 2014: COROT

- ◆ Exo-planetary research,
- ◆ Launched 27 December 2006,
- ◆ Final orbit 890 x 590 km, passivation.



# REGULATORY ACTIVITIES

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- **French Space Act applicable since December 2010**
- **Technical compliance is checked by CNES before launch or critical operations**
- **Authorization given in 2014:**
  - ◆ Athena-Fidus (CNES/French Defense),
  - ◆ Eutelsat 3B,
  - ◆ AstroTerra/Spot7 (Airbus).
- **Authorization given for in orbit delivery**
  - ◆ KRS, Measat-3B, Turkmenistan NSSC
- **Conformance status for ESA : ATV-5**

# REGULATORY ACTIVITIES

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## 2014 : authorized end of life operations

- **EUTELSAT**

- ◆ EUTELSAT 48C

- » Final orbit 541 km above geostationary orbit, passivation

- **CNES**

- ◆ PICARD

- ◆ COROT

- **ESA**

- ◆ ATV-4 controlled re-entry

# NATIONAL REGISTER OF SPACE OBJECTS

## French registered objects launched in 2014

- **2 satellites:**

Date	Name	Launcher	Launch base
6 February	ATHENA-FIDUS	Ariane 5	Kourou
26 May	EUTELSAT 3B	Zenit	Sea Launch

- **5 Ariane 5 upper stages**
- **5 Sylva**
- **3 Fregat (upper stage of Soyouz)**

# NATIONAL REGISTER OF SPACE OBJECTS

## French registered objects decayed in 2014

US number	Name	International number	Launch date	Decay date
25881	ARIANE 42P R/B	1999-042B	12/08/1999	10/03/2014
26039	ARIANE 44L R/B	1999-071B	22/12/1999	11/04/2014
37239	ARIANE 5 R/B	2010-065C	26/11/2010	16/08/2014
32770	ARIANE 5 SYLDA	2008-018D	18/04/2008	26/09/2014
21766	ARIANE 44L R/B	1991-075B	29/10/1991	20/10/2014

# MEETINGS AND WORKSHOPS

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- **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)**
  - ◆ **24 June 2014: annual national meeting on space debris  
Space Debris Synthesis Group (Toulouse)**