OVERVIEW ON 2013 SPACE DEBRIS ACTIVITIES IN FRANCE

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COPUOS STSC
10-21 February 2014
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
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)
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

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
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<tbody>
<tr>
<td>Satellites monitored</td>
<td>18</td>
<td>17</td>
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<td>Support requests</td>
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<td>Avoidance manoeuvres</td>
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<td>19</td>
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</table>

Overview on 2013 space debris activities in France, COPUOS STSC, February 2014, Vienna
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:

<table>
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<tr>
<th>Date</th>
<th>Name</th>
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<tr>
<td>14 May</td>
<td>EUTELSAT 3D</td>
<td>Proton</td>
<td>Tyuratam</td>
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<td>29 August</td>
<td>EUTELSAT 25B</td>
<td>Ariane 5</td>
<td>Kourou</td>
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● 4 Ariane 5 upper stages
● 3 Sylda
## NATIONAL REGISTER OF SPACE OBJECTS

French registered objects decayed in 2013

<table>
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<tr>
<th>US number</th>
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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)