Space Debris: a CNES top priority
COOPERATION

• France actively supports international groups in charge of establishing best practices, guidelines and standards:
  - ECSS
  - ISO
  - UN COPUOS
  - IADC
  - ...
• France advices states which aim to promote a space law by sharing its experience and feedback
• Cooperation frameworks on surveillance and technology blocks
SURVEILLANCE: collision risk monitoring

- CNES operational service called CAESAR (Conjunction Analysis and Evaluation, Assessment and Recommendations):
  - 106 satellites worldwide use CAESAR through EU-SST services

<table>
<thead>
<tr>
<th></th>
<th>LEO 2018</th>
<th>MEO 2018</th>
<th>GEO 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellites monitored</td>
<td>26</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Close approach alert</td>
<td>25</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Additional tracking request</td>
<td>10</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Effective collision avoidance</td>
<td>15</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

- Improving conjunction analysis methods
  - Improvement of collision probability algorithms
  - Improvement of cataloguing algorithms
  - Development of new planning/scheduling algorithms
### SURVEILLANCE: 2018 Re-entries followed by France

#### French objects

<table>
<thead>
<tr>
<th>Re-entry date</th>
<th>Norad</th>
<th>International</th>
<th>Name</th>
<th>Launch</th>
<th>Incl. (deg.)</th>
<th>Radius (m) / Mass (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/02/2018</td>
<td>N33753</td>
<td>2009-008E</td>
<td>Ariane 5 Deb (Sylda)*</td>
<td>12/02/2009</td>
<td>1.89</td>
<td>5.6 / 0.4</td>
</tr>
<tr>
<td>27/02/2018</td>
<td>N37395</td>
<td>2011-016D</td>
<td>Ariane 5 Deb (Sylda)*</td>
<td>22/04/2011</td>
<td>5.49</td>
<td>5.6 / 0.4</td>
</tr>
<tr>
<td>05/03/2018</td>
<td>N24754</td>
<td>1979-104C</td>
<td>Ariane 1 Deb</td>
<td>24/12/1979</td>
<td>17.57</td>
<td>NC / NC</td>
</tr>
<tr>
<td>03/04/2018</td>
<td>N31309</td>
<td>2007-016D</td>
<td>Ariane 5 Deb (Sylda)</td>
<td>04/05/2007</td>
<td>5.74</td>
<td>5.6 / 0.4</td>
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<tr>
<td>28/10/2018</td>
<td>N37267</td>
<td>2010-070D</td>
<td>Ariane 5 Deb (Sylda)</td>
<td>29/12/2010</td>
<td>3.07</td>
<td>5.6 / 0.4</td>
</tr>
</tbody>
</table>

#### Foreign objects

<table>
<thead>
<tr>
<th>Re-entry date</th>
<th>Norad</th>
<th>International</th>
<th>Name</th>
<th>Launch</th>
<th>Incl. (deg.)</th>
<th>Radius (m) / Mass (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/02/2018</td>
<td>N25039</td>
<td>1997-069A</td>
<td>Iridium 43 (US)*</td>
<td>09/11/1997</td>
<td>86.35</td>
<td>4.7 / 0.7</td>
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<tr>
<td>02/04/2018</td>
<td>N37820</td>
<td>2011-053A</td>
<td>Tiangong-1 (PRC)*</td>
<td>29/09/2011</td>
<td>42.74</td>
<td>8.5 / 6.6</td>
</tr>
</tbody>
</table>
SURVEILLANCE: TIANGONG Re-entry IADC Campaign

ANALYSING

SAFETY

TRACKING

Inter-Agency Space Debris Coordination Committee
**TECHNOLOGY : Tech4SpaceCare**

*Tech4SpaceCare* Initiative aiming to develop technological elements to ensure the **sustainable** use of space and the **safety** of space operations in synergy with *CleanSpace* ESA activities.

### Re-entry Safety
- **Modeling**
  - Fragmentation, Mechanical stress, Wind tunnel, tools
- **Design for Demise**
  - Testing, Advanced Studies, materials
- **Reentry Observation**
  - GSTP support, advanced studies, International cooperation for reentry observation
- **Impact on environment**
  - Toxicity, hazardous materials

### Space Sustainability
- **End of Life**
  - Post Mission Disposal, Reliability, Autonomous desorbitation, ADR Compatibility & Maturity, Passivation Systems, tools
- **Mission extension**
  - Health Monitoring & Machine Learning, EOL decision
- **Protection/Vulnerability**
  - Hypervelocity impact, debris generation, MMOD protection, pressurized tanks, Battery
IDEAS: Innovation DEorbiting Aerobraking System:

- 2 inflatable beams (4m70, Ø = 0.16 m)
- 4 sails providing 9 m² additional surface
- Total mass: 17 kg

Natural decay

70 yrs

25 yrs

Satellite MICROSCOPE du CNES avec ses 2 ailes de désorbitation déployées (17/10/2018)
Modèle CAO (à gauche) et image radar capturée par le système TiRA du Fraunhofer Institute (à droite)
MITIGATION : Licences under French Space Law

Satellites

- 65 satellites flying under FSOA licence
- 4 End of Life
- 3 Mission extension
- 4 Preliminary conformity
- 21 on-going submission
- 6 New licences

Launchers

- VEGA
- SOYUZ
- ARIANE 5

Launch authorisations

EUTELSAT
GLOBALSTAR
AIRBUS GEO
CSUM
CSUT
AIRBUS
TAS
CNES
MITIGATION: to invert debris increase trend

90% of satellite and rocket bodies should perform Post Mission Disposal

Space debris evolution for the next 200 years vs Post mission disposal compliance
MITIGATION: deorbitation compliancy

- French law technical regulation criteria
  - Leave LEO protected zone in less than 25 years after EOL
  - Free GEO protected zone during 100 Yrs after EOL

50% worldwide launchers compliant in 2017

72% worldwide LEO satellite EOL compliant in 2017 (cubesat excepted)
MITIGATION: Need of new space traffic rules

“2019 paradigm is not anymore 2008 paradigm”

International guidelines, best practices, national regulatory acts to be updated
WORKSHOPS

- 7th Workshop on Satellite End Of Life - CNES HQ - Paris, Jan 25, 2018
- 5th European Workshop on Space Debris Modeling and Remediation - CNES HQ - Paris, June 25-27, 2018

Coming soon


38th IADC Meeting – June 2020 - Toulouse