OVERVIEW ON SPACE DEBRIS ACTIVITIES IN FRANCE

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Regulatory framework

End of life operations

Collision risk monitoring

Studies (Active Space Debris Removal)
REGULATORY FRAMEWORK

- Space Operations Act voted by the French Parliament in June 2008
- Law entered into force on December 10, 2010
- Objectives: protection of people, property, public health and environment (including on orbit)
- Applicable to:
  - Operators carrying out operations from French territory
  - French operators carrying out operations anywhere in the world
- Operators shall demonstrate compliance w.r.t. Technical Regulations
- Authorizations are granted by the Ministry of Research after analysis of technical aspects by CNES
REGULATORY FRAMEWORK

- Technical provisions mandatory for space operators and applicable to any space system:
  - Specific rules for Launchers
  - Specific rules for Satellites

- Main common principles:
  - Mitigation of debris:
    - For launchers: for launch of a single space object, a single launcher element (upper stage) may be placed in orbit; for launch of several space objects, a maximum of two launcher elements (upper stage and the adapter structure) may be placed in orbit
    - For satellites: no debris produced during nominal operations

- Probability of occurrence of accidental break-up must be less than $10^{-3}$ until the end-of-life of the space object
REGULATORY FRAMEWORK

Following the disposal phase:

» all the on-board energy reserves shall be permanently depleted or placed in a state such that depletion of the on-board energy reserves is inevitable, or in a state such that they entail no risk of generating debris;
» all on-board energy production means shall be permanently deactivated

Obligation to de-orbit the components of any space system (through controlled re-entry or through the “25-years” rule) or to put them on a graveyard orbit

Interim provisions: some of the rules of the technical regulations are not fully applicable to existing space systems
Conformity verification office has been set up

Technical compliance is checked by CNES before launch or critical operations

Methods and tools are proposed to support the implementation of the Technical Regulations:
- Fragmentation modeling during reentry: DEBRISK
- Estimation of ground risk in case of reentry: ELECTRA
- Determination of compliance with the 25-year rule: STELA
- Long term stability of the GEO graveyard orbit
- Collision risk during launch phase: ARCL
END OF LIFE OPERATIONS:
DEMETER satellite

- Detection of Electro Magnetic Emissions Transmitted from Earthquake Regions

- Main characteristics:
  - Size: about 1 m x 1 m x 1 m
  - Mass 120 kg
  - Power 190 W at Beginning of Life

- Launched in June 2004

- Initial orbit 700 km SSO, local hour 22h

- Orbit lowered in 2006 following solar panel anomaly
END OF LIFE OPERATIONS:
DEMETER satellite

- **Disposal operations:**
  - 15 burns (January 4 - February 8, 2011)
  - Fuel exhausted during 13th burn
  - Burn #14 and #15 with lower pressure

- **Final orbit 650 km x 650 km**

- **Passivation:**
  - Batteries discharged
  - Solar panel power shunted
  - S band transmitters off

- **Atmospheric re-entry expected in less than 25 years**
END OF LIFE OPERATIONS:
SPIRALE satellites

**SPIRALE** : **Système Préparatoire Infra-Rouge pour l’ALERte**

- 2 micro satellites launched with Ariane 5 on 12 February 2009
- Geostationary Transfer Orbit  600 km x 35720 km
- Controlled by ASTRIUM Toulouse
- End of life operations in February and March 2011
END OF LIFE OPERATIONS: SPIRALE satellites

- Perigee altitude lowered to 200 km
- 2 maneuvers per satellite
- No collision risk with GEO satellites and with ISS due to orientation of the orbital plane
- Remaining orbital lifetime estimation very sensitive to:
  - S/m ratio
  - Sun and Moon attraction

- Simulations show compliance with the 25-year rule
END OF LIFE OPERATIONS:
EUTELSAT W75

- EUTELSAT W75 (ex HB3) launched on November 2, 1997
- Thrusters anomaly => satellite disposal decided by Eutelsat
- Nominal strategy: due to reduced efficiency the perigee would have been raised by less than 100 km
- Alternative strategy: reorbiting below GEO arc

- Passivation:
  - Fuel exhausted
  - Batteries configured to permanently discharge.
  - Switch-off on July 5, 2011

- Final Orbit:
  - Apogee radius: ~41655 km (~508 km below GEO)
  - Perigee radius: ~41448 km (~716 km below GEO)
COLLISION RISK MONITORING

=> 17 LEO satellites and 1 GEO satellite controlled by CNES

Permanent collision risk monitoring and avoidance maneuvers when necessary:

- Use of Conjunction Summary Messages received from US Joint Space Operations Center (JSpOC)
- Use of the Graves (French radar system) catalogue and measurements
2011 synthesis:

- 122 risks identified by the automated process (probability of collision $> 10^{-4}$)
- 89 risk alerts received from US JSpOC
- 15 requests for radar measurements or support to JSpOC (probability of collision $> 10^{-3}$)
- 5 avoidance maneuvers
ACTIVE SPACE DEBRIS REMOVAL

● Increasing risk to operational satellite

● Mitigation measures will not be sufficient

● Active Space Debris Removal will be necessary

● Complex issue: technical, economical and legal aspects

http://swisscube.epfl.ch
ACTIVE SPACE DEBRIS REMOVAL

- Several on-going studies at CNES, ASTRIUM, THALES ALENIA SPACE and BERTIN
- Objective to identify technical difficulties and critical technologies:
  - *Rendez-vous* with non cooperative target
  - Capture of a tumbling object
  - De-orbiting solutions: propulsion, tethers, inflatable devices,…
- Development of a space debris population model to analyze:
  - Future evolution
  - Influence of mitigation options
  - Risk level evaluation
  - Target selection

- 2nd European workshop on Active Space Debris Removal: 18-19 June 2012