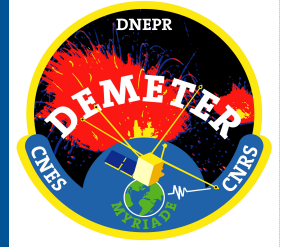




CENTRE NATIONAL D'ÉTUDES SPATIALES



DEMETER satellite disposal, CNES give an example of French Space Act compliance

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- French Space Act
- Disposal operations
- Part N°1 : fuel passivation
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- Conclusion



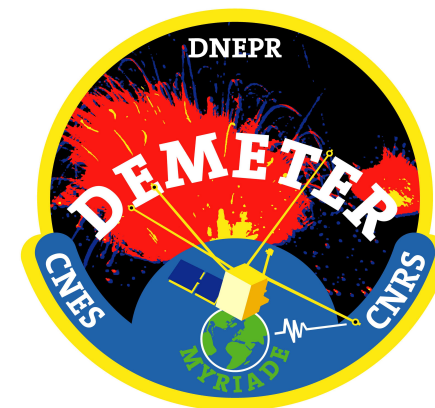
DEMETER is the first launched satellite of the MYRIADE family.

■ **June 29th 2004, DEMETER was launched with a required lifetime of 1 year and a 2 years target, the real life duration was 6,5 years.**

♦ **The initial orbit was a 700 km sun synchronous orbit**

■ **January 2006, due to a solar panel anomaly that might lead to satellite loss, CNES decided to lower the initial altitude to 660 km.**

♦ **This altitude allowed CNES to be compliant with a duration of 25 years to re-enter the atmosphere in case of loss of the satellite.**



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The French Space Act relating to space operations came into force in France on December 10th 2010.

■ **For the disposal of satellites already in orbit at this date, technical regulation requires to seek the best possible strategy.**

■ **By the end of 2009, CNES decided to retire the DEMETER satellite :**

- ♦ **2010/12/10 End of programming of the scientific mission**
- ♦ **2011/03/17 Satellite end of life**

➤ **With this disposal, CNES wanted to give an example of French Space Act compliance.**

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- **MYRIADE satellites are microsatellites designed by CNES with a low cost approach and they were designed without taking into account disposal issues.**

- **To be in line with the regulations ... we applied :**
 - ♦ atmospheric re-entry phase duration limited to 25 years,
 - ♦ fuel depletion,
 - ♦ electrical passivation.

- **In 2010, CNES sought the best possible disposal strategy to passivate a microsatellite.**

■ Part N°1 : fuel passivation

To lower the semi major axis of the orbit,
To empty propellant tank until fuel depletion.

■ Part N°2 : electrical passivation

To discharge the battery,
To switch off the satellite,
To minimize the probability of satellite restart in case of OBC restart.

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■ The aimed orbit choice

DEMETER orbit was already in line with regulation

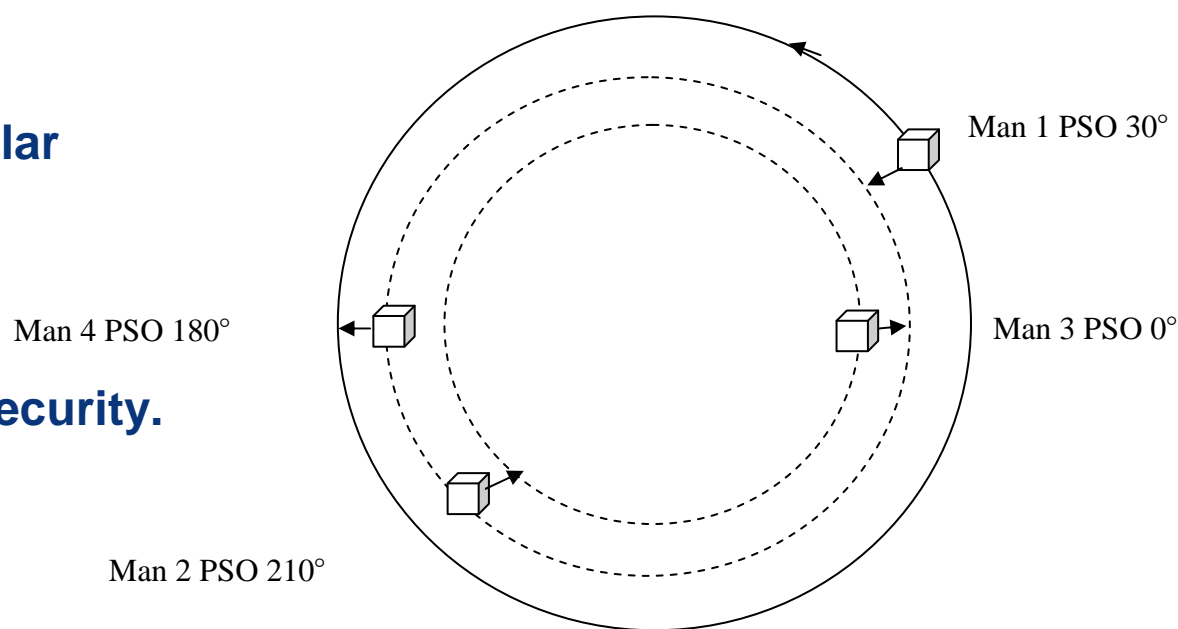
- In October 2010, CNES decided to use a “yo-yo” scenario (lowering / raising orbit) in order not to take into account collision risks with other operational satellites.

■ A scenario « yo-yo » means

- ♦ Day 1 : Maneuver N°1 with 1 burn $Da < 0$
- ♦ Day 2 : Maneuver N°2 with 1 burn $Da < 0$ on opposite position
- ♦ Day 3: Maneuver N°3 with 1 burn $Da > 0$
- ♦ Day 4: Maneuver N°4 with 1 burn $Da > 0$ on opposite position

■ We wanted to keep a circular orbit.

■ 1 burn per maneuver for security.



■ From January 4th 2011 to February 8th 2011

15 maneuvers were carried out to reach fuel depletion

- ♦ A maneuver = 2 minutes burn

... it means a 1,6 km variation on the semi major axis of the orbit.

- ♦ After each maneuver :

... the satellite behavior was analyzed,

... and if OK, the next maneuver was calculated.

■ We couldn't forecast exactly when the fuel depletion would be reached

- ♦ But for the two last maneuvers, we saw that these maneuvers were executed at lower pressure and with vapor state of hydrazine .



that was a signal that fuel depletion was reached.

Fuel passivation phase was finished.

- The reached orbit respects the duration of the atmospheric reentry phase , which is expected to be less than 25 years.

For DEMETER, it is particularly difficult to estimate the duration because of the long payload appendages.

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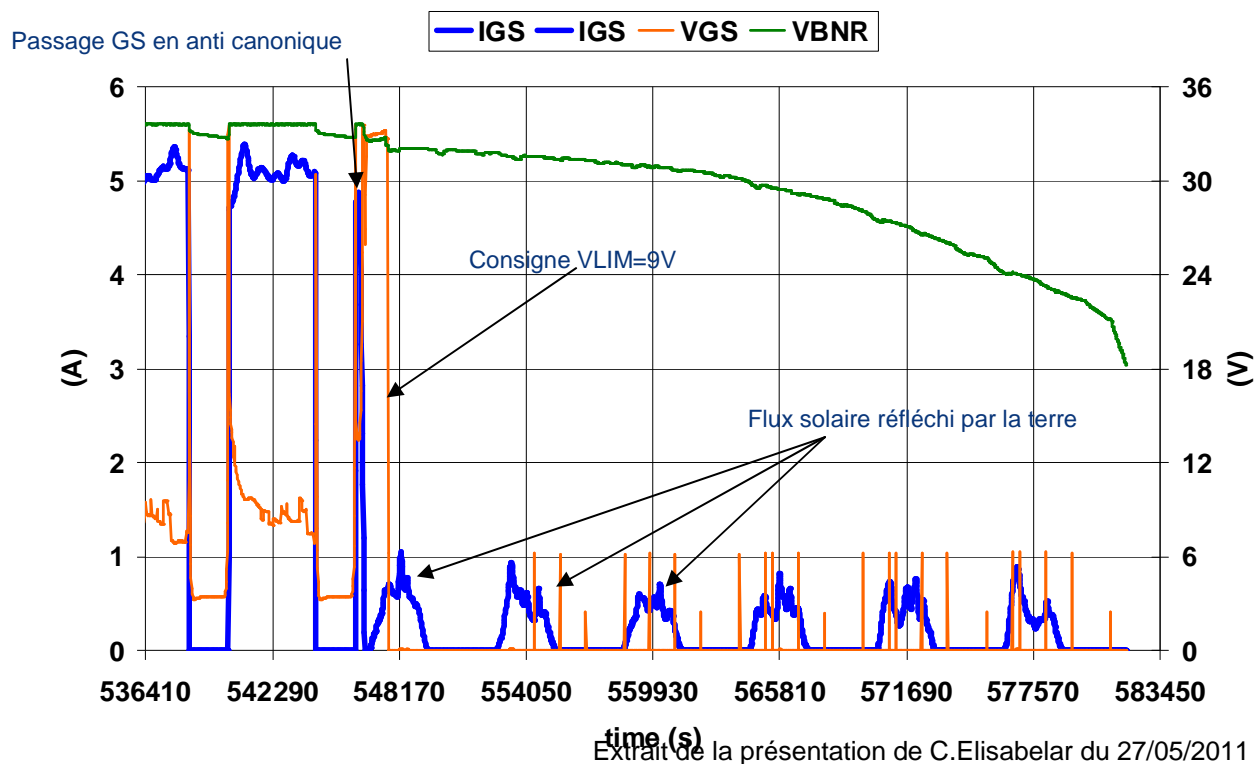
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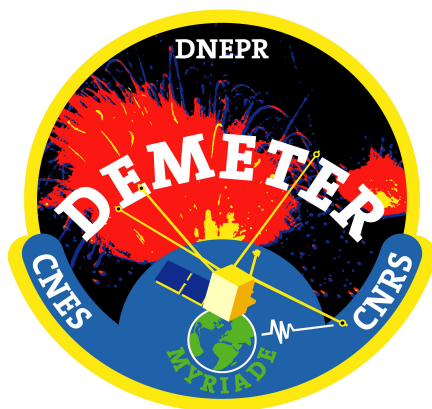
- We have to discharge the battery :
 - ♦ the solar panel is pointed with its back towards the sun.

- We have to minimise probability of satellite reboot because if enough power is supplied by the solar array it may restart.
 - ♦ a new flight software which “does nothing” was uploaded and activated at the end of the electrical passivation day.

The electrical passivation operations was processed on March 17th 2011
DEMETER satellite went out by the end of the day.



- **Satellite behaviour was excellent until the end.
No anomalies occurred during disposal operations.**



- **DEMETER disposal demonstrated the feasibility of a complete diaphragm tank depletion.**

- **This disposal will permit to achieve complete depletion for other satellites carrying such a tank.**

For CNES, it concerns the MYRIADE or PROTEUS families.

- Demeter was a scientific mission very pleasant to operate.
- More than 6,5 years in orbit without any major payload anomaly.



- Thank you for continuing to make live our work through your research works.
- Thank you for your attention.