



CENTRE NATIONAL D'ÉTUDES SPATIALES

2008 SPACE DEBRIS ACTIVITIES IN FRANCE

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Centre National d' Etudes Spatiales

CONTENT

- **Responsibility of France as Launching State**
 - ◆ **French objects in space: situation**

- **Space debris activities mainly focused on risk prevention**
 - ◆ **Collision risk monitoring**
 - ◆ **Controlled reentries**
 - ◆ **End of life operations**

REGISTERED FRENCH SPACE OBJECTS

■ Situation in January 2009:

| | |
|-------------------------------------|------------|
| ◆ Active satellites in LEO: | 15 |
| ◆ Defunct satellites in LEO: | 20 |
| ◆ Active satellites in GEO: | 25 |
| ◆ Defunct satellites in GEO region: | 18 |
| ◆ Upper stages and elements: | 154 |
| total | 232 |

REGISTERED FRENCH SPACE OBJECTS Launches in 2008

- **9 March: ATV-1 Jules Verne (Ariane 5 ES Kourou)**
 - ◆ Ariane 5 upper stage (controlled reentry)
- **18 April: Star One C2 and Vinasat 1 (Ariane 5 ECA Kourou)**
 - ◆ Ariane 5 upper stage + Sylda
- **12 June: Skynet 5C and Turksat 3A (Ariane 5 ECA Kourou)**
 - ◆ Ariane 5 upper stage + Sylda
- **20 June: Jason 2 (Delta 2 Vandenberg)**
- **7 July: Protostar 1 and Badr 6 (Ariane 5 ECA Kourou)**
 - ◆ Ariane 5 upper stage + Sylda
- **14 August: Superbird 7 and AMC21 (Ariane 5 ECA Kourou)**
 - ◆ Ariane 5 upper stage + Sylda
- **20 December: Hotbird 9 and W2M (Ariane 5 ECA Kourou)**
 - ◆ Hotbird 9 and W2M (Eutelsat)
 - ◆ Ariane 5 upper stage + Sylda

REGISTERED FRENCH SPACE OBJECTS Reentries in 2008

- **13 January: Ariane 4 2P upper stage (launched 10 June 1995)**
- **10 March: Ariane 5 EPS (ATV launch on 9 March): controlled reentry**
- **21 July: Sylda Ariane 5 (launched 13 October 2006)**
- **2 August: Ariane 3 upper stage (launched 8 September 1988)**

- **29 September: ATV-1 Jules Verne controlled reentry (launched 9 March 2008, registered by ESA)**

COLLISION RISK MONITORING IN LEO

Operational Procedure : a 5-stage process

Stage 1 : automated screening



Stage 2 : manual risk assessment



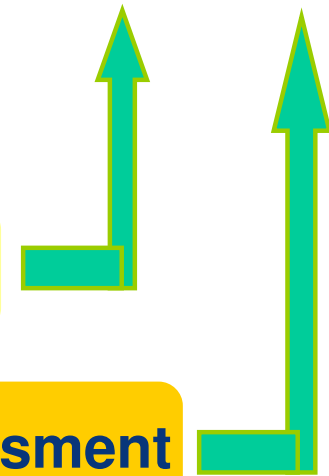
Stage 3 : dangerous risks fine assessment



Stage 4 : conjunction mitigation



Stage 5 : formal end of mitigation



COLLISION RISK MONITORING

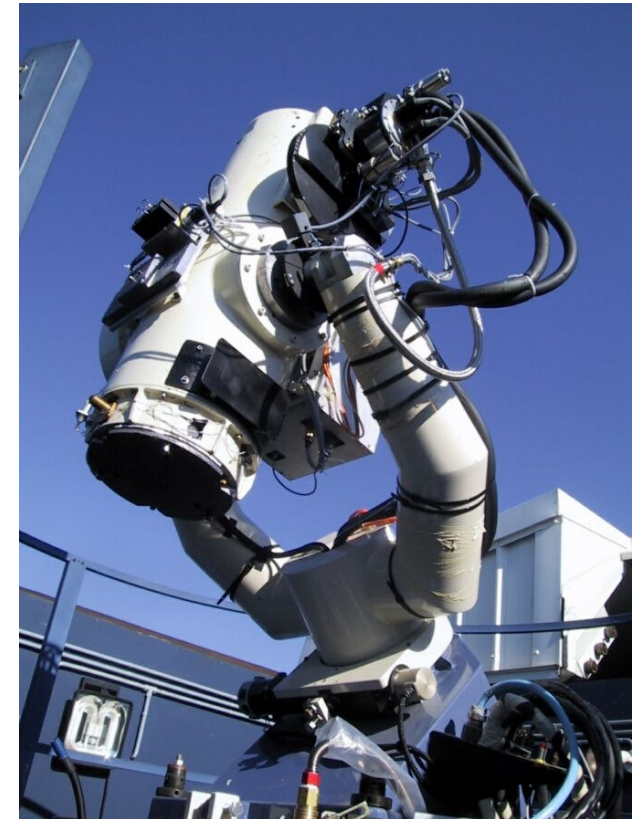
- **Operational monitoring of 17 satellites by CNES:**
 - ◆ Low Earth Orbit: Spot 2, Spot 4, Spot 5, Helios 1A, Helios 2A, Demeter, Parasol, Calipso, Corot, Jason 1, Jason 2, Essaim W23, Essaim E24, Essaim W11, Essaim E12
 - ◆ Geostationary orbit: Telecom 2C, Telecom 2D
- **Main results 2008:**
 - ◆ 344 close approaches identified
 - ◆ 16 tracking requests: FGAN, DGA radars, telescopes
 - ◆ 4 avoidance manoeuvres
- **Foreseen improvements:**
 - ◆ Estimation of orbit parameters accuracy
 - ◆ More accurate collision probability computation

ATV COLLISION RISK MONITORING

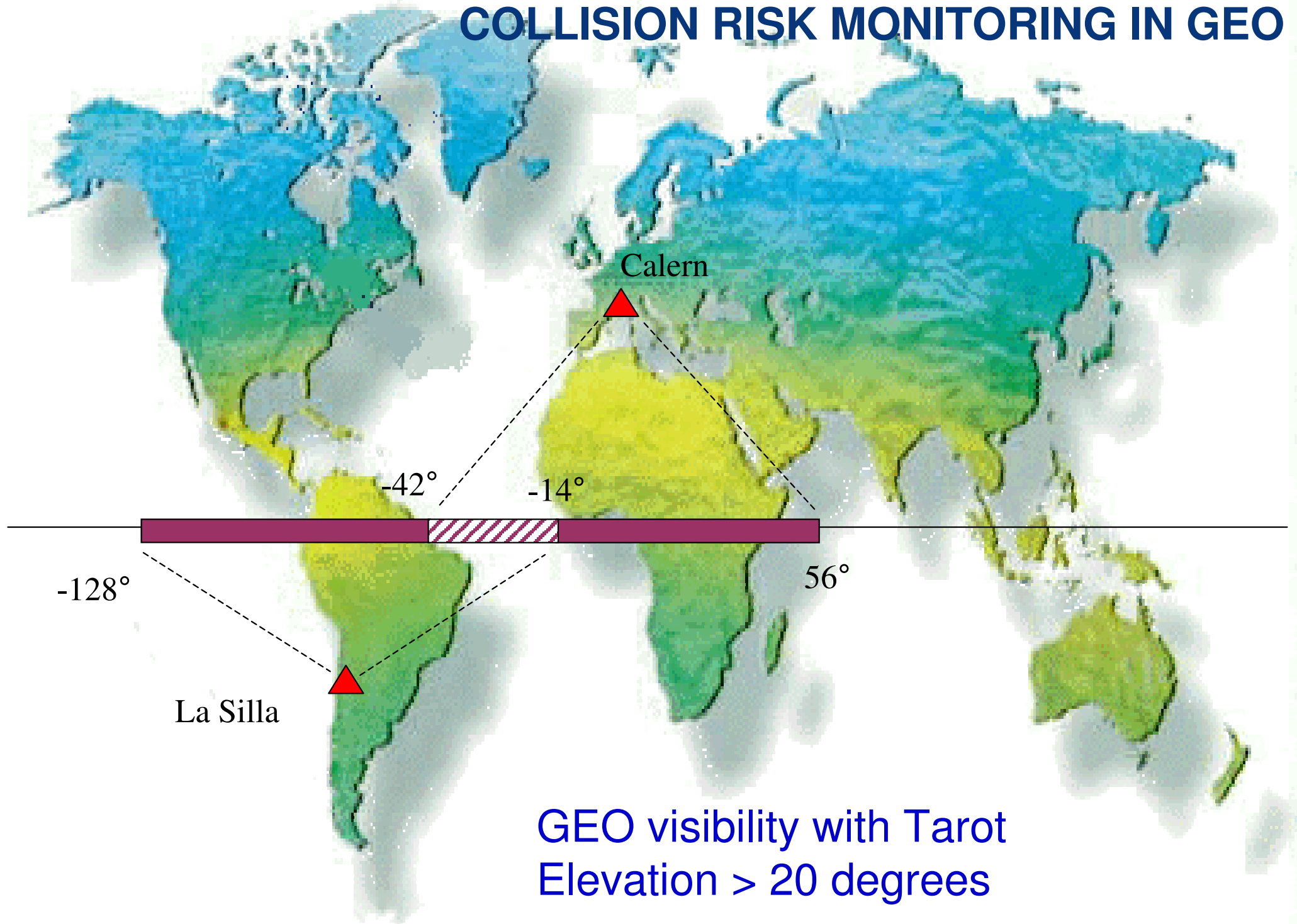
- **ESA project, Control Centre in CNES-Toulouse**
- **Collision risk estimation before and after each manoeuvre over a 36-hour period**
- **Parallel evaluation by NASA and CNES**
- **Large number of alerts due to recent fragmentation events**
- **No avoidance manoeuvre**
- **2 foreseen transfer manoeuvres modified to reduce the risk**

COLLISION RISK MONITORING IN GEO

- **Experimental process: feasibility to be demonstrated**
- **Detection, tracking and orbit determination capabilities necessary**
- **Development of the Tarot system: 2 telescopes (France and Chile)**
- **Demonstration of 2 functions:**
 - ◆ **Capability to automatically detect, track and estimate orbit**
 - ◆ **Basic principles for catalog maintenance established and tested**
- **Way forward:**
 - ◆ **Global control loop including these 2 functions to be developed**



COLLISION RISK MONITORING IN GEO

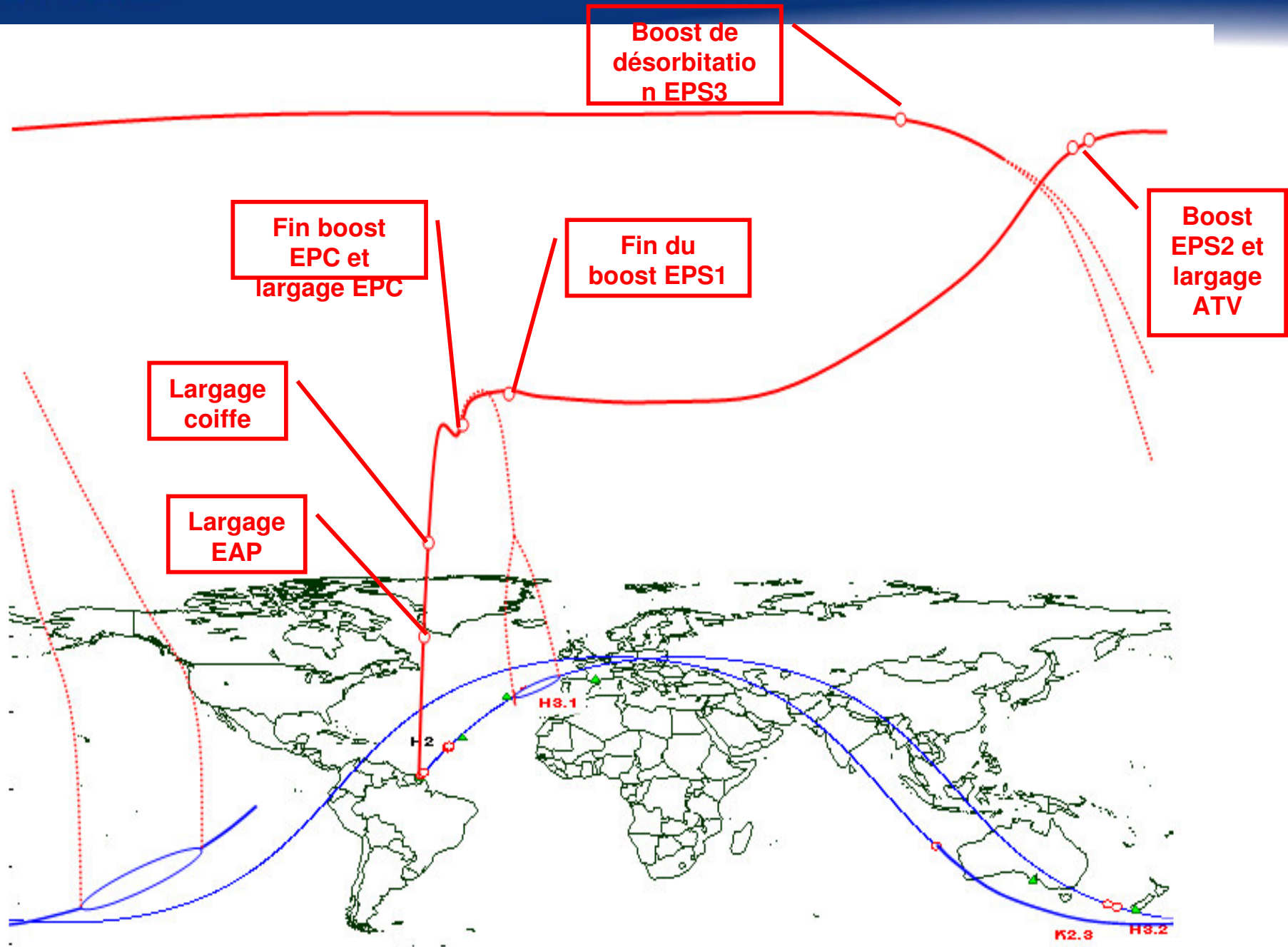


ARIANE 5 EPS DEORBITING ATV mission

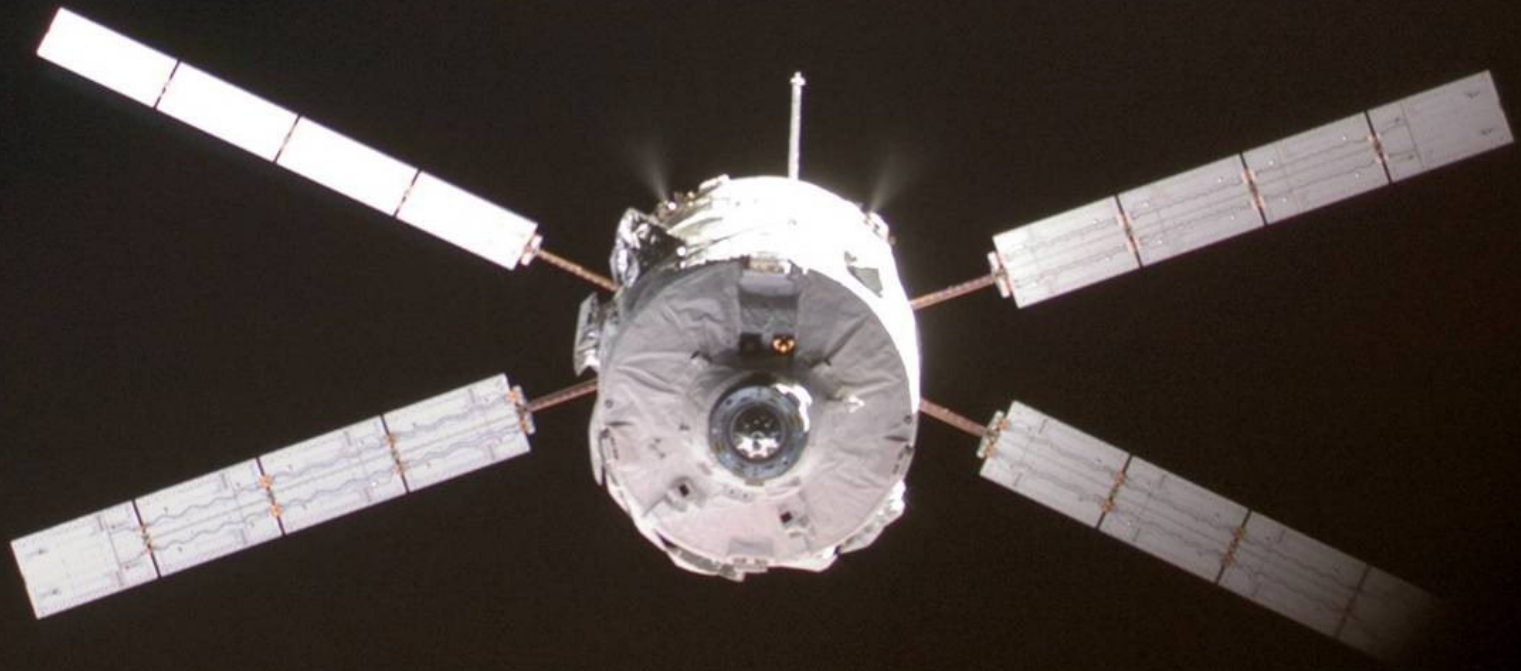
- **EPS (Etage à Propergols Stockables) = upper stage of Ariane 5**
- **After ATV injection, the EPS is left on an orbit:**
 - ◆ Flying over densely populated areas
 - ◆ Having an orbital lifetime of a few months
- **Random reentry not acceptable**
- **A ballistic phase has been added to the flight sequence, followed by a 15s deorbiting burn**
- **Controlled reentry in the South pacific**



Ariane 5 ES/ATV



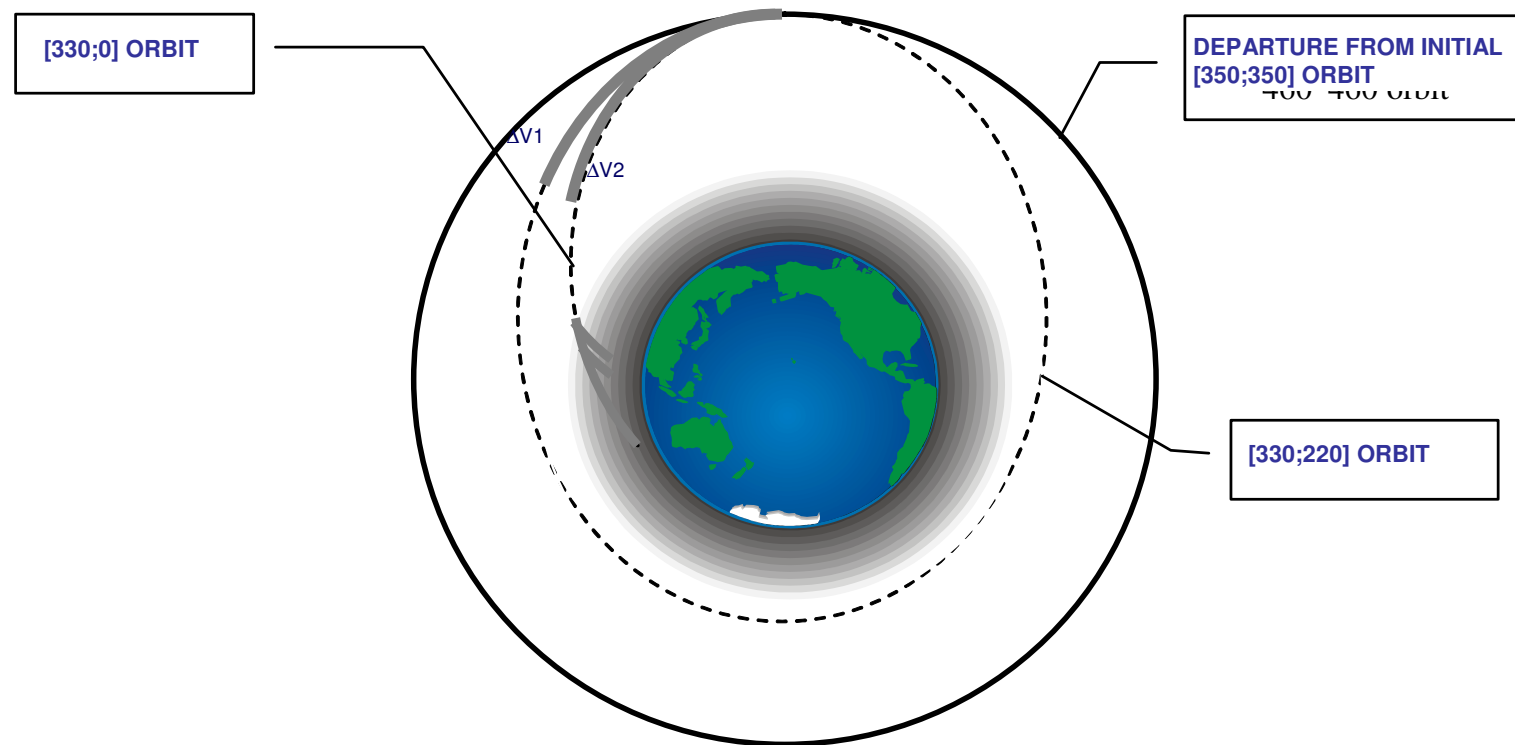
ATV CONTROLLED REENTRY



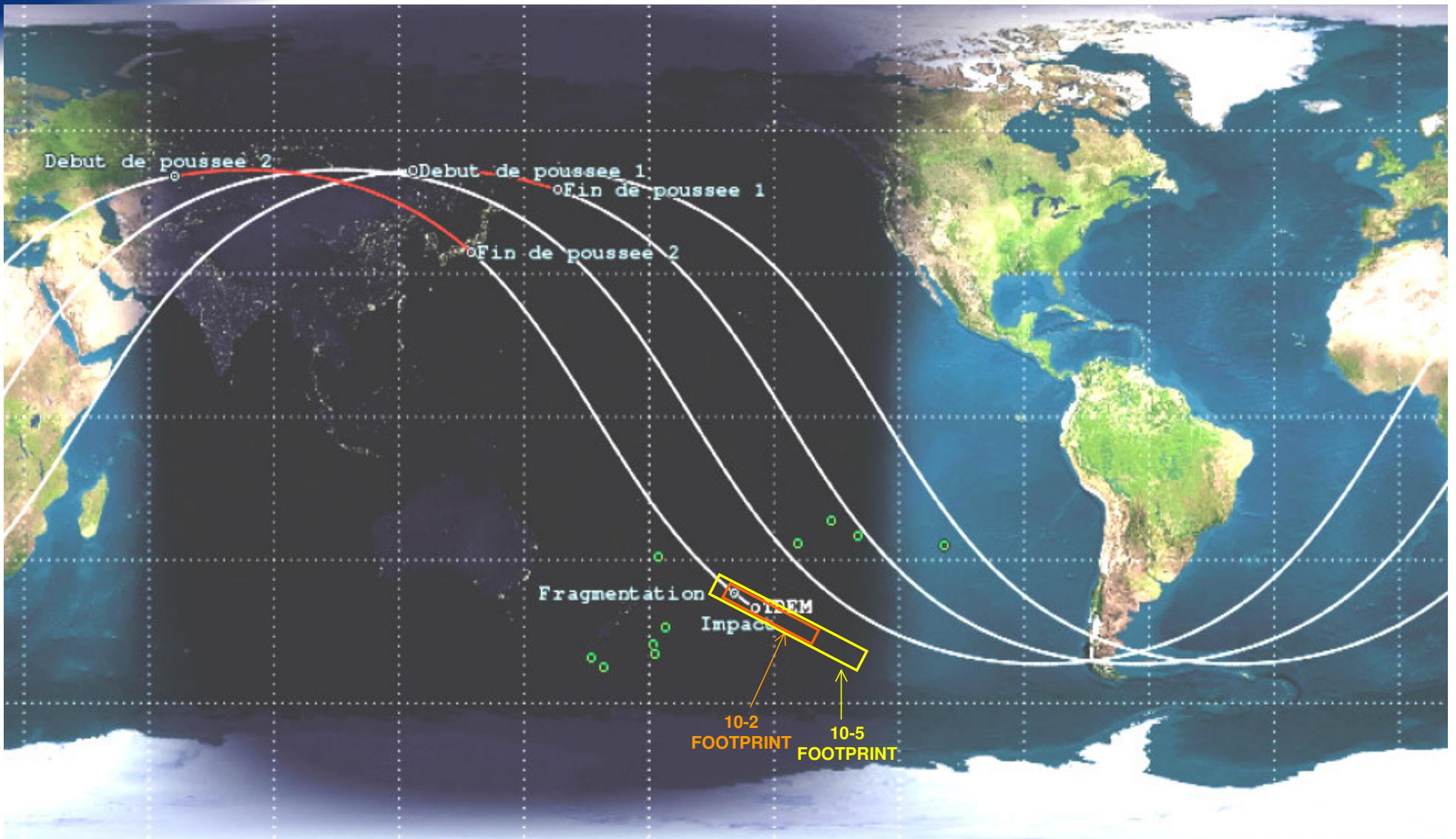
- Automated Transfer Vehicle (ESA programme)
- Launched from Kourou on 9 March 2008 by Ariane 5 ES
- Control centre located in CNES-Toulouse
- Orbit raising, phasing, rendezvous and docking with the ISS in March 2008
- Monitoring during the docked phase

ATV CONTROLLED REENTRY

- De-docking and 2 de-orbiting manoeuvres
- Successful controlled reentry in the South Pacific 29 September 2008



ATV CONTROLLED REENTRY



END OF LIFE OPERATIONS

■ Already performed:

- ◆ LEO: Spot 1
- ◆ GEO: Telecom 1A and C, TDF 1 and 2, Telecom 2A and B

■ Experience gained shows that:

- ◆ Margins on remaining fuel estimation shall be consistent with the accuracy and the probability of success
- ◆ Dedicated control modes are necessary
- ◆ The manoeuvre strategy shall be carefully prepared, considering off-nominal situations
- ◆ The passivation process is complex and may induce important orbit perturbations

■ Preparation of end of life operations: Spot 2 and Telecom 2C

SUMMARY

- **232 registered French space objects**
- **40 active satellites**

- **Technical and operational activities focused on risk prevention:**
 - ◆ **On-orbit collisions in LEO and GEO:**
 - Tracking measurements
 - Avoidance manoeuvres
 - ◆ **Controlled re-entries in case of large vehicles**

- **Implementation of UN-COPUOS mitigation guidelines: end of life operations**