CENTRE NATIONAL D'ÉTUDES SPATIALES

RECENT SPACE DEBRIS MITIGATION ACTIVITIES IN FRANCE

F.ALBY

GEO END OF LIFE WORKSHOP

BACKGROUND

- Particularity of the GEO orbit: unique resource
- Need to protect and to keep available orbital positions
- Mitigation measures are necessary
- Rules are being prepared by agencies
- End of life operations already performed by some operators

→ dialog between operators and agencies necessary
→ workshop organized by CNES

OBJECTIVES OF THE WORKSHOP

- **Objective 1: To inform operators on regulatory issues under preparation:**
  - **to convince,**
  - **to support, encourage their implementation**
  - **to be prepared to future evolution**
- **Objective 2: to get feed-back from operators having performed end of life operations**
  - **to highlight implementation difficulties**
  - **to update the rules when necessary**

GEO END OF LIFE WORKSHOP

- **Workshop took place on January 27, 2010 at CNES's Headquarters in Paris**

- **More than 60 participants represented:**
  - **Administrations: French Ministry of Defence**
  - **European space agencies: BNSC (STFC), CNES, DLR and ESA**
  - **Satellite operators: Eumetsat, Eutelsat, France Telecom, Hispasat, Inmarsat, SES-Astra, Paradigm Services**
  - **Launch operator: Arianespace**
  - **Industry: Thales Alenia Space, EADS Astrium, Astrium Space Transportation, Satel Conseil, Atos Origin**
  - **Insurance companies: Hiscox, AXA, Marsh**
  - **University : Cranfield University, Université de Bretagne**

GEO END OF LIFE WORKSHOP

Objective 1: information of operators and industry

- general overview of the situation in GEO: population, reorbiting practices

- regulatory issues discussed at different levels:
  - Practical implementation of the UK's Outer Space Act: GEO satellites
  - French law on space operations, technical regulations
  - DLR Technical Standards and Implementation Practice
  - Status of ISO standards development
  - IADC guidelines and the GEO disposal orbit: key parameters, future scenarios, and collision risks

GEO END OF LIFE WORKSHOP

Objective 2: feed-back from operators having performed end of life operations

- **Long Term sustainability of space activities**

- **Eutelsat model of the effective cross section of reorbited satellites**
- **Long term evolution of Telecom 2B**
- **Thales Alenia Space experience on propulsion during reorbiting operations**
- **Telecom 2C reorbiting operations**
- **Eurostar end of life operations and strategy**
- **Paradigm End Of Life Operations Experience**
- **Approach for Meteosat-6 re-orbiting**

MAIN CONCLUSIONS

- The rate of successful disposal is slowly increasing:
  - 29% in 1997-2002
  - 57% in 2003-2009
- Legal systems are implemented to reinforce application

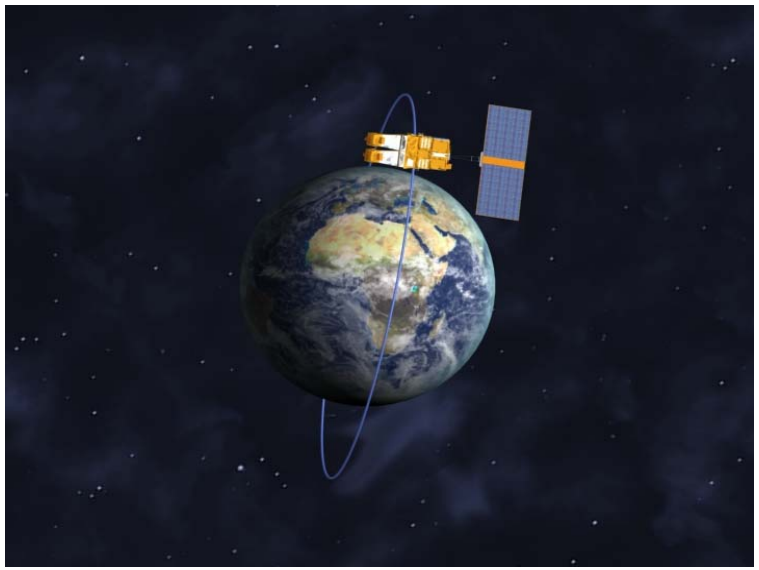
- Accurate estimation of remaining propellant is difficult:
  - Different methods exist with different results and accuracy
  - key issue to decide disposal operations
- Passivation is a complex process:
  - Time limitation due to ground station visibility (drift orbit)
  - Instability of attitude control due to gas bubbles in the propulsion lines
  - Need to keep control until the end for electric passivation and satellite switch-off

SPOT2 END OF LIFE OPERATIONS

- SPOT 2 launched by Ariane 4 on 21 January 1990
- Earth observation satellite
  - Heliosynchroneous orbit:
  - altitude 825 km
  - inclination 98 degrees
- Main characteristics:
  - Mass 1900 kg
  - dimensions: 2 x 2 x 4.5 m
  - Solar panel span 8 m
  - Hydrazine propulsion system
- 3-axis stabilization

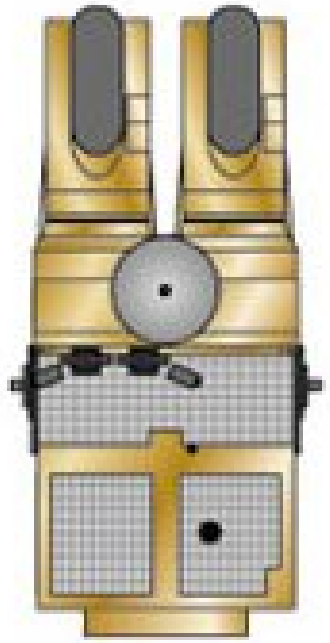
INTRODUCTION

- **Objectives:**
  - **Orbital lifetime lower than 25 years**
  - **Passivation**
- **Experience Spot 1 November 2003**
- **Initial orbit**
  - **Perigee altitude : 813.7 km**
  - **Apogee altitude : 830.8 km**
- **Hydrazin mass before de-orbiting: 60.3 kg**



SPOT2 END OF LIFE OPERATIONS

STRATEGY



- **First phase:**
  - **Spot 2 orbit lowered 15 km below the operational orbit to avoid any collision risk with Spot 4 and 5**
  - **positioning of the apogee above the Toulouse ground station**

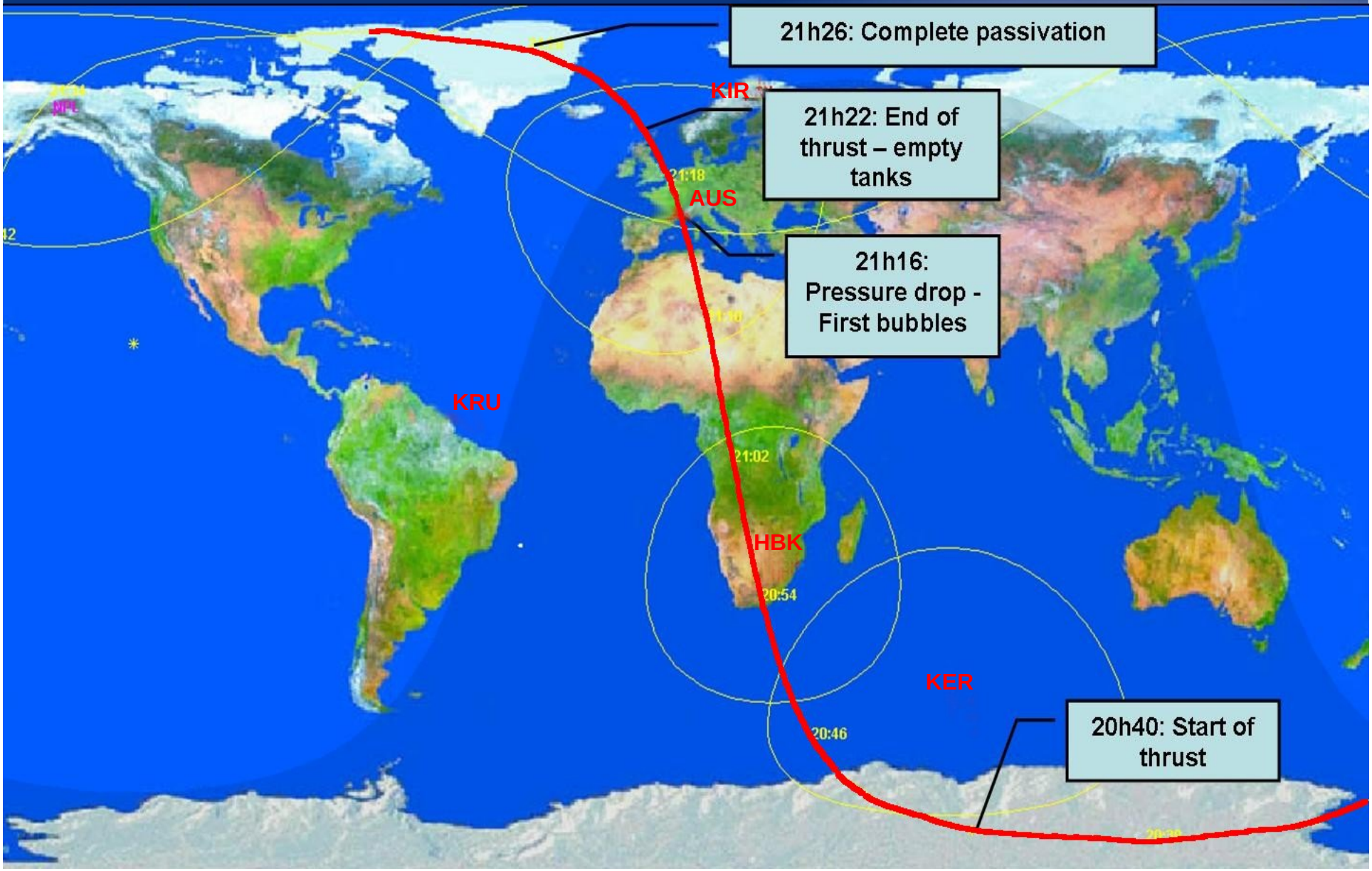
- **Second phase:**

  a series of 8 apogee manœuvres (1000 s each) to decrease the perigee altitude

- **Third phase:**

  large last manoeuvre (2100 s) to decrease the perigee and to empty the tanks, passivation of the satellite

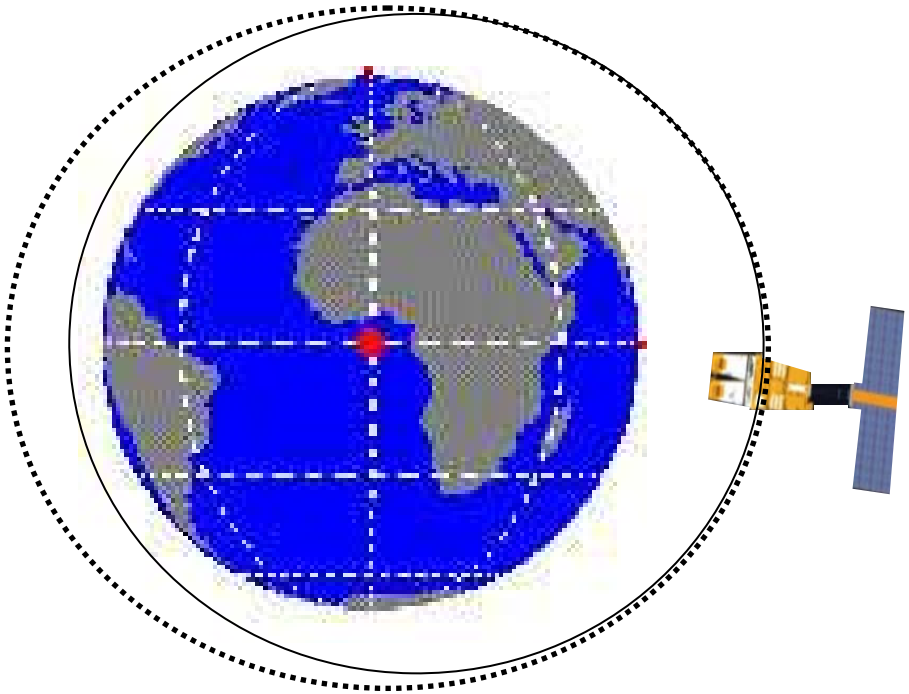
SPOT2 END OF LIFE OPERATIONS



SPOT2 END OF LIFE OPERATIONS

FINAL STATUS

- **Orbit:**
  - **Perigee altitude: 570 km**
  - **Apogee altitude: 796 km**
- **Remaining orbital lifetime:**
  - **Between 23 and 25 years**
- **Telemetry confirmed fuel exhausted**
- **Battery disconnected**
- **Switch-off telemetry emitter**



TELECOM 2C END OF LIFE OPERATIONS

- Launched by Ariane 44L on December 6,1995
- Geostationary orbit at 3 ° East longitude
- Built by EADS Astrium and Thales Alenia Space
- Mass at launch 2275 kg, solar panels span 22 m
- Mission: telecommunications, television
- Operated by CNES on behalf France Telecom

SEQUENCE OF OPERATIONS

- **Phase 0 (18 October 2009):**
  - **beginning of operations,**
  - **satellite upside down to optimize thrust efficiency**

- **Phase 1: exit from the GEO operational corridor:**
  - **1 apogee and 1 perigee manoeuvre to get out the GEO operational zone without crossing windows of neighbours**
  - **→circular orbit 70 km above GEO**

- **Phase 2: orbit raising**
  - **sequence of apogee and perigee manoeuvres to progressively raise the altitude,**
  - **IADC altitude obtained after 9 manoeuvres**

SEQUENCE OF OPERATIONS

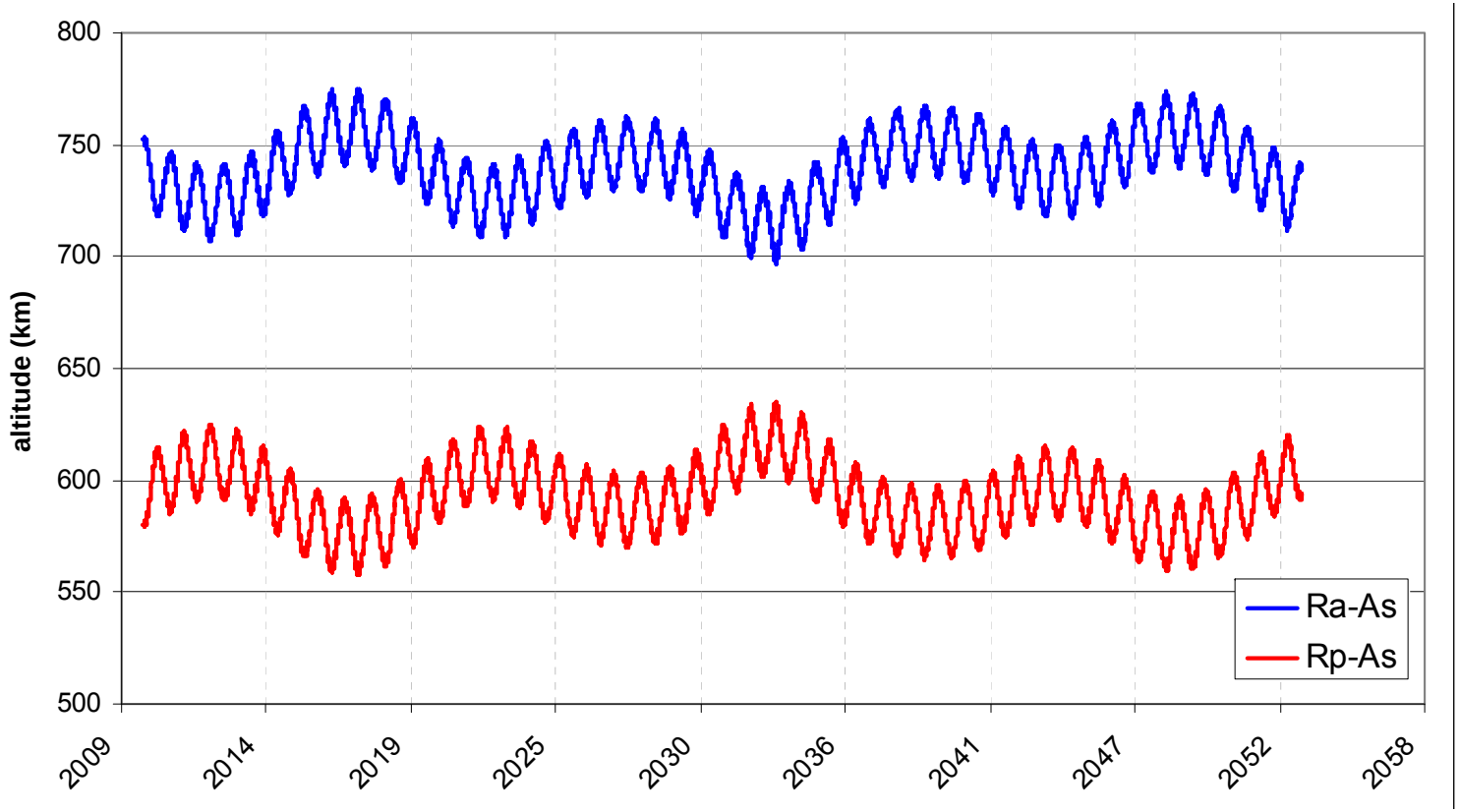
- **Phase 3: management of the tanks**
  - 8 additional manoeuvres
  - Use of one pair of tanks until bubble detection
  - Switch on the other pair of tanks when bubble detection
- **Phase 4: passivation:**
  - Sun pointing attitude,
  - use of thrusters to decrease pressure without attitude and altitude loss
- **Phase 5: satellite switch-off**

FINAL STATE

- 17 East manoeuvres performed
- Duration of operations: 14 days (2 days off)
- 11.4 kg propellant mass
- Final orbit: 580 x 750 km above GEO
- Eccentricity 2 10-3
- 4 propellant tanks empty
- Compliance with IADC guidelines

TELECOM 2C END OF LIFE OPERATIONS

Long term simulations of perigee and apogee altitude evolution



non interference with the GEO protected region

SUMMARY

- As space agency CNES
  - Prepares the Technical Regulations associated with French Space Act
  - promotes the application of the guidelines: workshop in Paris with industry and operators
    - Information on regulatory issues given by agencies
    - Feed-back from the operators based on their experience

- As operator of national satellites CNES applies the end of life guidelines:
  - to LEO satellites: SPOT 2 in July 2009 after SPOT 1 in November 2003
  - to GEO satellites: TELECOM 2C in October 2009 after TDF1 and 2, TELECOM 1A and C, TELECOM 2A and B