CENTRE NATIONAL D'ÉTUDES SPATIALES

MAIN SPACE DEBRIS 2006 ACTIVITIES IN FRANCE

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BACKGROUND

UN COPUOS STSC

Mitigation Guidelines

principles

IADC

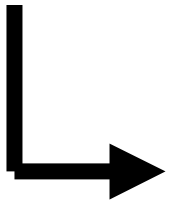
Mitigation Guidelines

technical guidelines

European

Code of Conduct

applicable rules



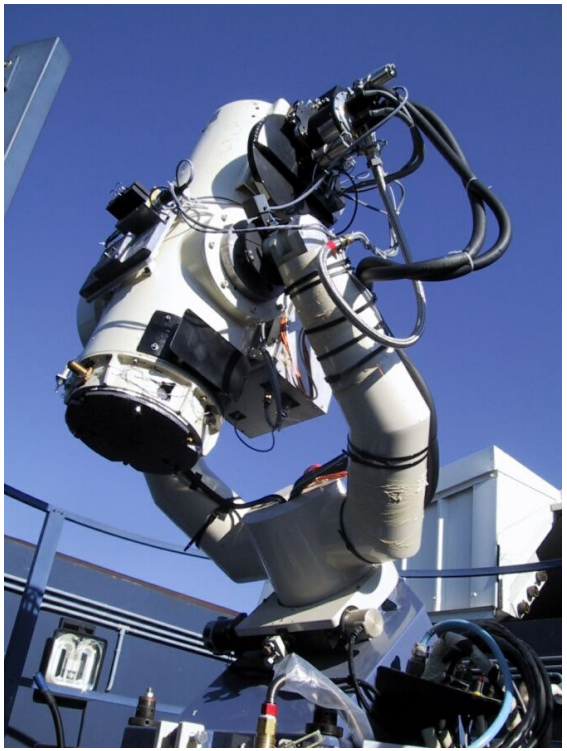
Applicable to new projects
Recommended for objects already in orbit

IMPLICATIONS

- **Activities of the projects to demonstrate compliance**
- **Activities to support the future projects:**
  - Knowledge of the environment: optical observation from ground
  - Research and Technology: search for innovative solutions inflatable devices, behavior of tanks under debris impact
  - Operational activities for on-orbit satellites: collision risk management and atmospheric reentry

OPTICAL OBSERVATIONS OF DEBRIS IN GEO

- System developed several years ago (Tarot)
- On-going improvements of the system:
  - Image processing
  - Accuracy of the datation process
- Operational utilization:
  - Participation to the IADC campaigns
  - Monitoring of close approaches in GEO

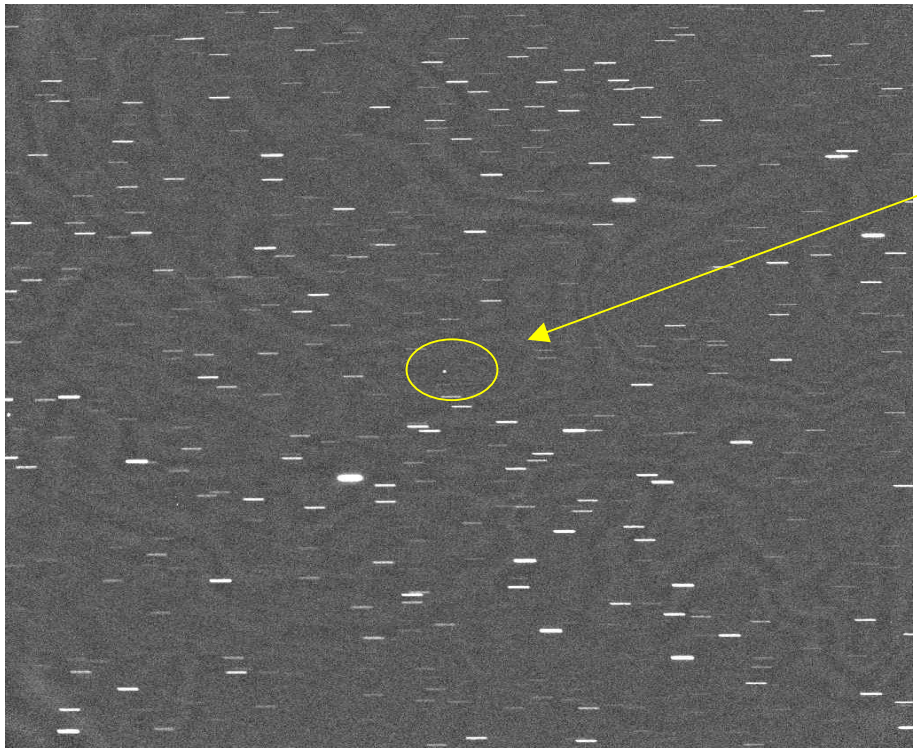


OPTICAL OBSERVATIONS OF DEBRIS IN GEO

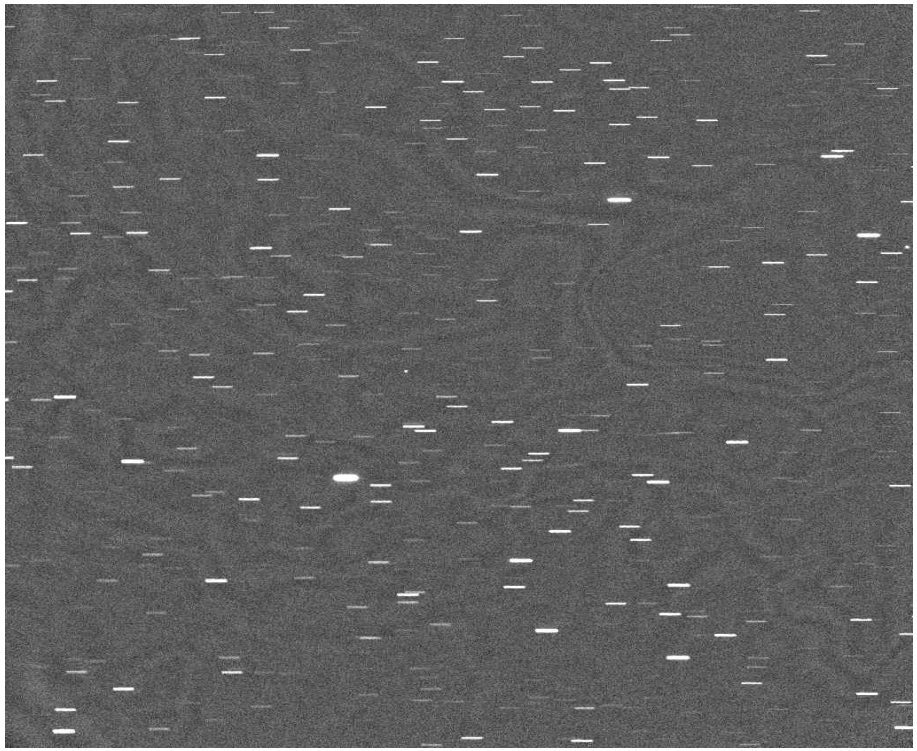
Inmarsat 3F5

- Sequence
  - Epoch : 2006-12-09 18:10
  - Pointing : 25 degrees GEO

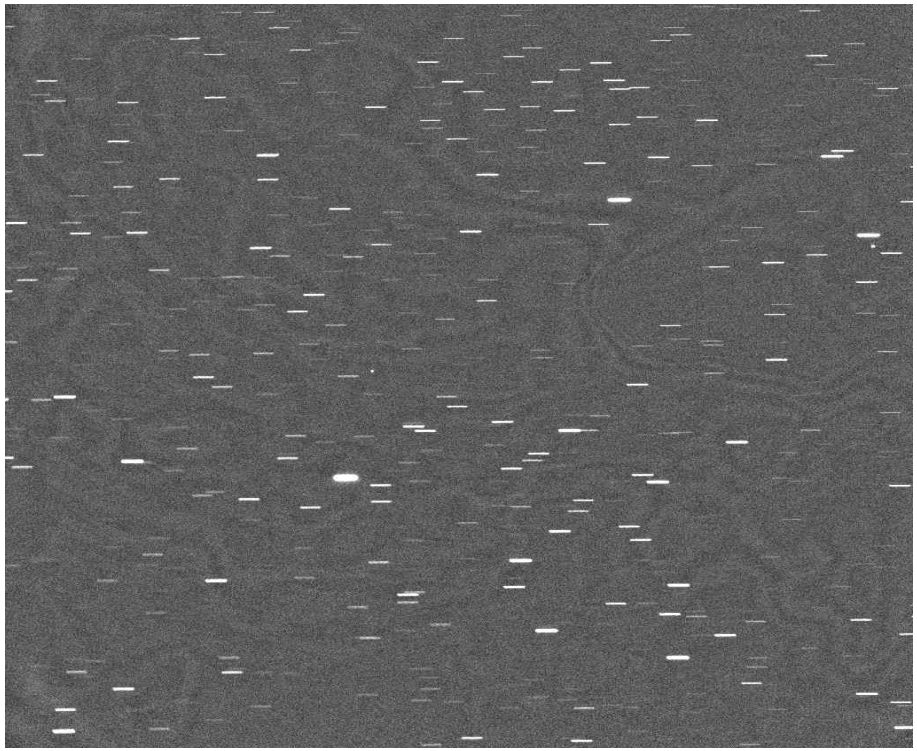
Inmarsat 3F5 : sequence 1



Inmarsat 3F5 : sequence 1



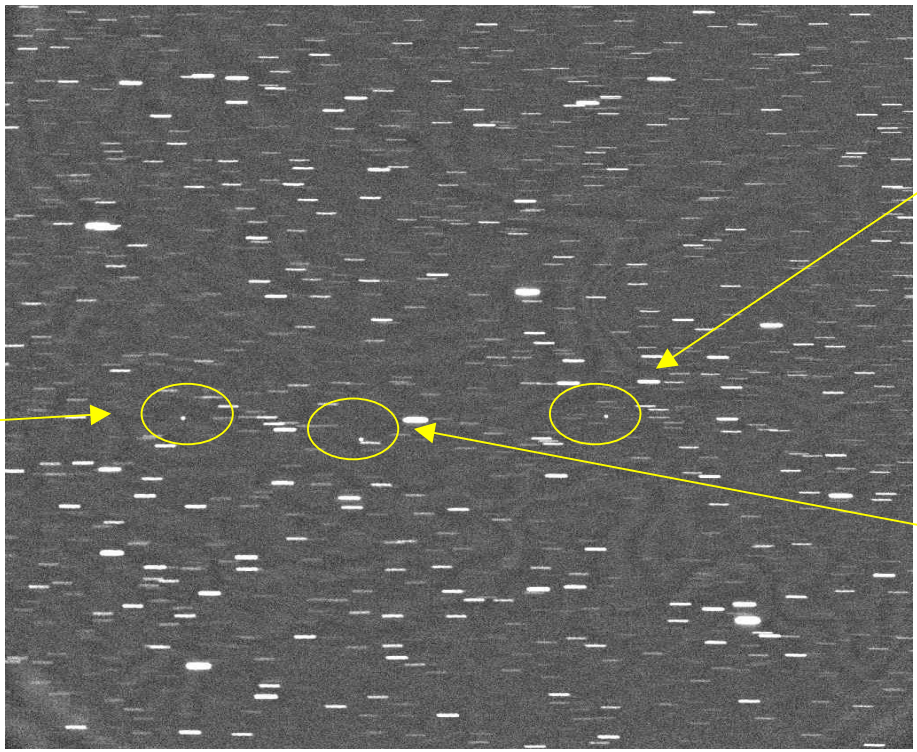
Inmarsat 3F5 : sequence 1



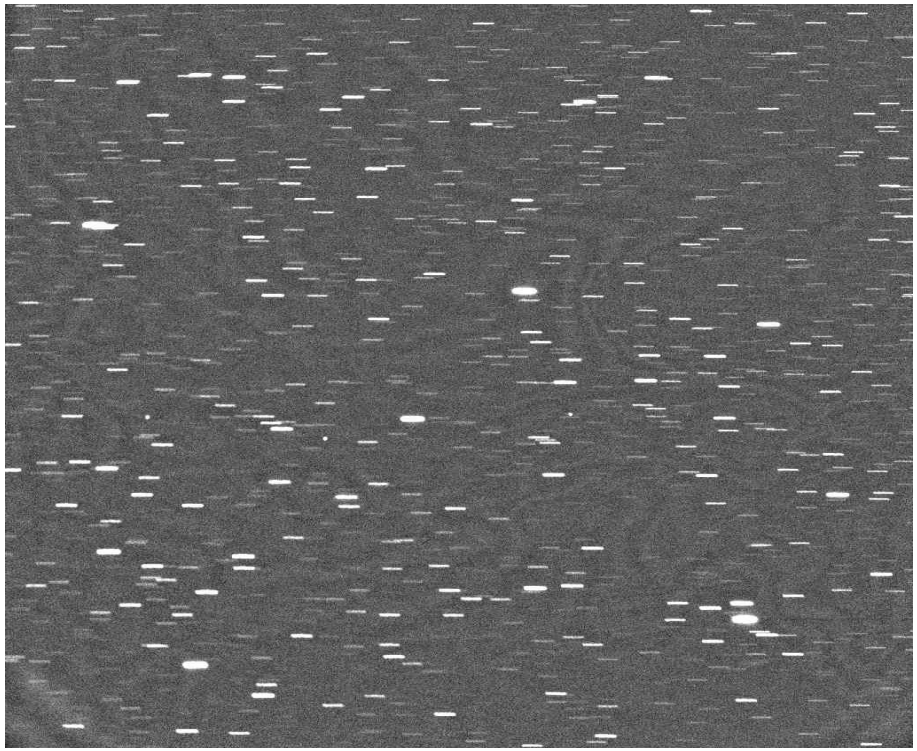
Inmarsat 3F1

- **Sequence**
  - Epoch : 2006-12-09 20:15
  - Pointing : 64 degrees GEO

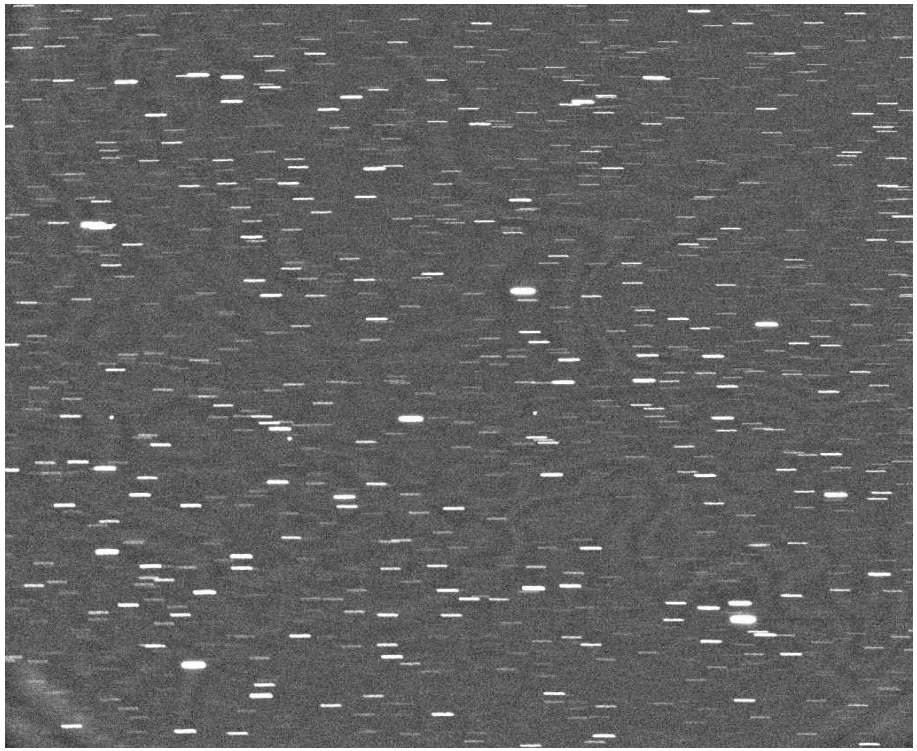
Inmarsat 3F1



Inmarsat 3F1



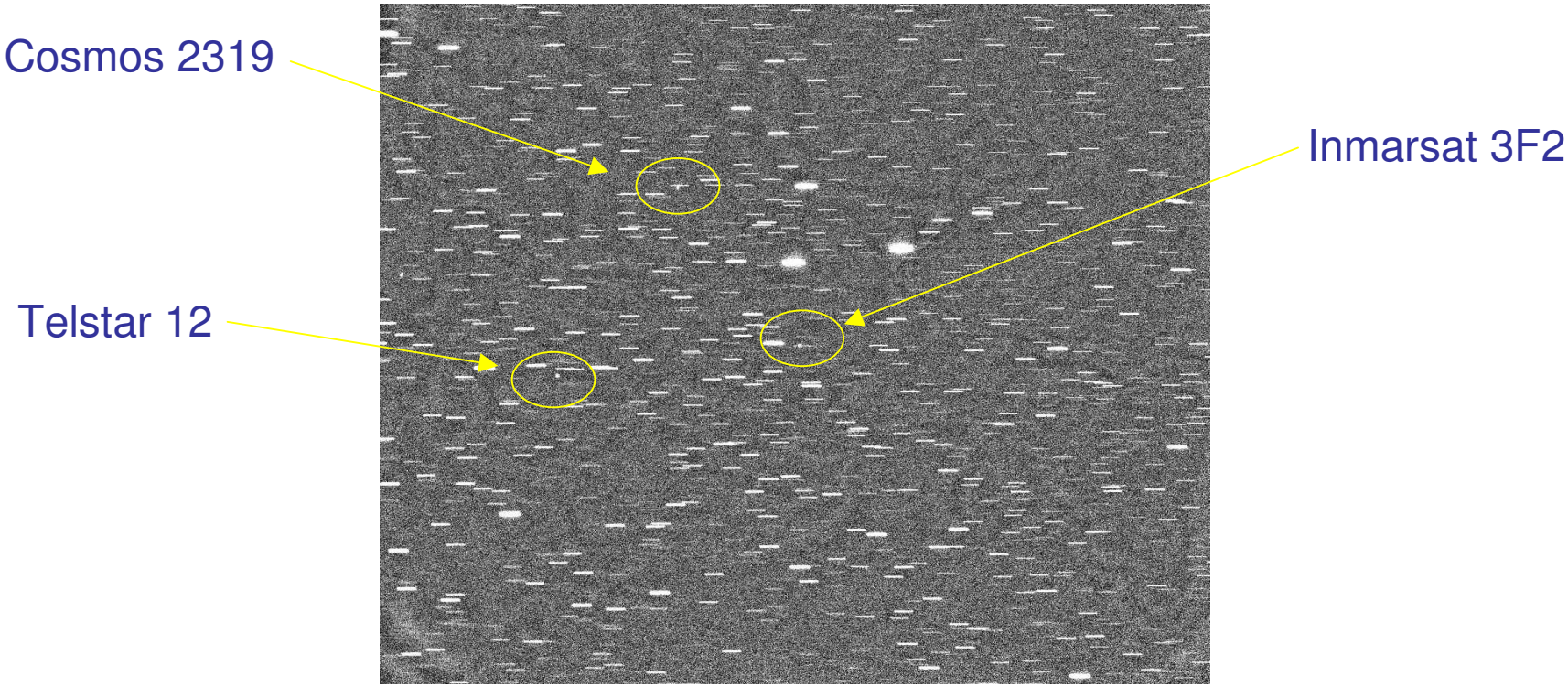
Inmarsat 3F1



Inmarsat 3F2

- **Sequence**
  - Epoch : 2006-12-10 00:20
  - Pointing : -15.5 degrees GEO

Inmarsat 3F2



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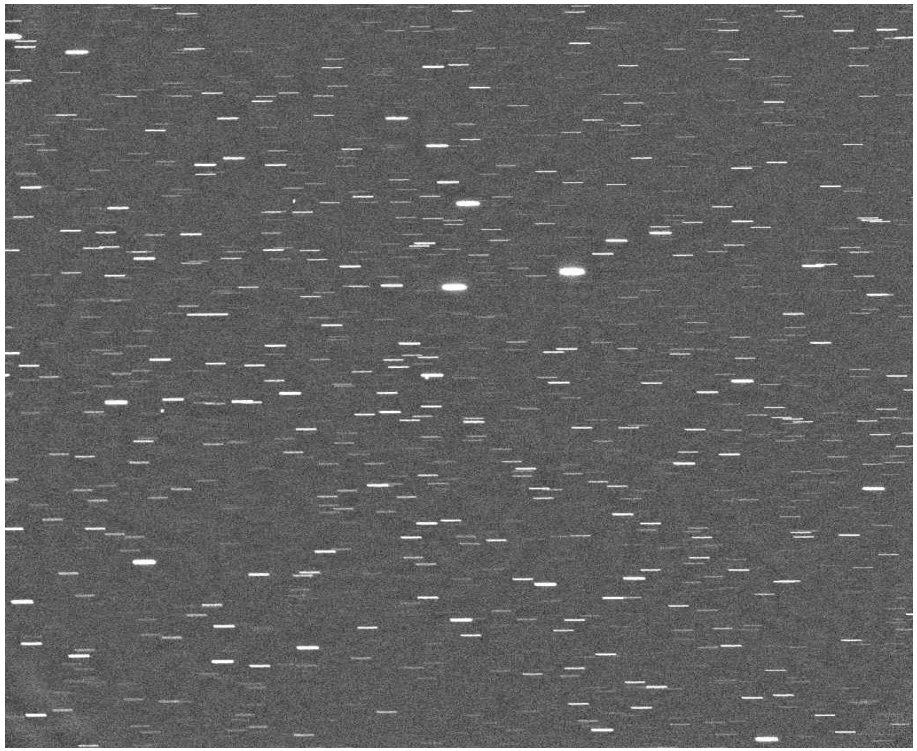
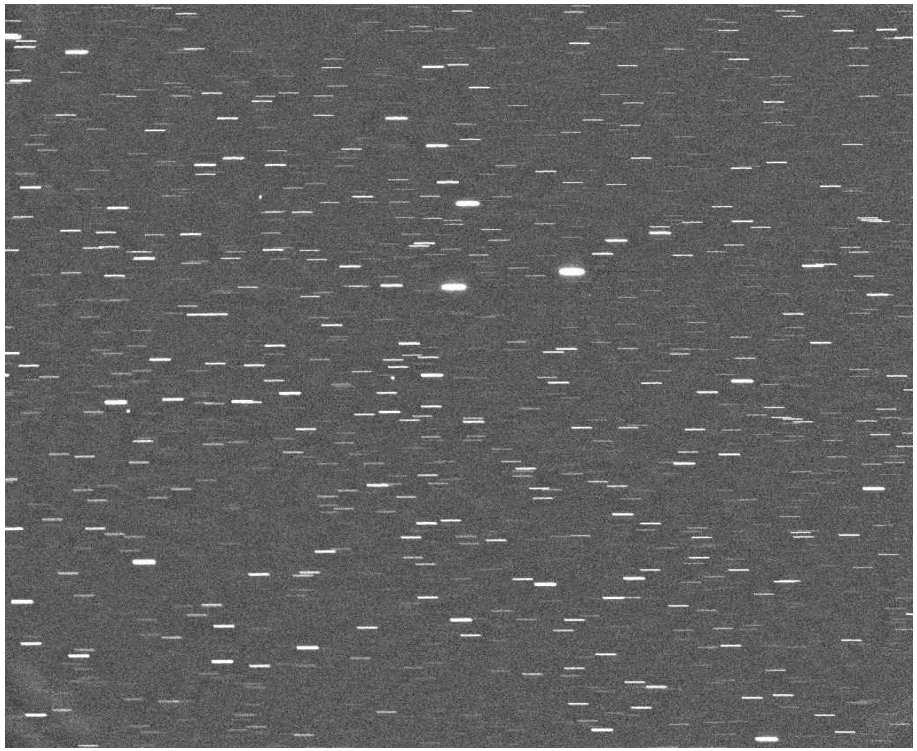


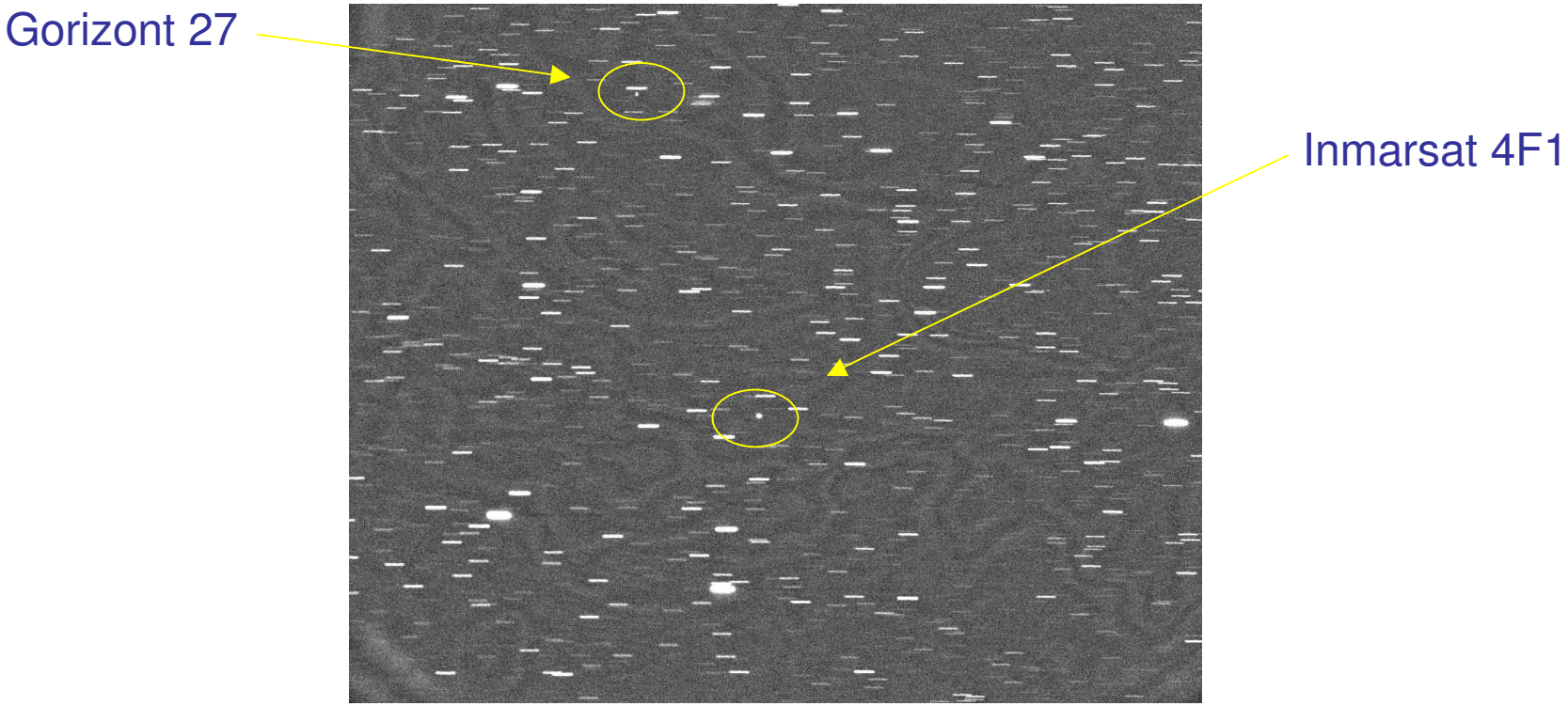
Inmarsat 3F2



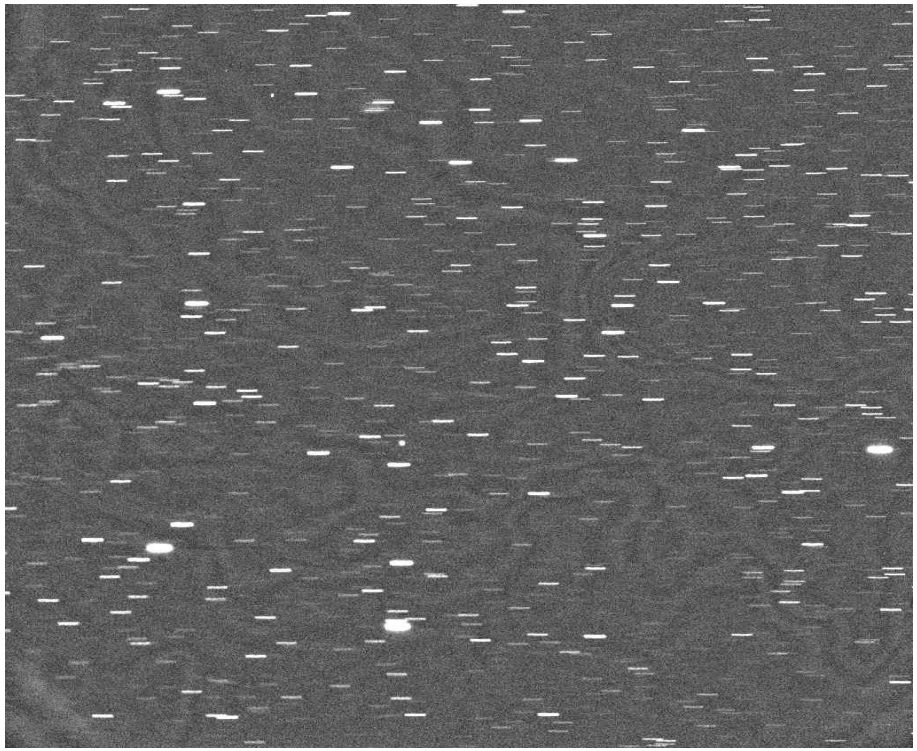
Inmarsat 4F1

- **Sequence**
  - Epoch : 2006-12-09 19:15
  - Pointing : Two line elements (inclination greater than Tarot field of view)

Inmarsat 4F1



Inmarsat 4F1



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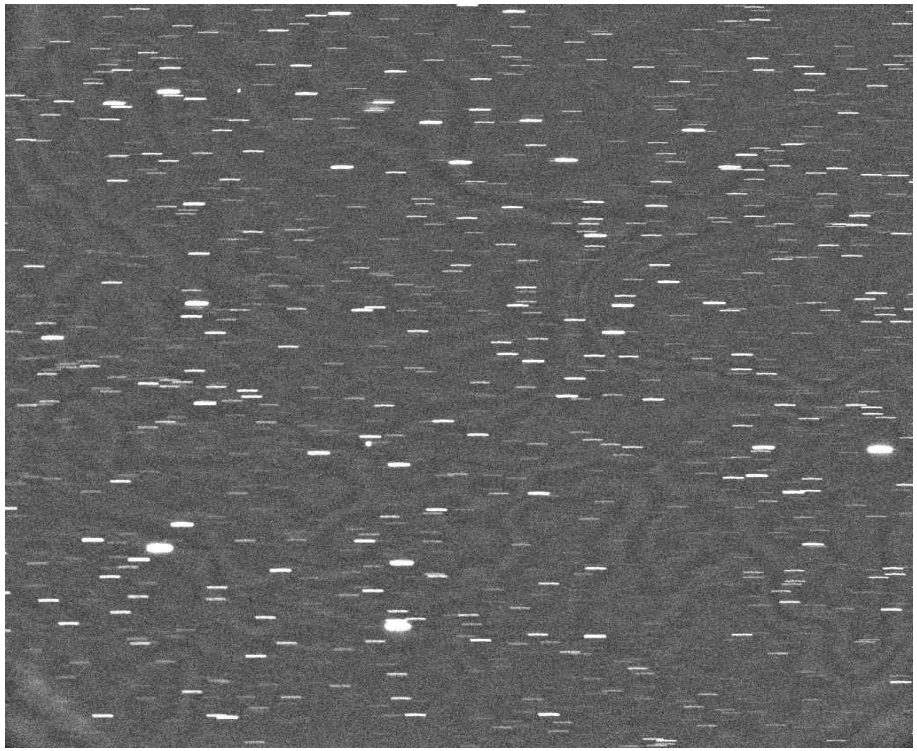
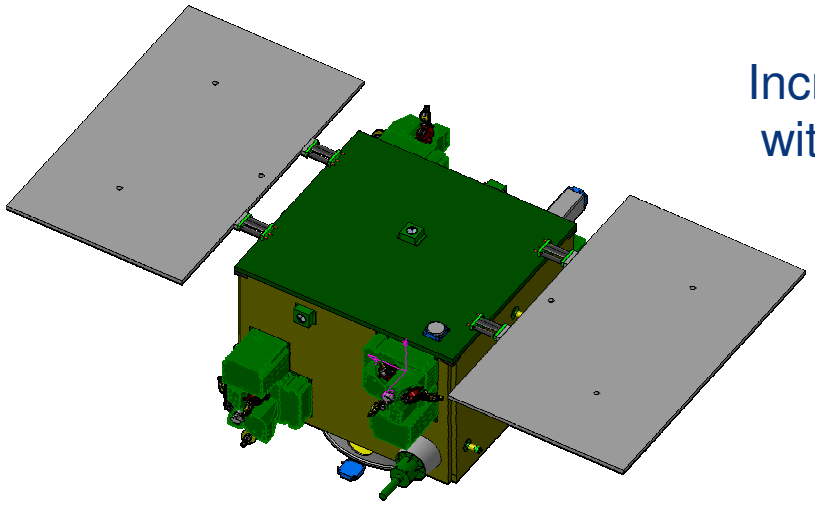


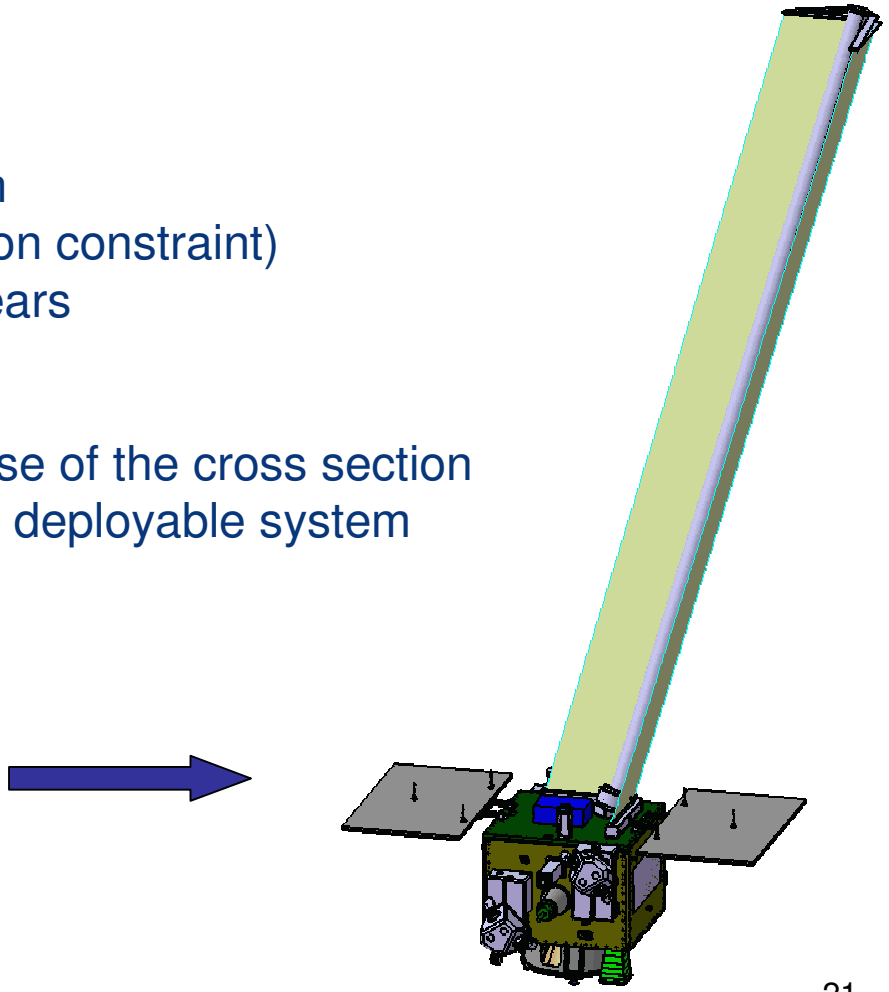
RESEARCH AND TECHNOLOGY
search for innovative solutions

Satellite Microscope:

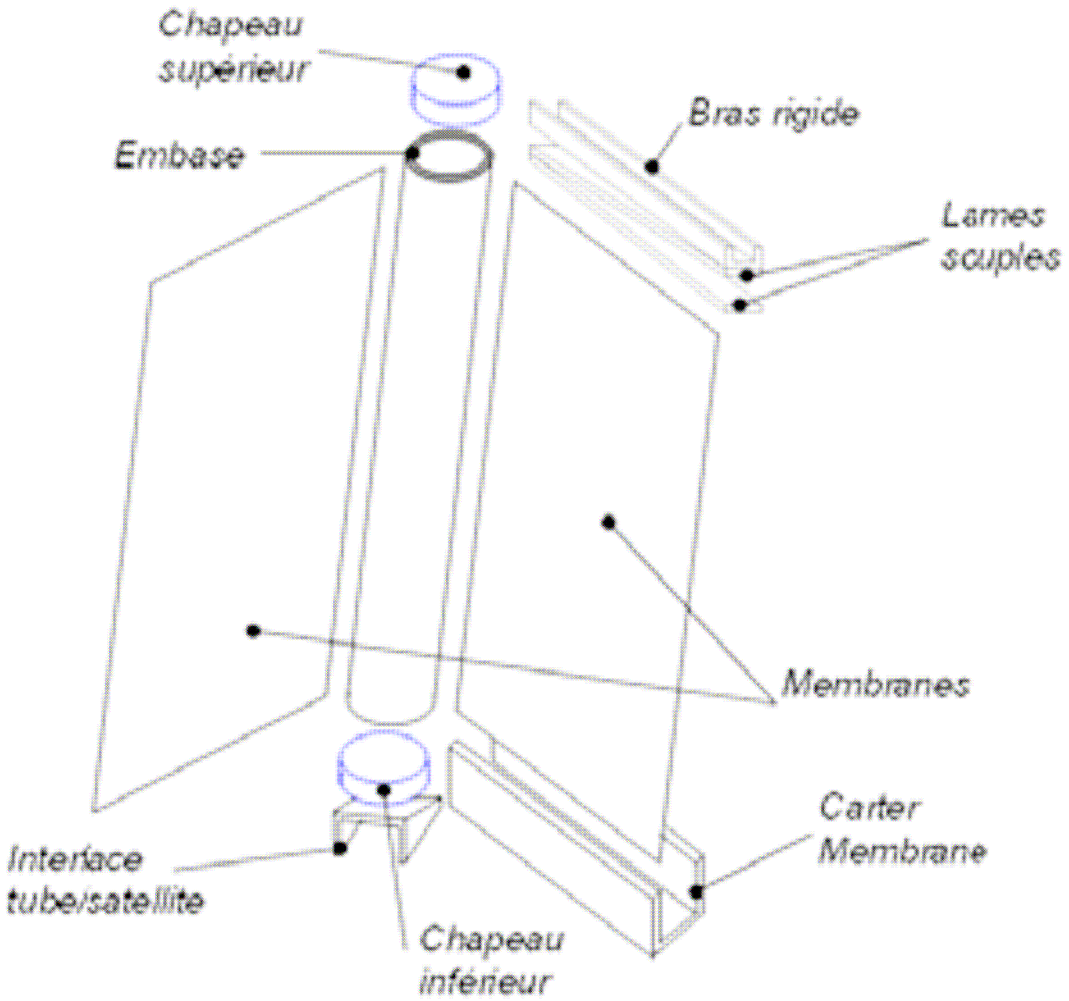
Mass 210 kg
Orbit altitude around 730 km
No propulsion system (mission constraint)
Orbital lifetime close to 60 years

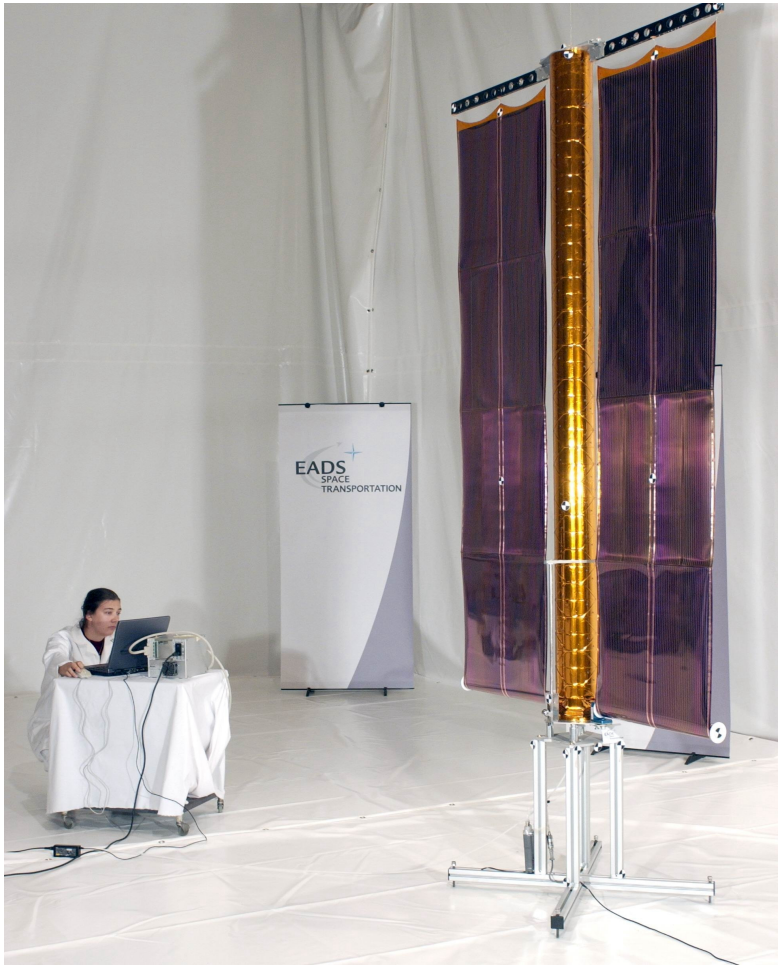


Increase of the cross section
with a deployable system

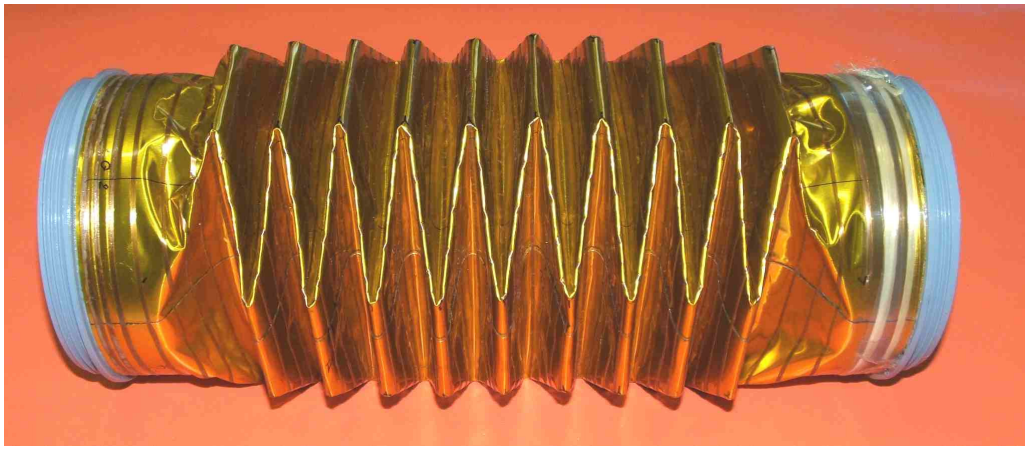


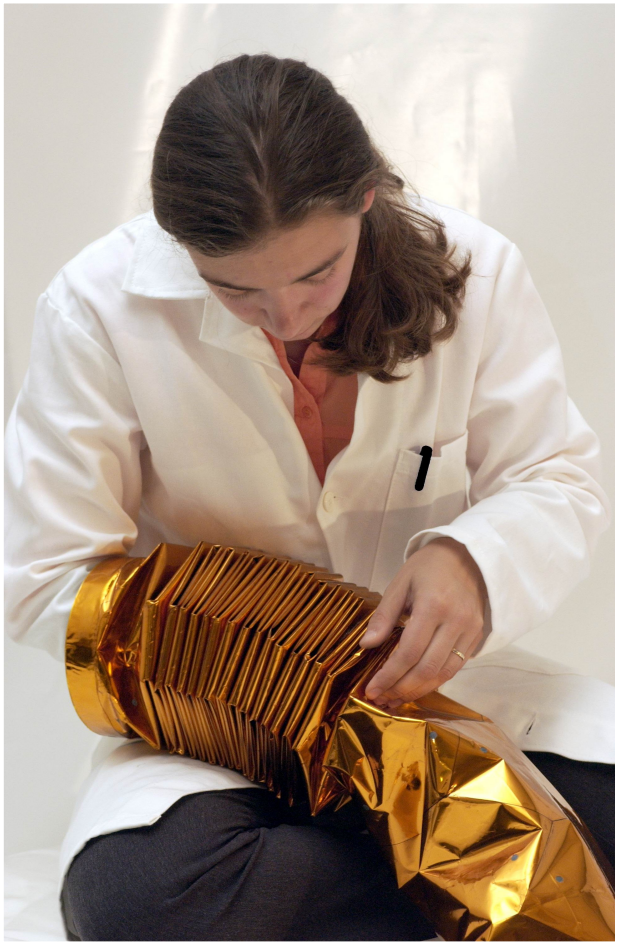
RESEARCH AND TECHNOLOGY
search for innovative solutions



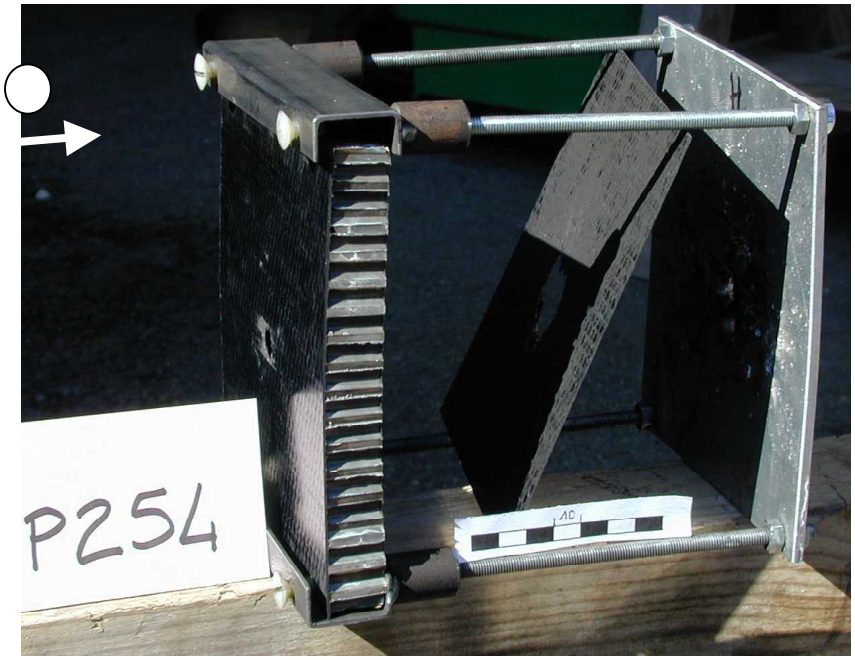


RESEARCH AND TECHNOLOGY
search for innovative solutions

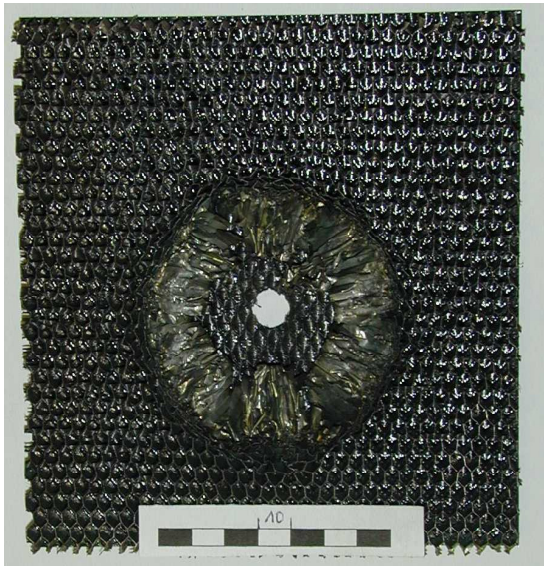




RESEARCH AND TECHNOLOGY
hypervelocity impacts



Test bed

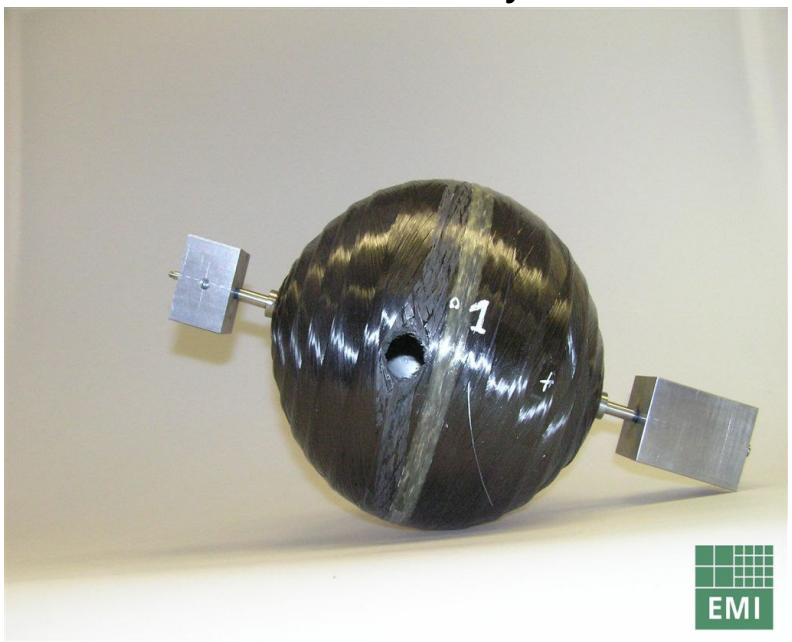


Aluminum honeycomb
(rear)

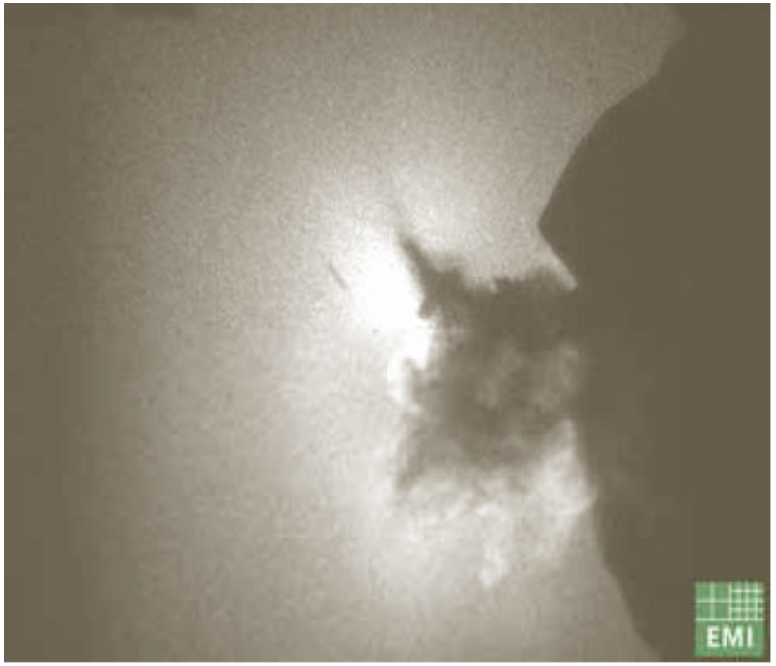
Impact P254 projectile Ø 7 mm, v = 5.6 km/s)

RESEARCH AND TECHNOLOGY
hypervelocity impacts

Test facility



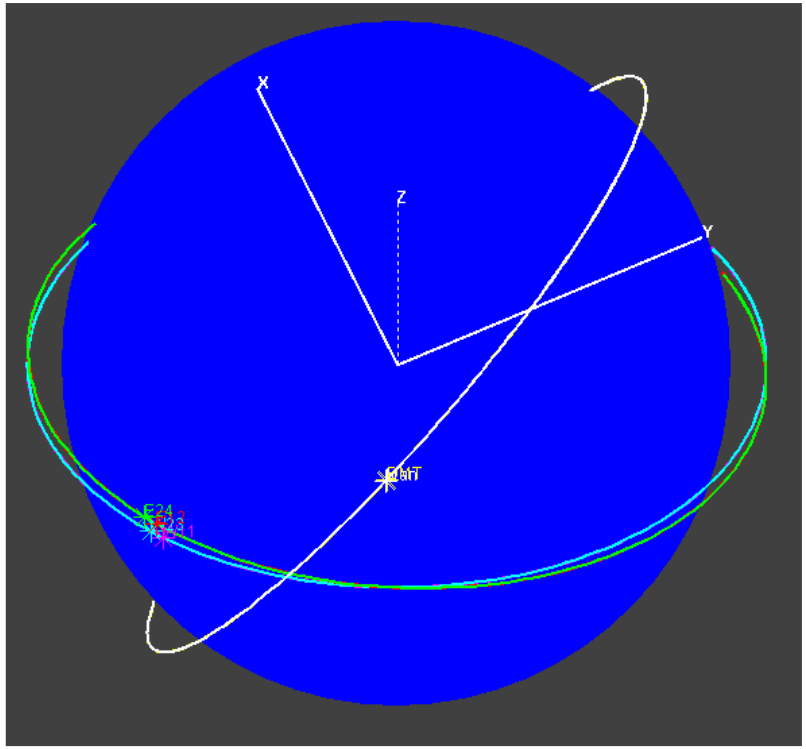
Tank after impact



X-ray photo of the impact

Impact 4833 (Ø 6 mm, v = 6.4 km/s)

OPERATIONAL ACTIVITIES



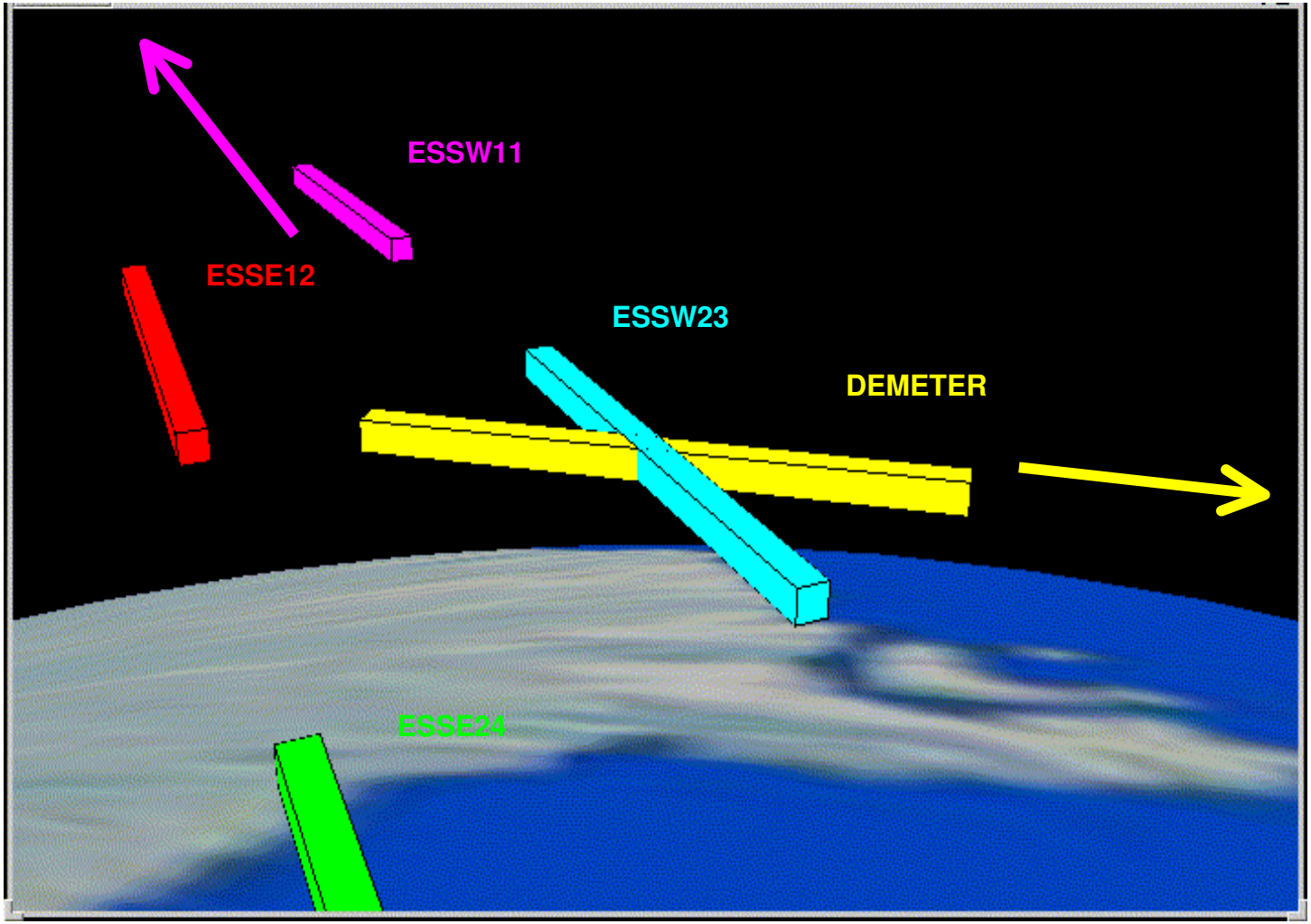
Close encounter between Demeter and the 4 Essaim satellites

Conjunctions occur every 6 months

In June 2006 several close approaches at apogees between DEMETER and W23

On June 25 difference in altitude below 150 m

CLOSE APPROACH DEMETER-ESSAIM



CLOSE APPROACH DEMETER-ESSAIM

Method :

1. **Identification and monitoring of the close approaches :**
   - Numerical computation of minimum distance in the local orbital frames
   - Graphical dynamic display 2D and 3D at the risky apogees
2. **Identification of the orbit determination accuracy :**
   =>statistical determination of a « security volume » around each spacecraft
3. **Definition and approval by the project :**
   - margins
4. **Determination of the avoidance strategy (mission constraints) :**
   - Latest date for the decision af an avoidance manoeuvre
   - Determination and validation of the avoidance manoeuvre

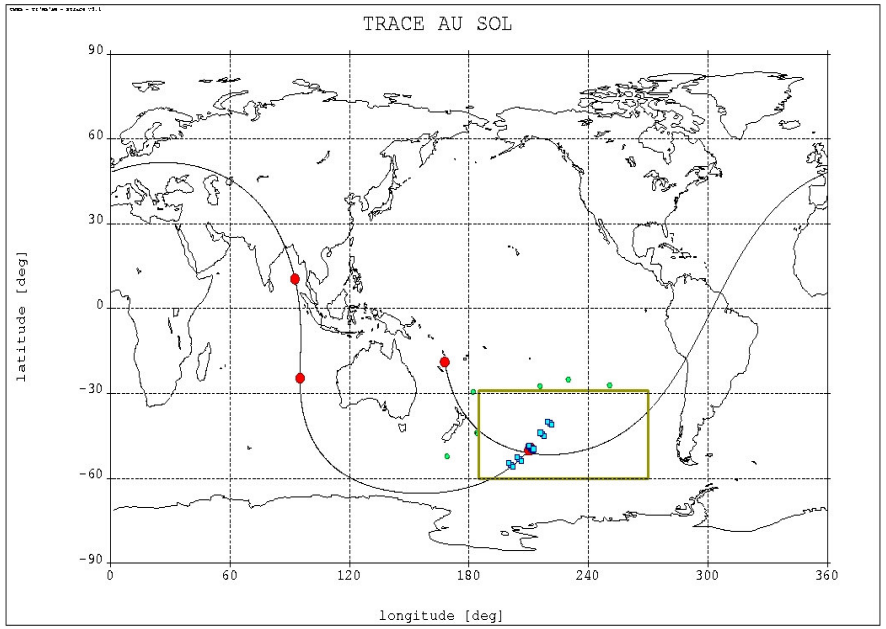
⇒ **Avoidance manœuvre performed by Demeter on June 21 at 11h59mn**
(ΔV=53 mm/s, decrease of apogee altitude 200m)

OPERATIONAL ACTIVITIES
ARABSAT 4A DE-ORBITING

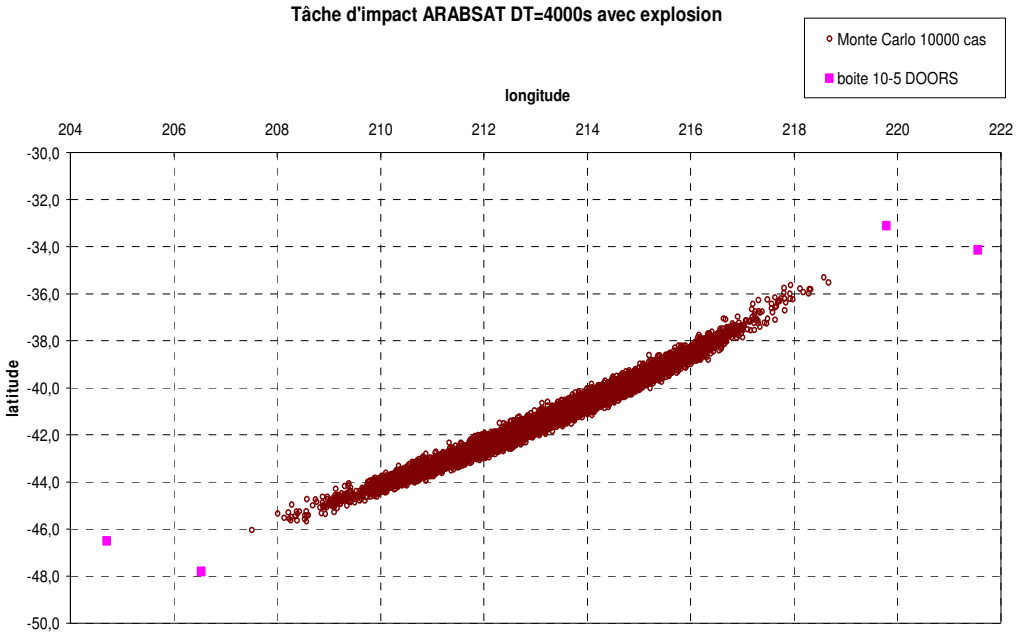
- Incorrect injection on orbit of the Arabsat 4A in March 2006
- The final GEO orbit cannot be reached, the mission is lost
- The satellite will remain a very long time on orbit, crossing all satellites between 480 and 14700 km altitude
- Decision to perform a controlled reentry to fulfill the space debris and safety requirements
- On-ground risk analysis, nominal and degraded cases
- Long duration boost: 4000 s
- Successful deorbiting operations on March 23, 2006 (EADS-Astrium with CNES support)

OPERATIONAL ACTIVITIES
ARABSAT 4A DE-ORBITING

ARABSAT 4A



Last ground track



On-ground footprint

SUMMARY

- **Experience gained through application of the Code of Conduct to CNES projects**

- **Difficulties: Conflict between several constraints:**
  - Mission objectives,
  - debris guidelines,
  - technical capacities
  - cost
- **Need for:**
  - **better knowledge of the environment: optical observations**
  - **Search for new technical solutions**
  - **Support to operations: collisions monitoring and reentry**