

# ACTIVE DEBRIS REMOVAL

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# 01

# INTRODUCTION

# 23 000+

## orbital debris

( > 10 cm)



# KESSLER SYNDROME

## A self-sustaining cascading collision of space debris in LEO

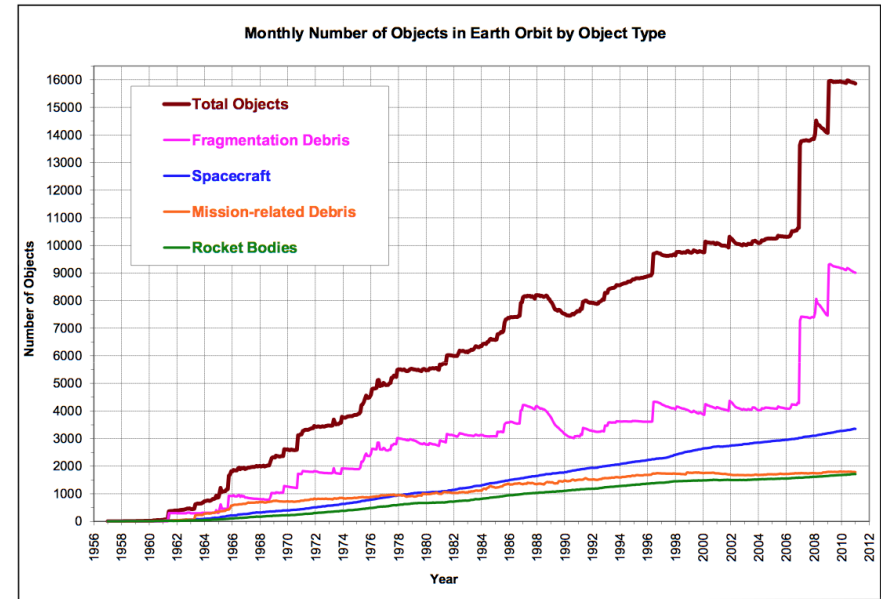
Proposed in 1978 by a NASA scientist Don J. Kessler

### Main events:

- 2007: Chinese anti-satellite missile test
- 2009: Cosmos/Iridium collision

### A worrying trend:

Satellite constellations...



Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.

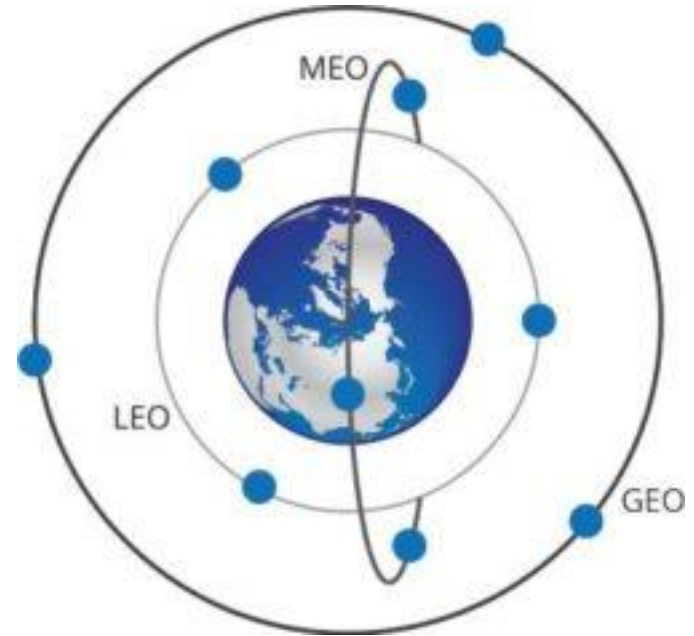
# Mitigation vs. Remediation

# MITIGATION

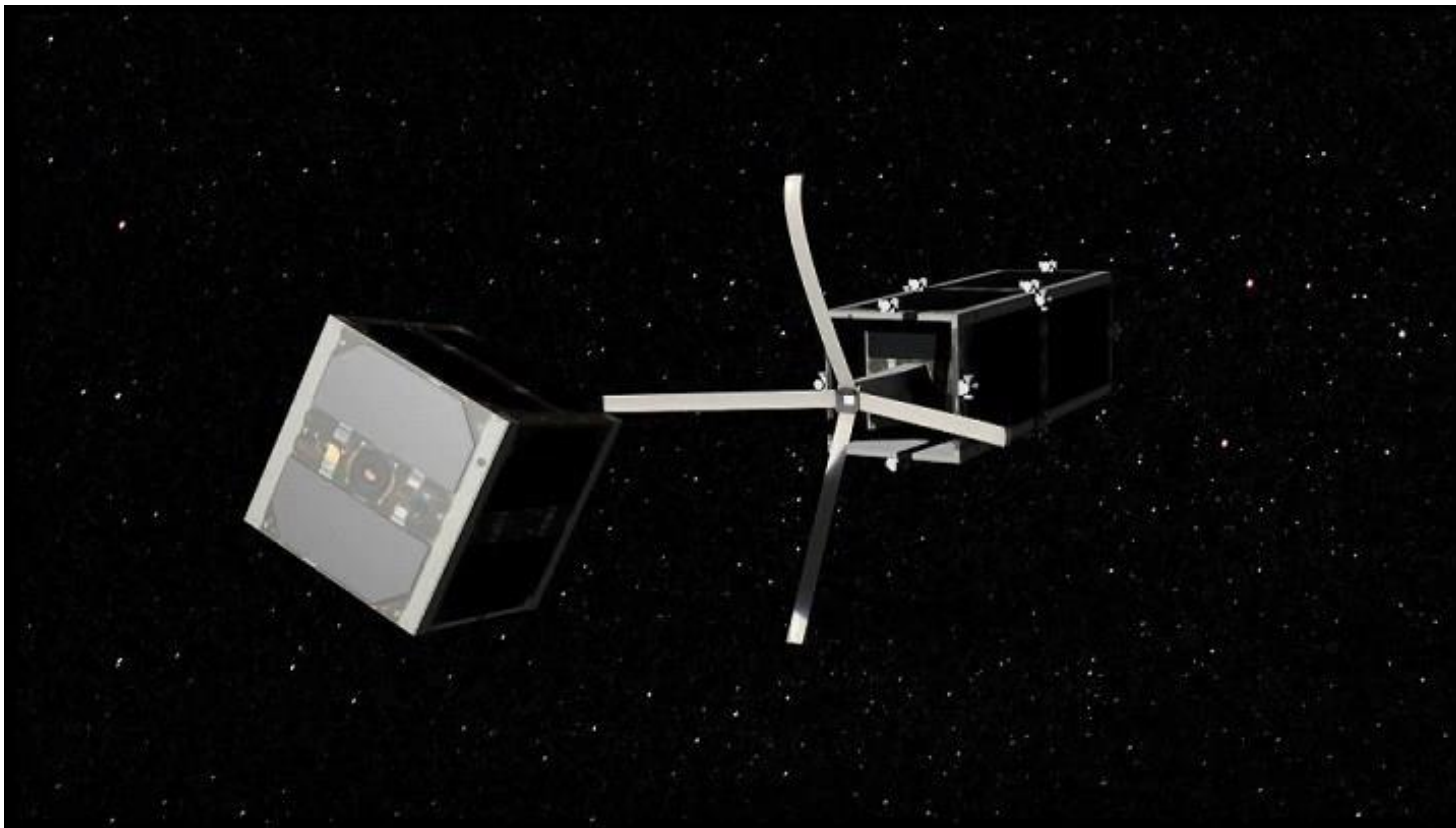
## Internationally Recommended Disposal Guidelines

Issued by the Inter-Agency Space Debris Coordination Committee (including ESA, NASA, JAXA)

1. Placement in a disposal orbit with lifetime less than 25 years
2. Placement in a storage orbit above GEO
3. Placement in a storage orbit between LEO and GEO



# REMEDIATION



# 02

# CHALLENGES



# TECHNOLOGICAL

[Taken from C. Bonnal, *Active Debris Removal : Current Status of Activities at CNES, IAF Workshop on Space Debris Removal, Vienna, 2013*]

1. Far-range rendezvous
2. Short-range rendezvous
3. Mechanical interfacing
4. Control, de-tumbling and orientation
5. De-orbitation

# LEGAL



# FINANCIAL



# 03

# SOLUTIONS

# FINANCIAL & LEGAL

## Financial

**Rendezvous technologies are being developed for other applications**

- Military
- Life-extension missions

**New Space solutions are leading to an increase in space objects which make business cases more viable**

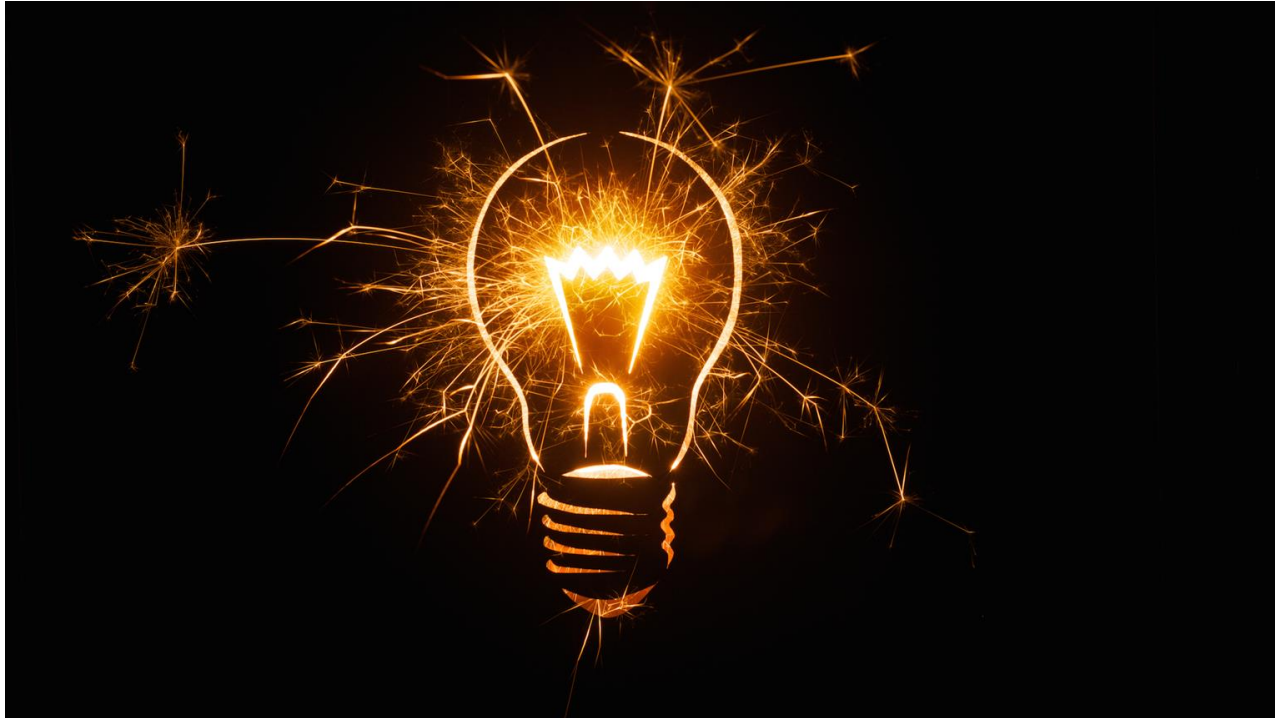
## Legal

**France has adopted the French Space Act which enforces the Internationally Recommended Disposal Guidelines**

**Ongoing efforts to establish international legal framework**

# TECHNOLOGICAL

Lots of ideas !





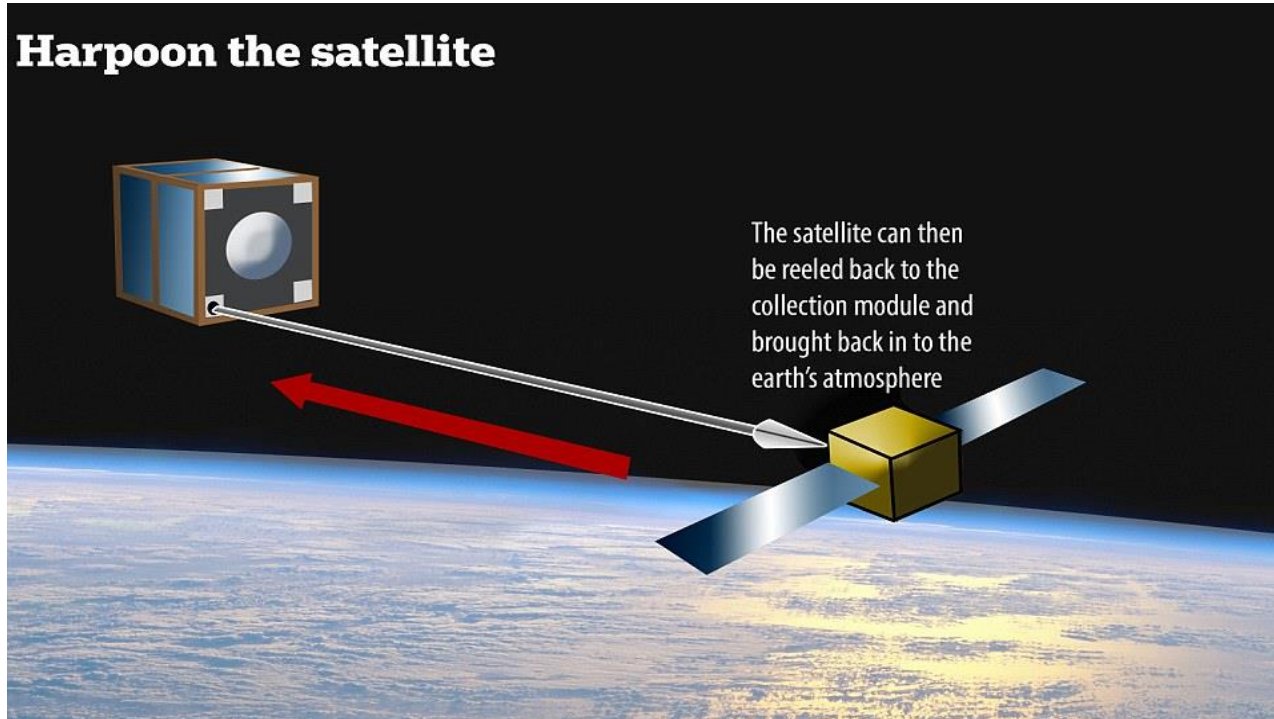
**ariane**GROUP

A blue-tinted image of Earth from space, showing the horizon and a bright light source. The Earth is curved, with a bright white glow along the horizon line, suggesting a sunrise or sunset. The surface of the Earth is visible, showing continents and oceans. The background is a dark blue space filled with stars.

**QUIZ**

# TECHNOLOGICAL

## Harpoon





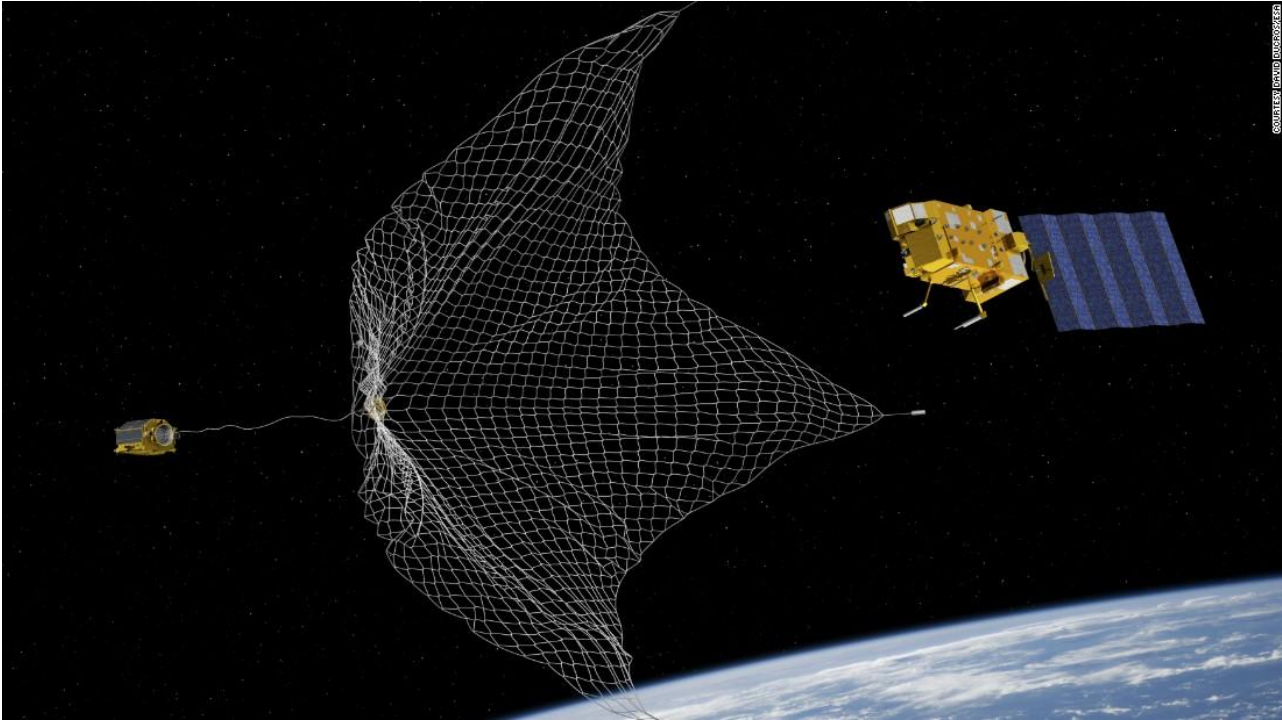
# TECHNOLOGICAL

## Robotic arm

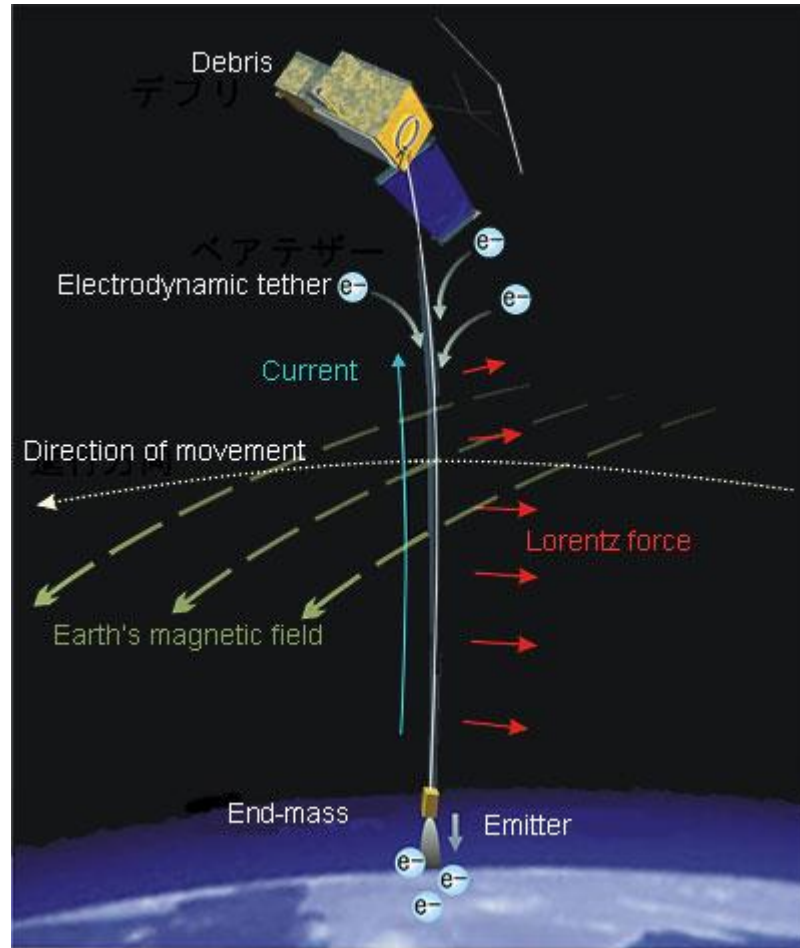


# TECHNOLOGICAL

## Net

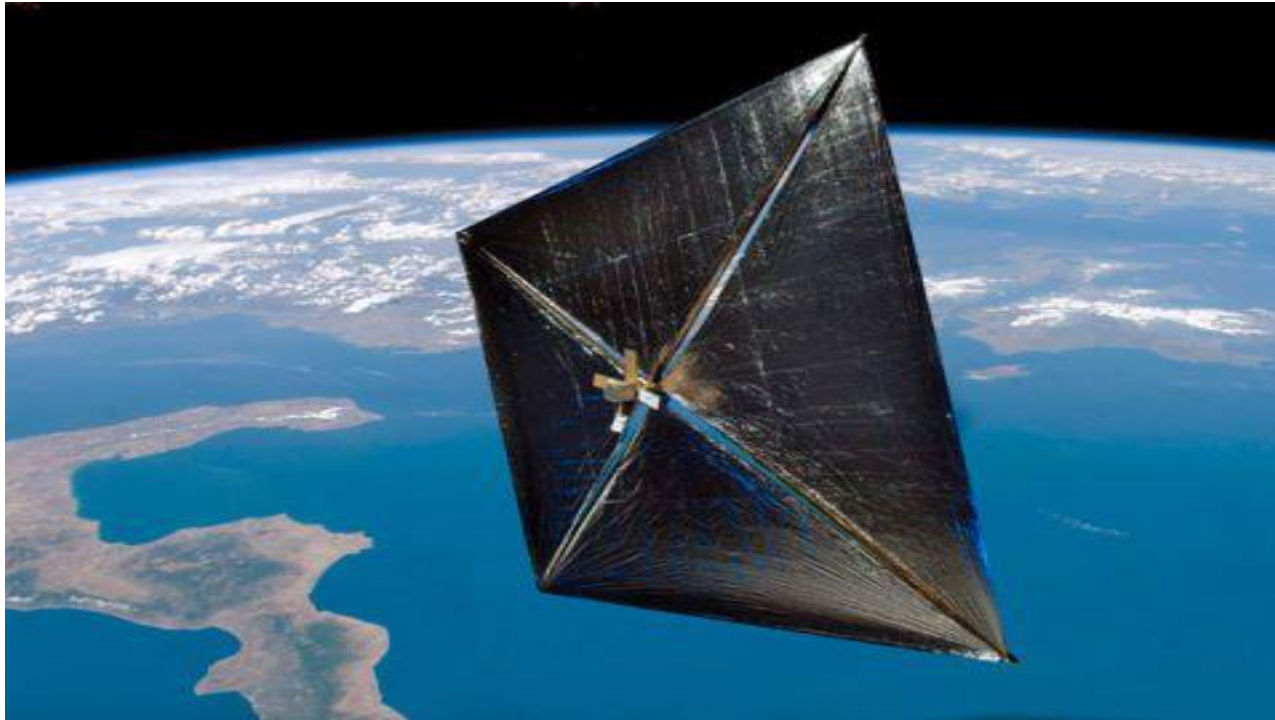


# TECHNOLOGICAL Tether



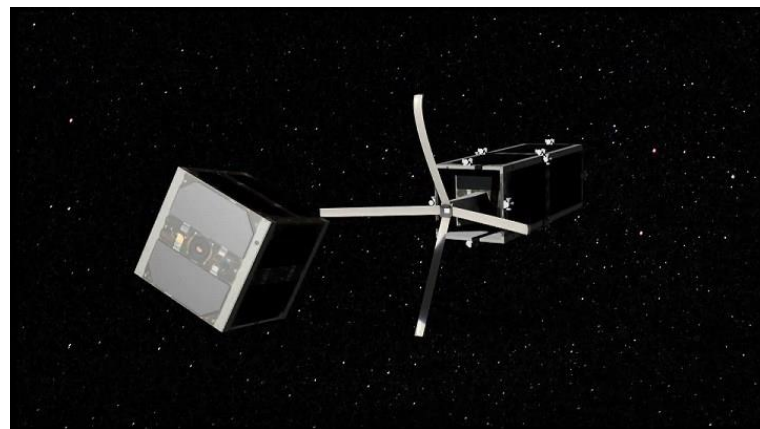
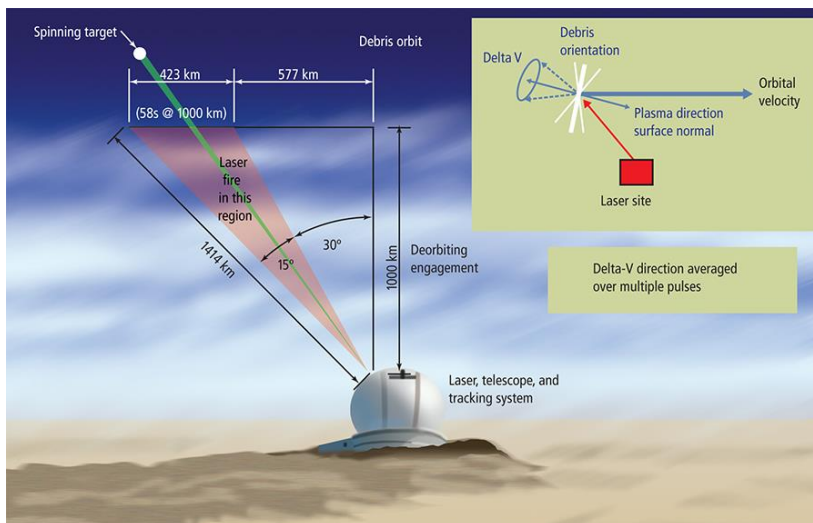
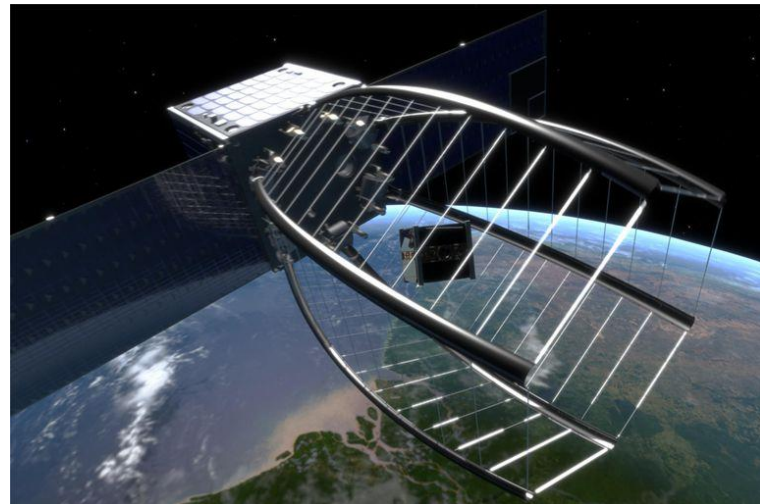
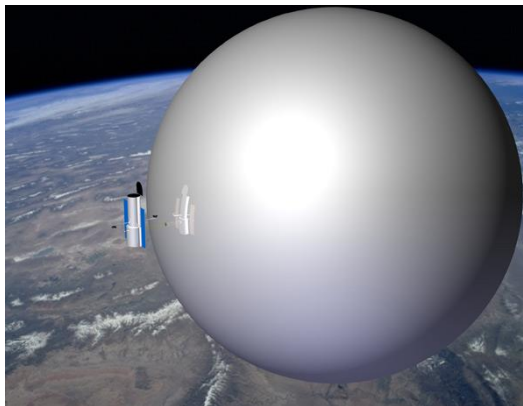
# TECHNOLOGICAL

## Dragsail



# TECHNOLOGICAL

And many more...



# 04

# REMOVEDEBRIS

# INTRODUCTION

## Objective

Performing an in-orbit demonstration, in a low-cost manner, of active debris mitigation techniques using novel, realistic capture techniques

## Low-cost

13 M€ (launch included)

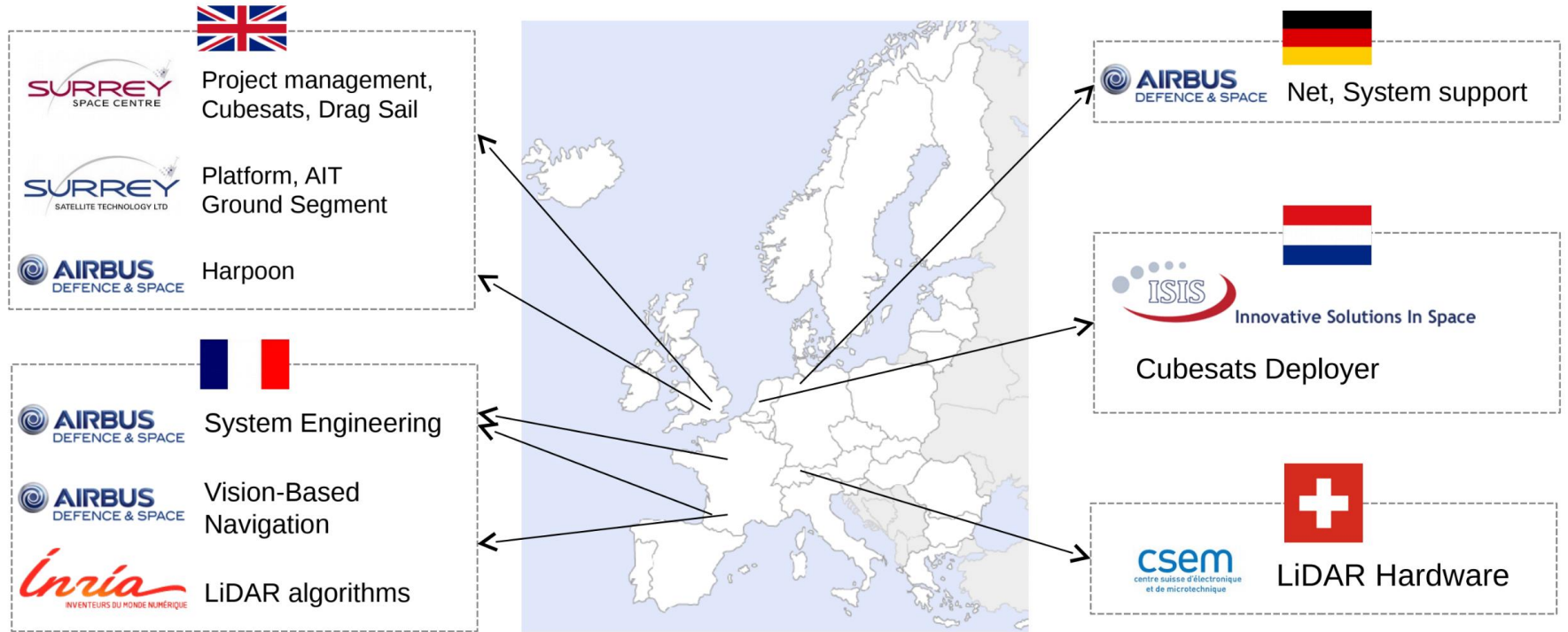
## Innovative

First of its kind

Raising Technology Readiness Levels (TRL) for :

- Dragsails
- Vision-Based Navigation
- Harpoons
- Nets

# A EUROPEAN ENDEAVOUR





# DEMONSTRATIONS

## Concept of operations

<https://youtu.be/7CEH9V9psKY>

## Mission Highlights

<https://youtu.be/CwTHnglMVlg>

A satellite with a gold-colored frame and solar panels is shown in orbit above a dense layer of white clouds on a blue Earth. The satellite is positioned in the lower center of the frame.

THANK YOU FOR YOUR ATTENTION

# REFERENCES

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