SSA/SST ed il mondo civile

Ruolo e considerazioni dell'Agenzia Spaziale Europea

Pascal GILLES

European Space Agency

Centro Studi Militari Aeronautici, 22/03/2022

Presentation content

ESA & ESRIN

ESA Space Situational Awareness Programme

- Space Weather Segment
- Space Surveillance and Tracking Segment
- Near Earth Objects Segment

Toward Space Safety

ESA ESRIN Establishment - Activities

- Earth Observation
- Space transportation
- NEO Coordination Centre
- Disaster Charter Coordination Centre
- Corporate IT
- Communication
- Archives
- ESA Security Office
- Contracts, Personnel
- Site Management

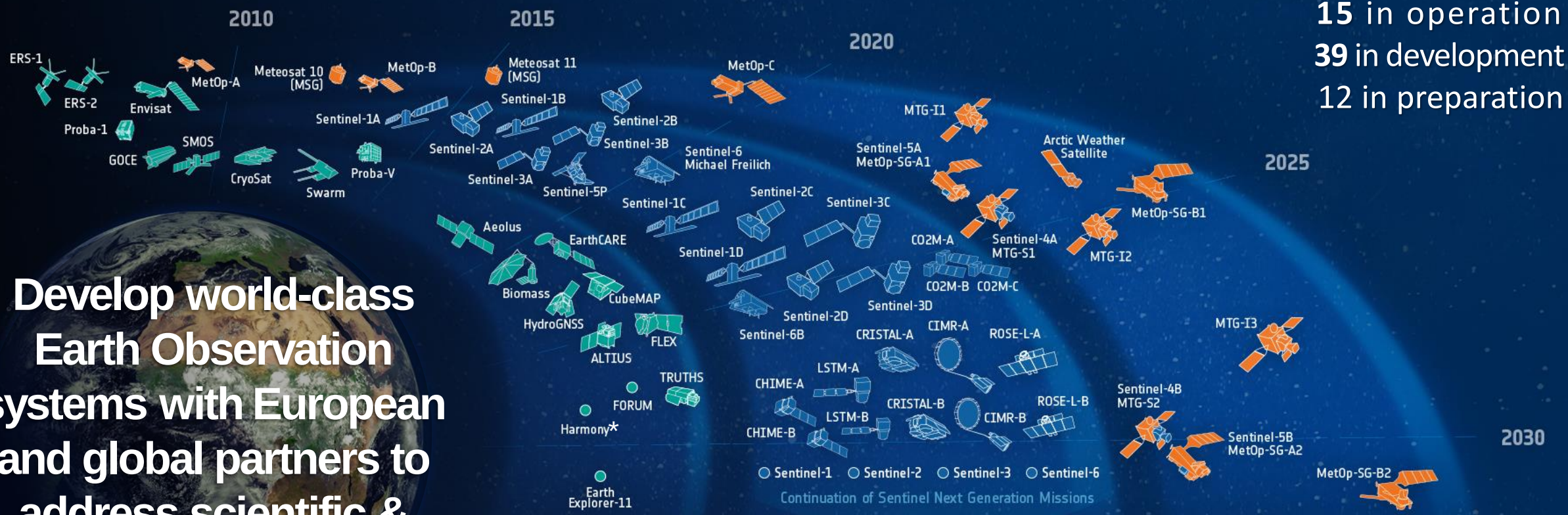
30-40% of ca.870 personnel on site

50.000 visitors per year (pre-Covid)

ESA's Earth Observation Mission

Missions

15 in operation
39 in development
12 in preparation

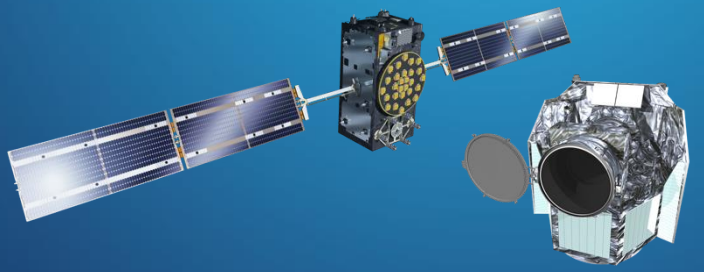


Develop world-class Earth Observation systems with European and global partners to address scientific & societal challenges

Science | Copernicus | Meteorology

*Pending final mission selection

The European Space Agency



Make Space for Europe

5 500+

ESA Workforce

85+ missions developed, tested and operated

Pushing the limits of what is possible in space since 1975

22

Member States

3 Associate Members
6 Cooperative Members

2022 Budget

7.15 billion =

12 per European

ESA AGENDA 2025

Common European Space Vision for 2035+

5 priorities with targets for 2025

- ESA-EU relations
- Commercialisation
- Safety & security
- Programme challenges
- ESA transformation

Strengthen Space for Safety & Security

IN SPACE

- Space traffic management
- Debris removal & mitigation
- Space weather monitoring
- Space logistics
- Planetary defence
- Cyber security

FROM SPACE

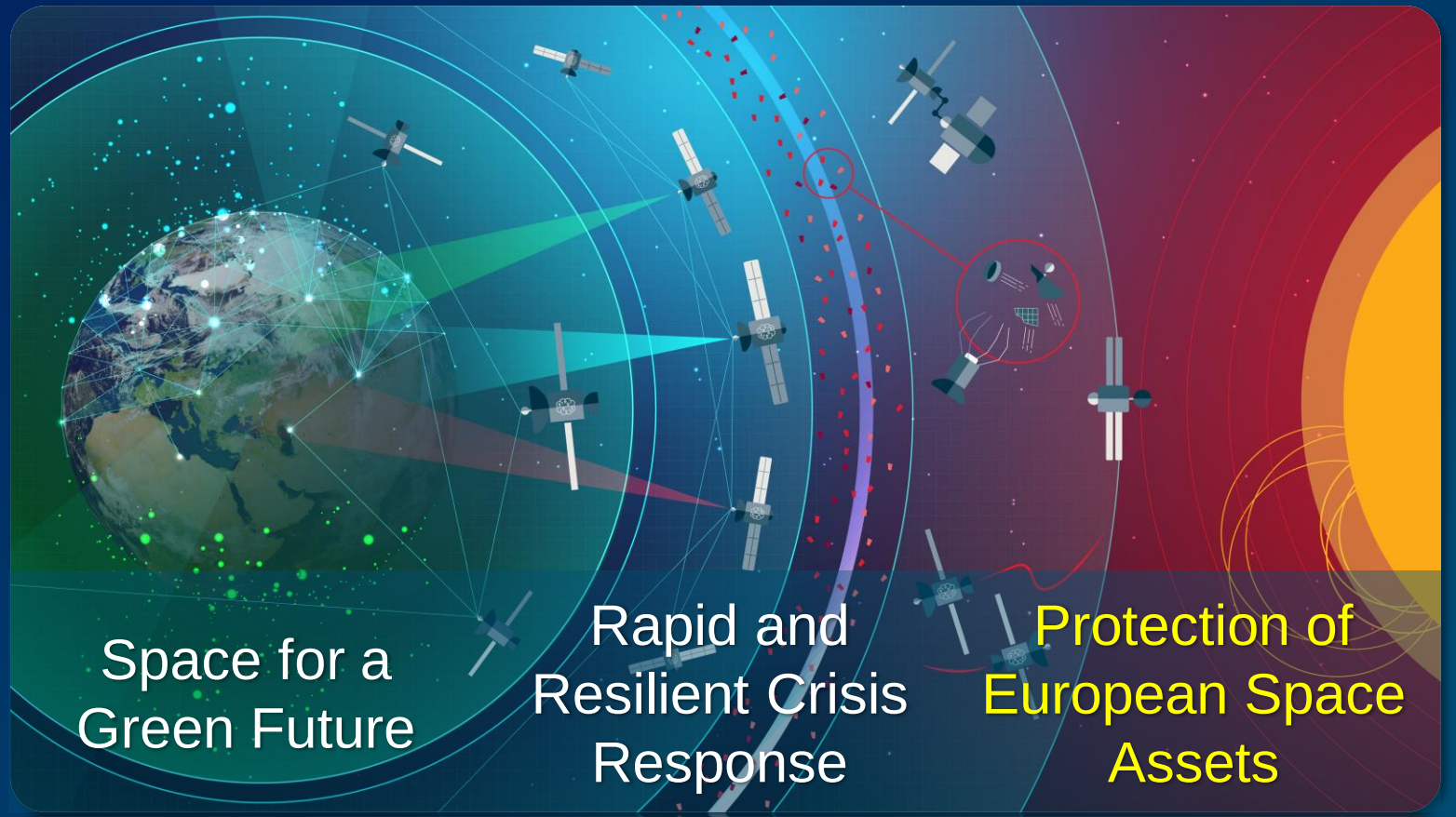
Smallsats and HAPS

Secure communication

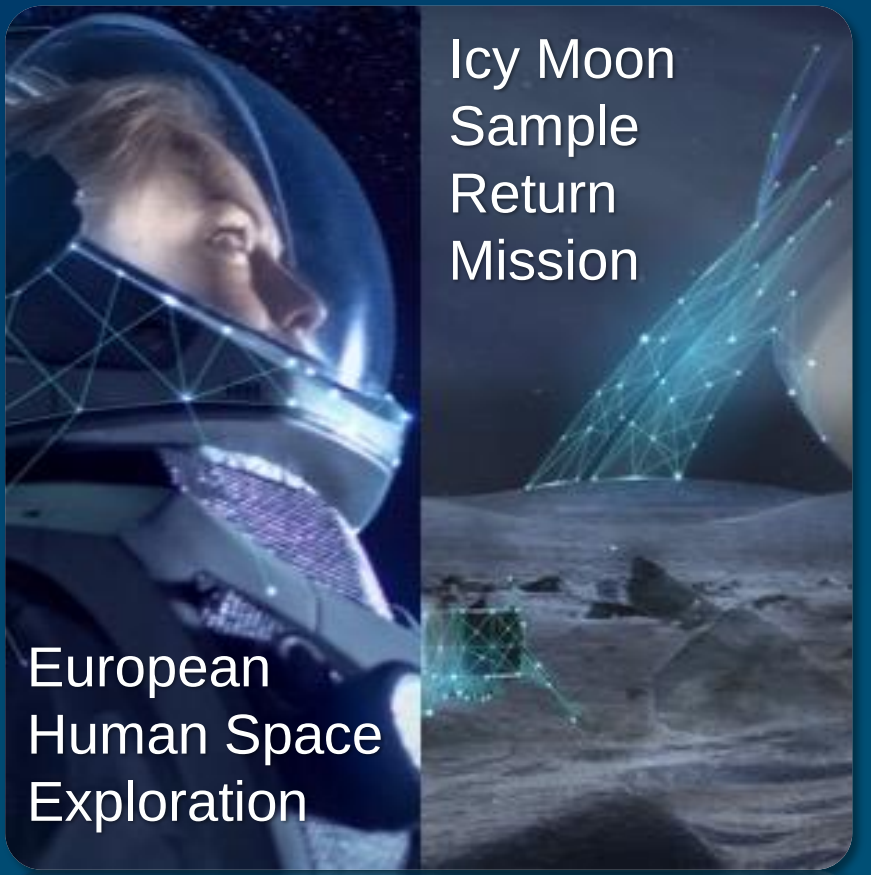
Rapid response EO

Accelerating the Use of Space in Europe

3 Accelerators



2 Inspirators



Accelerator 3: Protection of European Space Assets

Space Debris

Enable European industry to build up a novel debris monitoring system

Safeguard space now and in the future, and establish commercial leadership in orbit-servicing

Space Weather

Ensuring Safety of our Space and Ground Assets

Protecting astronauts, satellites, power grids and the internet

ESA SSA Programme Introduction

Objective:

- Protection of space and ground assets against adverse effects from space
- Three main areas or segments:
  - Space Weather (SWE)
  - Space Surveillance and Tracking (SST)
  - Near Earth Objects (NEO)

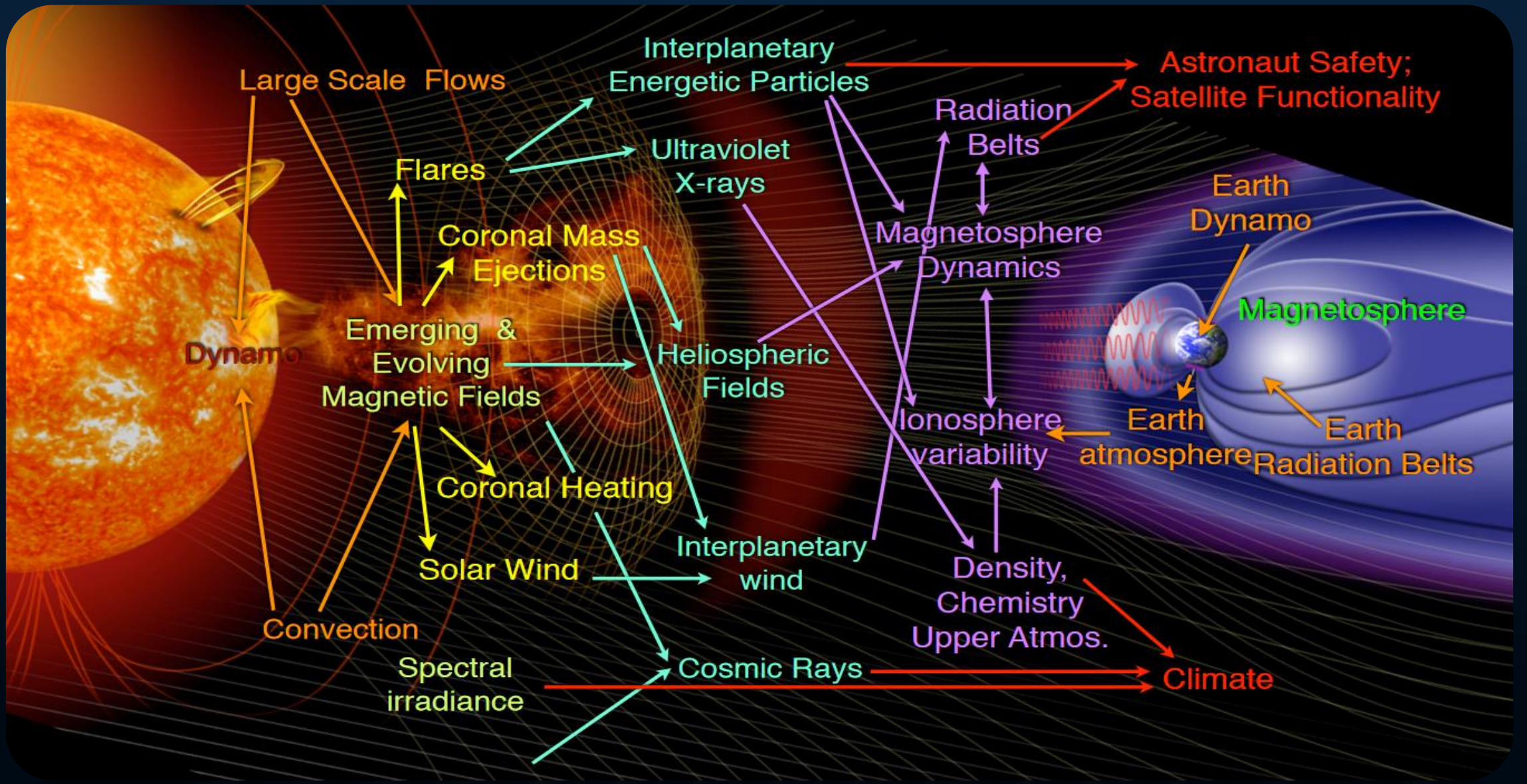
SSA Programme executed in Periods

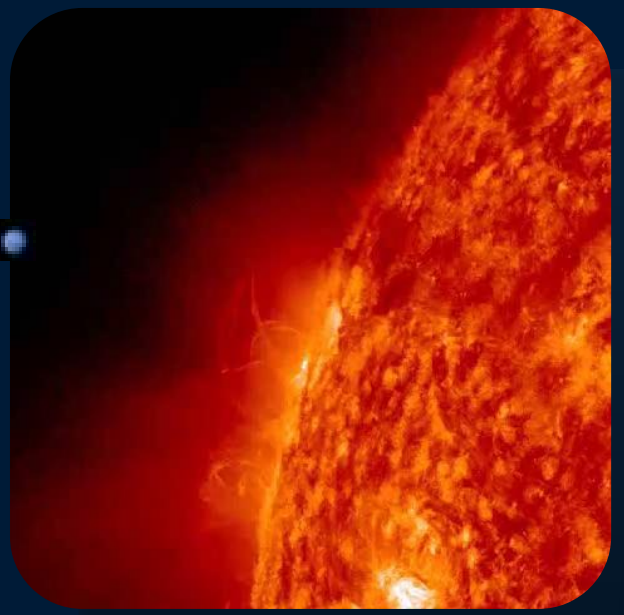
- Period 1 decided at MC in November 2008 (Prep. Programme)
- Period 2 decided at MC12 in November 2012
- Period 3 (2017-2020) decided at MC16

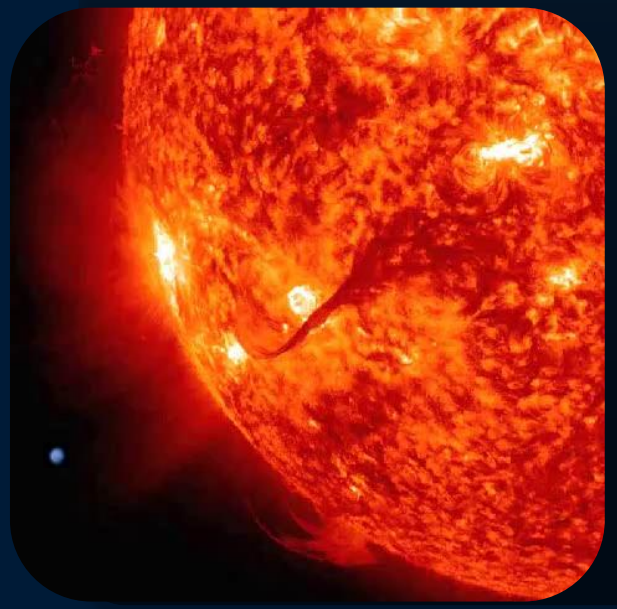
Space Safety Programme (S2P) (2021-)

SSA SWE Segment

Understanding Space Weather Interactions

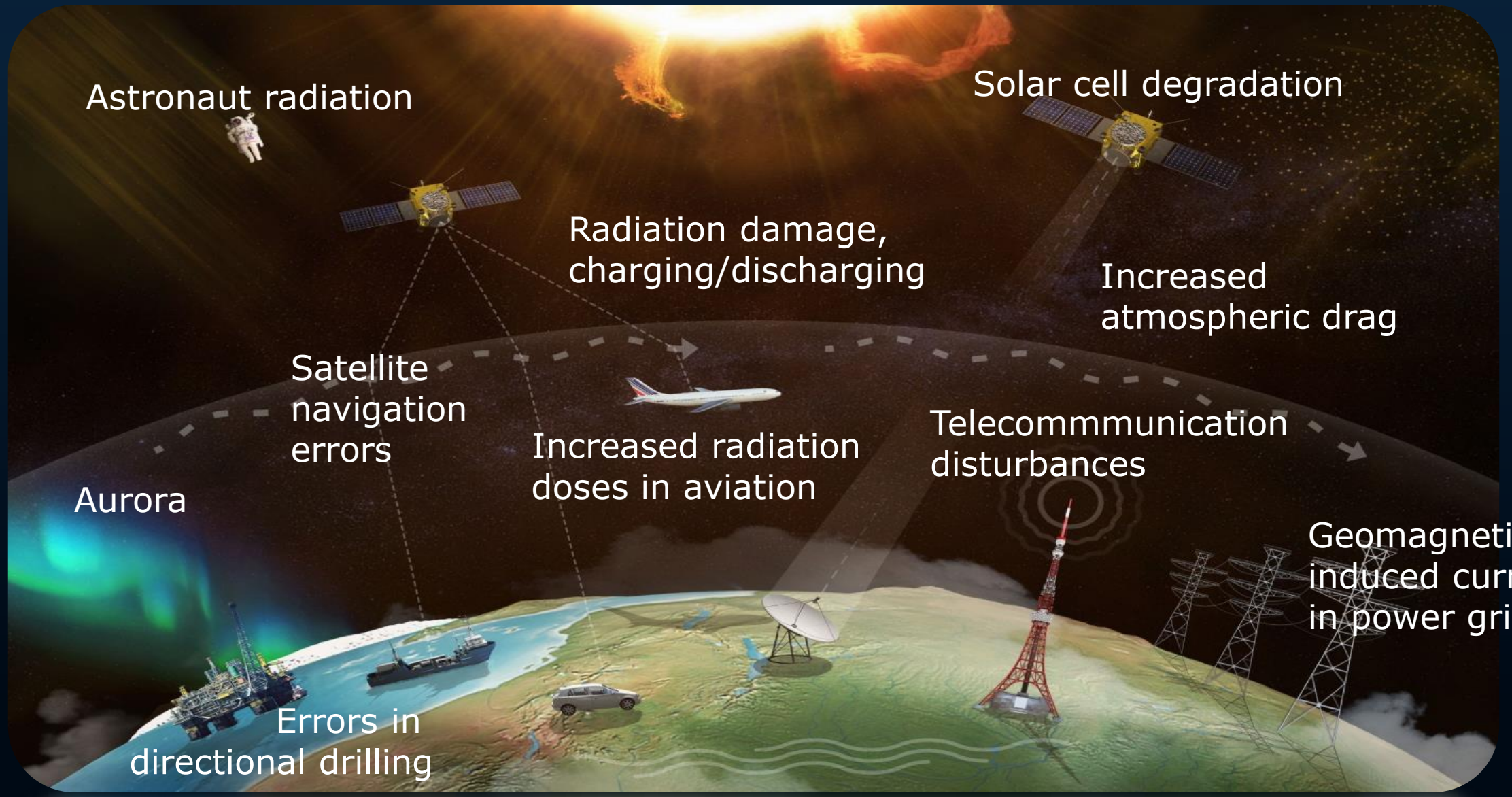






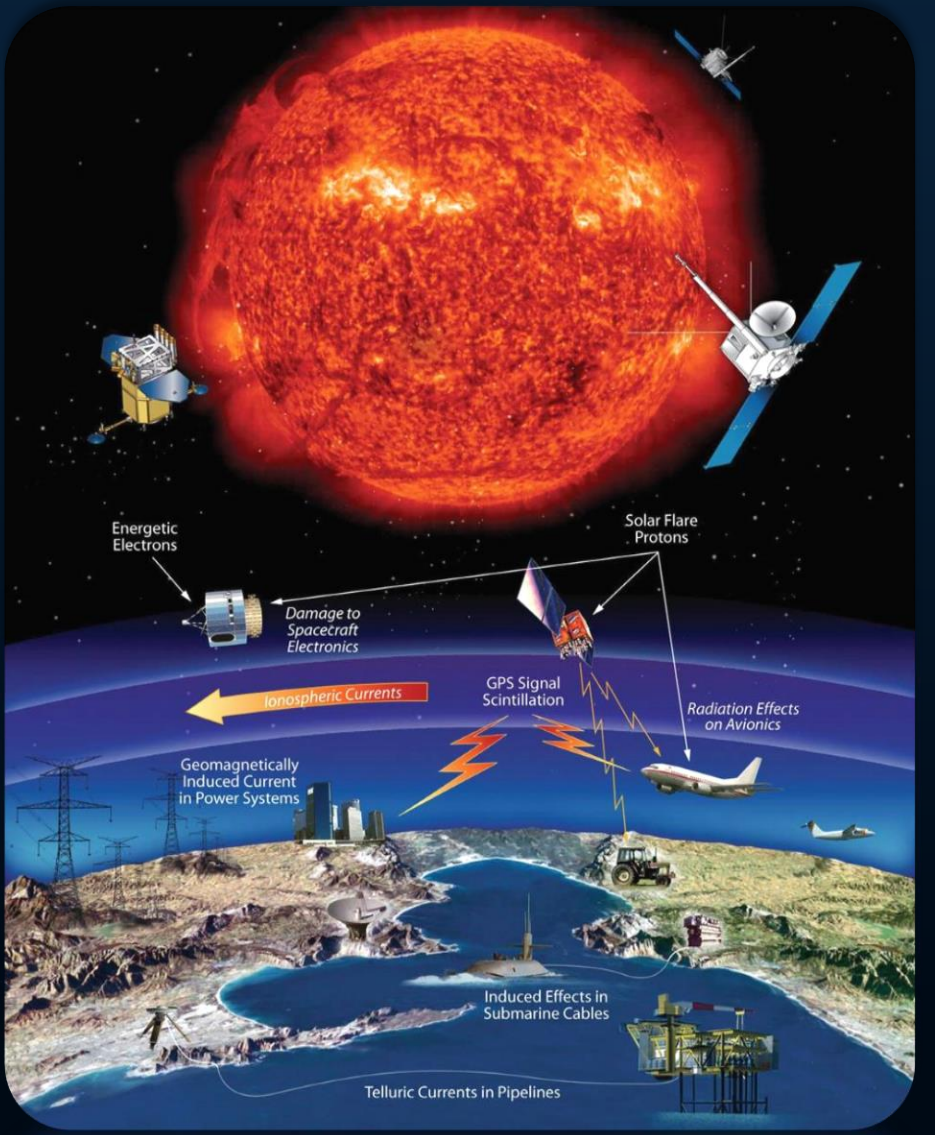
Video appear by courtesy of ESA/NASA

Space Weather Impacts on Infrastructure



SSA SWE Network Goals

- Leverage European expertise in all areas of space weather to build a network of space weather services based on high quality data, state-of-the-art modelling and scientific know-how.
- Advance space weather service provision for SWE customers & stakeholders according to the SWE Customer Requirement Document baseline as part of a sustainable network

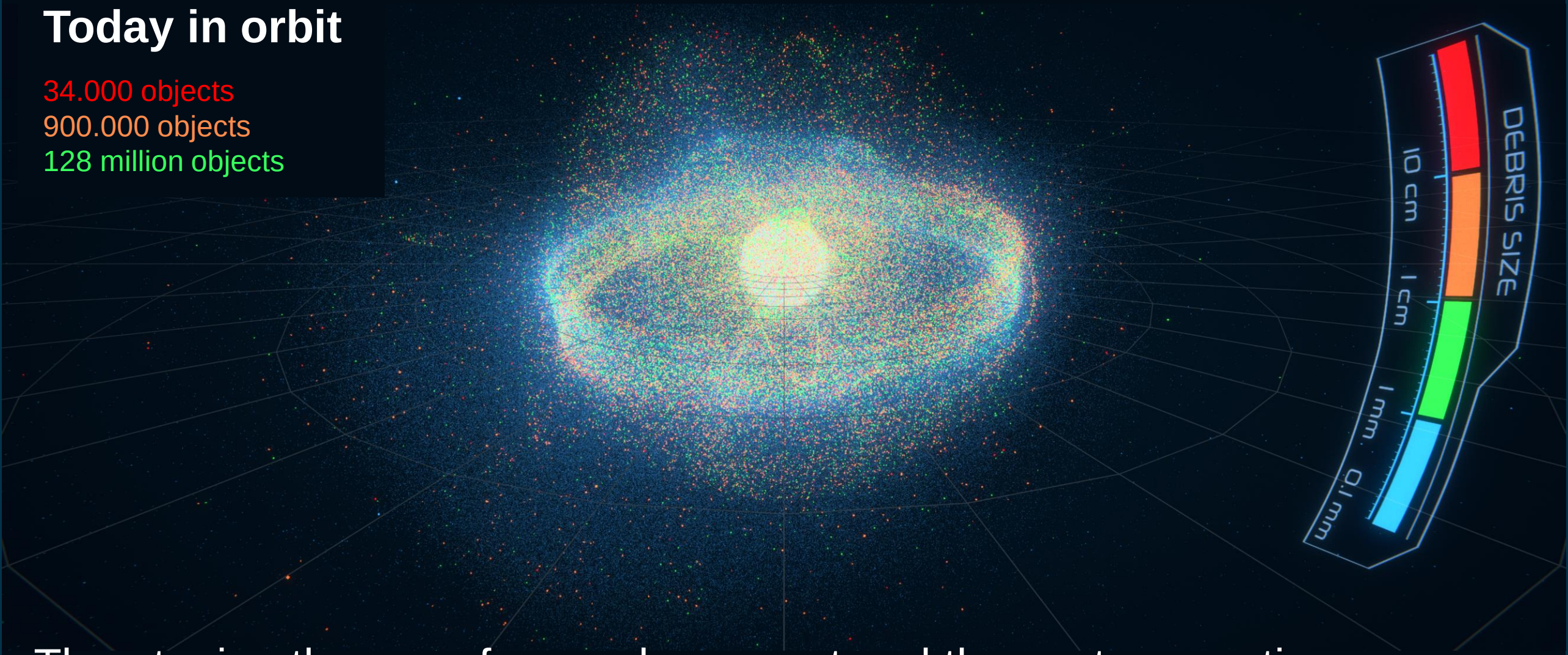


SSA SST Segment

What is the problem? Space debris

Today in orbit

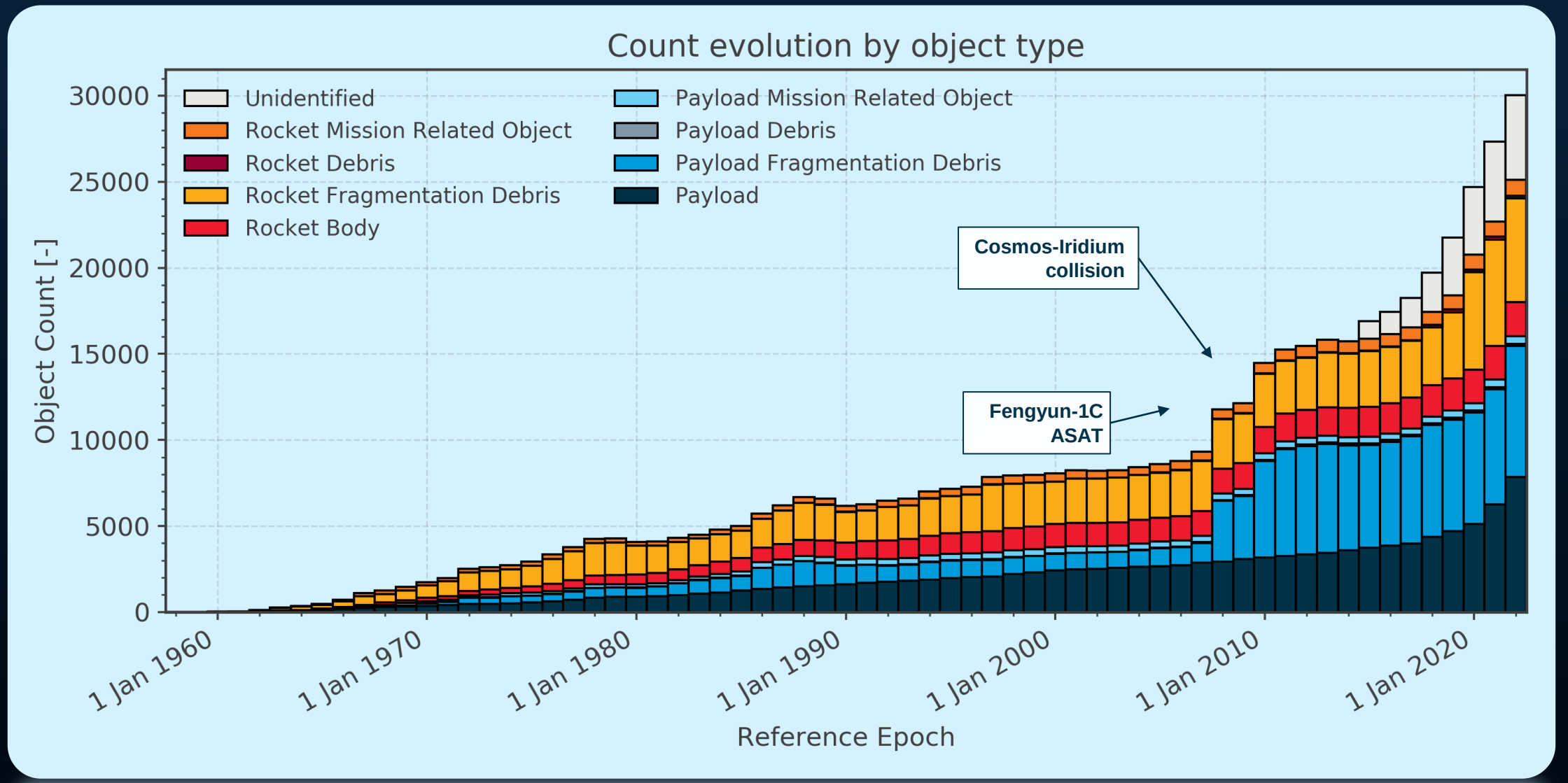
34.000 objects
900.000 objects
128 million objects



Threatening the use of space by current and the next generations

The Space Debris Problem

The Space Debris Problem

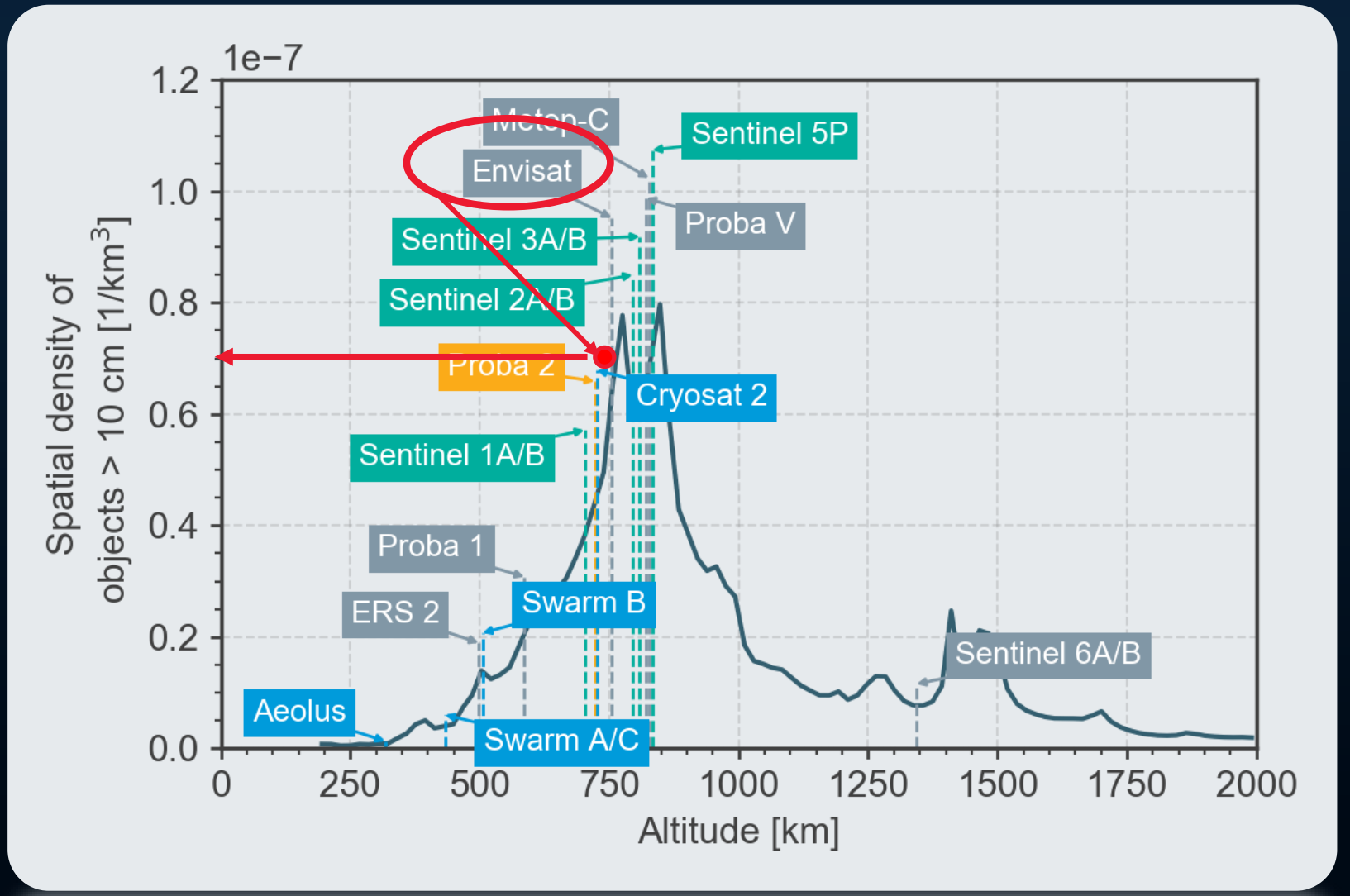


The Space Debris Problem

- Space, and the possibility to still send and operate satellites in various orbital regimes, is nowadays vital.
- An uncontrolled increasing number of space debris might make in the future very difficult, if not impossible, to utilize this essential resource.
- It is extremely important then to be able to characterize the problem, by ensuring that we can detect and catalogue the man-made orbiting objects and avoid as much as possible further collisions.
- Current and future applications will impact the strategy for the space debris risk control and mitigation (e.g. Richard Branson's OneWeb, Elon Musk's SpaceX Space Internet Constellation, Cubesats, etc.).

- Repetitive collisions in space increase the number of debris and in particular small debris, which are more and more difficult to detect and catalogue.
- It has been even theorised that when the density of the objects in a certain orbit (in particular the Low Earth Orbit – LEO) will reach a certain level, a cascading effect could be initiated by random collisions.
- Kessler Syndrome (Donald J. Kessler, 1978): self-sustaining cascading collisions of space debris.

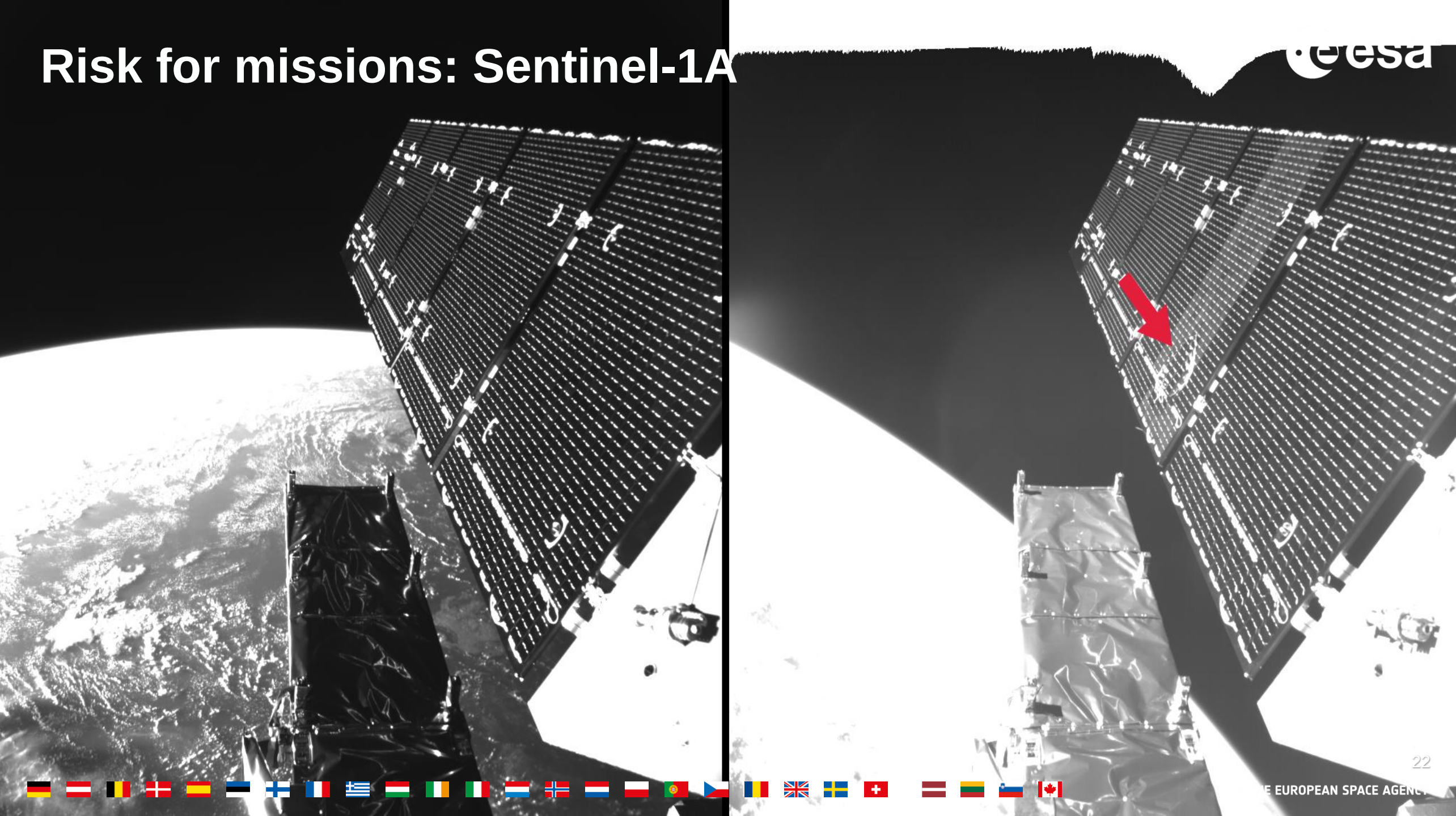
Missions



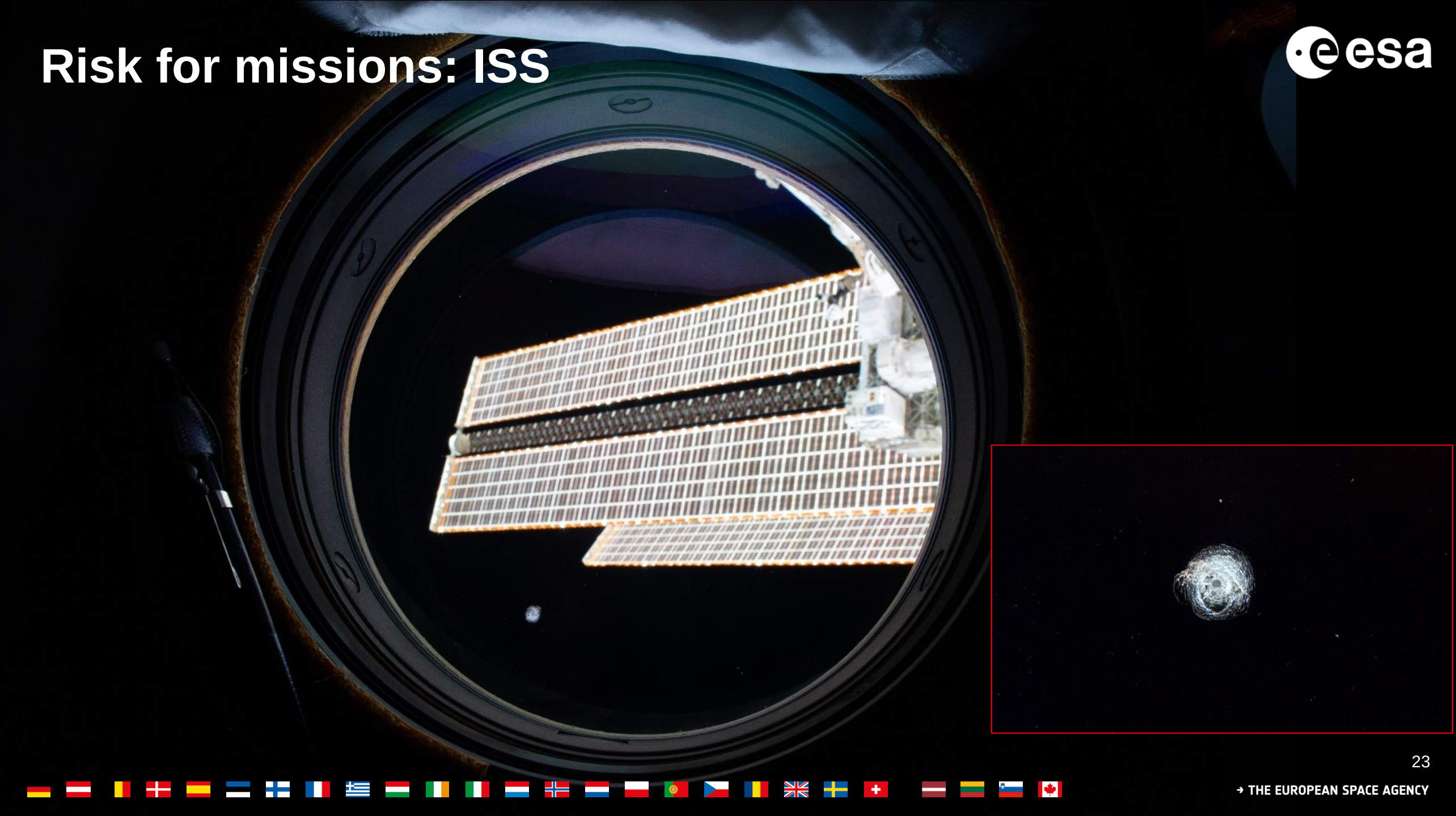
Missions in LEO

- Earth Explorers
- Copernicus
- Other and former missions

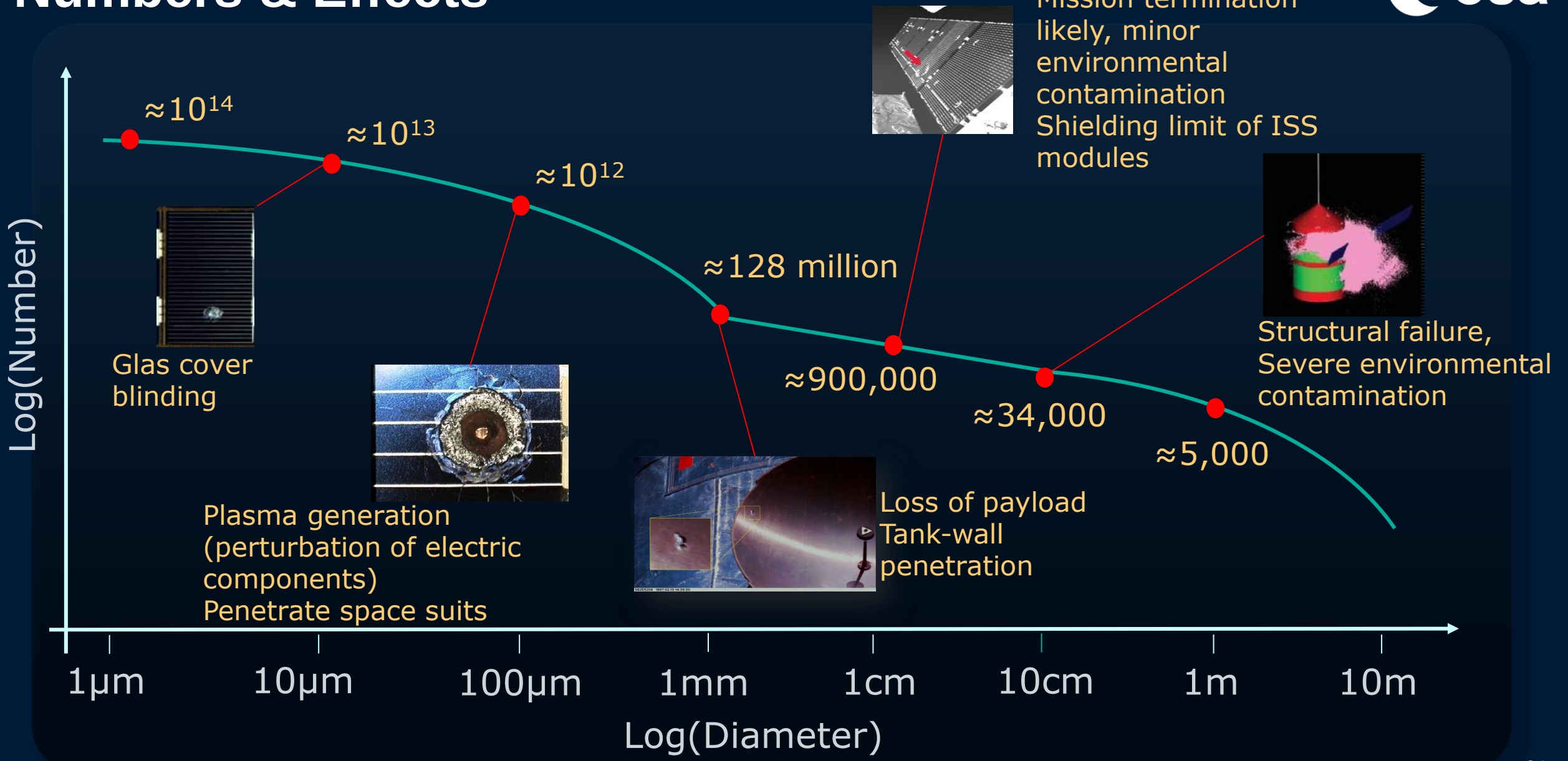
Risk for missions: Sentinel-1A



Risk for missions: ISS



Numbers & Effects



Future evolution - Trends

Larger catalogue(s) (covering smaller object sizes)

- More known high risk conjunction events and
- more Collision Avoidance Manoeuvres (CAMs) unless criteria change
- **Factor 3 to 10 more (tbc)**

Further increase of launch traffic

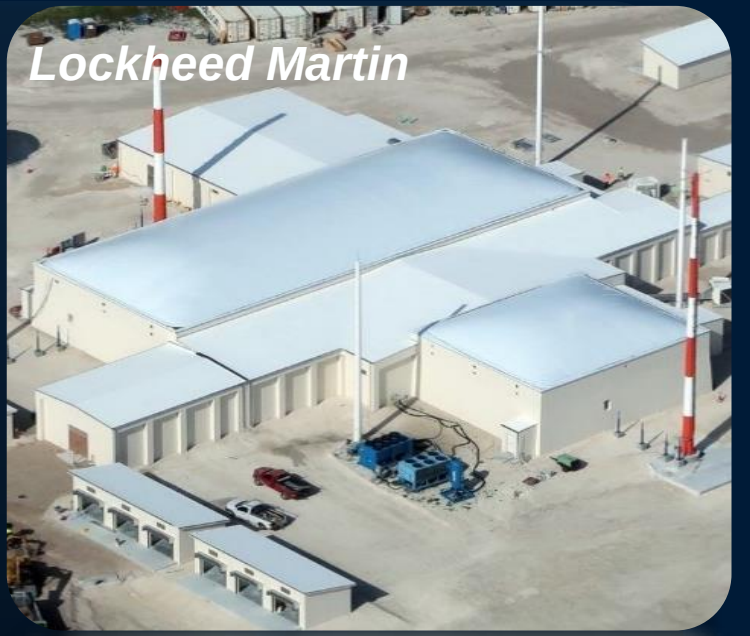
- More conjunctions between active spacecraft
- Coordination needs
- + ~50% overall, order of mag in specific altitudes due constellations

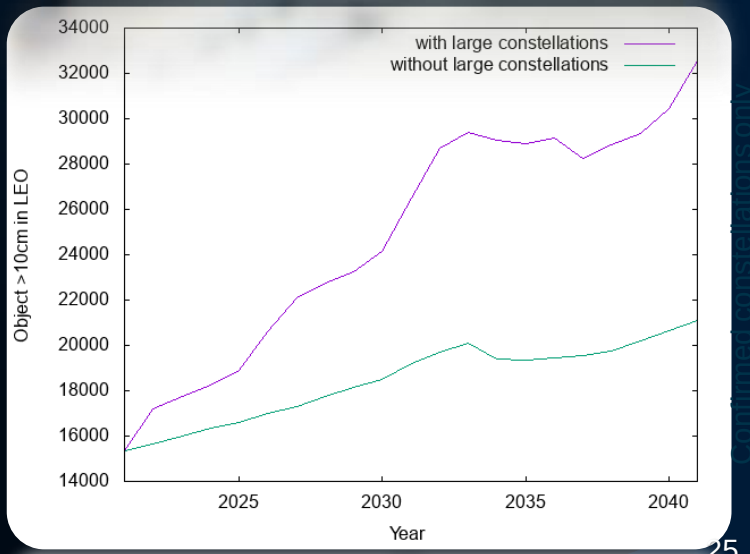
Multiple catalogues

- (Enlarged) US catalogue, other institutional and commercial
  - Not accessible to all operators
- Data fusion needs

➢ **Need for increased automation and enhanced decision criteria**

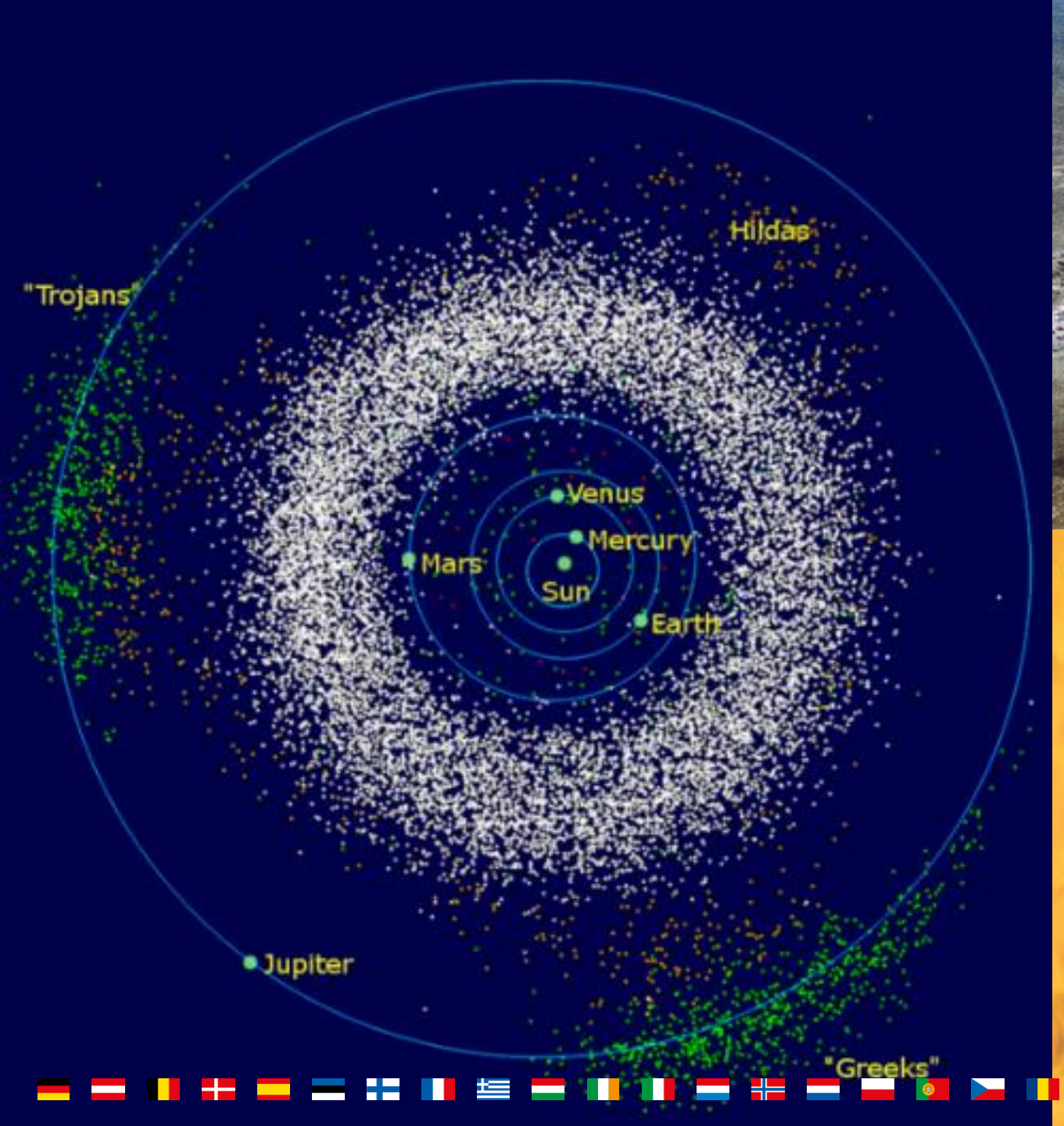
- Even now CAM preparation represents >50% of "extra effort"





SSA NEO Segment

Image credit: ESA


Hildas
"Trojans"
Venus
Mercury
Mars
Sun
Earth
Jupiter
"Greeks"


Texas
Florida
Buried
crater
Gulf of Mexico
150km
Cuba
Chicxulub Crater
Mexico

Mission statement

To establish and support a European capability for protection of its critical space and ground infrastructure from threats by potential asteroid impacts.

- Near-Earth Object (NEO): Any asteroid or comet with a perihelion less than 1.3 AU
- 1 AU = Astronomical Unit = distance Sun-Earth = 149.6 Mio km
- Threatening object: Any asteroid that may hit the Earth
- Risk list: A list containing all threatening objects

Chelyabinsk Impact Event

Video from dashboard camera (from N. Artemieva)

Chelyabinsk Impact Event: Effects on ground

NEO impacts: frequency and effects

- Asteroids (and Comets) hit Earth with very high velocities.
- typical: 10 - 20 km/s, 20 times faster than a gun bullet!

NEO diameter	Impact energy [Megatons TNT] (1g TNT ≡ 4184 J)	Typical interval [Years]	Effect
2mm		1 per hour (visible from each location)	Nice meteor
3 m	0.002	0.5	Bright fireball, Sudan Event, Meteorites reach ground
10 m	0.08	5	Big fireball, fear, shock wave, 5-fold energy of Hiroshima bomb
40 m	5	300	Tunguska explosion or crater
140 m	220	10,000	Regional destruction, Tsunami
500 m	10,000	200,000	Europe-wide destruction
1 km	80,000	700,000	Millions dead, global effects
10 km	80 million	100 million	End of human civilisation

Number of Asteroids and NEOs

(Data from ESA NEO Coordination Centre)

1,076,589 known Asteroids (February 2022)

28,230 known NEAs (February 2022)

3,785 known NECs (February 2022)

1,336 NEAs in risk list (NEAs with small but non-zero impact probability in next 100 years) (February 2022)

Number of known and estimated NEOs:

- 90% of NEOs with diameter > 1 km
- 15-25% of NEOs larger than 140 m (total ≈ 20,000 - 30,000)
- < 1.0% of NEOs larger than 30 m (total ≈ 500,000 - 1,000,000)
- << 1.0% of NEOs larger than 10 m (total ≈ 5 – 10 Million)

Which means: **MOST NEOS ARE STILL UNKNOWN!**

Latest info at ESA NEO Coordination Centre: http://neo.ssa.esa.int/neo-home

NEO mitigation in case of a real threat - 1/2

Two basic classes of impact scenarios:

1. Asteroid on direct collision course with Earth
   a) Object is not discovered >> **bad luck**
   b) Object is detected days or weeks before impact
      - Object is usually rather small (< 100 m)
      - Effects are local (but severe damage is possible)
      - Impact time and ground corridor are known
      - Uncertainties of effects remain until actual impact
      - Time for warnings/evacuations

NEO mitigation in case of a real threat - 2/2

2. Object is discovered years or decades before potential impact.

- The object can be big or small
- Impact effects can be local or global
- Only an impact probability can be calculated long in advance but no certainty
- There is time for further studies of the object
- Impact time and ground corridor (usually thin (100-200 km) but long (half around Earth)) are known
- Deflection via space mission is in principle possible

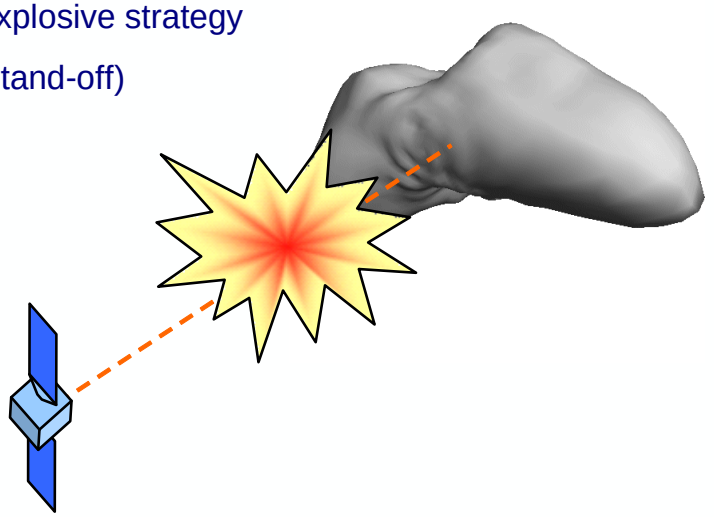
The sooner the easier!

A velocity change of 3 cm/s moves the NEO position by 14000 km in 15 years!

NEO deflection strategies

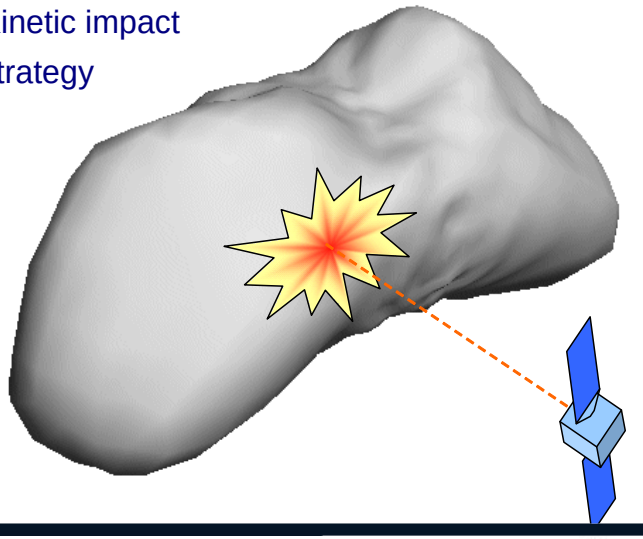
Explosive strategy

(stand-off)

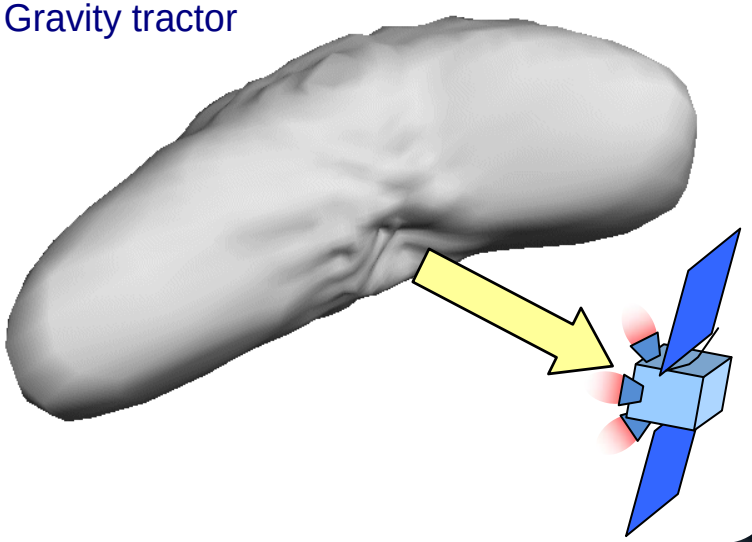


Kinetic impact

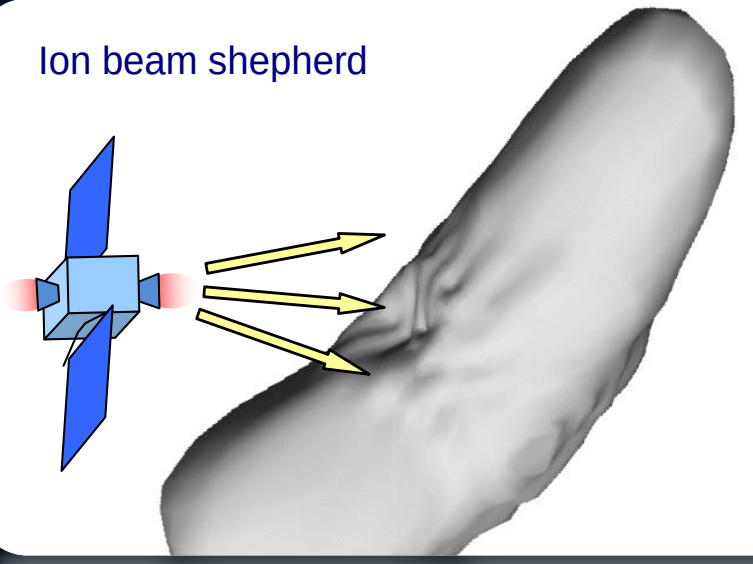
strategy



Gravity tractor



Ion beam shepherd



(Illustrations from J.L. Cano, Deimos)

From SSA to Space Safety (S2P)

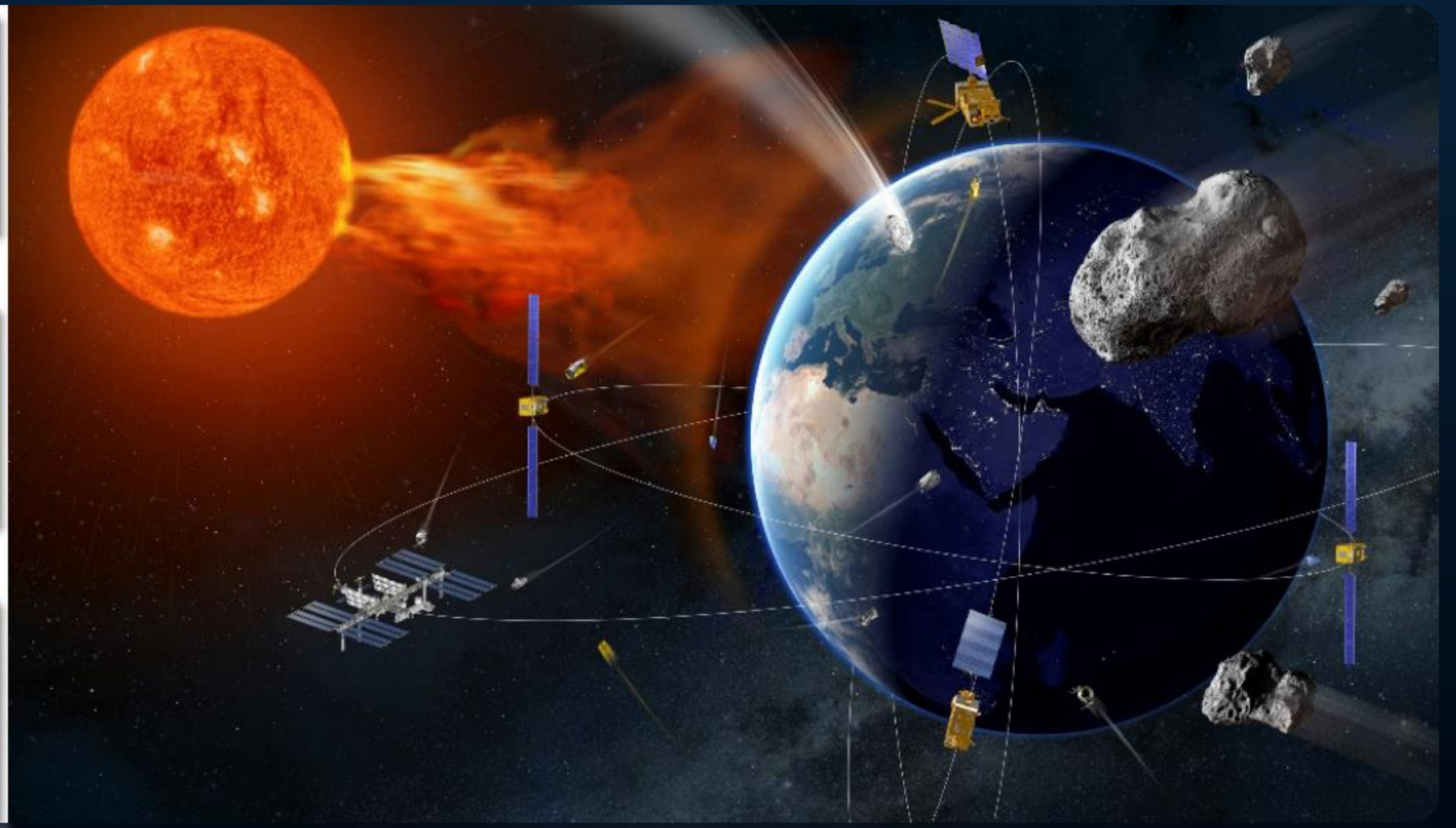
Threat Detection and Analysis

↓

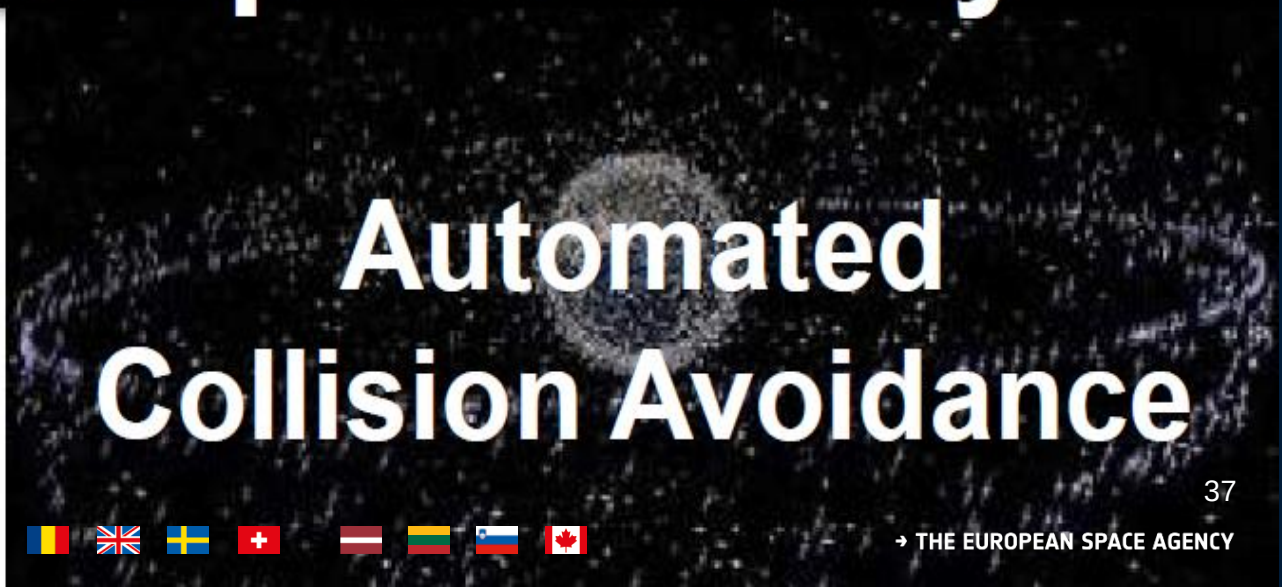
Threat Mitigation

↓

Threat Remediation Response



Cornerstones of Space Safety



Dedicated SSA SWE Space Missions to L-points

Solar monitoring data from Sun-Earth line + in-situ data from L1 are mandatory for SWE services

L1

Collaboration and coordination with international partners:

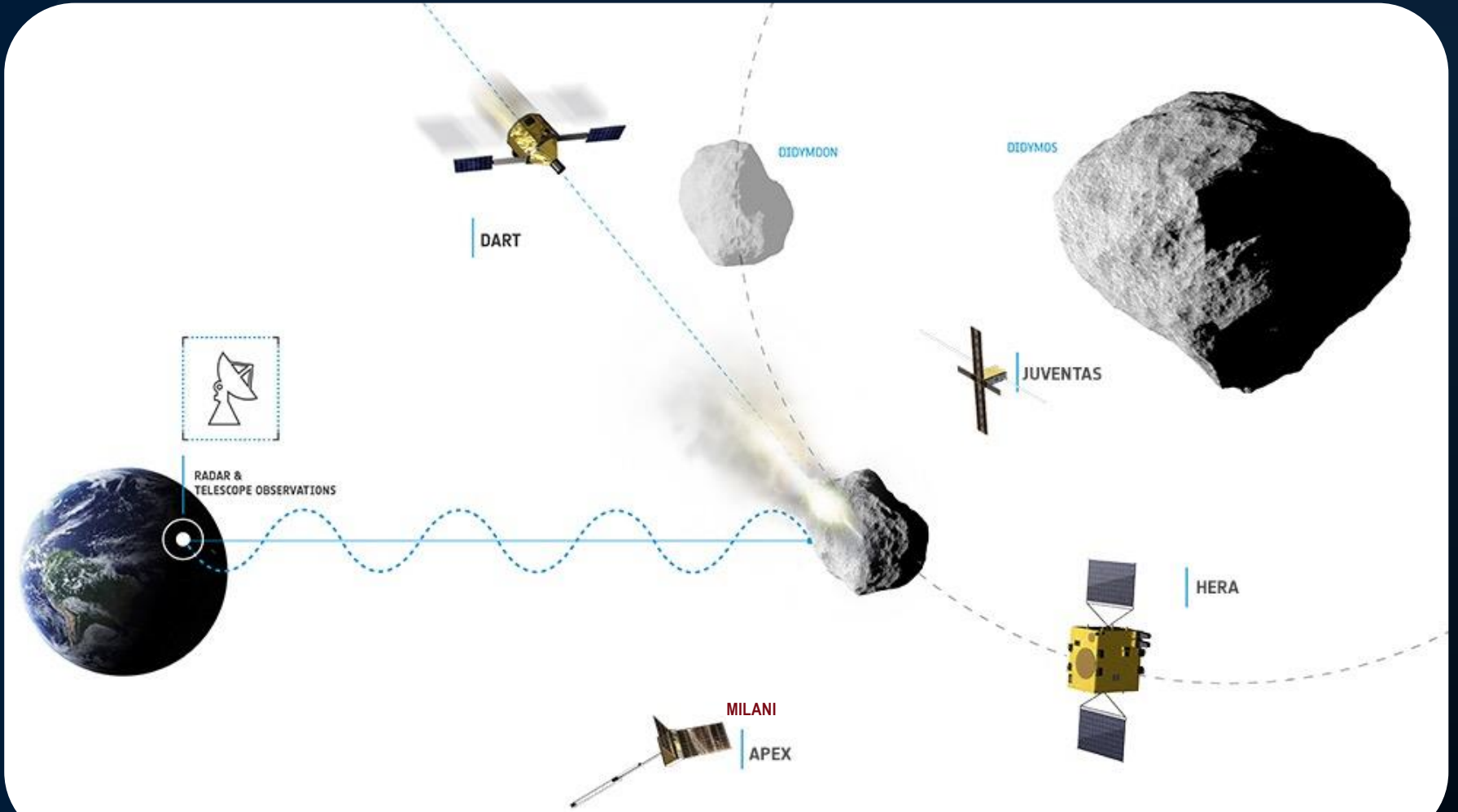
- **ensured continued availability of L1 measurements**
- **Implementation of L5 mission**

Data from L5 can substantially improve SWE forecasting capability

- Solar corona monitoring
- Heliospheric imaging
- Solar disc magnetic field
- EUV imaging
- In-situ measurements

L5

HERA: intl. collaboration with NASA



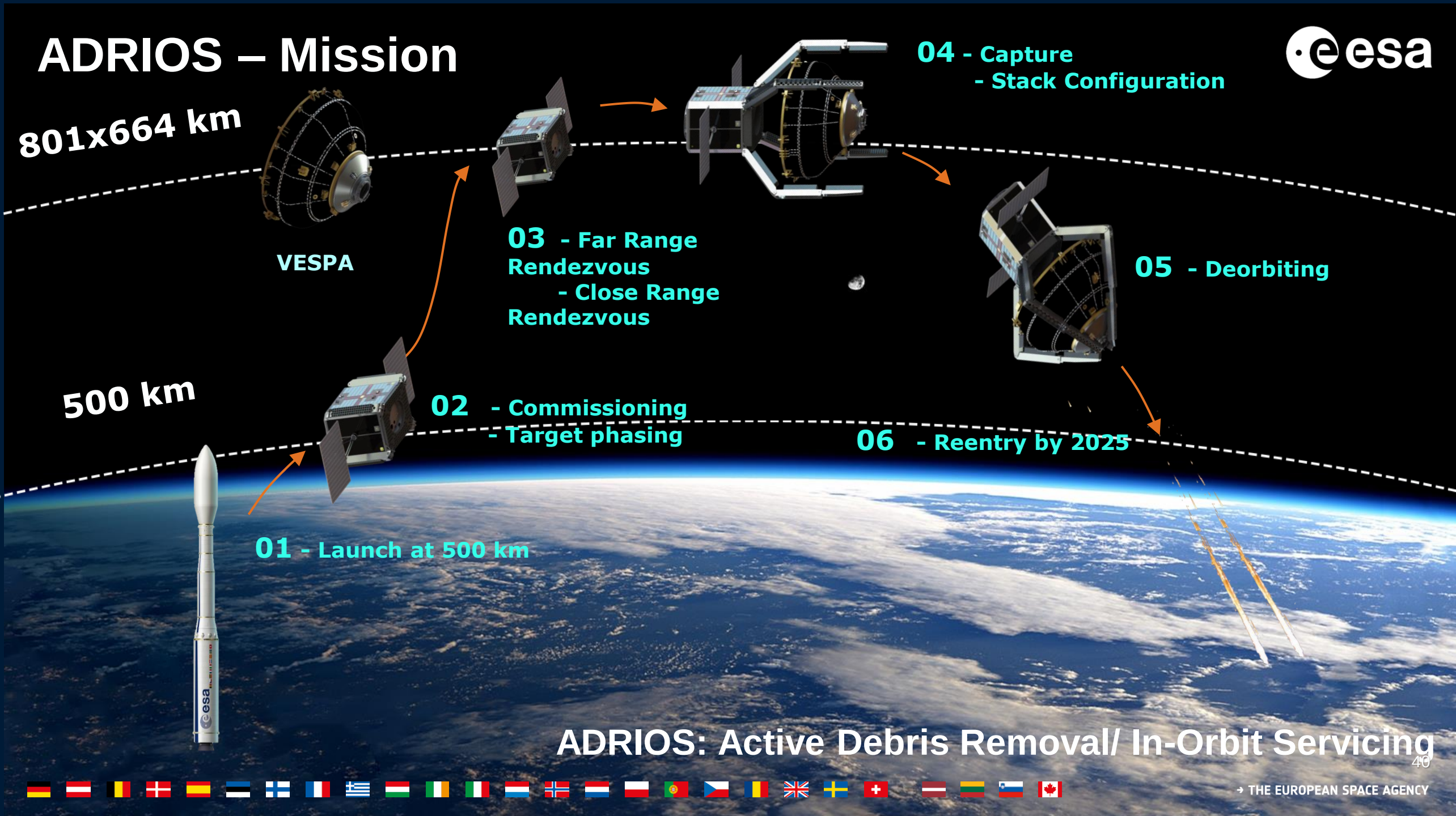
HERA is ESA's contribution to AIDA (Asteroid Impact Deflection Assessment)

HERA mission firsts

- First mission to **binary asteroid**
- **Smallest asteroid** ever studies
- First full scale **cratering physics assessment**
- First **radar tomography of an asteroid**

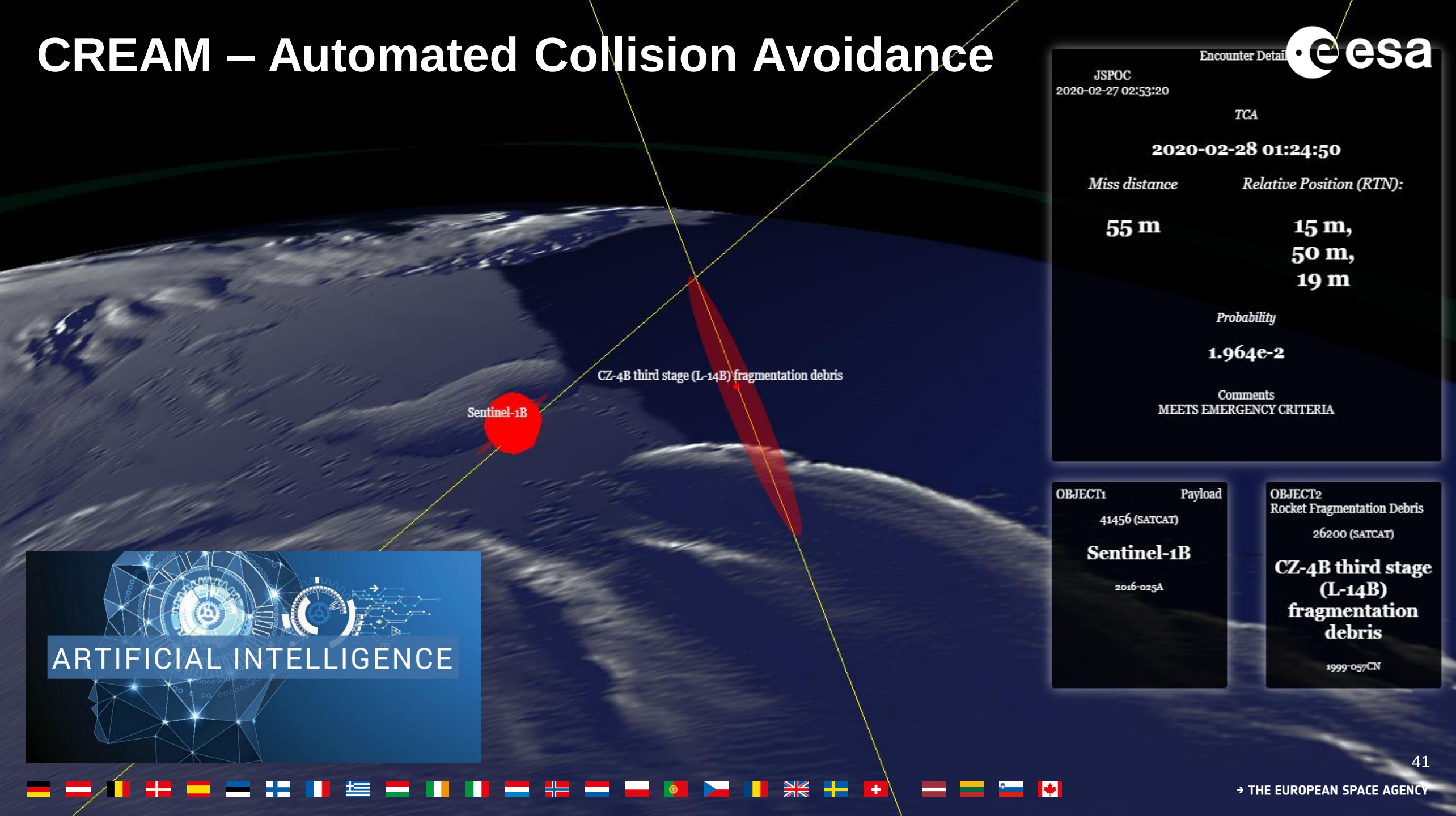
"kinetic impactor" validation = impactor (NASA/DART) + observer spacecraft (ESA/Hera) retrieve physical and dynamical parameters of Didymos to validate numerical impact codes

ADRIOS – Mission



ADRIOS: Active Debris Removal/ In-Orbit Servicing

CREAM – Automated Collision Avoidance




esa
THANK YOU
MAKE SPACE FOR EUROPE
www.esa.int
→ THE EUROPEAN SPACE AGENCY