# Sustainable Space: an Earth Observation Programme perspective

## 2022 Clean Space Industry Days - 10th Oct. 2022

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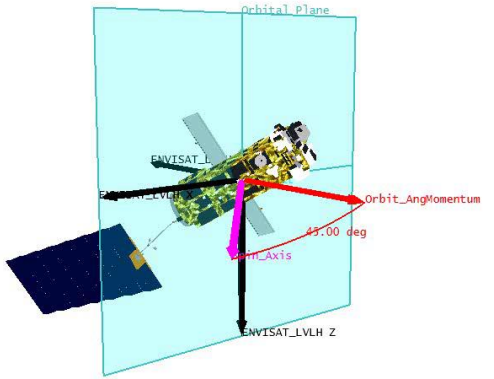
# Envisat - 8 tones tumbling - ALERT, ALERT !

Failure on 8th April 2012

- Launch on 1st March 2002
- Twice its design lifetime



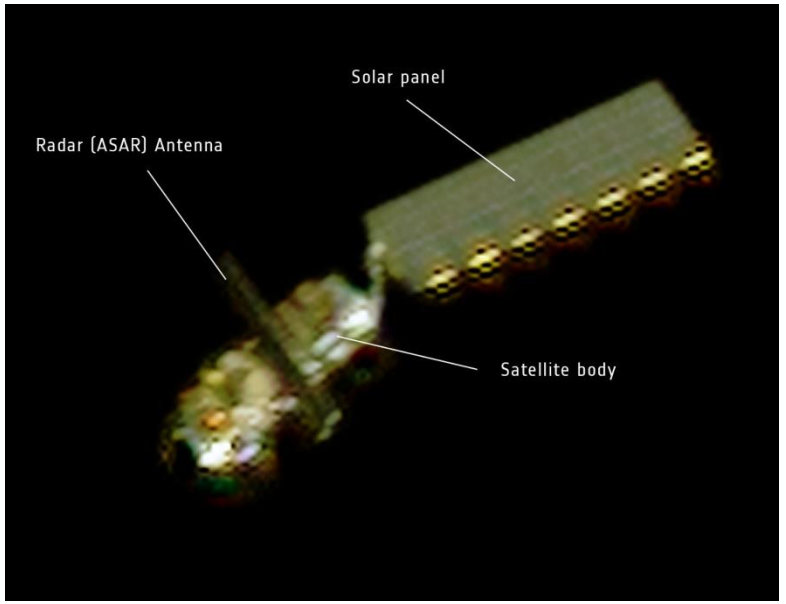




Image from Pleiades on 15th April 2012 (100 km away)

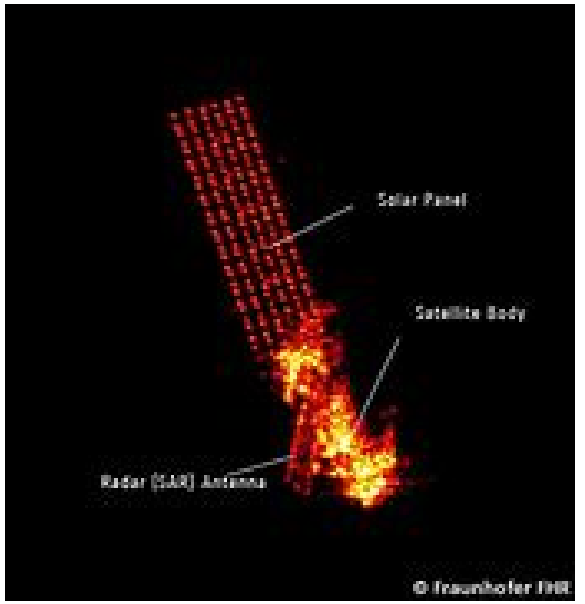
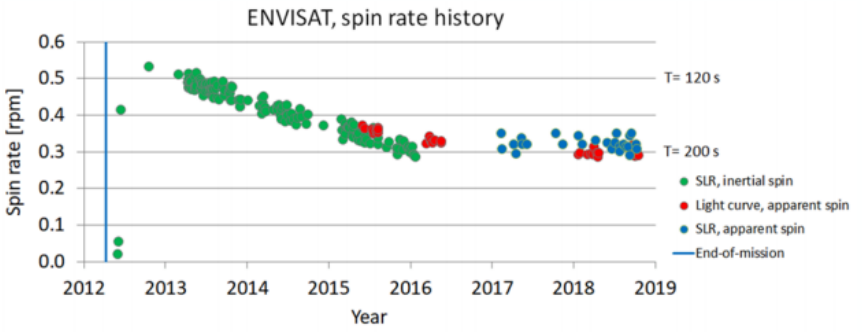



Image from ground based radar

**No capture interfaces**

**Debris objects spin ~ 2 deg /sec**

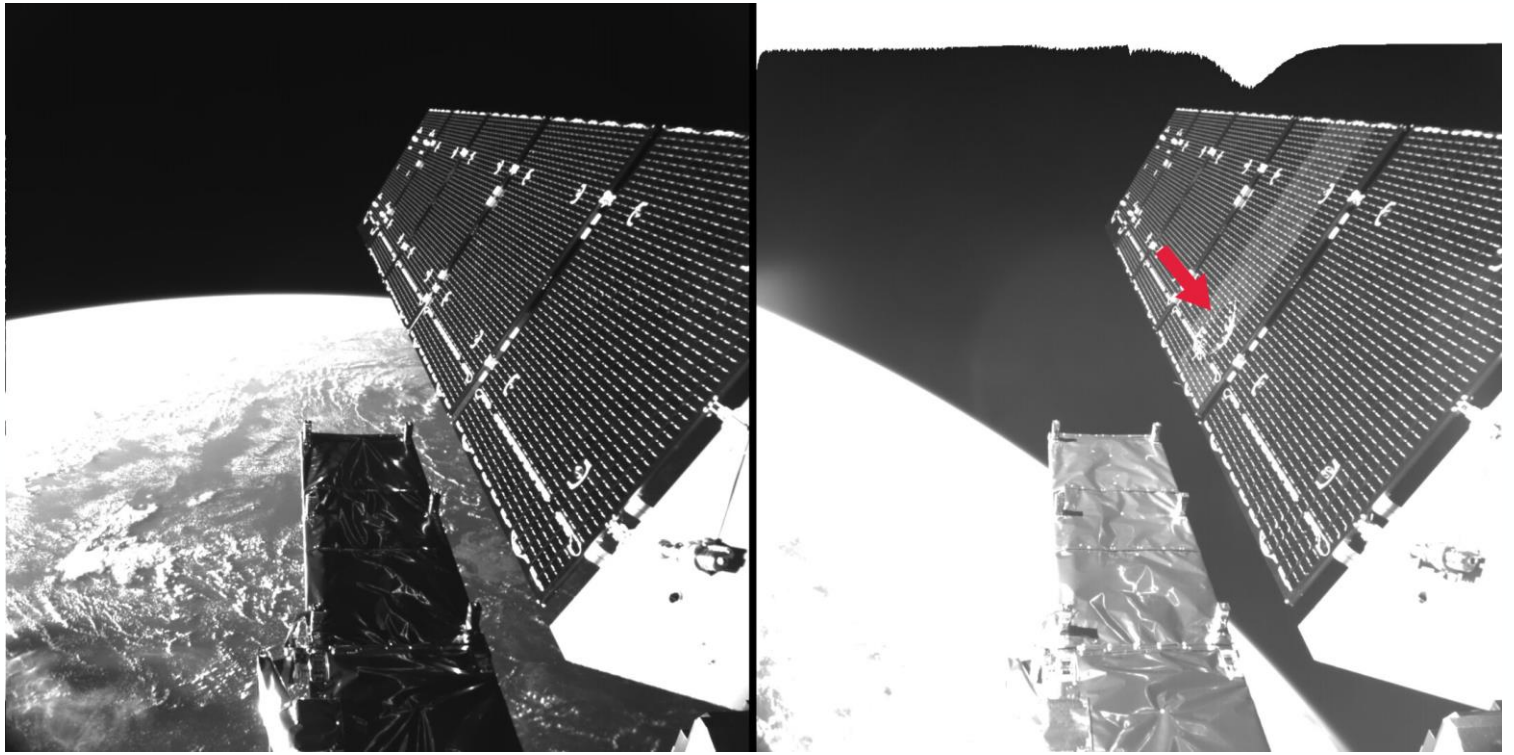


# Sentinel-1a hit by debris (23-Aug-2016)

40 cm diameter – damaged by < 5 mm particle

- Small Power loss
- Minor orbit change / orientation

At least 8 trackable fragments generated (>5 cm)



# Decadal Evolution in ESA Earth Observation

Preparing 21 + Developing 40 + Operational 14 + Heritage 6 = 81 Satellites (mostly in LEO)

2010

ERS-1
ERS-2
Envisat
MetOp-A
Meteosat 10 (MSG)
MetOp-B
Proba-1
SMOS
GOCE
CryoSat
Swarm
Proba-V
Sentinel-1A
Sentinel-2A
Sentinel-3A

2015

Meteosat 11 (MSG)
Sentinel-1B
Sentinel-2B
Sentinel-3B
Sentinel-5P
Sentinel-6 Michael Freilich
Sentinel-1C
Sentinel-2C
Sentinel-3C
Aeolus
EarthCARE
Biomass
CubeMAP
HydroGNSS
FLEX
CubeMAP
FORUM
Harmony
TRUTHS
MAGIC
Earth Explorer-11

2020

MetOp-C
MTG-I1
Sentinel-5A MetOp-SG-A1
Sentinel-1D
Sentinel-2D
Sentinel-3D
Sentinel-6B
CO2M-A
CO2M-B
CO2M-C
Sentinel-4A MTG-S1
CRISTAL-A
CIMR-A
ROSE-L-A
LSTM-A
CHIME-A
CRISTAL-B
CIMR-B
ROSE-L-B
LSTM-B
CHIME-B

2025

Arctic Weather Satellite
MetOp-SG-B1
MTG-I2

2030

Sentinel-5B MetOp-SG-A2
MetOp-SG-B2
MTG-I3
Sentinel-4B MTG-S2

Sentinel-1 Sentinel-2 Sentinel-3 Sentinel-6

Sentinel Next Generation Missions

Small Sats

Many in GSTP Fly

FSScat – Φ-sat-1 UPC

Mantis
OpenCosmos -+Satlantis

HyperField
Kuva + VTT

Φ-sat-2
OpenCosmos

MSCM
AerospaceLab

Hive
ConstellR

OroraFire
Ororatech

InCubed Commercial

IOD

Science esa

Copernicus European Union

Meteorology EUMETSAT

# EOP supports the four transversal pillars in the Zero Debris Approach

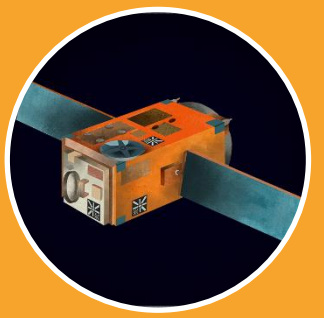
## 1. Evolution of ESA Policy

EOP will comply
(lead by example)

## 2. Upgrade platforms

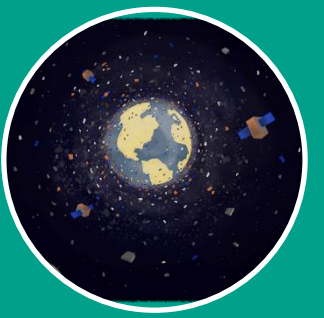
EOP supports and
will keep supporting:
System & Innovative technology

## 3. Removal services



Copernicus Expansion
already anticipating :
standard I/F & retro Reflectors

## 4. Improving operations

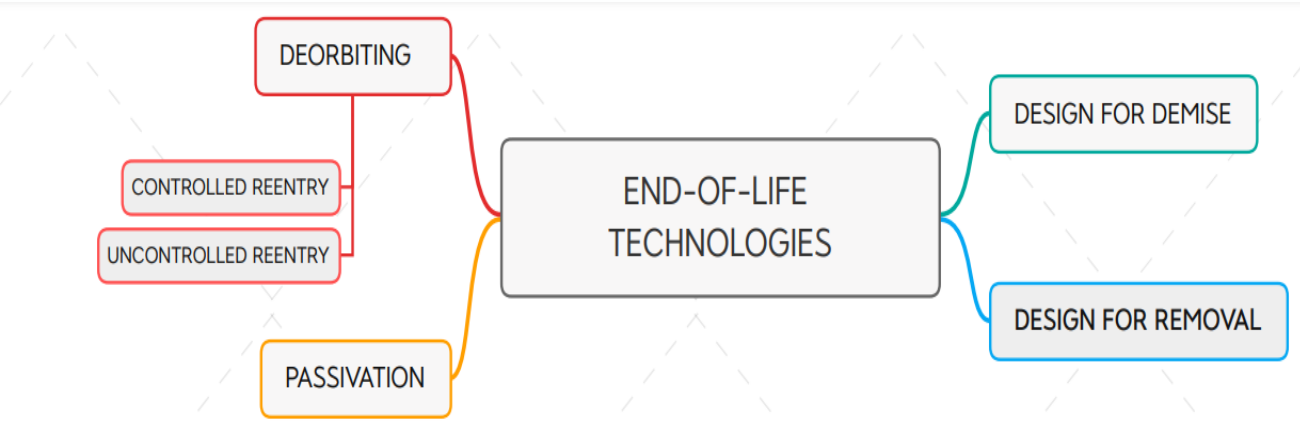


EOP already collaborating with
ESOC – Clean Space office

# What has been done until now (together with Clean Space Office)

3. Removal services

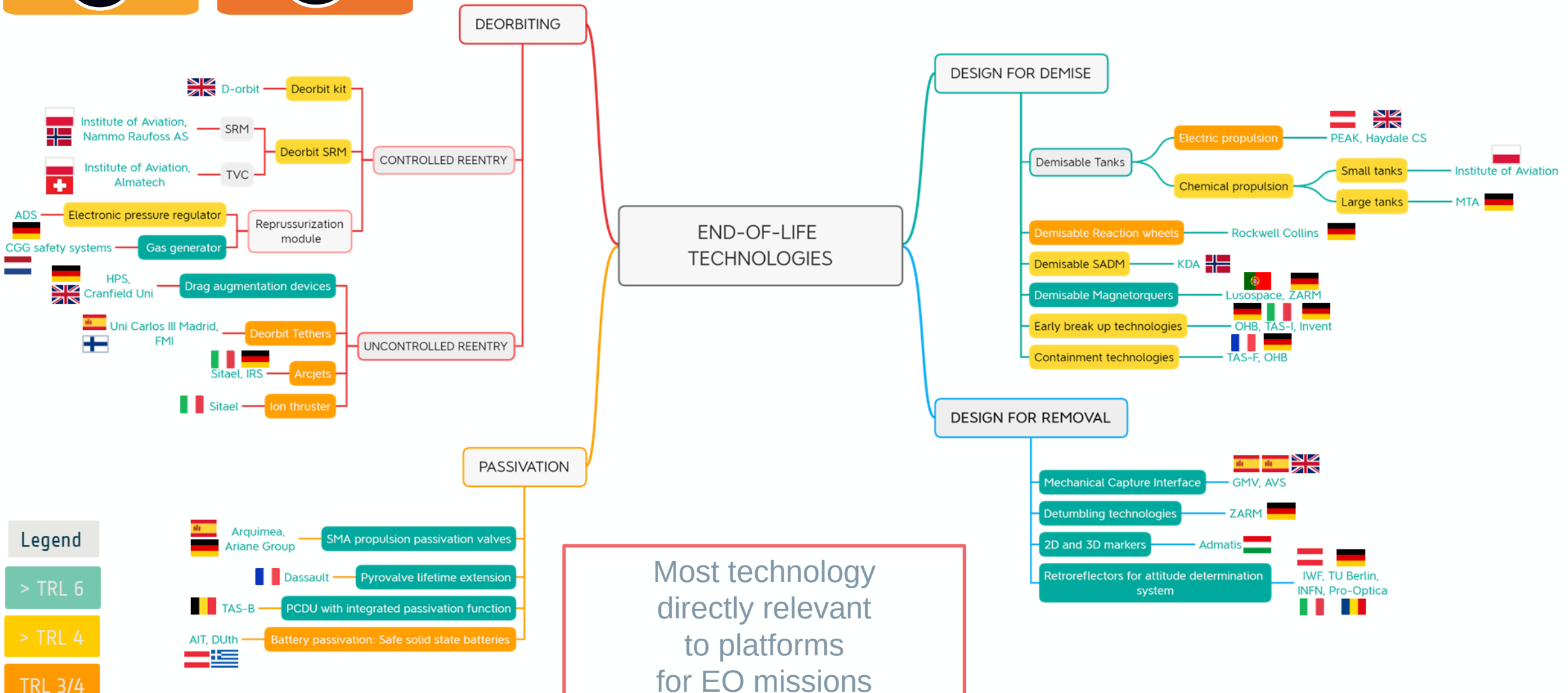
2. Upgrade platforms



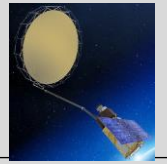
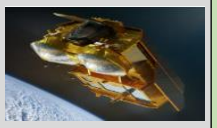
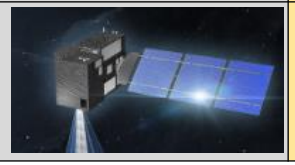
# What has been done until now (funded by FutureEO, TDE, GSTP, S2P)

3. Removal services

2. Upgrade platforms



# Copernicus Expansion Missions (in Ph.B2)

| Mission | Instrument | Orbit altitude Km | Reentry |
|---|---|---|---|
| **ROSE-L**  | SAR | 693 | Uncontrolled |
| **CIMR**  | RF Radiometer (large antenna) | 825 | Controlled |
| **CRISTAL**  | Altimeter | 750 | Controlled |
| **CHIME**  | Optical Hyperspectral | 630 | Controlled |
| **LSTM**  | Optical TIR | 651 | Controlled |
| **CO2M**  | Optical VNIR / SWIR | 735 | Controlled |

# What has been done until now in Earth Observation

Requirements (already in Ph.0) for all new EO mission

- ensure re-entry in less than 25 years : 2 options
  - removal from operational orbit
  - or **controlled** re-entry capability
- Passivation of all energy sources (also prevent re-activation)

Substantial progress made with Copernicus Expansion Missions:

- Life Cycle Analysis (LCA) introduced
- Passivation
- Initiated studies on demisable technologies
- Support for potential need of Active Debris Removal (ADR)

**Upgrade platforms**

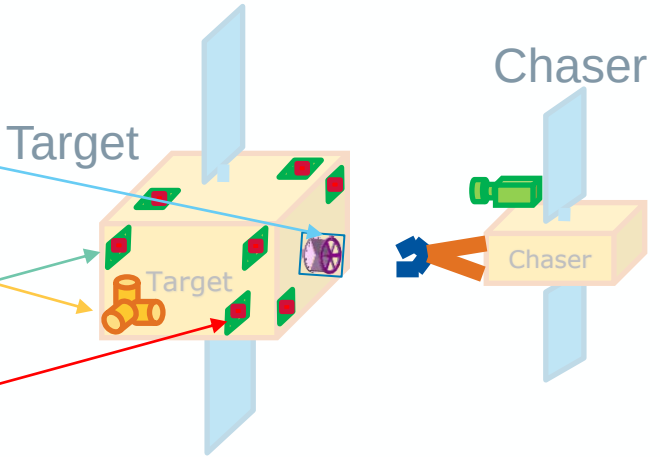
**Removal services**

- **Mechanical Interface for Capture**

- **Passive Magnetic Detumbling**
  - Short-circuit magnetorquers to detumble at EoL

- **2D & 3D Markers to Support Navigation** – to ease relative navigation

- **Retroreflectors Attitude Determination System**
  - enhance ground based attitude reconstruction



# Future EO Missions (Phase 0/A/B1)

| | Mission | | Phase | Instrument | Orbit altitude Km | Re-entry |
|---|---|---|---|---|---|---|
| Copernicus | S1 | NG | B1 | SAR | 693 | Not decided<br>Uncontrolled / Controlled ? |
| | S2 | NG | 0 | Optical | 786 | |
| | S3 Optical | NG | 0 | Optical<br>(2 Instruments) | 815 | |
| | S3 Topo | NG | A | Altimeter | 750 | |
| Research Missions | Harmony | EE-10 | A | Bistatic SAR | 693 | Uncontrolled |
| | CAIRT | EE-11 * | 0 | Optical | Range between 485 and 817 | Not decided<br>Uncontrolled / Controlled ? |
| | Nitrosat | | | Optical | | |
| | Wivern | | | Radar | | |
| | Seastar | | | SAR | | |
| | NGGM | MoO | A | Gravity | 397 | Uncontrolled |
| | CubeMAP | Scouts | B1 | Optical | 520 | Uncontrolled |
| | HydroGNSS | | B2 | GNSS-R | 550 | Uncontrolled |
| Earth Watch | TRUTHS | | B1-(Ext.) | Optical | 600 | Controlled |
| | Artic Weather Sat. | | C/D | MW Sounder | 595 | Uncontrolled |

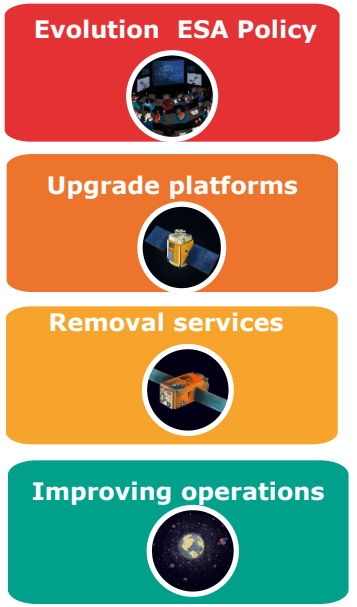
# Future Missions

**Continue support to technology developments using TDE, GSTP and FutureEO**

- Specific to EO  e.g. Demisable optical payload elements
- Not only EO:  e.g. tanks, Reaction wheels  (together with Clean Space Office)

**Need to increase capability / flexibility for EO projects**  (different system size / scenarios)

- **Upgrade platform:**
  - **Demisable**  off-the-shelf units (RW, Tanks, MTQ)  ➔  key technology enablers for **un-controlled**
  - **modularity** to add **controlled re-entry**, as necessary
- **Methods**: Already **in early mission phases** ➔  to include re-entry trade-offs of designs
  - "**life mission extension**"  &  "**operations**" procedures needed for informed decisions
- **Cost** is a concern : for the use of new clean **technologies / methods** (not affecting mission performance)




What's next ?  Need for a Top-down view for prioritisation

➔ **New Sys studies in 2023**  (under discussion with Clean Space Office and LSIs)

- Understand the implications of the **ESA Policy Evolution**
- Set up top-down methods / technology  priorities
- Facilitate adoption in Industry product line  (for ESA missions, and beyond)

# Take Aways

- EOP : committed to safeguard the Earth environment
  - EOP satellites monitor the Environment & support the application of environmental policies
  - EOP also aims at not generating more debris ➔ Leading by example

- EOP satellites are already in danger: e.g. Sent-1 debris collision in 2016
  - EOP supports the evolution of the ESA Policy
  - Support to develop methods / cost effective technology

- EOP already a pioneer in Copernicus Expansion missions:
  - Initiated LCA → to better understand the impact on the Earth Environment
  - Embedding some technologies to enable removal services

- EOP aims at going even further in future missions : in all 4 pillars of the Zero Debris Approach
  - aiming at clean and competitive Industrial product lines ➔ for ESA missions (and beyond)

4 Pillars of
Zero Debris Approach