30th AIAA/USU Conference on Small Satellites
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Purpose of ESA

"To provide for and promote, for exclusively peaceful purposes, cooperation among European states in **space research** and **technology** and their **space applications.**"

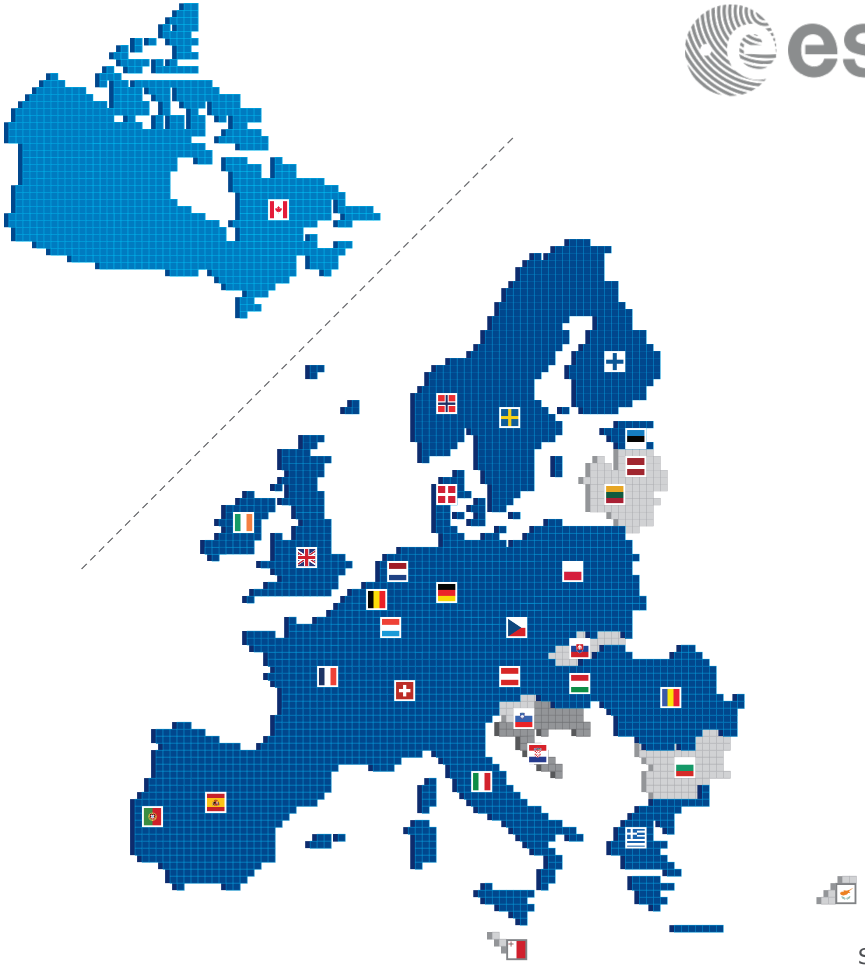
Article 2 of ESA Convention

Member States

ESA has 22 Member States:
20 states of the EU (AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, GR, HU, IE, LU, NL, PT, PL, RO, SE, UK) plus Norway and Switzerland.

Seven other EU states have Cooperation Agreements with ESA: Bulgaria, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia. Discussions are ongoing with Croatia.

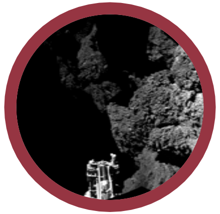
Canada takes part in some programmes under a long-standing Cooperation Agreement.



Activities

ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.

* Space science is a Mandatory programme, all Member States contribute to it according to GNP.


space science


human spaceflight


exploration


earth observation


launchers

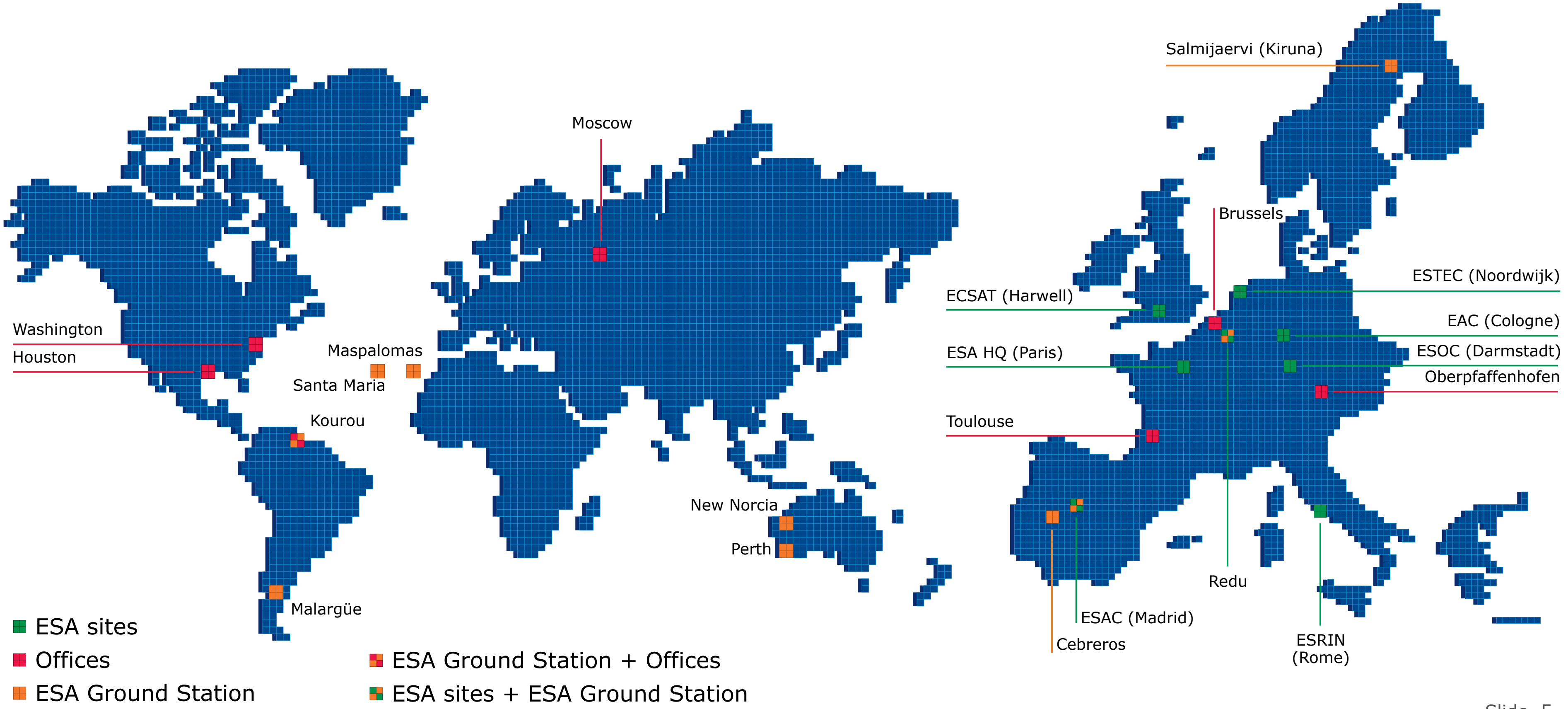

navigation


operations


technology

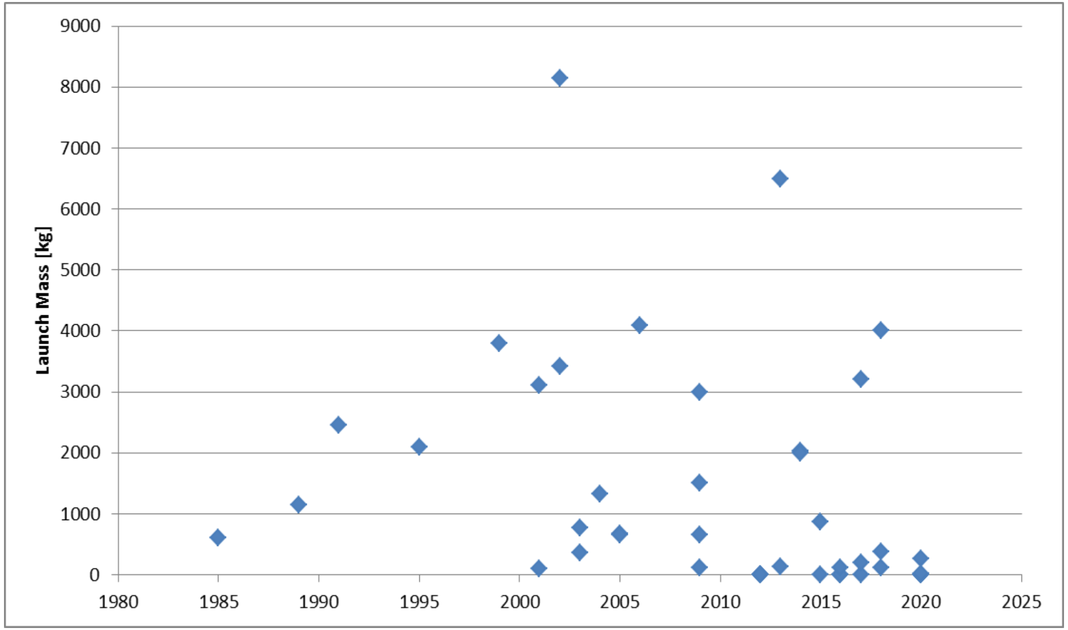

telecommunications

ESA's locations



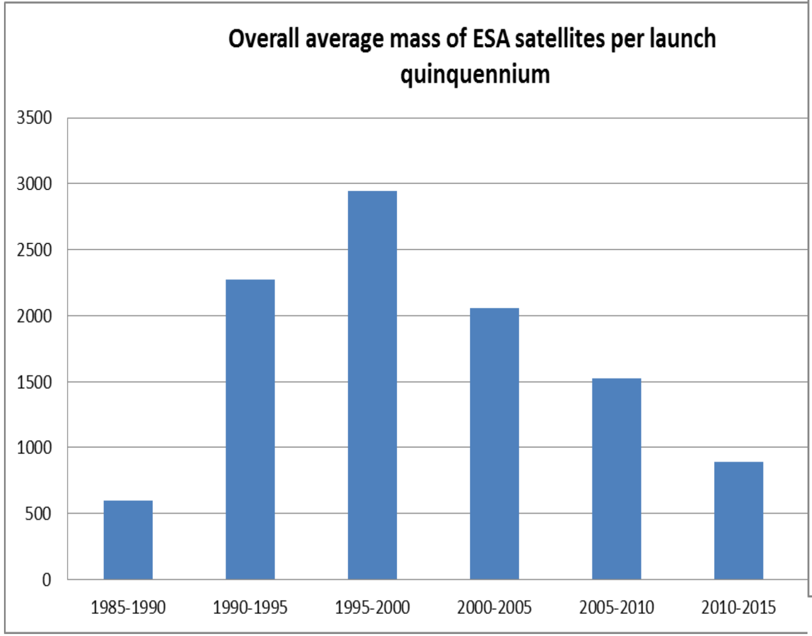
Some missions trends in ESA (1/3)

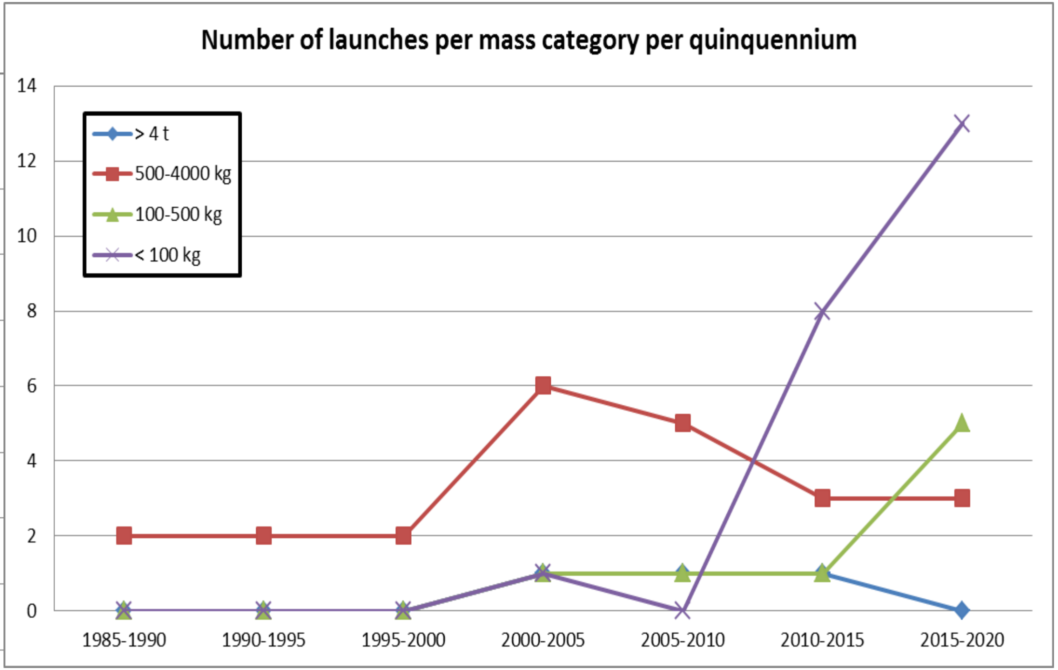
ESA missions are selected for a purpose, not to be large or small, the increase in type of missions confirms this. This picture does not include the ATV nor the Galileo and Copernicus constellations.



Some missions trends in ESA (2/3)

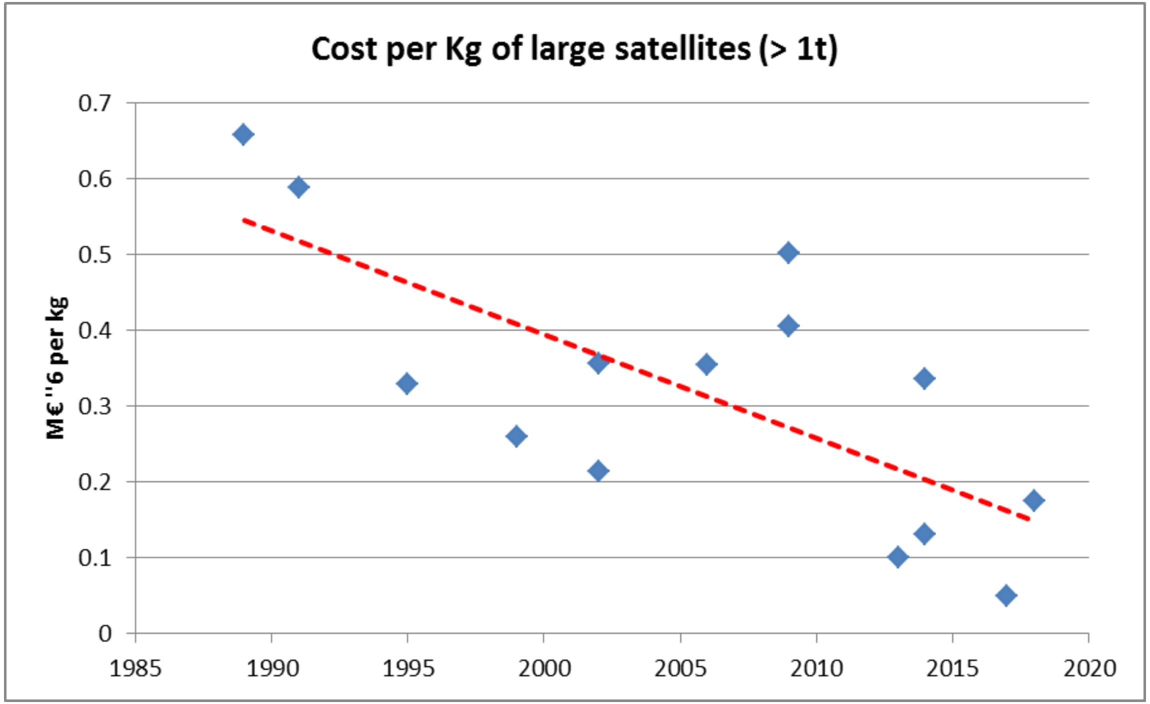
However, although by averages, we see a clear trend towards smaller and more frequent missions:





Some missions trends in ESA (3/3)

Cost-wise, large missions are getting cheaper, smaller missions are still more expensive on a per-kilo basis, but enable cost reduction on the larger ones.

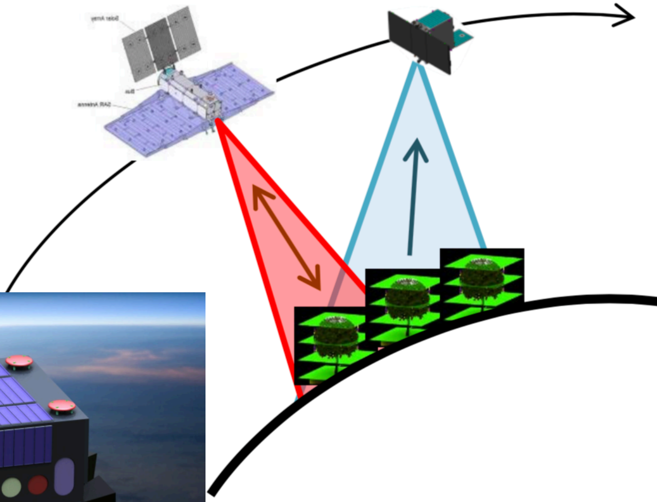


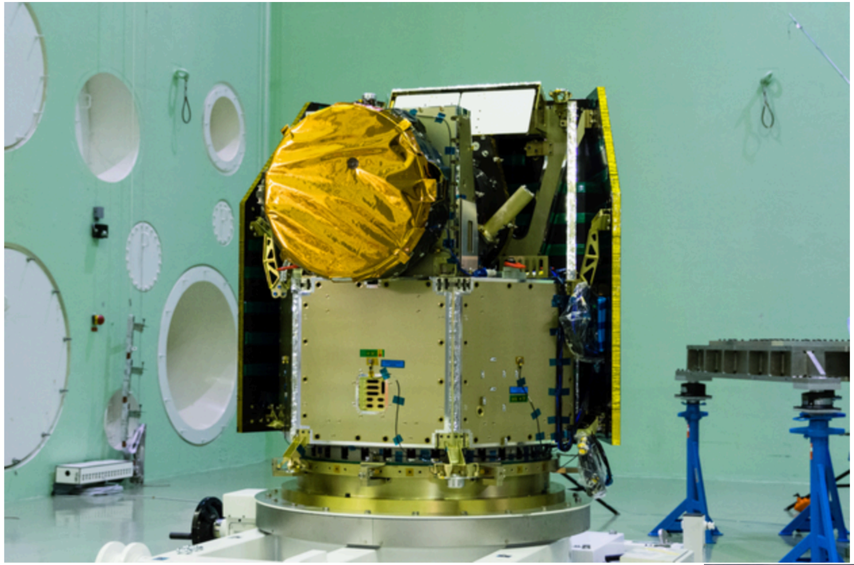
Small missions approaches in ESA (1/2)

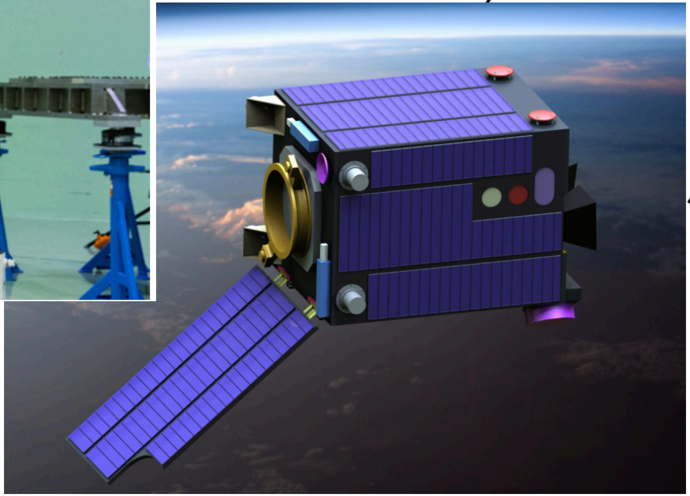
- Small missions allow to test new space technologies and techniques, typically In-Orbit Demonstration (Proba-1) but also opportunity to test new applications (Proba-V, AIS, ADS-B) or invest in new programmatic directions (AIM, GIOVE-A)
- They serve targeted scientific applications, Smart-1, Lisa Pathfinder, CHEOPS, S-Class missions from Science, or the proposed SAOCOM CS and ALTIUS from the EO, at lower cost and higher launch frequency.
- They help Member State industries moving toward delivering more integrated, complex space system, and ESA is often the natural partner for these Member States.

Small missions approaches in ESA (2/2)

SAOCOM CS







CHEOPS

ALTIUS

ESA's Experience in IOD – PROBA missions

PROBA 1 – 10/2001,

EO 3rd party mission for multispectral EO;

PROBA 2 – 11/2009,

1st SSA mission;

PROBA V (Vegetation) – 5/2013,

1st Copernicus operational

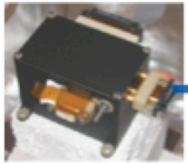
PROBA 3 Formation Flying – 1QTR 2019

"Small missions" (1,2,V) of ~100 kg class (Proba 3, 2x)

Designed to demonstrate in orbit platform and payload technologies,

Example of IOD benefits, Proba -2

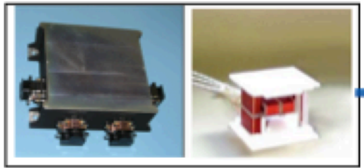
Long term:
- Future missions,
- First SSA mission providing SWE data with SWAP



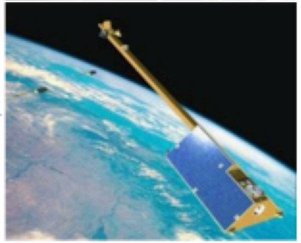
Credit Card Magnetometer

ADM-AEOLUS

ESA's Wind Mission



Science Grade Vector Magnetometer



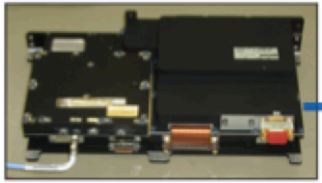
SWARM

ESA's Magnetic Field Mission

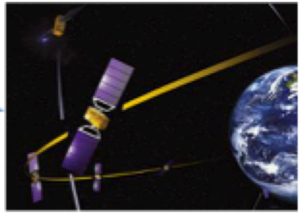
Bepi Colombo Star Tracker

BEPI COLOMBO

ESA's Mission to Mercury

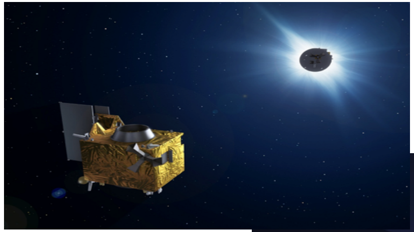


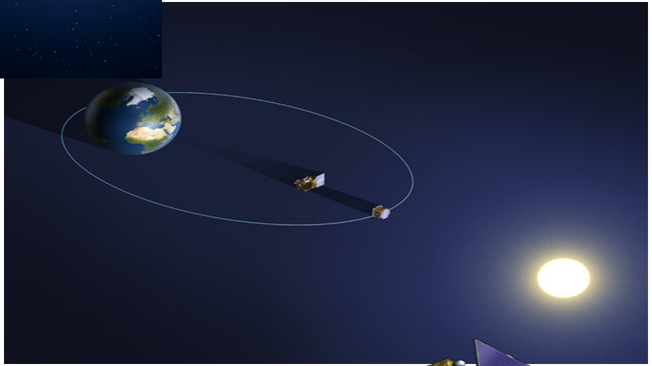
Topstar GPS

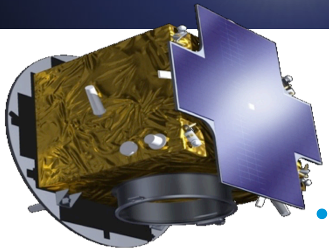


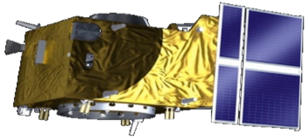
New generation GPS, with increased accuracy (L2C band). To be used on future missions

Breakthrough mission - Proba-3









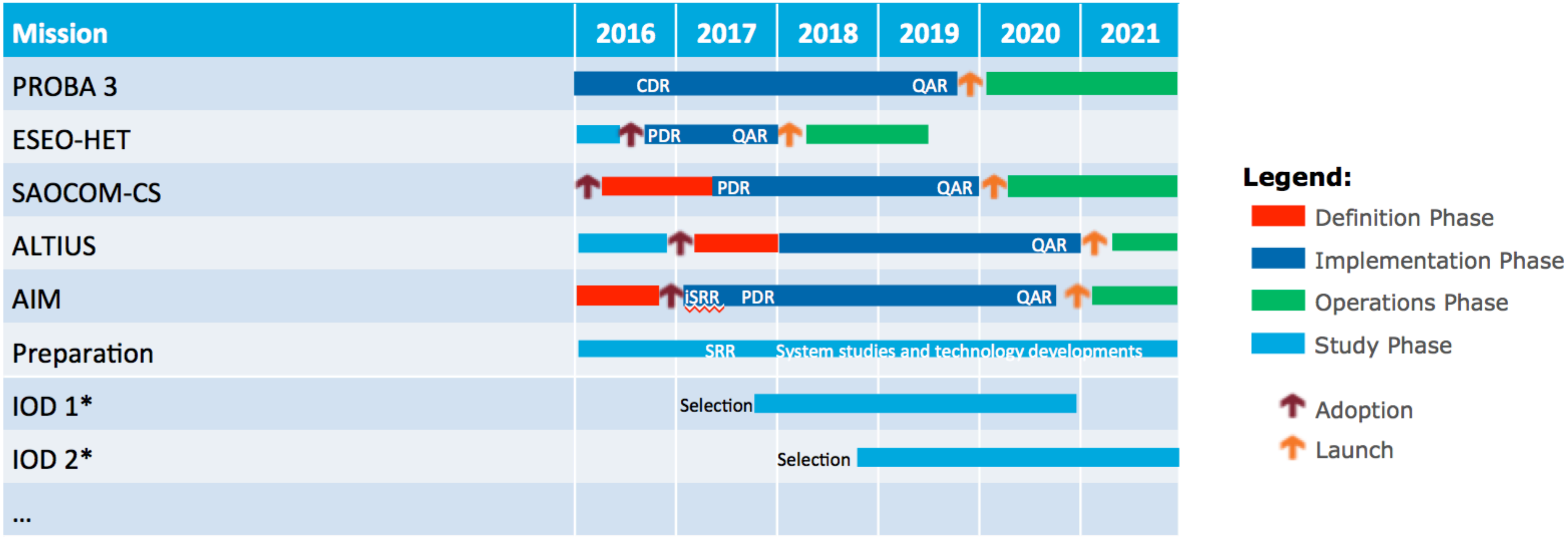
- Proba-3, in development
  - the power of 2 satellites to synthetise missions unaffordable to even the largest systems,
  - New architecture / system concepts, distributed instruments,
  - New technique: satellite precise formation flying, to overcome the limitations of monolithic or deployable structures,
- Two small satellites flying in formation 150 m apart with mm and arcsec precision to synthetise a giant coronograph

IOD mission - Proba-3

Proba-3 will demonstrate precise Formation Flying (FF) and distributed instruments, including:

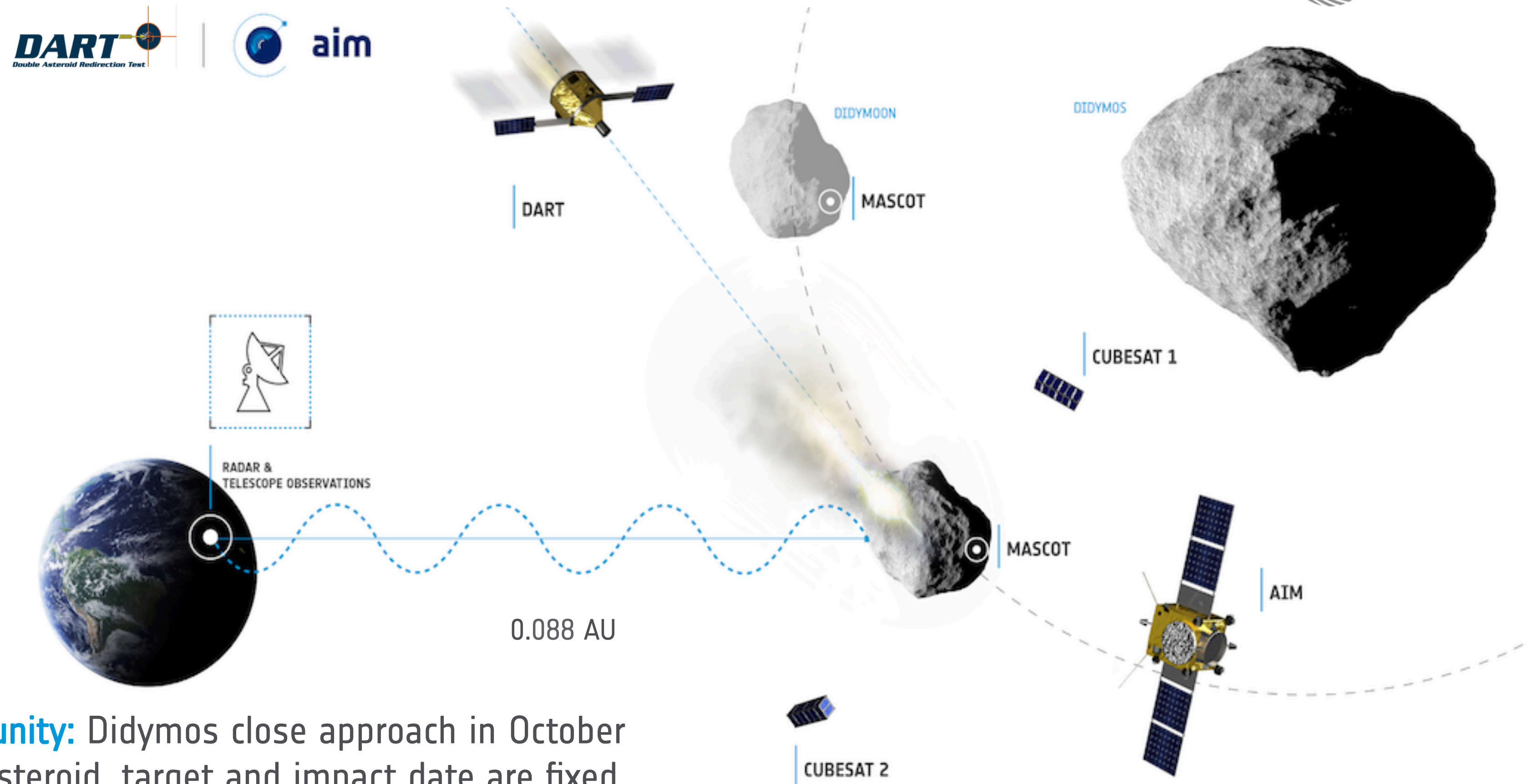
- ✓ Technology and products, for the formation flying itself, including space products and ground products such as FF system test bed for validation of future FF missions, 150 m distance and mm, arcsec precision.
- ✓ Techniques for research: coronagraphy: very large focal length telescopes, very long gradiometers and very large structures in space; e.g. for astronomy, planetology, remote sensing, etc.
- ✓ Techniques for operations in orbit: FF, RV, proximity operations, convoy flying, very high precision relative navigation and control, as required for Exploration, CleanSpace, etc.
- ✓ Operation approaches, e.g. use of models, integrated system/SW

Schedule: small missions and breakthrough IOD



(*) Duration depends on IOD type (experiment, mission…)

AIDA COOPERATION



→ **opportunity:** Didymos close approach in October 2022 asteroid, target and impact date are fixed

AIM: AN OPPORTUNITY

→ SPEED

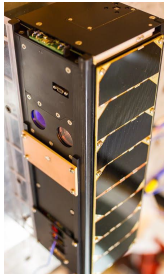
- Fast “return on investments”, 2 years (Ariane 6.2)
- Asteroid operations: 6 months, favourable for operations
- Demonstrate approach integrating platform-payload-operations teams for faster implementation

→ TECHNOLOGY

- Technology “firsts” enabling future:
  LEO spacecraft architectures (swarms) and applications, debris-removal, sample-return, and human exploration missions
- Based on currently funded developments for:
  laser comm, on-board autonomy, CubeSats, advanced GNC
- New industries to demonstrate technical capabilities in deep-space, steeping stone to future missions
- Demonstrate use of payload to support close-prox operations

COPINS – A case for cubesats in deep space

ASPECT



- Space Weathering
- Shock experiment
- Plume Observations
- Spectral observations

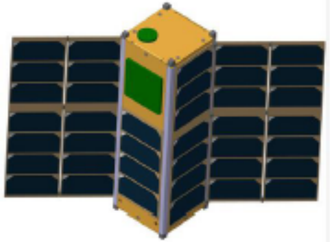
AGEX

- Mechanical properties of surface material
- Seismic properties of sub-surface
- Determine kinematics prior and after DART

PALS

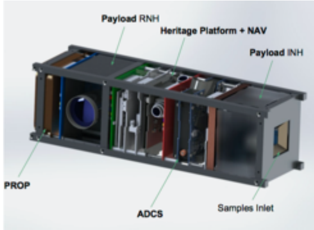
- Characterize magnetization
- Composition of volatiles
- Volatiles released from DART impact
- Super-resolution imaging
- DART collision and plume observation

CUBATA



- Gravity field
- Observe DART impact
- Perform seismology
- Velocity field of the ejecta

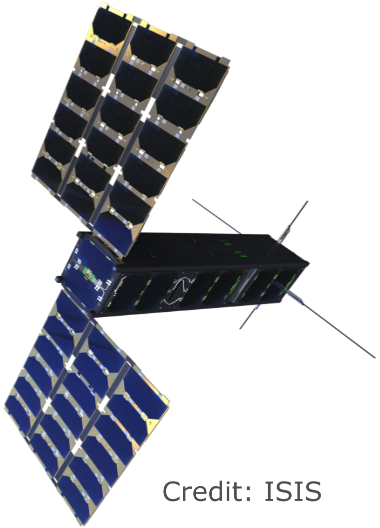
DUSTCUBE



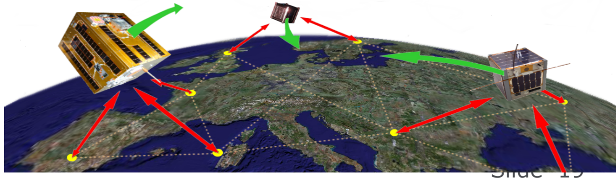
- Size, shape and ejected dust analysis
- Mineralogical composition
- Compliment com demo
- Measure the BRDF of the asteroid surface

CubeSat and IOD

- CubeSats serve several objectives in the context of IOD at ESA:
  - A driver for drastic **miniaturisation** of systems
  - An opportunity to **demonstrate** innovative technologies in orbit at a **low cost** and **fast pace**
  - An opportunity to carry out **distributed in-situ measurements** of the space environment simultaneously
  - Potential to deploy small payloads in a **constellation or swarm system**, where the potential deficit in performance may be largely compensated by the multitude of satellites



Credit: ISIS



ESA’s First IOD CubeSat in Space

Project: GOMX-3

Contractor: GomSpace DK

Platform: 3U CubeSat (3 kg)

Duration: 1 year KO to flight readiness

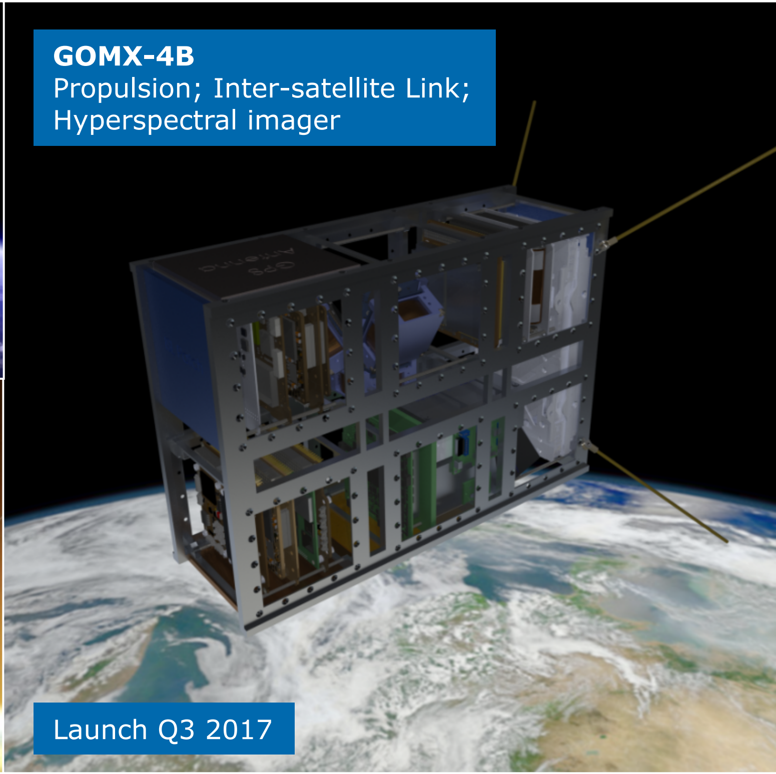
Deployed from ISS: 5 October 2015

Status: Fully operational, mission success

Achievements:

- 3-axis pointing <3° (3σ)
- X-band Downlink @ 3 Mbps
- Reconfigurable software-defined radio
- GEO Telecom L-band signal analysis
- ADS-B Aircraft tracking from a CubeSat

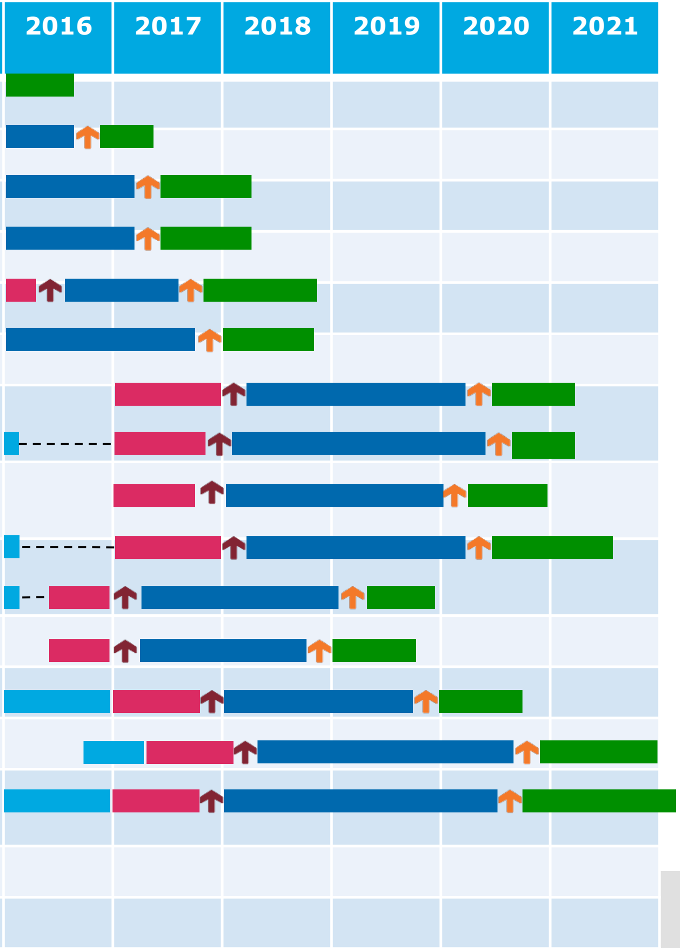
ESA IOD CubeSat Missions in development (1)



ESA IOD CubeSat Missions in development (2)

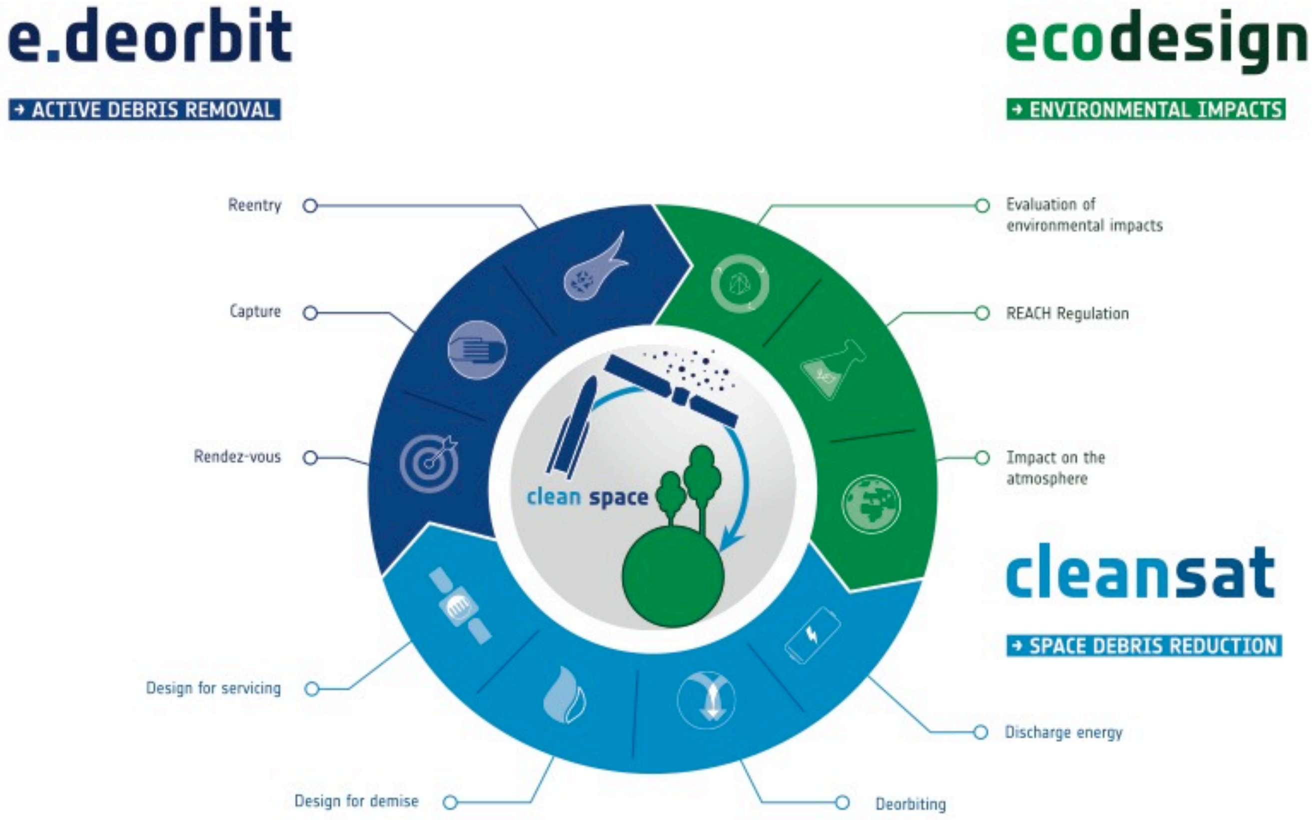
Schedule: IOD Missions (cubesats)

	Mission
Past/Ongoing projects	GOMX-3 RF comms tech demo
	QARMAN re-entry demo
	PICASSO atmospheric science demo
	SIMBA radiometric science demo
	GOMX-4B constellation tech demo
	OPS-SAT operations tech demo
Close Prox Ops	Rendezvous Autonomous CubeSats Experiment (RACE)
	Pre-capture Autonomous CubeSats Experiment (PACE)
	Formation Autonomous CubeSats Experiment (FACE)
Cons Pre-cursors	Compact optical EO demo
	Compact RF EO demo
	Space Weather demo (RadCube)
Beyond LEO	Astrochemistry & radiation demo GTO (SpectroCube)
	LUnar CubeSats for Exploration (LUCE)
	Near Earth Object CubeSats



Legend:
- Definition Phase
- Implementation Phase
- Operations Phase
- Study Phase
- Adoption
- Launch

CleanSpace in a nutshell



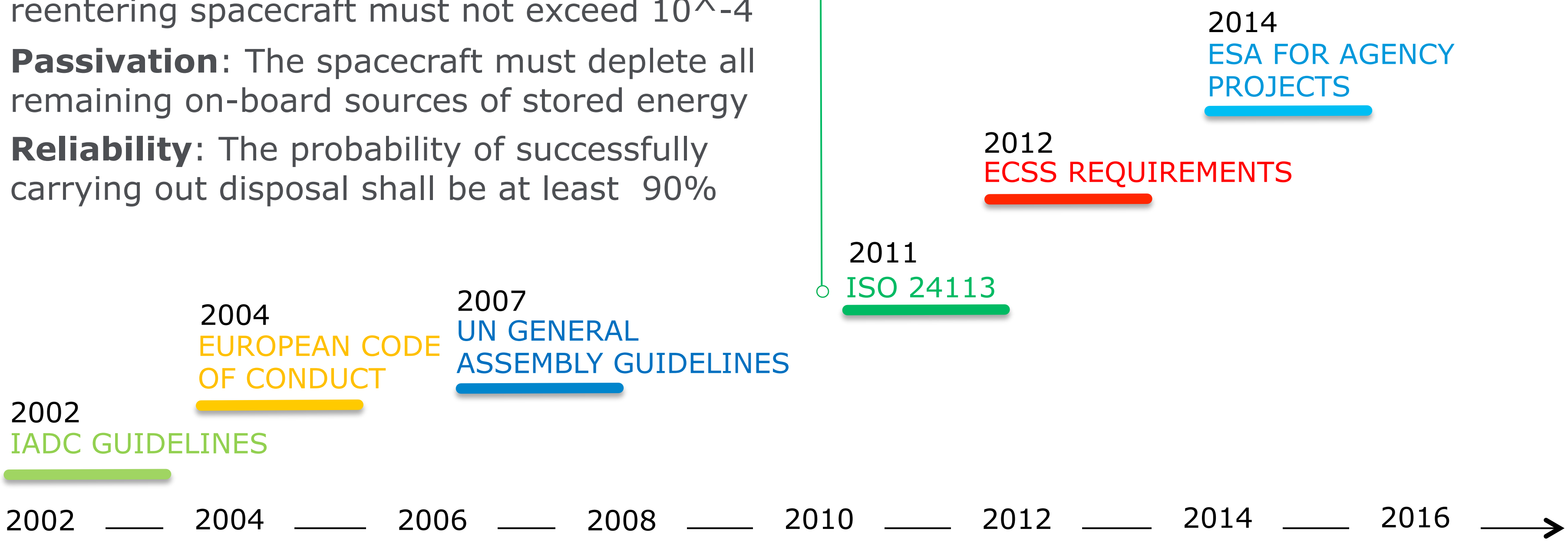
Space Debris Mitigation Requirements

EoL: LEO spacecraft must exit the protected region within 25 years of the end of mission

Casualty Risk: The on ground casualty risk of a reentering spacecraft must not exceed 10^-4

Passivation: The spacecraft must deplete all remaining on-board sources of stored energy

Reliability: The probability of successfully carrying out disposal shall be at least 90%



CleanSat, ESA’s response

to support European industry in complying with SDM requirements

→ DESIGN FOR DEMISE

The risk of casualty on ground shall not exceed 10^{-4}.
To ensure this S/C must be based on designs that demise upon re-entry

→ DEORBITING SYSTEMS

Satellites shall be removed from LEO within 25 years after their end-of-life;
Ideally without detracting from mission efficiency

→ PASSIVATION

At the end of life the satellite shall permanently deplete or make safe all stored energy, namely propulsion and power subsystems

Coming soon:
LUnar Cubesats for Exploration (LUCE)

ESA SysNova Challenge #4

- Open competitive ITT
- Expected Q3 2016
- Proposals from joint academic/ industry teams
- New mission concepts involving Nano-sats/CubeSats operating either individually or in (mini)constellations
- Lunar orbit delivery & data relay provided by mothership
- Multiple parallel study contracts to be awarded (6 months duration)
- Prize: CDF study for the winner(s)

Themes:

1. Resource prospecting
2. Investigations into the environment and effects
3. Fundamental scientific research
4. Demonstrating new technologies and operational capabilities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