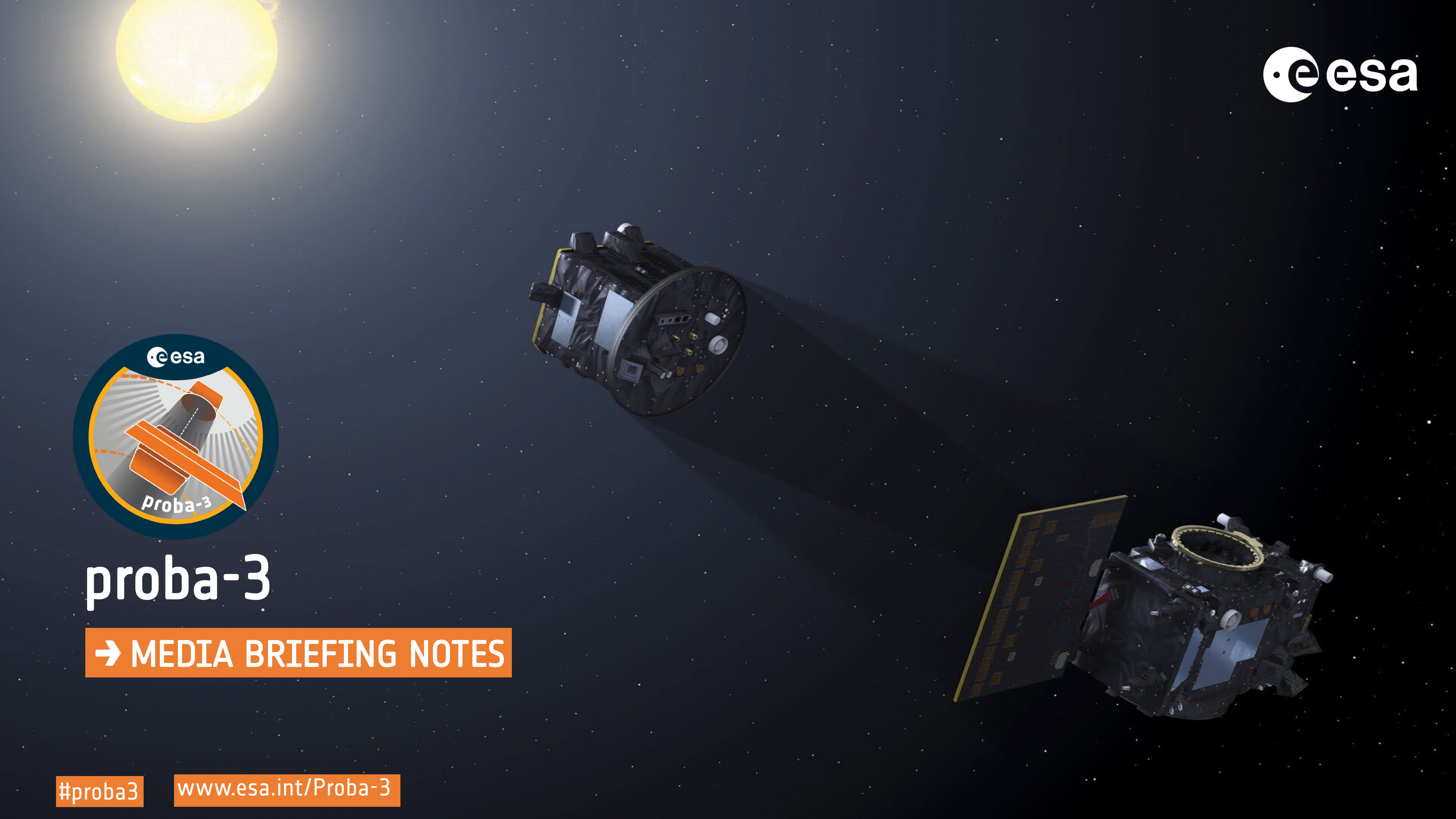


proba-3

→ MEDIA BRIEFING NOTES

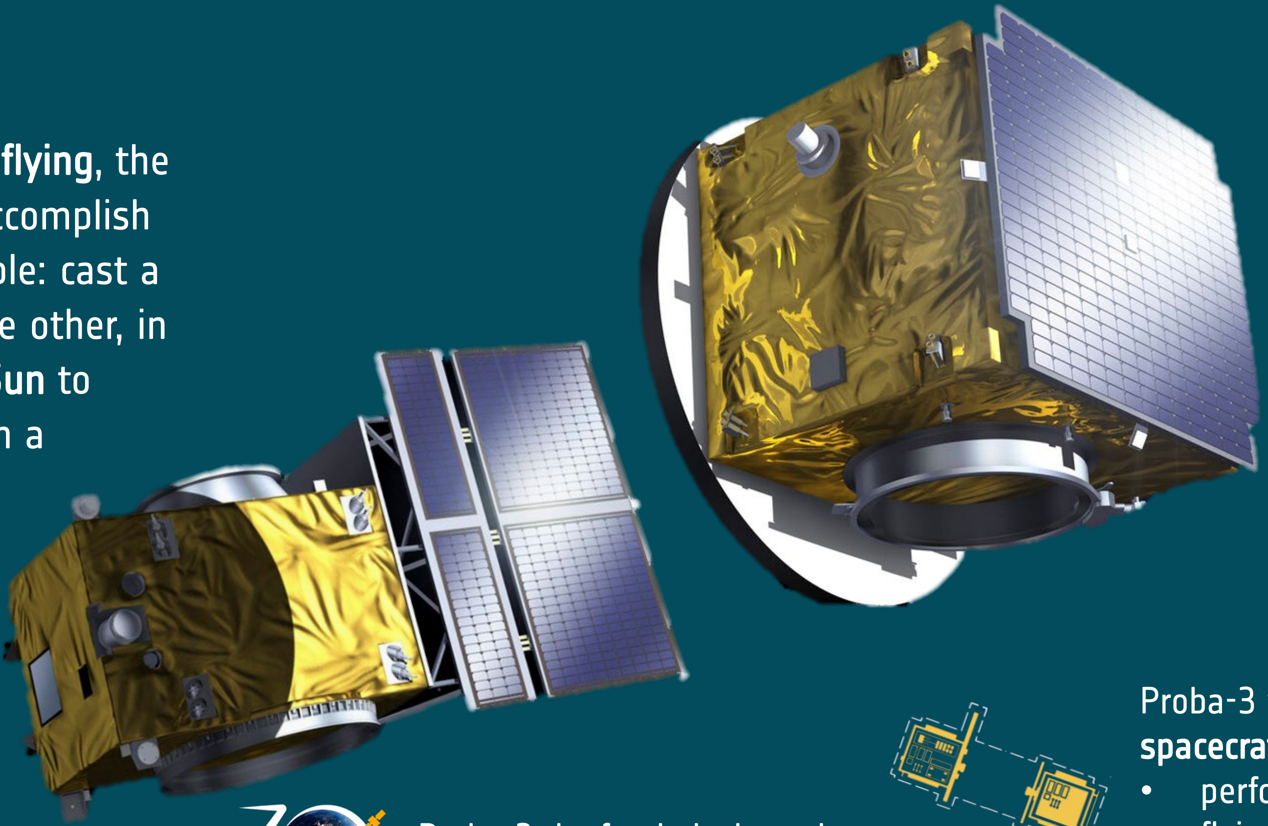
#proba3 www.esa.int/Proba-3

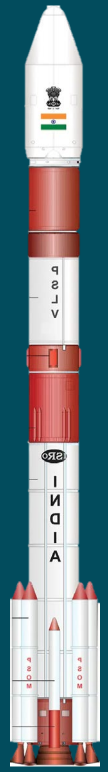
→ TOP THINGS TO KNOW ABOUT PROBA-3

1. Proba-3 is an ESA technology demonstration mission
2. It will mimic a natural solar eclipse
3. It marks the first time ever ESA will attempt the challenge of flying two spacecraft in precise formation together
4. The two satellites, the Occulter and the Coronagraph, will fly together autonomously to perform 6 hours of formation flying per orbit, 150m apart
5. Proba-3 will be on a highly elliptical orbit, around 60,000 km from Earth
6. Many new technologies were invented to make it possible, involving industries and companies throughout Europe, building experience and expertise

PROBA-3 in a nutshell

Through exquisite, **millimetre-scale, formation flying**, the **dual satellites** making up **ESA's Proba-3** will accomplish what was previously a space mission impossible: cast a precisely held shadow from one platform to the other, in the process **blocking out the fiery face of the Sun** to observe its ghostly surrounding atmosphere on a prolonged basis.

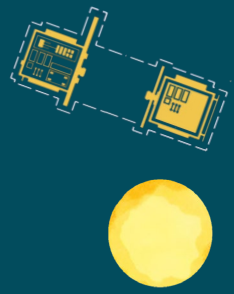




Proba-3 launches on a **Polar Satellite Launch Vehicle (PSLV)** from the Indian Space Research Organisation's Satish Dhawan Space Centre (SHAR) at the end of 2024.

Its destination is a **highly elliptical orbit** (600 x 60530 km at around 59 degree inclination).

Proba-3 is funded through ESA's General Support Technology Programme, which supports the development of technologies for ESA's future missions. 14 Member States and over 29 companies have participated in developing the mission.



Proba-3 will be the **first spacecraft** to:

- perform precise formation flying manouveres
- study the sun's corona this close to the solar rim

QUICK FACTS

esa

High elliptical Earth orbit
60 530 km from Earth

Spain and Belgium are the main contributors

SIZE
Coronagraph: 1x1.5m wide
Occulter: 1.4m diameter

MASS
Coronagraph: 314 kg
Occulter: 231 kg

NATURAL ECLIPSE
10mins study time
1.5/ year

PROBA-3 ECLIPSE
6 hours study time
50/year

DEC 2024
READY FOR LAUNCH

150m
Distance between spacecraft

14
Participating States and 29 industrial partners

19.7hrs
orbital period

6hrs
of formation flying

Mission antennas: VillaFranca & Maspalomas in Spain, and Hawaii

3
instruments onboard
Including the external coronagraph

ESA Ground Control Centre
Redu, Belgium

~200 million €

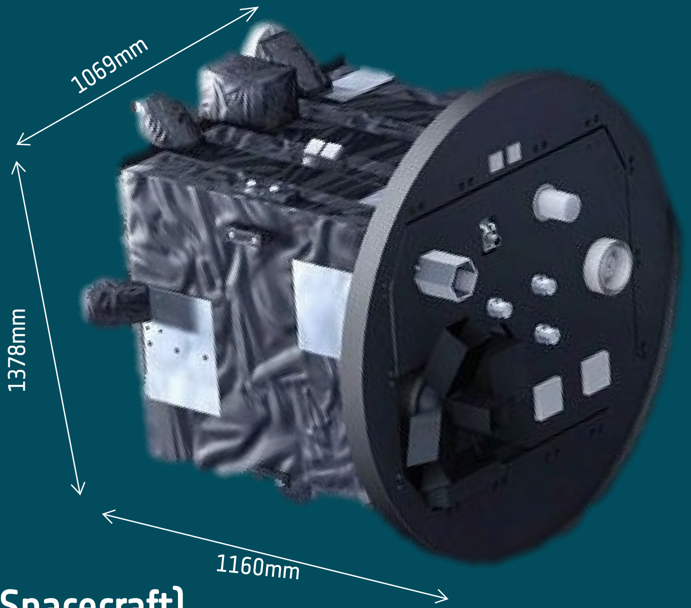
Millimetric position accuracy and arcsec accuracy in orientation

The two spacecraft

The two satellites have been designed with maximum commonality in design and configurations. Both spacecraft share the same power generation and on-board data handling system.

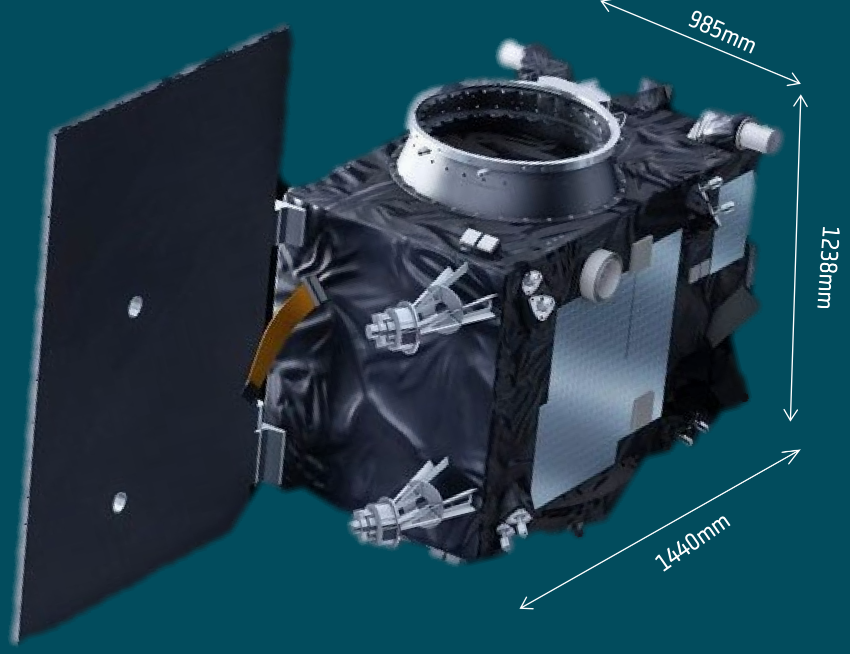
CSC (Coronagraph Spacecraft)

Like the Occulter, the Coronagraph Spacecraft is designed to always be pointing the same face at the Sun. The satellite has a mass of about 300kg. Particular care was taken to design the solar panel as it will often by in shadow when the Sun is eclipsed by the OSC. The design of the spacecraft is based on the asymmetric solar sail concept: a rigid support structure is used to position the single solar panel outside the shadow. During launch, the deployable solar panel is stowed against the rigid support structure. The CSC is responsible for performing the main orbital maintenance manoeuvres with monopropellant thrusters.



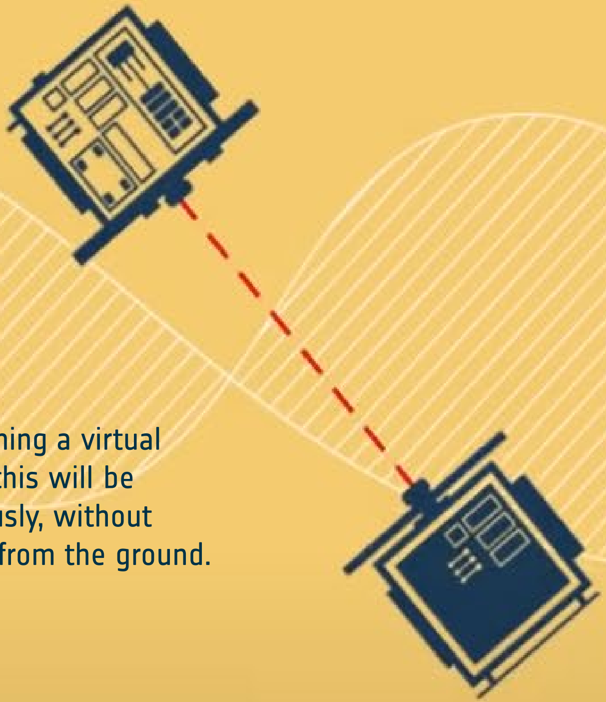
OSC (Occulter Spacecraft)

The OSC is designed to fly with the same face towards the Sun at all times. For the mission's science operations it acts as an occulting disc, creating a stable eclipse and leaving only the solar corona visible to the Coronagraph instrument located in the CSC. It weighs about 250 kg. The Occulter spacecraft structure is essentially a cube with all the avionics and instrument equipment mounted on the inner panels and with the occulter disc on the anti-Sun face. The OSC is responsible for performing the high accuracy actuation formation control using cold gas milli-Newton thrusters.



→ Formation flying – technology testing

The two satellites making up Proba-3 will **operate in formation as if they were a single giant-sized space mission**. They will achieve **an order of magnitude better relative positioning than ESA's ATV space truck**, which docked autonomously with the International Space Station with centimetre-level precision.



The pair will be forming a virtual giant satellite. And this will be achieved autonomously, without relying on guidance from the ground.

The satellites will repetitively demonstrate acquisition, rendezvous, proximity operations, formation flying, coronagraph observations, separation and convoy flying every orbit.

Star trackers will be used for absolute attitude determination for both spacecraft, co-located on a **rigid optical bench** with the other metrology systems. The Occulter will be equipped with **precision cold gas thrusters** – working at 10 millinewton scale – to precisely maintain the relative positions of the two satellites while the Coronagraph will incorporate a one-newton scale **monopropellant propulsion system** for all necessary manoeuvres.

The cost in fuel would be too high to maintain formation throughout the orbit, so each orbit will be divided between six hours of formation flying manoeuvres at apogee and the rest of the orbit will be spent safely passively drifting.

➔ ASPIICS – a coronagraph like no other

Proba-3 carries 3 instruments onboard. The most important is the coronagraph, called ASPIICS, which stands for Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun.

ASPIICS will address a long-standing scientific mystery:
why is the solar corona significantly hotter than the Sun itself?

ASPIICS will:

- **observe** the structure, dynamics and the heating process **very close to the Sun's surface**
- refine our understanding of the interaction between the Sun and its atmosphere.
- study **Coronal Mass Ejections (CMEs)**

The instrument is made of a large 1.4m diameter occulting disk mounted on the Occulter spacecraft and a solar coronagraph system carried by the Coronagraph spacecraft.

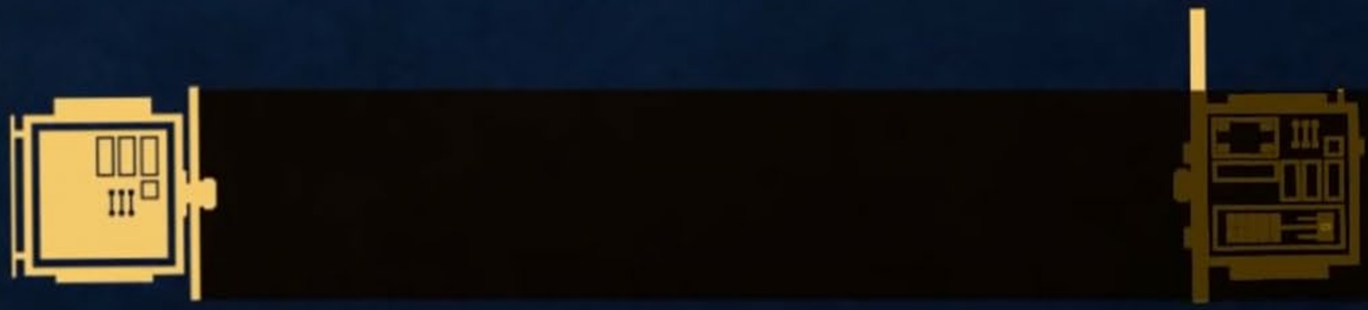
In addition to ASPIICS, Proba-3 will host **two other science payloads**:

The **Digital Absolute Radiometer** (DARA) is an absolute radiometer for measuring the total **Solar Irradiance**.

The **high-fidelity 3D Energetic Electron Spectrometer** (3DEES) is embarked as a a technology demonstration. It has been developed as a science-class instrument that will measure **electron spectra in Earth's radiation belt**.

➔ ECLIPSE MANOUVERES

Through exquisite, millimetre-scale, formation flying, the dual satellites making up ESA's Proba-3 will accomplish what was previously a space mission impossible: casting a precisely held shadow from one platform to the other, in the process blocking out the fiery face of the Sun to observe its surrounding atmosphere on a prolonged basis.

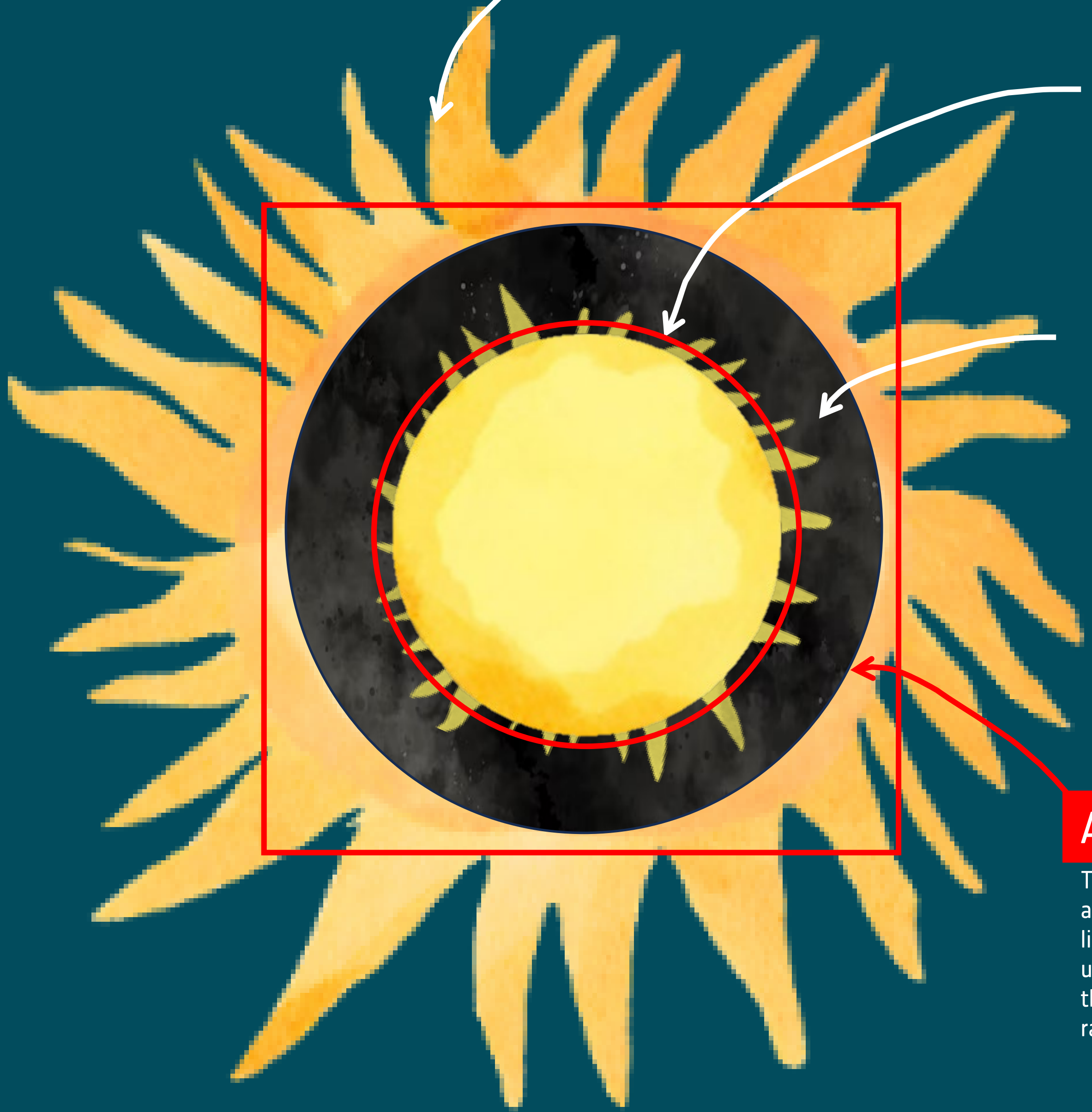


The Occulter, will fly closer to the Sun, lining up with it to block the most blinding light in the same way the Moon creates a shadow during an eclipse. Once the dazzling disc is hidden just the surrounding corona remains visible and the other satellite, hosting the specialist coronagraph instrument, will be able to photograph the inner part of the corona region and study its faint features.

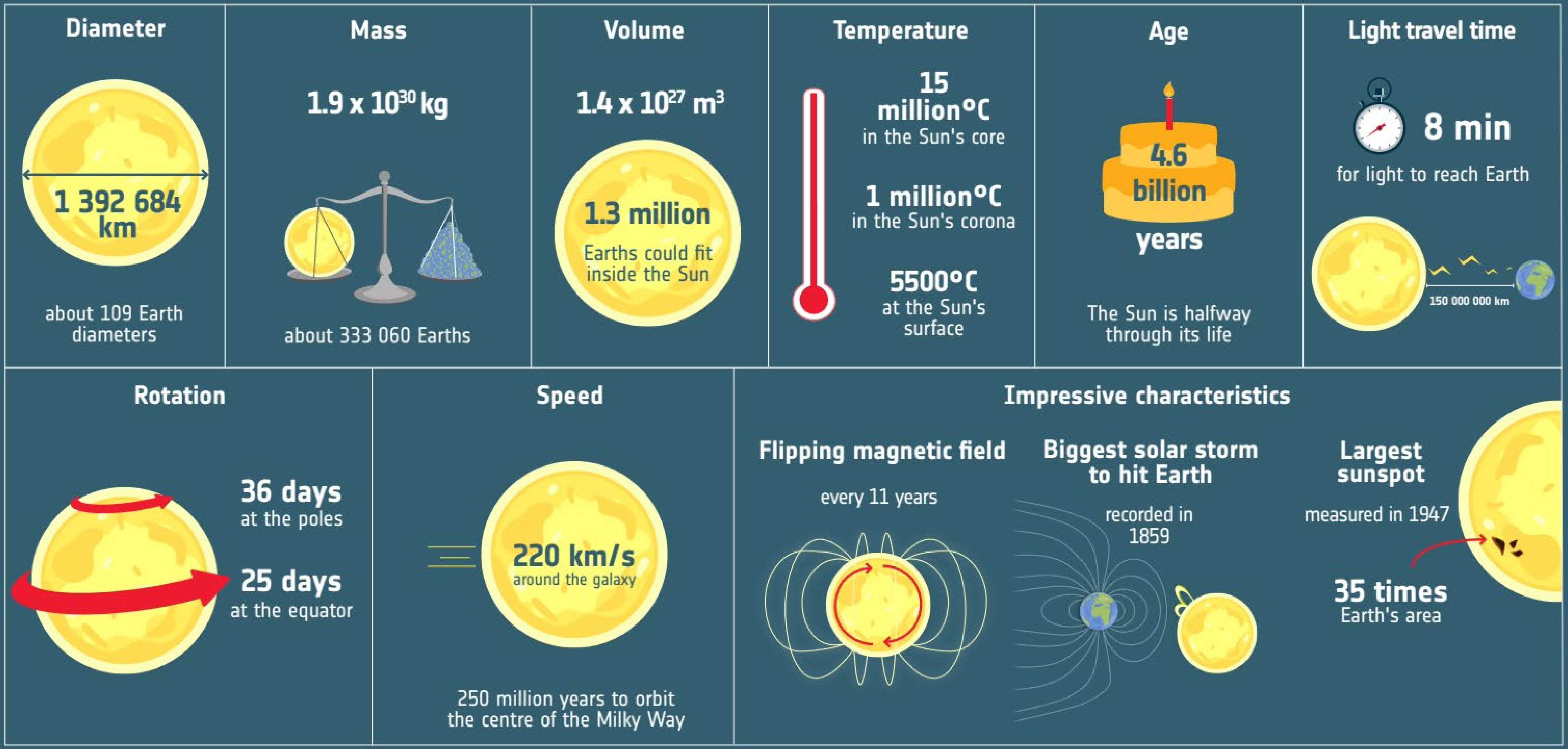
The two satellites will together form a **150-m long solar coronagraph** to study the Sun's faint corona closer to the solar rim than has ever before been achieved.

➔ ANATOMY OF THE SUN'S CORONA

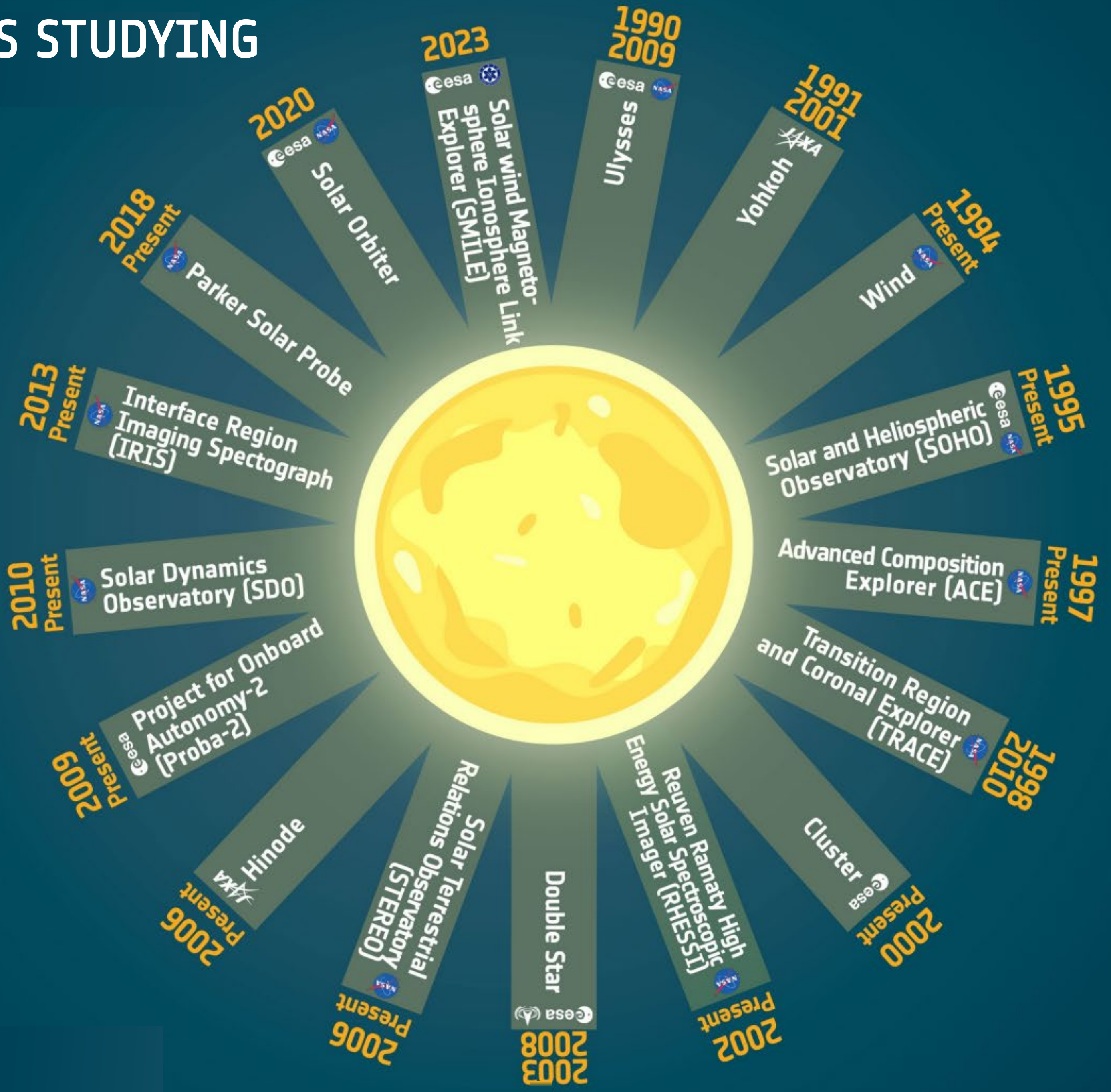
The enigmatic corona – much hotter than the Sun itself – is where space weather originates. We already have instruments that can study the Sun, the low corona and the high corona and several solar physics missions have probed the corona at these various temperatures and heights but between the low corona and the high corona there is a region, a gap, where observations are difficult to make. This region, within three solar radii, where the solar wind and coronal mass ejections are born remains largely unexplored, and extremely difficult to observe with sufficient spatial resolution and sensitivity to understand these phenomena.



→ MEET THE SUN


Diameter
1 392 684 km
about 109 Earth diameters
Mass
1.9 x 10^30 kg
about 333 060 Earths
Volume
1.4 x 10^27 m^3
1.3 million
Earths could fit inside the Sun
Temperature
15 million°C
in the Sun's core
1 million°C
in the Sun's corona
5500°C
at the Sun's surface
Age
4.6 billion years
The Sun is halfway through its life
Light travel time
8 min
for light to reach Earth
150 000 000 km
Rotation
36 days
at the poles
25 days
at the equator
Speed
220 km/s
around the galaxy
250 million years to orbit the centre of the Milky Way
Impressive characteristics
Flipping magnetic field
every 11 years
Biggest solar storm to hit Earth
recorded in 1859
Largest sunspot
measured in 1947
35 times
Earth's area

→ OTHER MISSIONS STUDYING THE SUN



➔ PROBA-3: MADE IN EUROPE

This **small but ambitious mission** is a collaboration **by ESA's smaller Member States**, in the process gaining valuable know-how and strengthening their national space sectors. The mission is being supported through ESA's long-established **General Support Technology Programme** – which **identifies leading-edge technologies and develops them for space readiness** – along with ESA's Science Directorate – Proba-3 is designated a Science **'mission of opportunity'**.

SPAIN

Sener in Spain leads the consortium while Spain's **Airbus Defence and Space** supplies the spacecraft platforms and **GMV** developed Proba-3's guidance navigation and control and flight dynamics

BELGIUM

Redwire Space is responsible for avionics, integration and testing. **Spacebel** is developing the mission software and simulation system while **Centre Spatial de Liège** contributes its ASPIICS coronagraph. Proba-3 will be operated in orbit from ESA's ESEC, the European Space Security and Education Centre, at Redu in Belgium, also home base for the previous Proba missions

POLAND

N7S has developed the ASPIICS software and **CBK** the payload electronics and filter wheels, with **Creotech** contributing electronics and **Sener** in Poland supplying mechanisms

ITALY

The mission solar arrays come from Leonardo while Italy's **National Institute for Astrophysics** developed the Coronagraph's shadow position sensor

SWITZERLAND

The **DARA** radiometer comes from the **Physical Meteorological Observatory and World Radiation Centre**

→ INDUSTRIAL PARTICIPATION

SPAIN
Sener: System Prime Contractor
Airbus DS: Spacecraft platform
GMV: GNC and Flight Dynamics
Crisa: Electrical Interface Unit
Thales: S-band transponder
Deimos: Mission analysis

POLAND
CBK: payload electronics, filter wheel
N7S: payload software
Creotech: electronics
Sener: mechanisms
GMV: relative GPS algorithm
Solaris Optics: polarisers
PCO: payload structure

ITALY
INAF: Shadow position sensor
Leonardo: solar panels
Aviotec: MLI

ROMANIA
IMT: Occulter position sensor
Comoti: MGSE

BELGIUM
Redwire: Spacecraft avionics, AIV, operations
Spacebel: software, simulator, GS
CSL: Coronagraph instrument
OIP: focal plane assembly
AMOS: laser optical head
Antwerp Space: RF baseband equipment

IRELAND
Onsemi: electronics

PORTUGAL
Tekever: Inter-satellite link
Deimos: in-orbit RDV experiment

CZECH REPUBLIC
Toptec: optics
Serenum: Front door assembly
Honeywell: gyroscope

AUSTRIA
Beyond gravity: GNSS receiver
ATOS: RF SCOE
Siemens: ground operations software

CANADA
NGC: GNC
MDA Space: laser metrology electronics
MSCI: reaction wheels

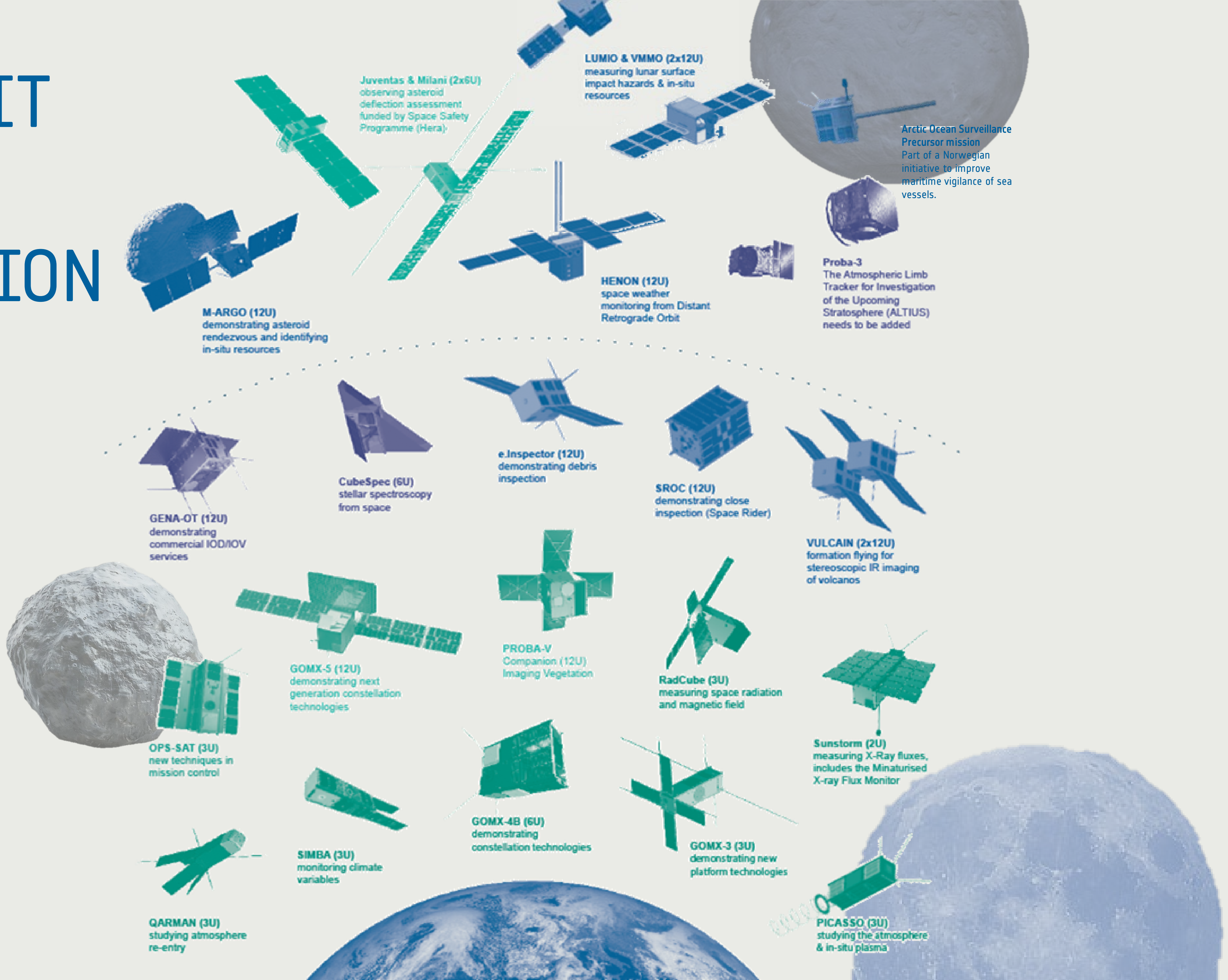
DENMARK
DTU: Visual Based Sensor

LUXEMBOURG
Eurocomposite: structure

SWITZERLAND
MICOS: laser metrology optical head
PMOD: DARA

UK
MDA Space: laser metrology
ABSL: battery

ESA'S IN ORBIT TECHNOLOGY DEMONSTRATION FLEET



➔ FREQUENTLY ASKED QUESTION 1/2

What is the Proba suite of missions?

The Proba missions are a series of IOD (in-orbit demonstration) missions from the European Space Agency, for demonstrating and validating new technologies and concepts in orbit. They are based on small satellites, embarking payload and instruments to deliver actual data to users to demonstrate a new capability. They are developed under the General Support Technology Programme (GSTP) of ESA.

- •Proba-1, launched in 2001, an Earth observation satellite with advanced on-board autonomy and embarked an innovative hyperspectral instruments. It was operational for more than 20 years.
- •Proba-2, launched in 2009 and is observing the Sun, with more than 20 technology payloads and scientific instruments.
- •Proba-V (for Vegetation), launched in 2012, it flies an innovative Earth imager, for multi-spectral global vegetation mapping.
- •Proba-3, to be launched in 2024, will demonstrate precise formation flying by flying 2 satellites to achieve observation of the Sun's inner Corona.

Who developed Proba-3 and how long did it take?

Proba-3 is a project more than 10 years in the making, which has been implemented with the industrial support of more than 40 companies in Europe, under the leadership of a core team of companies in Spain and Belgium:

- •Sener (System Prime)
- •Redwire (avionics, satellite assembly and testing, satellite operations)
- •Airbus Defence and Space (satellite thermo-mechanical and propulsion, satellite environmental test)
- •GMV (formation flying algorithm and software, on-ground flight dynamics system)
- •Spacebel (on-board and on-ground software)
- •Centre Spatial de Liege (Coronagraph scientific instrument)

Why are there two satellites?

For Proba-3, there are two satellites to create the conditions for observation of the Sun corona, synthetising the equivalent of an extremely large instrument. One satellite features a telescope, kept in the centre of the shadow cast by the other satellite 150 m away, thanks to an occulter disk.
Maintaining the correct position in the shadow requires precise formation flying capability.

How is Proba-3 powered?

Each Proba-3 satellite is powered through high efficiency solar panels

Why will we launch in India?

PSLV was chosen since the lift required to place the proba-3 satellites (550 kg) on their desired highly elliptical orbit is above the Vega-C capability, and Ariane-6 would be too costly.

Do the satellites fly in formation autonomously or is it controlled on the ground?

As the Proba acronym indicates 'PRoject for OnBoard Autonomy', Proba-3 formation flying experiments will be performed autonomously on-board.

Why do we need the accuracy for the formation?

When in position the two satellites will be precisely aligned so that the occulter spacecraft casts a shadow across the coronagraph spacecraft. If the two are not perfectly aligned then the bright disc of the Sun will not be hidden from the instrument and the corona will be obscured by its bright light.

Why do we do it at a high altitude?

Any force exerting more on one satellite than the other will cause the satellite to drift apart, which must be corrected for by the formation flying system, which consume on-board propellant. The Earth gravity is such force, and the higher altitude, the weaker it is.

Why do we need this distance?

Stray light makes it difficult to study the corona images we have currently. It is exacerbated by a small distance between the occulter and the coronagraph. For PROBA-3 the distance is around two orders of magnitude larger than that in any other coronagraph so far.

FAQS 2/2

Why do we study the corona?

The solar corona is a field of scientific research and study, not only to improve our understanding of the Sun, but also as a predictor of solar weather, such as coronal mass ejections or solar storms which can affect how communication networks or power grids on Earth function.

Why is it so hard to study the Sun's inner corona?

The inner corona is the corona region that is close to the Sun. The Sun is about 1 million time brighter than the brightest point within the corona.
If the light from the Sun is not blocked, any observing telescope is blinded by this light and cannot see the Corona. The concept of a Coronagraph instrument, invented in the 1930s, is to use one or more occulting disks to block the Sun's light. However, when attempting to observe the inner corona, an optical phenomenon called diffraction, which causes the Lightwave to spill over obstacles, reduces the effectiveness of the Coronagraph.
Occulter size matters. During a total solar eclipse, the Moon is the occulting body and offers excellent opportunities to observe the inner corona. However total eclipses are rare and very brief.

How will Proba-3 create an eclipse?

The satellite called "OSC" features a 1.4 meter diameter occulting disk, which will be kept perpendicular to the direction of the Sun's light. This disk will cast a shadow, of about 8 cm width at 150 m.
The satellite called "CSC" hosts a scientific telescope which has a 5 cm aperture. The goal is to maintain, thanks to formation flying, the "Coronagraph" aperture within the 8 cm shadow with millimetric accuracy. This will happen when the two satellites are close to the apogee along their highly elliptical orbit (60000 km altitude), where the Earth gravity force is weaker and formation maintenance requires less propellant.

When will we get the first results from Proba-3?

Around 4 months after launch, once the commissioning phase is complete.

What will we learn from the Proba-3 eclipse?

We already have instruments that can study the sun, the low corona and the high corona but between the low corona and the high corona there is a region, a gap, where observations are difficult to make.

Normally it is only possible to observe this region during a solar eclipse. This occurs when the Moon's orbit places it between the Sun and Earth, casting a shadow on Earth. Solar eclipse's can only occur during a new moon and when the orbit is precisely right, making them a rare occurrence.

The PROBA-3/ASPIICS (Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun) Coronagraph will examine the structure and dynamics of the corona in this crucial but hard-to-observe region.

Compared to a total eclipse, which lasts under ten minutes and occurs around 60 times a century, Proba-3 will be able to study the corona for 6 hours in every 20-hour orbit, a 100-factor improvement in uninterrupted study time.

Why is the formation flying only performed at the orbit apogee?

The cost in fuel would be too high to maintain formation throughout the orbit, so each orbit will be divided between six hours of formation flying manoeuvres at apogee and the rest of the orbit in passive safe drifting. The Proba-3 satellites will repetitively demonstrate acquisition, rendezvous, proximity operations, formation flying, coronagraph observations, separation and convoy flying every orbit.

What will happen with the satellites at the end of the mission

The mission is expected to last 2 years. Afterwards, the orbit on which the satellites are flying will slowly decay due to gravitational perturbations from the Sun and the Moon, which will cause the satellite to naturally re-enter into the atmosphere within ~5 years after launch, in compliance with the latest space debris mitigation approach.

→ Further information

More about the mission, images, fact sheets and videos can all be found on the ESA website at:

https://www.esa.int/Proba-3