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Hipparcos – 3D mapping of the stars

Regarded as one of the greatest astronomers of Antiquity, the Greek Hipparchos created – in the second century before Jesus-Christ – the first catalogue of known stars, listing almost a thousand astral bodies.

More than 2000 years later, the Hipparcos (*Hi*gh *p*recision *par*allax *co*llecting *s*atellite) mission took over from him. Between 1989 and 1993, the satellite launched by the European Space Agency (ESA) enabled the precision mapping of more than 100,000 stars. A second catalogue then mapped around two million stars, but with a lower precision.

Hipparcos also contributed to a more precise dating of the age of the universe, as well as to the development of strategies for the study of exoplanets.

Launch of Hipparcos, August 1989 - Credit: ESA

CSEM's first adventure into space

Each era has its technology! For his observations, Hipparchos developed an astrolabe, an instrument that enables the measurement of the position of a star in relation to the horizon.

In 1989, the Hipparcos satellite was equipped with a Schmidt telescope, for which CSEM developed a modulating grid with more than 2600 slits. The satellite was rotating on itself at a determined and stable speed. For each observed star, the light collected by the telescope was projected on sensors through the modulating grid. The light collected, thus modulated, allows a much more precise determination of the position of its source.

This was one of our first projects related to space exploration.

The brightest of 12 early intruders into the Milky Way, identified with the help of ESA's Hipparcos satellite – Credit ESA

For more information: Hipparcos mission on ESA

XMM Newton – Exploring the universe

With the opportunity of better understanding enigmatic black holes, observing the birth of stars, and studying the formation of galaxies to understand the origins of the universe, the main objective of the XMM Newton satellite is to study "soft" X-rays in space.

As one of the most powerful satellites ever built, XMM Newton is a precious and tireless observer thanks to its three telescopes.

Initially intended to last two years, its mission will be extended to end-2018, which is twenty years after its launch.

Artist's impression of the XMM-Newton spacecraft in orbit around the Earth – Credit ESA / D. Ducros

Open sesame

For this mission, CSEM developed a hermetic door-opening mechanism to protect the telescope's Focal Camera Units' CCD enclosed in a detector box.

This development (one for each of the two detector boxes) was a mission-critical mechanism and was considered as a single point of failure. Robustness and reliability were demonstrated with a successful opening following the Ariane launch in 1999.

These units contributed to the observation of mysterious and captivating phenomena such as the absorption of a star by a black hole!

CSEM's door-opening mechanism

For more information: XMM-Newton mission on ESA

Main partners : Paul Scherrer Institute (PSI), 15 sub-contractors, among which Steiger Galvanotechnique SA,

Envisat – Earth's check-up

The changes in the ozone layer, the melting of the Arctic ice-cap, or the receding Aral Sea. These are just some examples of the phenomena ENVISAT observed continuously between 2002 and 2012.

In 10 years, this satellite – developed by the ESA to measure a series of environmental parameters – has generated more than a thousand terabytes of data. This information has enabled more insights into climate change, the monitoring of atmospheric pollution, and a better understanding of the mechanisms of tectonics and volcanic activity.

Artist's impression of ENVISAT – Credit ESA

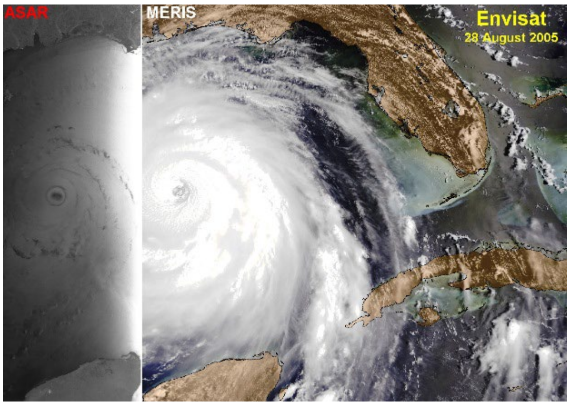
Initially designed to operate for five years, ENVISAT stopped transmission just after the 10th anniversary of its launch, having circled the Earth more than 50,000 times.

Ensuring accuracy of observations

Among the instruments taken on board was MERIS (Medium-spectral resolution, imaging spectrometer), tasked with gathering oceanographic parameters.

CSEM designed its calibration mechanism. To compensate the drift of the instrument over harsh space environments, regular calibration needs to be performed directly on board the satellite. This ensured that the evolution of the various phenomena could be accurately followed over years.

The instrument also delivered impressive images of Hurricane Katrina in 2005, and the volcanic eruption of Eyjafjöll in Iceland in 2010.



Ouragan Katrina captured by Envisat (USA), 2005 – Credit ESA

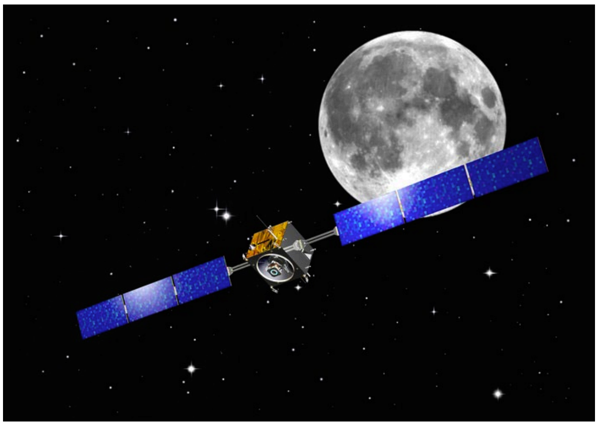
For more information: Envisat mission on ESA

Main Partner: Thales Alenia SPACE France (former Aerospatial)

Smart-1 – Improving space technologies

Launched in 2003, Smart-1 (Small Missions for Advanced Research in Technology) was the first European mission designed to test different technologies, with the goal of minimizing the cost and weight of space probes.

In parallel, the demonstrator sent into space observed the moon for three years, with the objective of increasing our knowledge of the composition of Earth's satellite. It was the first European moon mission.



Artist's impression of Smart-1 – Credit ESA

CSEM's contribution

CSEM has developed the miniature digital micro-cameras (AMIE-Asteroid-Moon micro-Imager Experiment) that photographed the moon from every possible angle for three years.

To meet the constraints and objectives of the mission, this system had to combine miniaturization and performance. This was achieved, as in the end the system weighed only 450 grams, and enabled a large number of photos of the celestial body to be taken.

Hadley rille captured by Smart-1 – Credit ESA

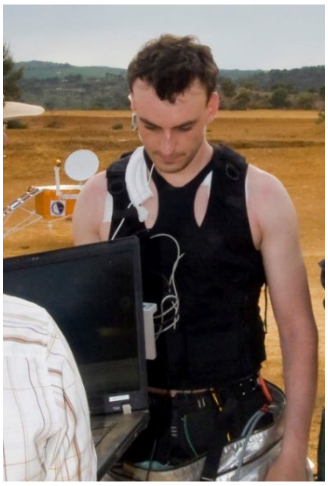
For more information:
Smart-1 Mission on ESA
AMIE presentation on ESA
AMIE in CSEM scientific and technical report

Main partner : FISBA AG

LTMS – Monitoring astronauts' health

The health of the astronauts is critical in ensuring the success of a space mission, and in the efficient running of activities on board the International Space Station.

Very early on, the space agencies developed and tested sophisticated systems for monitoring the physiological parameters of the teams. These developments, started in the early 2000's, are now also leading to applications in the medical and sports areas.

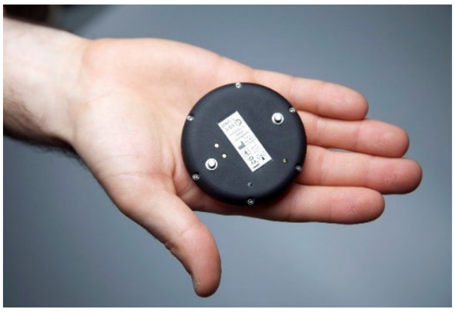


Checking the LTMS - Credit ESA

Paving the way for easier vital signs monitoring

CSEM's expertise in wireless, low-energy integrated systems led rapidly to its interest in this type of development, and to their work for the European Space Agency (ESA).

In partnership with CHUV and HNE (CH), CSEM performed the Long-Term Monitoring Survey in Concordia, Antarctica (LTMS). Its goals were to:



CSEM's LTMS sensor

build final LTMS based on CSEM's SENSE technology (wireless)

clinically validate SpO2 chest sensor

clinically validate core body temperature chest sensor

This work enabled the development of the SENSE technology, which allows wireless monitoring of vital parameters, and can be used for sports or medical applications.

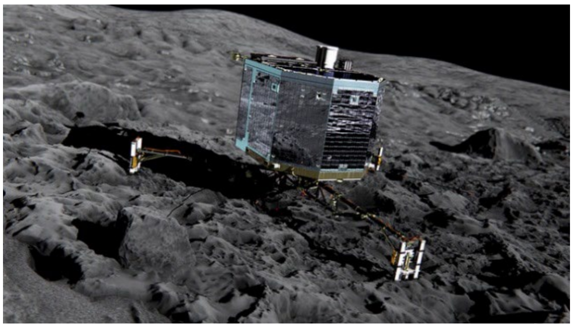
For more information: Long Term Medical Survey System

Main partners: CHUV, University of Bern, NE Hospital, Adnovum AG

Rosetta – Rendez-vous with a comet

Some scientists compare this epic and fascinating saga with the first steps on the moon. Indeed, when the project was first imagined at the end of the 20th century, the goal was bold and the technology requirements were more than challenging.

After a ten-year voyage in space, Rosetta arrived at Comet Chury (67P/Churyumov-Gerasimenko) in 2014 and got into orbit. Its lander, Philae, was then released onto its surface in order to take pictures and obtain other information on the nature of the comet's ices and organic crust.



Artist's impression of Rosetta's lander Philae – Credit ESA

The mission ended in 2016 with Rosetta's landing on Chury to meet up with Philae again and to sleep on the comet forever. However, the scientific adventure continues with the analysis of the collected material, which will help in understanding the Earth's origins.

CSEM's achievement: Philae's eyes

Thanks to CSEM's contribution to the project, the Philae lander was able to deliver the first pictures ever taken from the surface of a comet. CSEM took part in the development of seven tiny, low-power, and robust high-definition cameras.

The devices were developed between 1998 and 2001, based on a prototype developed between 1992 and 1997 for the European Space Agency (ESA). At that time, space-quality cameras were almost the size of the Philae lander itself, which goes some way to explaining just what a challenge CSEM faced.

Weighing 100 grams each, the cameras compose part of CIVA (Comet nucleus Infrared and Visible Analyzer), one of ten on-board instruments for Philae's in situ analysis of the comet.

For more information:

[Rosetta Mission on ESA]

[FISBA AG]

METOP – The orbiting weather man

The Metop platform consists of three meteorological satellites in a heliosynchronous polar orbit, developed by the ESA and managed by Eumetsat. Metop-A, the first of them, was launched in 2006 from Baikonur (KAZ). The launch of the third satellite, METOP-C, is scheduled for end-2018.

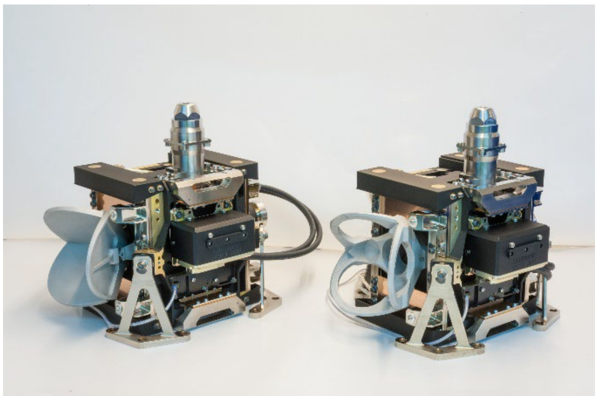
These satellites have 11 measuring instruments on board. Their deployment is enabling improved accuracy of weather forecasts, but also the gathering of valuable climate data, such as the discovery of the reduction of holes in the ozone layer.

Artist's impression of METOP satellite – Credit EUMETSAT/ESA

CSEM inside Metop's key instrument

The IASI – built for the *Centre Nationale d'Etudes Spatiales* (CNES) by Thales Alenia Space in Cannes – provides meteorologists with accurate and high-resolution data on atmospheric temperatures.

Its key element in terms of high-precision measurement is an opto-mechanical delay line known as the "Corner Cube Mechanism", based on the innovative Flextec technology and developed, together with its control mechanism, by CSEM.



CSEM Corner Cube Mechanism

CSEM has delivered three CCM flight models for MetOp's meteorological missions.

For more information:

http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/index.html

Main partner: RUAG (former Mecanex)

TURBISC – Ensuring astronauts' health

In space, as well as in remote areas or after natural disasters, portable devices for fast and autonomous diagnostics can be very useful.

In 2013, the astronaut Chris Hadfield tested in the International Space Station a flow cytometer made by the Canadian company INO.

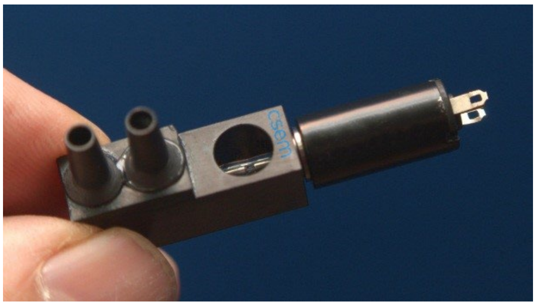
Toaster-sized, this compact and autonomous device enables the white blood-cell count of space travelers and is able to deliver a diagnostic in 10 minutes. Such measurements are very helpful in detecting infections or inflammation.

Astronaut Christer Fuglesang during his second spacewalk – Copyright Nasa

Tiny lightweight pump unit

CSEM's TURBISC pump was chosen as the pumping unit for this bio diagnostics test system. The CSEM team was also involved in making minor adaptations to the pump's fluidic connectors, to ensure a perfect fit with the Microflow system.

Its absolutely pulsation-free performance, bi-directionality, together with its light weight, were decisive in INO's choice.



CSEM's TURBISC pump

More information:

Canadian astronaut Chris Hadfield showing how Microflow works
TURBISC on CSEM

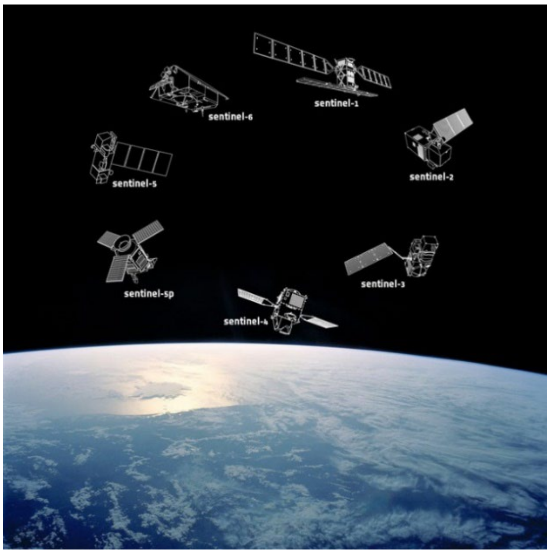
Main partner: INO

Sentinel – Observing the Earth

Following the success of Envisat, the European Space Agency (ESA) has launched the ambitious Sentinel program, a family of six missions dedicated to monitoring the Earth.

As the space component of the European environmental initiative Copernicus, this aptly named program consists of several new satellites and three instruments embedded on existing satellites. The deployment began in 2014 and is expected to be completed by 2029.

Each mission focuses on a specific target and delivers detailed data for ocean, atmosphere or land monitoring. The information collected will support the management of the environment, helping us to understand and mitigate the effects of climate change and to ensure civil security.

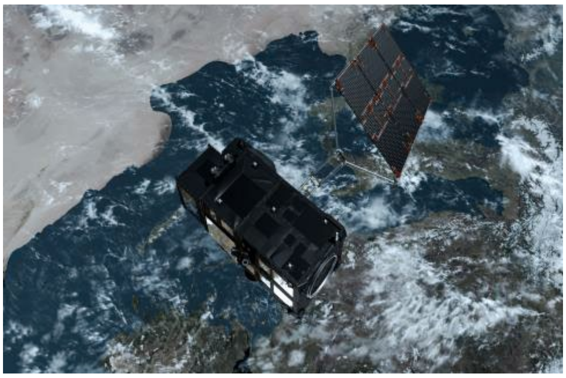


Sentinel program – Credit ESA

Precision – a key factor

Among other Swiss companies, CSEM was involved in the development of the satellite Sentinel 3A which collects data about land and sea areas. This allows, for instance, the measurement of surface temperatures, currents and pollution levels.

As with Envisat, CSEM transferred to CSL the design of a calibration mechanism for the multispectral camera's in-flight calibration unit, which is essential in ensuring high data quality over the whole duration of the mission.


Artistic representation of Sentinel 3 a – Credit ESA

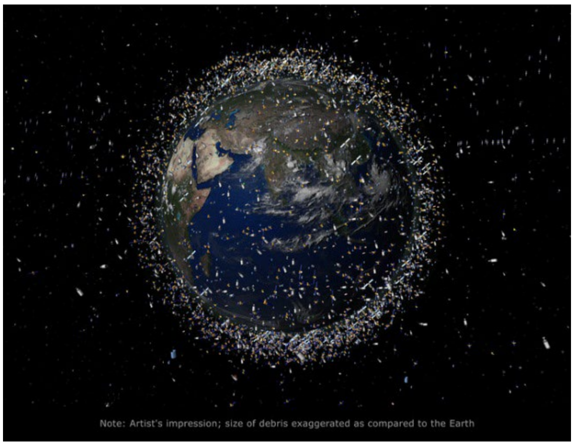
The calibration unit will enable compensation for instrument drift due to the harsh space environment, so that the evolution of the various phenomena could be accurately followed over the years.

For more information: [Copernicus on ESA]

RemoveDEBRIS – A “cleaning” operation in space

The multiplication of satellites used for meteorological and communication purposes has resulted in a plethora of “space junk” floating around. Now, a number of initiatives have been taken with the goal of “cleaning up” space by removing these objects, which could otherwise collide with working satellites.

The FP7 European RemoveDEBRIS project is one such initiative, and will enter its operational phase in spring 2018. Its objective is to send a satellite into space to test – in real situations – various technologies designed to remove debris from orbit.



Artist’s impression of debris objects in low-Earth orbit – Copyright ESA

The omnipresent watchful eye of CSEM

CSEM has developed a “Vision Based Navigation Sensor” made of a LiDAR 3D (Laser detection and ranging) imaging system and a 2D color camera – a precious instrument for taking precise pictures of the target to be “captured” under difficult lighting conditions.

In the future, this technology could be used for missions involving landing on Mars, the Moon, or on an asteroid, to enable a variety of craft to land safely, and more accurately, on the surface than is possible today.

The Vision Based Navigation System (VBN) developed by CSEM

For more information:

Project RemoveDEBRIS
LIDAR at CSEM

Main Partner : Airbus; Surrey Space Centre , INRIA

EXOMARS 2 – Revealing the secrets of the red planet

Launched by the European Space Agency (ESA) in partnership with the Russian Space Agency, the EXOMARS program consists of two missions.

It aims to reveal more about the composition of the atmosphere on Mars, and also to detect possible signs of past or present life.

On the technological front, the partners will experiment for the first time a lander and a Martian rover which will test air-braking and landing techniques, as well as moving over the Martian soil and collecting samples.

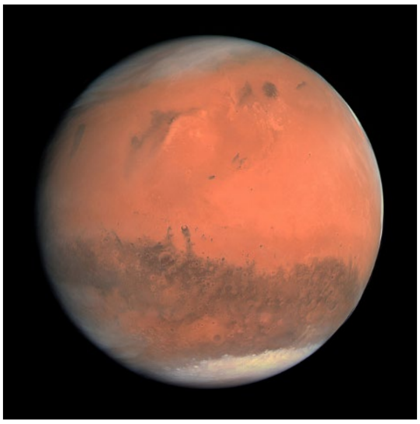
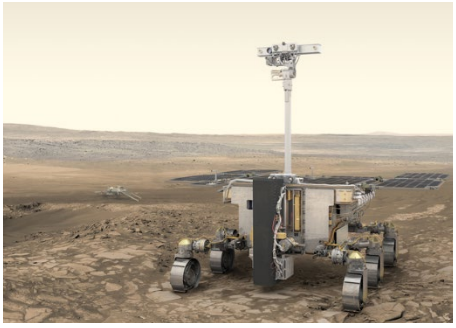


Image of Mars acquired during Rosetta's swing-by of Mars - Credit ESA

What is Mars made of?

CSEM is participating in the second phase of the mission (EXOMARS 2) with the development of a focus mechanism for the CLUPI camera.

This camera is manufactured by Thales Alenia Space Switzerland while its conception and exploitation is done by the Space Exploration Institute in Neuchâtel. It will be able to acquire close-up, high-resolution color images of rocks, outcrops, drill fines and drill core samples.



Mars rover – Credit ESA

Clupi mechanism

For more information:

Exomars on ESA
Clupi camera

Main partners: Space Exploration Institute (Prime Investigator), Thales Alenia Space Switzerland, FISBA AG

MTG – Weather forecasting 3.0

From 2021, MTG – Meteosat Third Generation will replace the Meteosat Second Generation in order to provide high-resolution meteorological data up to 2037 and beyond.

Jointly led by Eumetsat and the European Space Agency (ESA), the mission will comprise three pairs of satellites – four MTG-I imaging and two MTG-S sounding satellites – which will be placed in geostationary orbit 36,600 km above the Equator.

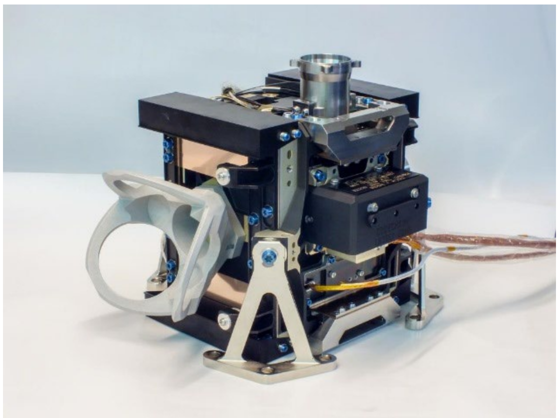
Together, they are expected to improve the quality and accuracy of the data, being for instance able to provide very short-term weather forecasting such as severe warnings. Other improvements include the monitoring of climate, small particles in the atmosphere such as volcanic ash, and air pollution.

Meteosat Third Generation shall enable a better quality and accuracy of the data.

Sounding the atmosphere

In this new fleet of satellites, the infrared sounder (IRS) will play a significant role, measuring the water vapor and temperature structure of the atmosphere, both being essential for a more comprehensive understanding of the impact of climate change.

As with METOP, CSEM – in partnership with Thales Alenia – has developed a "corner cube" mechanism for this instrument. The displacement of the "corner cube" enables a constant probing of the IR spectrum. It is through the characteristics of this spectrum that the water vapor quantity and temperature are calculated for each observed point.



MTG Corner Cube Mechanism

The mechanism will have to operate over many years, continuously and without any possibility of maintenance. CSEM will apply its well-established "Flextec" technology to both alleviate wear and tear over time and ensure efficiency and accuracy in providing reliable data.

For more information: MTG on EUMETSAT

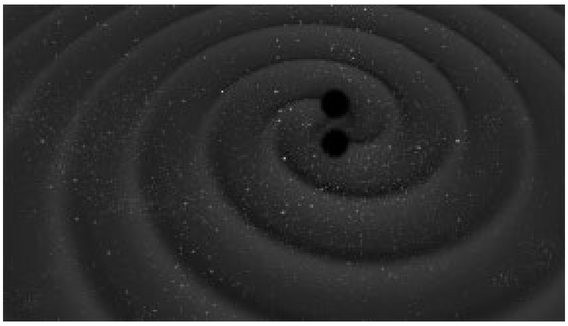
Main partners: Almatec, Syderal, Ruag

LISA – Following Einstein to understand our origins

Initiated by the European Space Agency (ESA), the LISA mission will provide the first space-based observatory of gravitational waves, which were detected for the first time in 2015, confirming their prediction by Albert Einstein a century earlier.

Consisting of three spacecraft separated by 2.5 million km in a triangular formation, this observatory will significantly contribute to our understanding of the formation of galaxies, stellar evolution, the early universe, and the structure and nature of space-time itself.

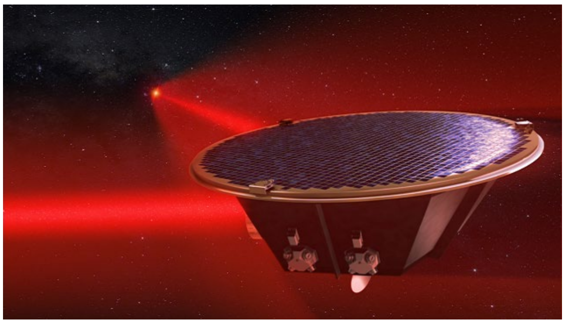
LISA is planned to be launched in 2034.



A gravitational wave signal was triggered in 2015 by the merging of two black holes some 1.3 billion light-years away – Credit ESA

Revealing the secret of gravitational waves

LISA's gravitational-wave measurement is based on the laser interferometry technique. The three satellites form a giant "Michelson interferometer" with three arms. While a gravitational wave passes through the interferometer, the lengths of the LISA arms undergo temporary variations due to space-time distortion resulting from the wave. This variation will have to be measured to a few tens of picometer at a distance of millions of kilometers.



LISA concept – Credit AEI/Milde Marketing/Exozet

The stability of the laser sources of the interferometer is of primary importance. CSEM is working on a complete system that can stabilize the light emitted by the lasers, so that gravitational waves reveal some of their secrets.

In 2021, CSEM has been selected by ESA to provide expert metrology support to the LISA mission due to its solid experience in space research and extensive know-how in ultra-stable lasers. Its role includes testing the stability of the NASA lasers' frequency and power to make sure they meet the demanding specifications of the LISA mission.

For more information:

LISA on ESA
Stabilization of the lasers

Main partner: Syderal