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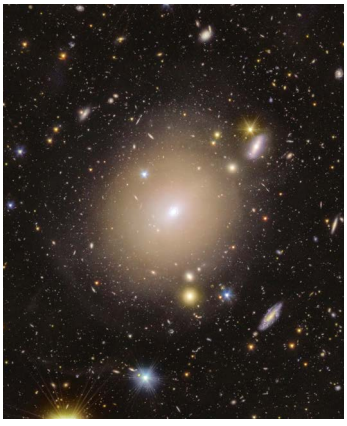
CNESMAG

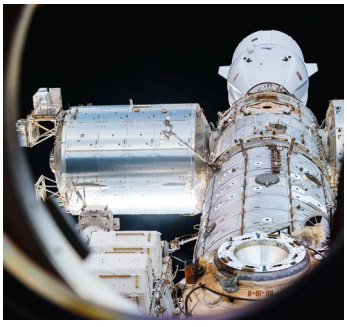
#99 WINTER 2026

Space Science at the core

Launchpad

#99 — WINTER 2026





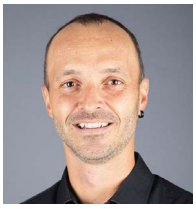
Read the magazine on line

Crew

Olivier Joie-La Marle

In charge of universe science programmes at CNES, Olivier is a qualified engineer and trained in astrophysics. He joined the agency in 2001 on the Helios military programme. His focus has since shifted to universe science, a world where cooperation and curiosity are the watchwords: cooperation with multidisciplinary teams in France and with international partners; and curiosity in the minds of those doing science, and in the eyes of youngsters. For him, inspiring younger generations and communicating this mindset is vital.

Martin Boutelier



With CNES since 2015, Martin is qualified in both engineering and astrophysics, ideal for keeping his head in the stars and feet on the ground. His passion is understanding space phenomena that can't be replicated in the laboratory. Previously, Martin worked on flight software—the brain—of several satellites. Rubbing shoulders with the scientific community and seeing their needs led him to become a subject matter expert in gravity, cosmology and metrology, for missions like LISA and PHARAO, covered in this issue.

Jean Blouvac

A qualified engineer, Jean joined CNES in 1989 at the Guiana Space Centre. Today he is in charge of space exploration and human spaceflight programmes, representing France in these fields at ESA. Cooperation at CNES and with international partners is central to his missions. For human spaceflight, the challenges are huge: preparing the post-ISS landscape and aiming for the Moon and then Mars. Serving this programme as it ramps up in Europe and worldwide is a great source of motivation for him.

Louise Lopes

After graduating in space engineering and fundamental physics, Louise worked in industry and then at ESA on Mars projects. Driven by her firm belief in the importance of public service, she subsequently joined CNES, notably studying potential future space missions. Today she is deputy head of the universe science sub-directorate, conceiving missions with scientists and working on subjects that inspire young and old. She defends the idea of science that is international and universal, two key factors in the current geopolitical context.

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Horizons

“Science for the future”

Marie-Claude Salomé
Director of communication

Advancing knowledge through space science is a key goal that lies at the core of CNES’s ecosystem.

The certainties of today stem from the discoveries of yesterday, and we must keep searching to push the boundaries of what we know.

It is also vital that CNES communicates its passion for science to younger generations, exposed more than most to misinformation or—worse still—to conspiracy theories that continue to prosper in spite of well-structured scientific approaches.

In so doing, we are also aiming to sustain these approaches and to raise people’s awareness. Space projects are driven by a long-term perspective, so we will always need science, engineering and other disciplines to probe the puzzles of the universe, and maybe one day resolve them!

Day to day, CNES’s teams are showcasing France’s scientific contributions in Europe and worldwide, helping to accomplish technological feats on many missions and continue advancing science, as you will see in this issue.

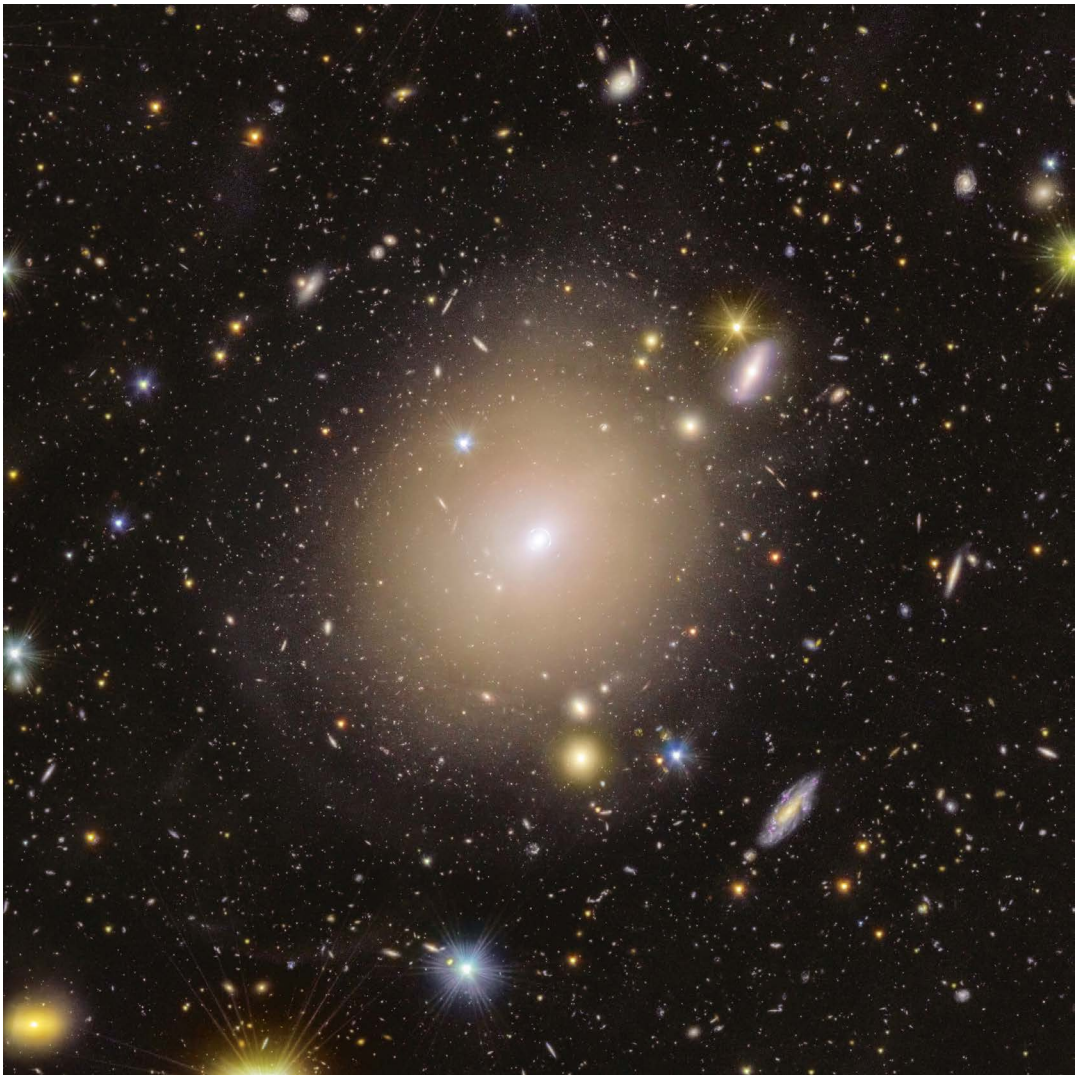
We hope you enjoy reading CNESMAG.

PARTNERS

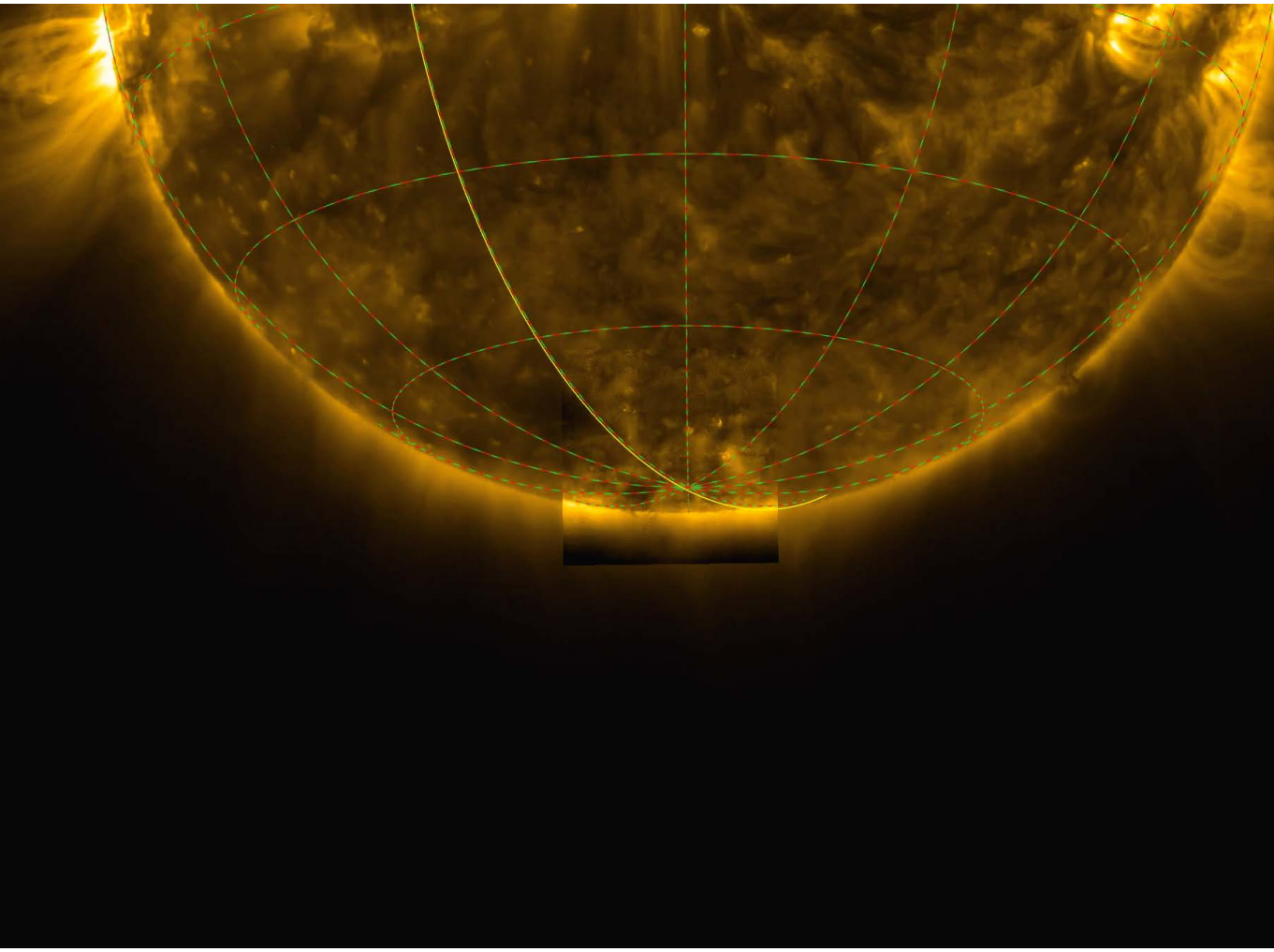
In this issue:
ESA - p. 6, 11, 17, 22, 25, 31, 36; University of Leicester - p. 9; NASA - p. 10, 16, 24, 25, 31; IRAP - p. 10; Los Alamos National Laboratory - p. 10; Ecole Polytechnique - p. 11; Novespace - p. 11; CNRS - p. 14, 16, 28, 33, 36; EU - p. 17; Sorbonne University - p. 17, 28; Ministry of Education - p. 17; Ministry of Agriculture - p. 17; DLR - p. 22, 30; JAXA - p. 24, 30, 35; Ministry of Armed Forces - p. 26; LATMOS - p. 28; University of Versailles-Saint-Quentin-en-Yvelines - p. 28; Paris Observatory - p. 29; AID - p. 29; ISAS - p. 30; Airbus - p. 31; CEA - p. 33, 36; Zooniverse - p. 34; Macon & Lesquoy - p. 35; Merlin - p. 35

A very distant ring

In February 2025, Europe's Euclid space telescope found this Einstein ring (in the centre of the image below) around galaxy NGC 6505, 590 million light-years from Earth. The ring is in fact the light from a much more distant background galaxy, bent by gravity. Such gravitational lensing[1] effects, which scientists use to estimate the mass of this type of foreground galaxy, are central to the Euclid mission launched in 2023 by ESA to map the universe and probe dark energy and dark matter.



1. Bending of light by an object.

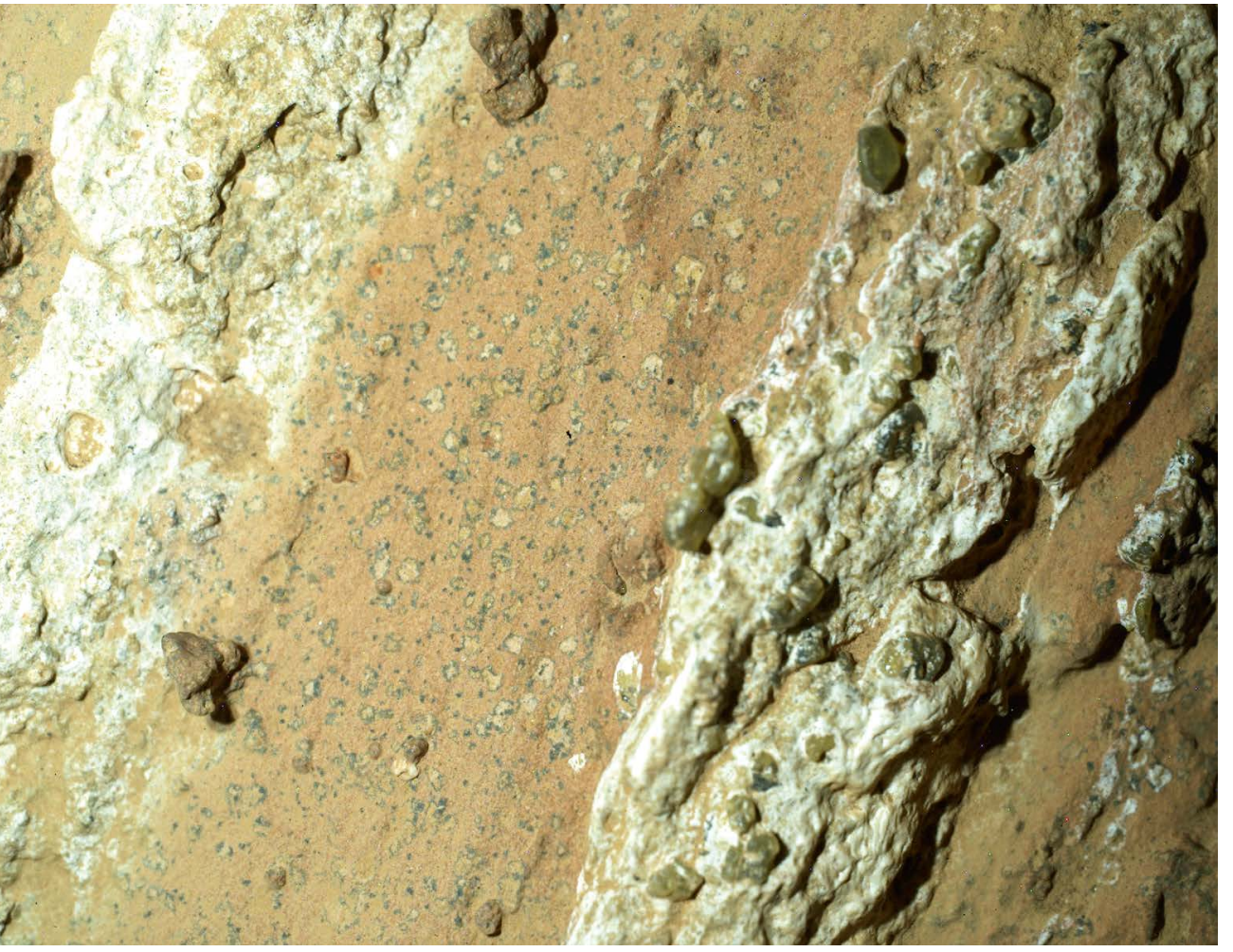


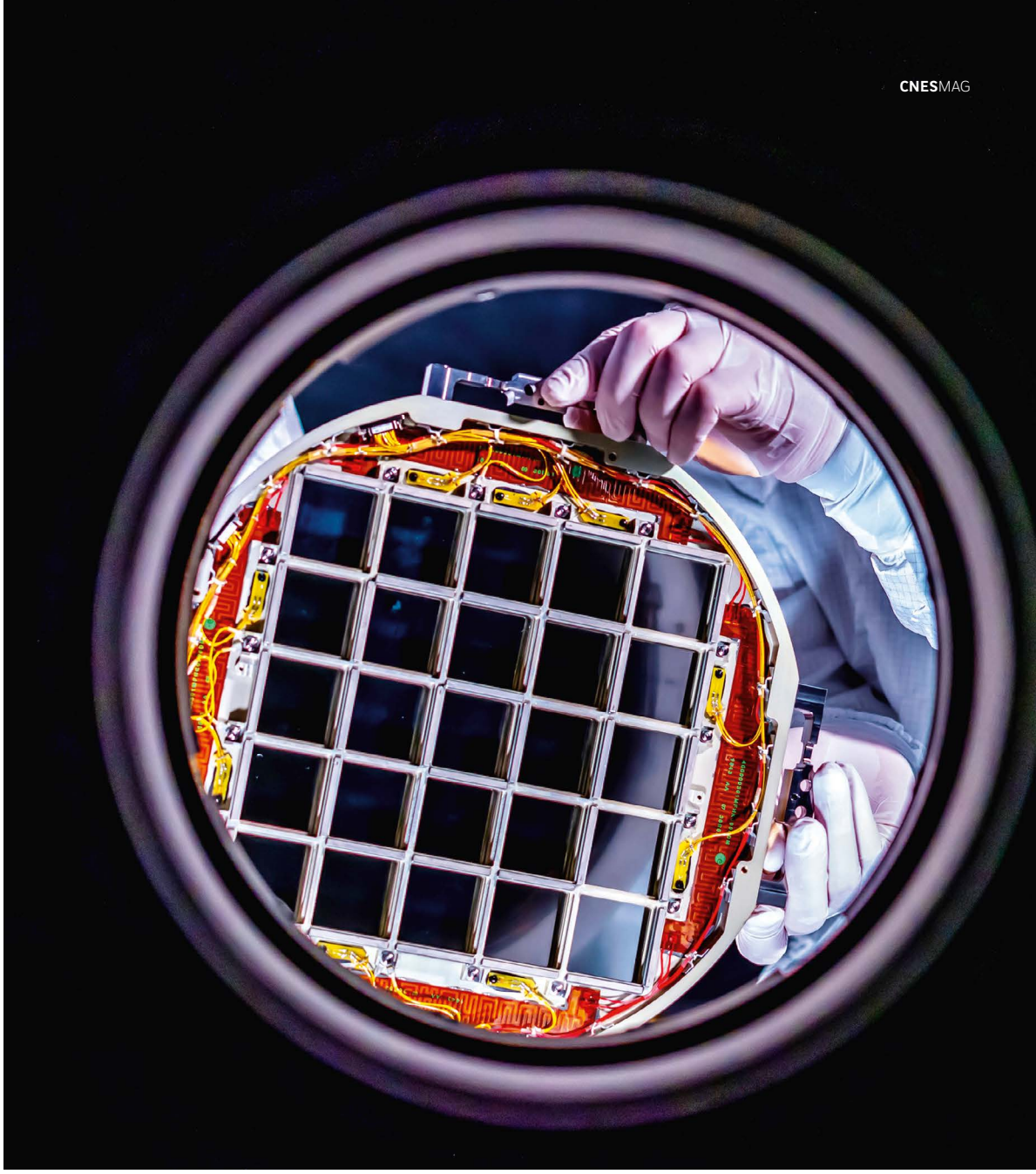
First snapshot of Sun’s poles

Last June, Europe’s Solar Orbiter spacecraft tilted its orbit outside the ecliptic plane of the solar system to obtain the first-ever views of the Sun’s south pole. A feat that will help us gain new insights into the mechanisms driving our closest star, like for example its 11-year cycle of activity or the origin of the solar wind.

Perseverance and the puzzle of Cheyava Falls

Last year, the Perseverance rover found a rock in Mars' Jezero Crater, named Cheyava Falls by the mission science team. The rover's instruments detected structures in the rock typically associated here on Earth with biological activity. Could this be the signature of past life on the red planet? It is of course far too early to say, but the samples collected by the rover might yield more clues in the years ahead.



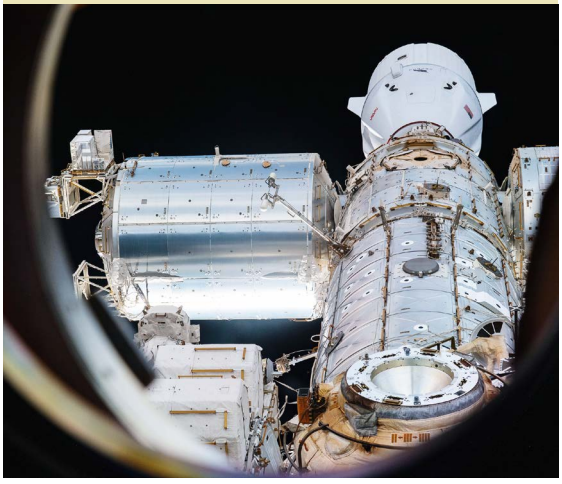


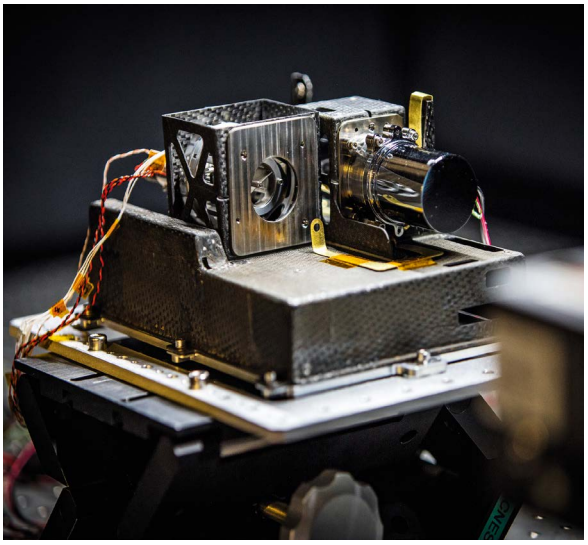
Bursts in the eye of the lobster

Immortalized here during integration, MXT, the X-ray telescope flying on the French-Chinese SVOM mission, is based on a design that mimics a lobster's eye. Conceived by the University of Leicester and built in France, the telescope's square micro-pore optics (MPO) focus light on the detector to pinpoint the location of gamma-ray bursts—extremely powerful explosions observed when a star dies—more accurately.

What post-ISS landscape after 2030?

No later than 2030 or 2031, the United States is set to decommission the International Space Station (ISS), bringing to a close 30 years of operations that have seen more than 3,000 scientific experiments conducted there. While SpaceX and NASA are developing the cargo module that will control the station's re-entry and splashdown in the Pacific, the world's leading powers are readying for the next phase. The United States is developing private space stations through its Commercial Low-Earth-orbit Destinations (CLD) programme, while China is extending its Tiangong station and India plans to launch its BAS station. Europe, meanwhile, is considering a range of scenarios, including joining the U.S. project, closer cooperation with India, a station with other partners (Canada, Japan, United Arab Emirates) and the use of robotic systems for certain experiments in microgravity.

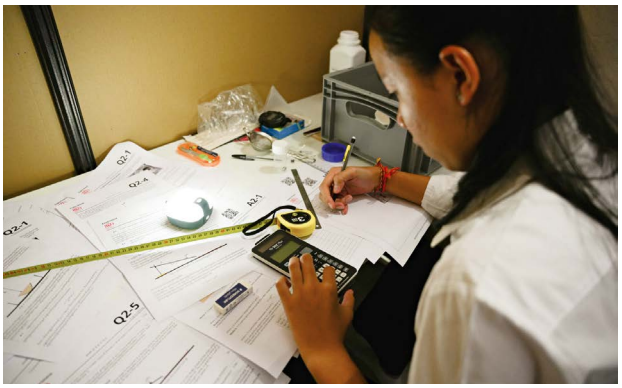




MicroLIBS

A small instrument with big ambitions

Designed by CNES, the IRAP astrophysics and planetology research institute and Los Alamos National Laboratory (LANL), and following in the footsteps of the emblematic ChemCam and SuperCam instruments on NASA's Mars rovers, MicroLIBS is a miniature instrument that relies on a technique called laser-induced breakdown spectroscopy (LIBS). Unlike its predecessors, it is designed to map rock surface elements at the microscale and compact enough to fly on light platforms like a hexacopter drone, offering revolutionary prospects for Mars geology through the ability to scout terrains that rovers can't reach.
A first prototype of MicroLIBS is currently in integration, the aim for CNES and its partners being to demonstrate that the instrument weighing less than 1.5 kilograms can deliver the targeted performance.



CNES prize at International Physics Olympiad gives taste of weightlessness

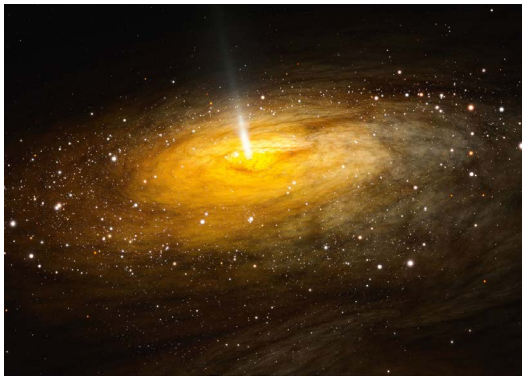
Last July, the campus of the Ecole Polytechnique engineering school in Palaiseau was buzzing as the host venue of the 55th International Physics Olympiad. The seven-day event, the most prestigious of its kind for under-twenties, attracted more than 400 entries from 80 countries. As one of the event's partners, CNES contributed its own prize for the best candidate overall. The agency's goal was to showcase what it does and promote space careers to an audience of budding talents. The CNES prize went to Ionut-Gabriel Stan from Romania, who will soon be climbing aboard the Airbus A310 Zero G operated by Novespace for a scientific flight in weightless conditions.

SVOM

sees blasts from the past

Launched in June 2024 from Xichang, the French-Chinese SVOM satellite came through its test and validation phases with flying colours and is officially operational since January 2025. Its instruments—among them the French ECLAIRs and MXT instruments—are tracking gamma-ray bursts (GRBs), brief but extremely powerful events produced by the merger of neutron stars, the birth of black holes or the explosion of massive stars. Since reaching orbit, the satellite has detected 210 GRBs[1] to cue ground telescopes in near-real time, opening a new window into the universe's evolution. In March, SVOM detected a faint GRB that turned out to be from the oldest supernova ever recorded, occurring when the universe was only 729 million years old (as opposed to 13.8 billion years today).

1. As of 15 December 2025.

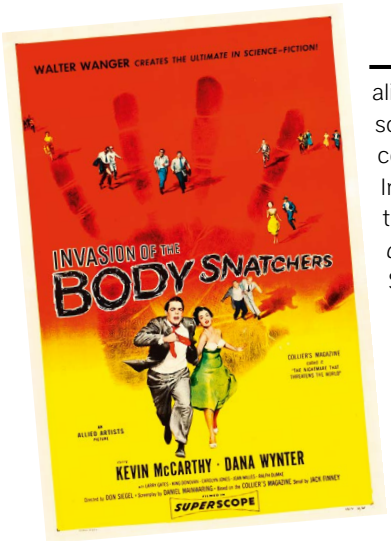


PHARAO putting clocks right

PHARAO is an ultra-precise laser-cooled cold-atom clock designed to test Albert Einstein's theories of relativity from space. As part of ESA's Atomic Clock Ensemble in Space (ACES) project, it is operating alongside another atomic clock called SHM (Space Hydrogen Maser) and systems for communicating time to ground. Developed, assembled and tested by CNES, PHARAO was launched to the International Space Station (ISS) last April by a SpaceX Falcon 9 vehicle, then attached outside the station's European Columbus module. The clock has been put through its paces and is delivering the expected performance in space. The mission's science team is now concentrating its efforts on devising a workaround for SHM, not yet operational.

From Little Green Men to Big Human Questions

From *The Invaders* to *Close Encounters of the Third Kind*, from *Alien* to *Men in Black*, cinema has made extraterrestrial life a mirror of our beliefs, doubts and fears. Between scientific fascination and conspiracy-fuelled suspicion, these stories tell us as much about the eras that produced them as they do about the way we look at the sky.



Since the 1950s, aliens have been colonizing screens as fast as our collective fears can spread. In McCarthy-era America, the flying saucers of *Invasion of the Body Snatchers* (Don Siegel, 1956) and *The Thing from Another World* (Christian Nyby, 1951) channel an obsessive fear of infiltration and brainwashing. Monsters from outer space become convenient metaphors for an elusive enemy within.

Science-fiction cinema then becomes a testing ground for politics, where every invasion retells the Cold War under the cover of fiction. By the late 1970s, fear gives way to friendly curiosity: *Close Encounters of the Third Kind* (Steven Spielberg, 1977) and *E.T.* (1982) reconcile humanity with the Other. During the era of East-West détente, extraterrestrials take on the guise of peaceful messengers, reflecting a longing for dialogue and a renewed faith in science. These films re-enchant space exploration, recasting it within a humanist and almost spiritual vision.

But the calm doesn't last. *Alien* (Ridley Scott, 1979), then *Predator* (1987) bring the threat back into the bowels of the spaceship: the unknown becomes biological, intimate and contagious, at a time when the AIDS epidemic is on everyone's minds. In the 1990s, the narrative swings between concern and mockery. The *X-Files* series and films like *Independence Day* (Roland Emmerich, 1996) and *Men in Black* (Barry Sonnenfeld, 1997) replay our fear of government cover-ups and our fascination with covert technologies. *Mars Attacks!* (Tim Burton, 1996) offers a flamboyant parody of all this: a satirical firework display where the clichés of alien invasion tip over into atomic farce. This dark humour brings to a close a decade in which all-pervading mistrust has become a spectacle in its own right.

Today, the boundary between fiction and belief has become even more blurred. Feature films such as *The Fourth Kind* (Olatunde Osunsanmi, 2009) use all the conventions of investigative reporting to pass off fiction as scientific testimony. The pseudo-documentary series *Alien Theory*—described by several researchers as a textbook case of "prime-time conspiracism"—recycles archaeological myths and repackages them as "proof" of extraterrestrial contact. These formats deliberately blur the lines, using pseudo-rational arguments and TV-style editing to lend credibility to unfounded theories. At a time when social media is amplifying these narratives,

scientific literacy and critical thinking are more essential than ever. Cinema can still remind us that curiosity is better than belief, and that the sky, before being a threat or the realm of the gods, is still a *terra incognita* waiting to be explored.

Insights

Christian Mustin,
HEAD OF EXOBIOLOGY,
EXOPLANETS AND PLANETARY PROTECTION AT CNES

"Ignorance is the gateway to blind belief..."

A 2023 Ifop study shows that young people are losing faith in science. What is your take on that?
From what I see, it's more to do with fuzzy or mistaken ideas about how the world works, rather than blindly buying into far-fetched theories. As an example, a teenager once asked me why the lava from Mars' gigantic volcanoes doesn't drip over the edges of the planet. Even in engineering classes, we still get some surprising answers when it comes to estimating the size of things—like bacteria supposedly being a millimetre long, for example.

Does this kind of ignorance worry you?
No—provided people understand that science advances through debate, formulating theories, then rigorously testing those theories. Ignorance of how science works is the gateway to blind belief. When a likely explanation suddenly becomes a certainty, it can forge unshakeable convictions, especially in our societies today, which are increasingly subject to the tyranny of the moment.

In today's world, where irrational 'belief' in conspiracy theories is a real danger, is it still legitimate to say we 'believe' in extraterrestrial life?
Of course—so long as 'believe' means we regard it as likely or plausible. Personally, I think the universe is vast enough for there to be planetary systems inhabited by other lifeforms. We've found organic molecules in certain asteroids that could serve as the building blocks of life. They may not be used as such here on Earth, but they could well make up part of other lifeforms elsewhere in the universe.

NABILA **AGHANIM**

CNRS Research Director, Chair of CERES

“The CNES-laboratory-industry trifecta forms a virtuous ecosystem”

Astrophysicist, research director at the French national scientific research centre CNRS and the IAS space astrophysics institute (CNRS/Paris-Saclay University), Nabila Aghanim is the current chair of the CERES space science research and exploration committee, a consultative body of CNES. This specialist in the cosmic microwave background (CMB) reviews for us the main challenges facing science and highlights the collective momentum driving exploration of the universe.

“I find it fascinating that we’re able to build a coherent model with so much that we don’t yet fully understand.”

You worked on the Planck mission to observe the “fossil” light from the very first instants of the universe. What did you learn from this journey back in time?

The Planck mission explored the origins and evolution of the universe. We observed the cosmic microwave background, the remnant light from the Big Bang, which holds the seeds of today’s cosmic structure, from its first instants to the formation of galaxies. Working like archaeologists, we’ve studied these signals to unravel some of the mysteries of the past and form an idea of how the very first density fluctuations gave birth to galaxies. Studying these traces is like going back to where everything started, and that for me remains one of the highlights of my scientific career. Planck has also enabled us to gain a clearer picture of the composition of the universe, 95% of which consists of unknown elements—dark matter and energy—and 5% ordinary matter. I find it fascinating that we’re able to build a coherent model with so much that we don’t yet fully understand; the challenge now will be to understand its precise nature.

What priorities did the latest Science Survey Seminar set for space projects and what is the role of CERES in this regard?

The latest Science Survey Seminar set out several key lines of research, from the origins of the universe to the study of life in space, encompassing gravitation, the formation of galaxies, the characterization of extrasolar planets and planetary exploration. In this latter domain, expectations are focused notably on icy moons like Jupiter’s Europa and Saturn’s Enceladus, likely to harbour oceans, and on returning samples from Mars, crucial to retracing the comparative history of telluric or Earth-like planets. CERES is made up of scientists federated by CNES who are working to sustain this momentum, by informing space research priorities in the field of universe sciences and exploration, and by formulating recommendations for France’s space agency.

How does the CNES-laboratory-industry trifecta operate, and how does this model benefit the French space ecosystem?

The great strength of this trifecta is how we complement one another: research maps out the science strategy, in other words, questions to be answered and instrument concepts required to do that; manufacturers then transform these concepts into reliable space systems; and CNES oversees this process to ensure it functions effectively. This model spans the entire cycle, from scientific ideation through to data exploitation. It’s a virtuous ecosystem in which science spurs technology, opening up new fields of scientific investigation—a balance founded on mutual trust between research scientists, engineers and industry.

Why is international cooperation so important in space and how is it standing up to today’s geopolitical turmoil?

Large-scale space projects are too ambitious to be undertaken by any single nation alone. They require the collective intelligence that only an international consortium offers, in which costs, expertise and risks are shared. Such cooperation is vital, not only to accomplish projects, but also to advance science through diverse approaches and perspectives.
The turmoil we’re seeing today doesn’t stem from an inability to work together, but rather from high-level

1997
Awarded postdoc grant by CNES.

1999
Joins CNRS and IAS space astrophysics institute after postdoc studies at CNES and the University of California, Berkeley.

2009-2016
Coordinates international science teams for Planck mission.

2017
Awarded CNRS silver medal.

2022
Receives Grand Prix Huy Duong Bui from French academy of science.

“Science sheds light on the world while sustaining our sense of wonder.”

political decisions. Nevertheless, major space initiatives are designed to be robust and plan for contingencies. But sometimes a break in cooperation can jeopardize a mission; that’s one of the fears right now for space, on a number of projects where NASA was expected to play a leading role.

_____ It’s often said that young people, especially girls, are turning away from scientific careers. What is your take on this and did anything in particular ignite your interest in science?

Every time I visit a classroom, I see curiosity shining in youngsters’ eyes. Boys and girls are both interested in science; it’s social and cultural biases that are holding them back. A lot of youngsters are self-censoring, because they think they’re not made out for a long, demanding and uncertain career path in a society obsessed with short-term gain. For girls, these hurdles are compounded by persistent gender stereotypes, even if recruiters are more in tune these days. What ignited my interest was when a supply teacher read us a few pages of a book about how the Earth-Moon system formed. I was only nine at the time and what struck me was the idea that we could actually understand how the Moon was formed! I was also fortunate that my parents and teachers got right behind me when I had to leave Algeria and come to France to complete my master’s degree. I was able to make my own career choices, rather than reproducing tired old models, and that’s what I would wish for today’s young women—and young men, of course!

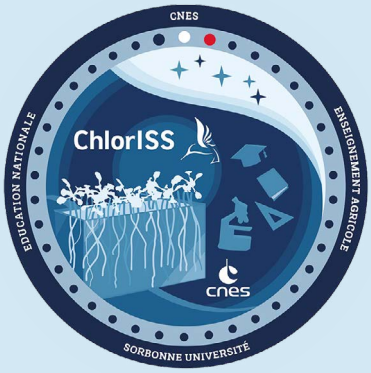
_____ How would you describe your personal relationship with sky and space?

Space has always been a source of fascination for me. When I was a child living in Kabylie, in northern Algeria, the skies weren’t yet saturated with light pollution and nights were pitch black, studded with stars. I remember long walks under the moonlight with my father and grandfather. The sheer immensity of the scheme of things that I felt then has never left me. The skies remain a place for contemplation, for both the senses and the intellect; for the senses, because of their breathtaking beauty; and for the intellect, because we can decipher this splendour to understand the physical laws that underlie it, which takes nothing away from its mystery and beauty, quite the opposite in fact. I like the idea that science sheds light on the world while sustaining our sense of wonder.

Pointers

Bremen 2025: decision time for spacefaring Europe

After Paris in 2022, Bremen hosted the latest ESA Ministerial Conference last November. This key rendezvous marked the moment for the agency's member states to take decisions on programmes to be funded and pursued over the 2026-2028 timeframe. The conference came at a time of significant shifts in space, with the European Union taking on a growing role in a new global and geopolitical landscape. The challenge is to meet space policy goals, notably in science, competitiveness and strategic independence, and to coordinate the actions of ESA, its member states and the EU effectively in the areas of universe science, space transportation, exploration, Earth observation, telecommunications, navigation, space safety and security, and technologies.



4,500

primary and secondary schools

will be taking part in the ChlorISS experiment, set to be performed in 2026 by ESA's French astronaut Sophie Adenot on her mission aboard the International Space Station (ISS). Developed by CNES in partnership with Sorbonne University, the Ministry of Education and the Ministry of Agriculture, ChlorISS will compare how two types of plants germinate on Earth and in microgravity. In all, more than 250,000 children and teenagers will be contributing to this adventure.

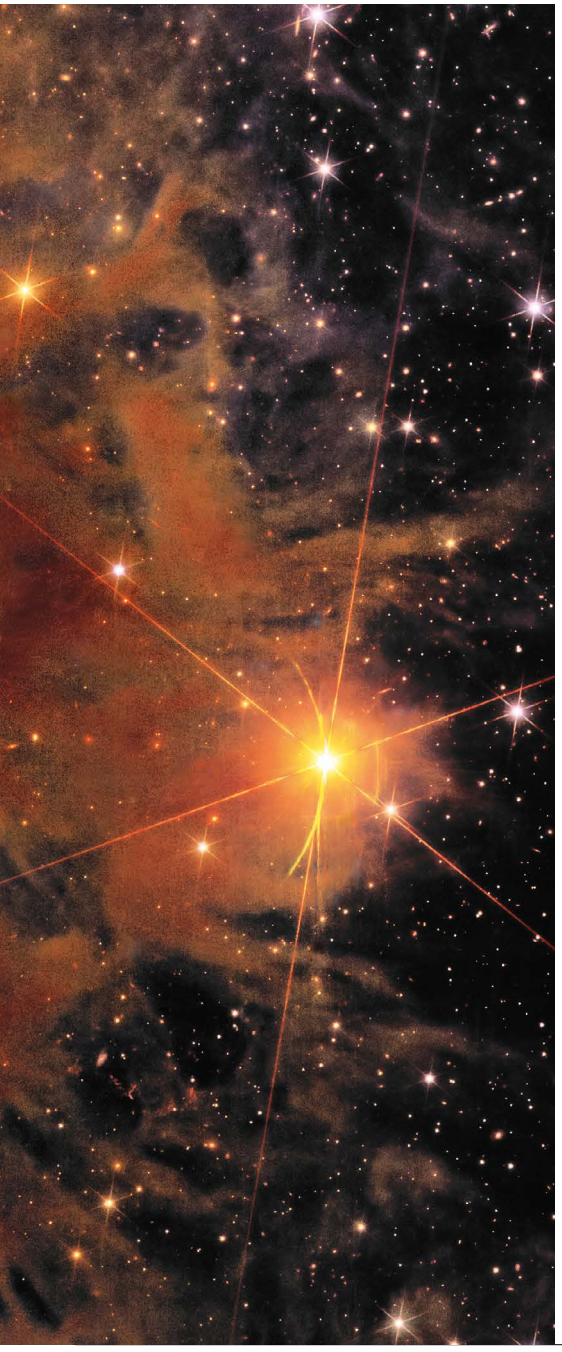
"Space science missions are universal and benefit the world's broader scientific community. However, behind every mission lies a consortium of science teams from research laboratories, universities and research institutions. With support from space agencies and coordinated by a Principal Investigator (PI), this team—almost always an international one—sets the mission's science goals, designs its instruments, lays the groundwork for data exploitation and does the science once it's in orbit."

Louise Lopes,
DEPUTY HEAD OF UNIVERSE SCIENCE SUB-DIRECTORATE, CNES

CNES tuned in to the universe

To explore the universe is to probe our origins and peer into the future. Through the major scientific missions to which it is contributing, CNES brings together research scientists, engineers and partners from around the globe to gain new insights.

Close-up of the Messier 78 (M78) star nursery viewed by the Euclid space telescope.

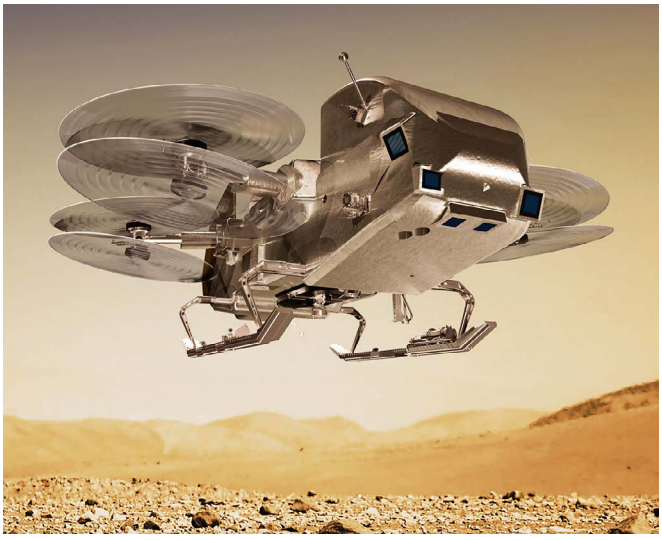


Head in the stars, feet on the ground

As a key player of space research, CNES works alongside French scientists from conception through to completion of major international missions. This role coordinating its ecosystem is built on scientific rigour, while adapting to a shifting global landscape.

Universe science and space exploration strive to answer time-old questions: Where did matter originate? How did life first form? What laws govern the evolution of the cosmos? Astrophysics, cosmology, fundamental physics and exobiology are just some of the fields of investigation seeking, each in their own way, to decipher the universe's history and how it works. "These fields have been a focus for teams of research scientists, engineers, manufacturers and space agencies around the world for decades," says Mioara Mandea, head of CNES's scientific coordination sub-directorate. "No one works alone: space science obliges us to adopt a long-term vision and a team or even global perspective." In this rigorous scheme of cooperation, CNES occupies the unique role of catalyst and coordinator of French space research, as well as being a key partner in the international science arena.

Towards this goal, the agency calls on the expertise of its in-house ecosystem. Spanning its Strategy, Orbital Systems and Applications, Digital and Technology, and Europe and International directorates, "our organization is geared to turning scientific ideas into operational missions," explains Thierry Bret-Dibat, head of the universe science and exploration sub-directorate. "We provide the linkages between research bodies, industry and space agencies to make missions possible."



The Dragonfly rotorcraft set to explore the surface of Titan, Saturn's largest moon.

CNES can also rely on solid mechanisms like its PARS space research support programme, which in 2024 provided €18 million in funding for 184 laboratories, or the PDoc+ programme that every year helps over 100 young research scientists, 30 working in the field of universe science and space exploration. "We co-fund theses, postdoc research, technology demonstrators and feasibility studies that feed into future missions," adds Mioara Mandea.

From canvassing scientific requirements to disseminating mission results, CNES's teams make every effort to scrupulously respect the foundations of any scientific approach: constructive doubt, systematic verification and transparency every step of the way. "Science isn't built on beliefs, but on measurable facts that can be reproduced," stresses Olivier Joie-La Marle, who heads the agency's universe science programme. "This is today a key stake in our domain of expertise, to counter conspiracy theories and misinformation." CNES actively fosters open data and open science. It is with this in mind that it opened the archives of its GEIPAN UAP research and information group to the public as early as 2007 (see Back to the Future, p. 26).

Changing context

Flagship science missions to which CNES has contributed—such as Planck (see Leading Light, pp. 14-16), Rosetta and Philae, Gaia (see box), Euclid and SVOM (see Stepping Stones, pp. 32-33)—have marked our knowledge of space. "These successes have forged France's science and engineering credibility and laid down key milestones to meet the challenges that lie ahead," underlines Olivier Joie-La Marle. "I'm thinking also of LISA, which has detected gravitational waves, NewAthena, to study high-energy phenomena and supermassive black holes, and of course Dragonfly, which is set to explore the surface of Titan in search of organic signatures."

Over the past year, this momentum has somewhat slowed in a shifting context. "Budget and geopolitical uncertainties, notably surrounding certain U.S. contributions to LISA and Mars Sample Return, remind us how fragile international balances are," notes Thierry Bret-Dibat. In response, CNES must continue more than ever before its mission as a government agency, sustaining France's commitments and consolidating partnerships. This constant effort is the only way to maintain open and rigorous space research for the benefit of humankind.

Gaia mission continues after final measurements

After ten and a half years of observations, the Gaia satellite ceased operating on 15 January 2025. But the mission goes on, with five years' worth of data still to sift through before releasing the final catalogue of more than two billion stars in 2030. Besides major discoveries like the Gaia-Enceladus dwarf galaxy and the black hole BH3, it offers perspectives for new practical applications like calibrating satellites' star trackers for attitude control or navigating in space.

The radiator of the SVOM mission's MXT telescope in integration at CNES's Toulouse field centre.

Experts on a mission

From the early concept phases through to data exploitation, CNES teams offer a broad palette of science, engineering, systems and operations expertise to bring space projects to life.

960
CNES subject matter experts
supporting space projects

Science missions are long, complex and costly projects, sometimes involving hundreds of people across several continents. As France's national space agency and a world-class centre of engineering, CNES can call on a vast range of skills and expertise and tailor it to requirements, from ideation through to operations.

The concept professionals. The PASO orbital systems architecture department oversees project conception, working with research and technology teams and subject matter experts. These Phase 0 specialists (see Stepping Stones, pp. 32-33) provide support to scientific communities, turning expressions of requirements into mission feasibility studies ready to respond to ESA calls for ideas.

Project teams. Depending on a project's nature and ambition, teams may vary in size, from a small unit supporting a research laboratory to a full-blown team, notably for complex projects like Athena. This team then coordinates all project engineering activities, orchestrating international collaborations alongside the principal investigator (PI), in charge of scientific matters.

Subject matter experts. CNES's 960 subject matter experts span almost all of the agency's expertise in hardware, software, orbital systems and more. They are involved in project development, as well as during early concept phases to anticipate technology requirements or support new entrants.

The Mars French Operations Centre for Science & Exploration (FOCSE) at CNES's Toulouse field centre.

Dedicated operational centres. At the CADMOS centre for the development of microgravity applications and space operations, CNES teams conceive and monitor experiments conducted aboard the International Space Station (ISS). Its counterpart, the FOCSE (French Operations Centre for Science & Exploration), coordinates Mars science activities and prepares future exploration missions.

IDEFIX all set to go

Designed by CNES and the German space agency DLR, the small IDEFIX rover is set to fly on Japan's Martian Moons eXploration (MMX) mission. The rover's task will be to analyse the composition, environment and mechanical properties of the surface of Phobos to prepare for sample collection. After arriving in Japan, IDEFIX is currently taking part in mission spacecraft integration testing. Launch is planned for October 2026 and landing two years later.

Forging space alliances

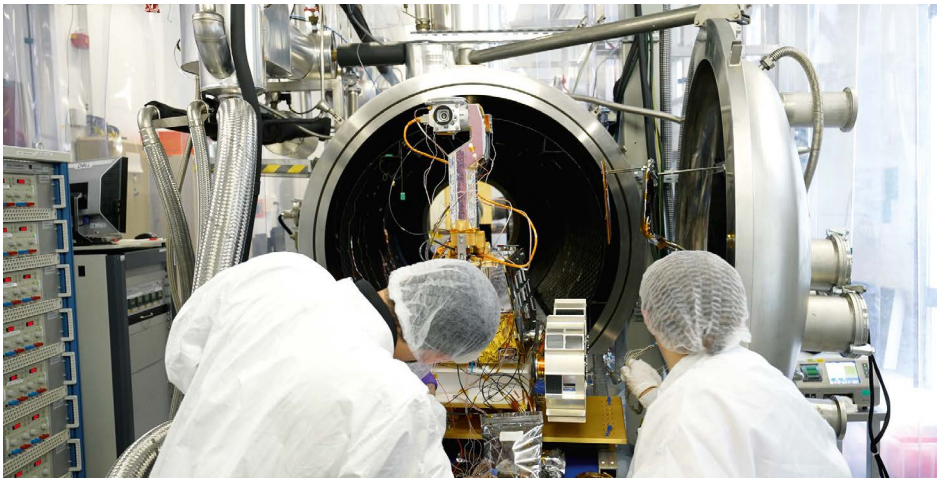
Working behind the scenes of space cooperation, CNES endeavours to combine diplomacy with science and industry to serve beacon missions.

With $9.7 billion spent, 20 years in design, three partner space agencies, 14 contributing nations, 258 institutions and firms, and more than 20,000 people involved, including more than 1,200 research scientists, the James Webb Space Telescope—Webb for short—today remains the most ambitious space project ever undertaken and a perfect illustration of the transformative power of global scientific cooperation. Obviously, not all space missions are like Webb, but many still imply a level of cost and engineering prowess that requires the involvement of partners from all over the world.

CNES's Europe and International Directorate (DEI) plays a key role in this respect. "We have a team of 30 people in Paris and eight embassies with embedded space advisers," says Rozenn Saunier, deputy head of DEI. This closely knit team covers a broad range of activities.

It is above all a spearhead for France's space diplomacy. "Working with our agency's engineering and operations directorates, we coordinate our relationship with ESA, taking the lead during preparations for ministerial conferences [see Pointers p. 17]," adds Rozenn Saunier. "Between ministerial

The James Webb Space Telescope is prepped for launch at the Guiana Space Centre.



The Emirati Rashid rover with its CASPEX cameras developed by CNES, in testing in Toulouse.

8
SPACE ADVISERS represent CNES abroad.

conferences we ensure proper execution of our commitments through programmatic oversight, ESA programme board meetings, quarterly council meetings and so on." The directorate also provides its technical expertise for key space stakes at European level—notably within the framework of the future EU Space Act—or during discussions at the UN Committee On the Peaceful Uses of Outer Space (COPUOS), especially regarding sustainable management of space.

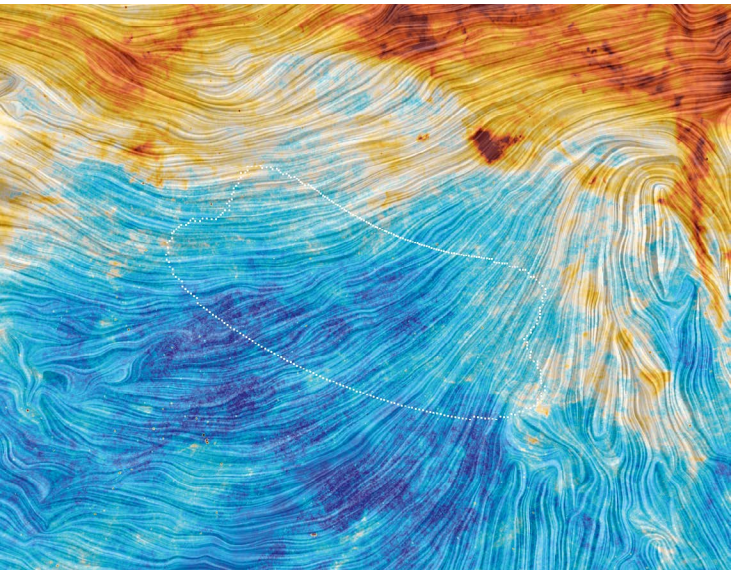
Another important part of what DEI does is assisting the conception and conduct of space programmes, from negotiating agreements through to tracking execution. And it of course supports the French industry ecosystem's international development by fostering European partnerships and programmes, and easing access to export markets. "We're kind of a bridge between institutions and the world of science and technology," says Rozenn Saunier.

CNES currently has 120 international agreements in force, and 20 or so new ones are signed every year. In today's fast-moving space environment and with the future directions of the U.S. administration clouded in uncertainty, the agency's intent is to maintain a balance between its historic partners—United States, Japan, Germany and India—and new entrants like Singapore, South Korea and the United Arab Emirates.

Julien Mariez, space adviser and CNES representative at the French Embassy in Japan

"My main mission is to develop cooperation with JAXA, Japan's space agency, which is CNES's number two partner after NASA, and to maintain strategic dialogue with the Japanese government and its ministries whose remit covers space. I'm also increasingly asked to help ease access to Japanese markets for French manufacturers, who are achieving increasing success in a country that until now has been the preserve of U.S. industry."

Uncertainty drives science



Map of dust (colours) and the galactic magnetic field (relief) measured by Planck. BICEP2's field of view is indicated by the white dots.

Take your mind back to March 2014: an American team claiming to have demonstrated the existence of gravitational waves from the very first instants of the universe after the Big Bang, using the BICEP2 telescope, is making headlines. A momentous discovery worthy of a Nobel Prize, you might think. Except that a few weeks later, the ESA Planck mission's science team, surveying the skies at a higher frequency than BICEP, casts a doubt on this claim: could the signal measured by the U.S. scientists be explained, at least partially, by dust in our own galactic neighbourhood?
Joining forces, the two teams finally arrive at the conclusion that primordial gravitational waves had not alas been observed in this instance. Something of a letdown? Far from it: for CNES's ethics officer Jacques Arnould, "on the contrary, it shows strong teamwork and scientific rigour, where uncertainty doesn't mean you've failed; it's a vital step in the process of investigation, because in science, you can't demonstrate anything without considering the degree of uncertainty. Each data point has to be tested and compared against others. Instruments are tested on the ground, and then again in orbit; results are checked against others from independent teams. This virtuous cycle of verification is what sets research apart from beliefs. The same applies to CNES's engineering efforts: when they're preparing a mission, our experts constantly strive to reduce uncertainties, while accepting that nothing that might occur in space is ever certain."
The BICEP/Planck episode reminds us that the path from intuition to proof is a long one, paved with contention and doubt, where cooperation takes priority over competition.

A living meteorite?

In August 1996, NASA made the Earth-shattering announcement that scientists had identified signs in Martian meteorite ALH 84001 of extraterrestrial life, in the shape of carbonates, magnetites, organic molecules and microscopic features reminiscent of bacteria. After the initial media frenzy and a series of contradictory analyses, doubt began to creep in. Twenty years on, the conclusion is that these clues are in fact due to geological processes on Mars and contamination from Earth. But every cloud has a silver lining: the false discovery, vaunted by Bill Clinton, gave new impetus to the robotic exploration of Mars to search for ancient signs of life.

Back to the future

GEIPAN investigates and documents strange sightings

For nearly 50 years, the French UAP research and information group has been working to explain unusual sightings reported by citizens.

Investigation into the case of a large burnt area, nicknamed "Le Trou Normand", found in 1989 near Brix, Normandy.

MILESTONES

1977
Birth of GEPAN

1988
GEPAN replaced by SEPRA, a permanent unit at CNES responsible for routine monitoring of orbital debris and risk objects

2005
Audit to rethink the unit's future, birth of GEIPAN

2007
GEIPAN releases its archives via a dedicated website (https://www.cnes-geipan.fr/)

In the 1970s, unrecorded sightings proliferated. "The explanations given were often fanciful and sometimes fairly biased," recalls Frédéric Courtade, who heads the GEIPAN unit. On the initiative of the Ministry of Defence and CNES, a scientific unit was set up to study unexplained phenomena: GEPAN. Its mission was to seek rational explanations for strange phenomena reported—a world first. "No other space agency apart from CNES has dared to include a dedicated UAP unit in its official organization chart," says Frédéric. In 2005, this unit became GEIPAN, adding an 'I' for "information".

"From then on, our investigations were no longer reserved for the eyes of a scientific committee and our mission was to be completely transparent with the general public about what we do." From day to day, a three-strong team collects and analyses the 5,000 "interactions" with citizens recorded every year. Of these, 800 to 1,000 sightings come within GEIPAN's remit. To conduct its investigations, the unit calls on a network of external experts (police, meteorologists, physicists, military, pilots, lightning specialists, ornithologists, sociologists, psychologists). "Eyewitness reports are reviewed to distinguish factual accounts from interpretations, unreliable memories or biased perceptions," notes the unit's director. Any unidentifiable phenomenon is looked at by one of GEIPAN's 15 volunteer investigators. Once all clues have been collected, cases are classified: 65% are explained or probably explained scientifically, while 3.2% remain unsolved. "These investigations leave a lasting impression, because people are sincere and it's hard to explain things to them," stresses Frédéric Courtade. "To avoid them lapsing into ideological conjecture, we show them our methodology."

Talking ethics

Jacques Arnould
Science historian and theologian, CNES ethics officer

Cosmet(h)ics

In the space of a few centuries, our view of the sky has changed profoundly. The few thousand stars once visible to the naked eye have now become billions upon billions, swept up in a vast expansion unleashed by a Big Bang buried in the depths of time. Yet for all that, have we forgotten the sky as it once was?

Nihil novi sub sole. There's nothing new under the Sun.

The sage who crafted this maxim didn't speak Latin, more likely Hebrew. Either way, he voiced a human idea shared across many cultures and eras: whatever the passing of hours, days and seasons, whatever turmoil our lives endure or create, nothing surpasses the reassurance, the certainty that nothing truly new can ever happen. And to see for himself, this sage needed only to raise his eyes to the sky: flooded with sunlight by day, plunged in the Milky Way by night, was it not the very image of order, of mystery, of the eternal cycle of renewal? Greek thinkers and poets didn't hesitate to name it *kosmos* in celebration of its beauty—the very same word they used to honour the beauty of their wives…

By turning their telescopes to the sky, modern astronomers seem to have dulled that beauty: it was no longer called the *cosmos*, but the *universe*, since scholars now said it was made of the same matter as Earth and governed by the same laws. From then on, heaven and Earth would form one and the same whole.

But has the cosmos really vanished from our minds? Certainly not. Just think of our excitement at the images from the Hubble and James Webb space telescopes… even though, to share them with us, astronomers haven't hesitated to hype them a little with a touch of cosmetic treatment. Did you know that, in doing so, they took their inspiration from 19th-century American artists who painted the great landscapes of the conquest of the West? But never mind that. Think also of our shock, our outrage, when we grasp the full extent of the pollution now cluttering Earth's orbits. Are we genuinely worried about the growing risk of collisions between satellites, which most of the time we can't even see anyway?

Or is it rather that we've held onto the idea of the sky as a cosmos—a place so beautiful, so mysterious, that we shouldn't stain it with our human footprints?

A single letter, a single breath separates cosmetics from "cosmethics" (a word coined just for you, dear reader!). And yet it's here that our responsibility as Earth-dwellers towards the sky truly lies. To know it better so we can better manage its riches, benefits and resources—as well as its dangers and rages. This task is still far from complete.

LATMOS

"New insights into the processes driving development of life"

CHARLOTTE CORBEL

research engineer, project leader for the Dragonfly mission's DraMS-GC instrument

Dragonfly is planned for launch in 2028 on a mission to Titan, one and a half billion kilometres from Earth. After a six-year journey through space, the rotorcraft will set down on the surface of Saturn's largest moon. The goal of this NASA exploration mission is to study Titan and find out if past or extant life could have developed there. "Dragonfly will collect samples of surface material, analyse their chemical compounds and look for traces of life and chemical indicators of life based on water or hydrocarbons," explains Charlotte Corbel, an engineer at the LATMOS atmospheres, environments and space observations laboratory, and project leader for Dragonfly's DraMS-GC instrument. "Our laboratory is supplying the gas-phase chromatograph for the DraMS mass spectrometer that will separate sample constituents for analysis and identification of molecules present on Titan," she reveals. Within this joint research unit of the national scientific research centre CNRS, the University of Versailles Saint-Quentin-en-Yvelines, Sorbonne University and CNES, Charlotte Corbel coordinates a team of 30 engineers and technicians. She is in charge of the project's technical, operational and budget management, working with CNES, which is funding the instrument up to its delivery and operations on Titan. "For Dragonfly, an integrated project team is keeping track of progress on a daily basis. On the technical side, we're calling on CNES's specific expertise in mechanical and thermal engineering, and in selecting materials," she notes. After joining CEETP, the French terrestrial and planetary environment research centre (now LATMOS) in 2002, Charlotte Corbel is still collaborating with the French space agency on the design and development of Wisdom, the radar for Europe's ExoMars exobiology[1] mission. While the presence of ancient water on the red planet has been the subject of debate, the Cassini mission has revealed liquid methane seas on Titan. "We know Titan has a very dense and carbon-rich atmosphere," says the engineer. So understanding the chemical reactions occurring there "will give us new insights into the processes driving development of life on a moon or planet and, possibly, whether life might have appeared elsewhere in our solar system."

1. The study of life in the universe.

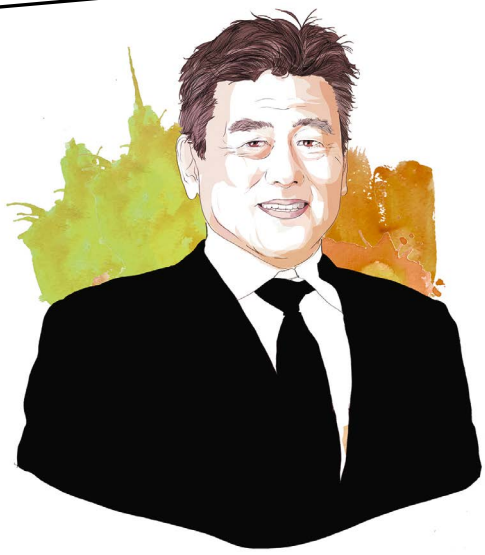
PARIS OBSERVATORY

"I've learned to work without worrying exactly where it will lead me"

SÉBASTIEN FERNANDEZ

PhD graduate student affiliated to the Paris Observatory

"I'm not a trained theoretician. I wanted to keep working in engineering but close to research scientists and physicists, in fundamental physics," says Sébastien Fernandez. At the age of 31, the graduate of the ISAE-Supaero aerospace engineering school traded his job in optical systems at French firm Sodern for a three-year research grant. Now a PhD graduate student affiliated to the LTE time-space laboratory at the Paris Observatory, he is based at CNES's Toulouse Space Centre. His thesis is being co-funded by the French space agency and the AID defence innovation agency at the Ministry of Armed Forces. In 2022, when Sébastien decided to change tack, he quite naturally consulted CNES's calls for contributions platform. "I was already familiar with CNES, as I'd done internships there," he recounts. In 2017, he was in charge of the optical instrument for the EyeSat nanosatellite. A year later, he moved to the Guiana Space Centre where he learned all about preparing satellites for flight. The subject of his thesis stems from his fascination for space optics and observing Earth and the universe. "The aim of my thesis is to compare the oscillation frequencies of two optical clocks 100 kilometres apart. I'm building a laser communication system to link them via an airborne relay," he explains. Flying aboard a helium balloon 300 metres above the ground, this system relays a laser signal whose frequency is tuned to one of the clocks. "It's a very concrete application of Einstein's theory of relativity, which predicts that the passage of time varies with the altitude of the clock measuring it." Recording this variation at different points on the globe will make it possible to map elevation and relief in a given area with unprecedented centimetre accuracy. Sébastien's work prefigures the next generation of optical space clocks that will succeed PHARAO. As he puts the finishing touches to his thesis, it's time to take stock of the last three years. "We have a lot of resources and freedom to test things. I've learned to work within a very open framework, without worrying exactly where it will lead me," he observes. Research provides a space to experiment, far from the formal specifications of industry. "It calls for rigour, as we need to be able to show our progress. So it's a great opportunity to learn and develop working methods." After his viva, Sébastien is keen to pursue his engineering career with CNES.



JAXA

"Some missions can only happen through tight collaboration with trusted international partners"

MASAKI FUJIMOTO

Director of JAXA's Institute of Space and Astronautical Science (ISAS)

October 2018: Masaki Fujimoto is in Bremen, Germany, for the International Astronautical Congress (IAC). During the night of 2-3 October, after a four-year journey, Japan's Hayabusa2 space probe has arrived in the vicinity of asteroid Ryugu. It sets down its MASCOT lander on the surface of this large rock spanning 920 metres, on a mission to gather key clues on the first instants of the solar system. "A few hours later, I was on stage with CNES's MASCOT project manager," he recalls. "She was shedding tears of joy. That was the defining moment that convinced me we were equally passionate in France and Japan about space missions." In 2015, his research expertise exploring the origins of the solar system led to him being called to head international collaboration on this science mission between the German space agency DLR, CNES and the Japan Aerospace Exploration Agency (JAXA). From 2020, as Deputy Director General of JAXA's Institute of Space and Astronautical Science (ISAS), he orchestrated cooperation on the LiteBIRD satellite. "This sort of cosmology mission probing the very beginnings of the universe can only happen through tight collaboration with trusted partners," he underlines. "CNES played a critical role in Planck, which is like a precursor mission to LiteBIRD, so it has expertise in space missions of this kind." Another of Masaki Fujimoto's research interests during his career has been space plasma physics, on which he worked with CNES for the European Space Agency's pioneering Cluster constellation, which for two decades gathered data on how the Sun interacts with Earth's magnetic field. Other projects in which he has occupied a leading role include BepiColombo, to unveil the secrets of Mercury, and the JUICE space probe to explore Jupiter's icy moons. Appointed to head ISAS in 2025, Masaki Fujimoto is also one of the founding fathers of MMX, a mission to explore Mars' two moons. The French-German IDEFIX rover flying on this probe is set to land on Phobos in 2026. "The big question here is life outside our planet, which is closely tied to the science theme of Hayabusa2 and astronomy missions observing exoplanets. This array of missions shows that JAXA is a key member of the global space exploration community."

AIRBUS

"To win a bid, you have to understand the mission and its challenges"

HÉLÈNE BOITHIAS

Business Development Manager

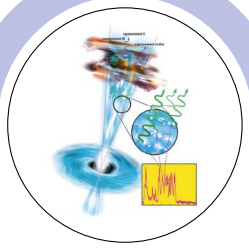
"To meet bid specifications and craft a winning proposal, you have to understand the mission and its challenges," says Hélène Boithias, Business Development Manager at Airbus. After graduating from the ENAC civil aviation school and the Ecole Centrale Paris engineering school, she joined the aircraft manufacturer in 1989. She spent her early career working on orbital rendezvous for the European Automatic Transfer Vehicle (ATV) that would ferry supplies to the International Space Station (ISS). "Airbus then seconded me to the European Space Agency (ESA) to work on a satellite to observe the Sun," she recalls. This involved moving to Maryland in the United States, where she joined the teams at NASA's Goddard Space Flight Center (GSFC).
On returning to France, she became an attitude control system architect for the Inmarsat-4 telecommunications satellites. In 2009, she decided to "leave the technical side of things for sales", specializing in science and Mars exploration missions. "I work on sales campaigns up to contract signature, that is, when we actually start developing the satellite." Before then, Hélène Boithias liaises with CNES to ensure she's cognizant with France's position regarding ESA's key space programmes.
"The funding contributions of each member state are adjusted at programme board meetings. The industrial return is proportional to the resources devoted to the programme. So, if you're leading a mission as prime contractor, that implies funding at least 35%," she notes.
For example, Airbus was selected to develop the telescope for the Euclid mission. Launched in 2023, this satellite plans to unravel the mysteries surrounding the expansion of the universe. Airbus also built the JUICE (Jupiter Icy Moons Explorer) spacecraft. As business development manager, Hélène Boithias is glad to have contributed to "the first European mission to explore the Jovian system". At its facilities in Toulouse, Airbus "integrated the spacecraft and its instruments developed partly by research laboratories with support from CNES." Another flagship project in which Hélène is involved is Mars sample return. "What fascinates me about these space missions is the mysteries they seek to unravel, and the new discoveries they make. It's the stuff of dreams."

From idea to orbit: Odyssey of a space mission

From scientific need to data analysis, space missions go through a six-phase process. Here we look at one example: the French-Chinese SVOM mission, 20 years in the making.

A scientific space mission is a long-haul effort, often spanning several decades. It all starts with a question to which space data could supply some answers. This is followed by years of study, technological research, testing and technical validation, as well as

Phase 0: Needs and ideas

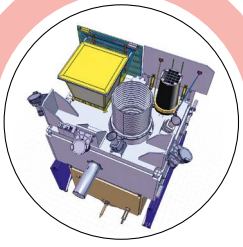


Phase 0 involves defining the mission in terms of scientific needs. What questions are we trying to answer? Initial scenarios are assessed for their technical, programmatic and financial feasibility, along with the different technical solutions to be deployed or designed. For SVOM, it all began in 2005 with an ambitious idea spearheaded by several French research laboratories to observe GRBs.

Phase A: Definition and scaling

Phase A is one of trade-offs. The challenge is to define needs, study scenarios and confirm the mission's feasibility. Schedules, risks and costs must be assessed. For SVOM, this phase concluded with the signature of a Memorandum of Understanding between France and China.

Phase B: Fine-tuning and validation



This is a pivotal phase where scientific performance is weighed against technical feasibility and cost in order to fine-tune the various options. It's also when the first industrial contracts are signed. SVOM's Phase B began in 2012, with the launch of in-depth system studies, and ended with a review validating transition to the development phase.

scouting for opportunities, partnerships and funding to make the mission a reality.
Once in orbit, the satellite begins conducting observations and collecting data that will fuel research for years to come. The entire process is divided into specific phases, from Phase 0 to define needs to Phase E dedicated to operations. While each CNES science mission is unique, they all follow the same pattern. A prime example is SVOM, the French-Chinese mission to detect gamma-ray bursts (GRBs)[1]. Born in 2005 out of a vision shared with France's national scientific research centre CNRS, its atomic energy and alternative energies commission CEA, and Chinese research laboratories, the SVOM satellite was launched nearly 20 years later, in 2024.

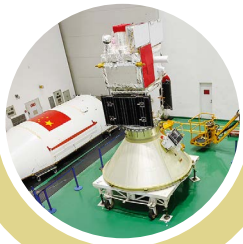
1. Very-high-energy phenomena observed during the death of a star.

Phase C: Design and qualification

This is the detailed design phase, where things get real. Each satellite component is designed down to the very last detail, before being produced and tested. A qualification model is subjected to intensive testing to ensure that everything will perform as intended in orbit. This then gives the go for production of the flight model.

Phase D: Integration and final testing

Next comes final assembly. For SVOM, this took place in 2023, when all of France's rigorously-tested instruments arrived in China for integration with the satellite. This was followed by a year of testing to ensure the flight model would work perfectly and to the required levels of performance in orbit, and that it would be able to withstand the launch. Nothing was left to chance before the big send-off!



Phase E: Launch and operation

SVOM took to the skies on 22 June 2024. Over the next six months, development teams and operators worked hand in hand to optimize the configuration of all satellite and instrument parameters and reach targeted performance levels.
In January 2025, following final validation, the keys were officially handed over to operations teams in China and France.

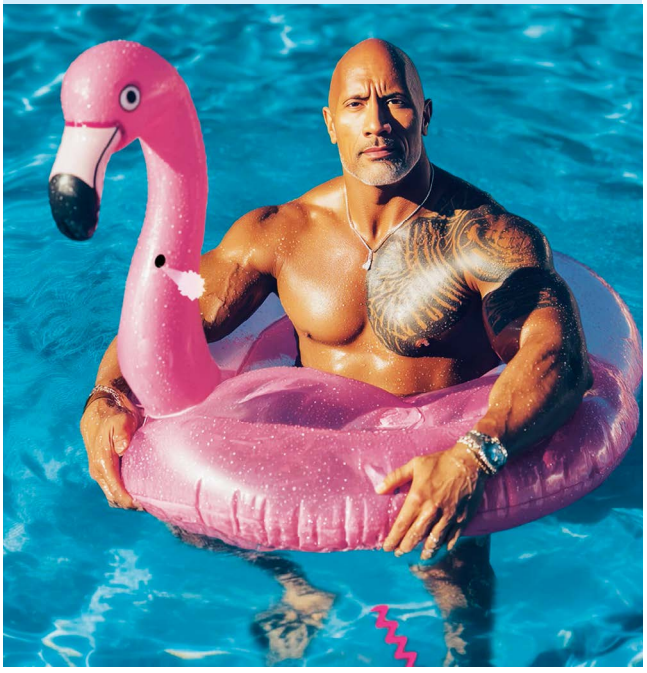
Earth attractions

Citizen science in a few clicks

Zooniverse is the world's largest platform for citizen science, where 2½ million Internet users interact with hundreds of researchers to fuel participative research: hunting for black holes, using light from distant galaxies to travel back in time, decoding signals from space. For the Euclid Galaxy Zoo project, citizens are asked to identify the shapes of thousands of galaxies in images taken by the Euclid space telescope. Zooniverse's ZooBot algorithm starts by filtering out images that are easiest to identify, then humans help the AI tool expand its knowledge. This work will eventually enable scientists to understand how galaxies change shape over time. Are you ready to join the citizen science movement?
zooniverse.org

Unlocking the secrets of the cosmos on YouTube

How was the universe created and formed? Are we alone in this vastness? How did our solar system form? What triggered the Big Bang? Who discovered dark matter? How do black holes form? CNES's new video series unlocks some of the great mysteries of the universe. Eight episodes explore its darkest corners and the theories developed by scientists in an attempt to explain them. They also show how advances in technology and astrophysics have revolutionized our understanding of the universe and its components.
Les Mystères de l'Univers (Mysteries of the Universe), coming soon on the CNES YouTube channel.



CNES store – a piece of the cosmos, made in Europe

CNES has got together with French embroidered-accessory brand Macon&Lesquoy to bring you *Cosmos*. Designed in France and woven in Portugal, this iron-on emblem will inject a hint of the great space missions into your everyday.
€30 – Available on maboutique.cnes.fr

Interplanetary podcast

If you could spend your holidays anywhere in the solar system, where would you go? To celebrate their 20th wedding anniversary, one couple decides to explore Mars, Venus, Jupiter and the Moon. Compulsive listening for young and old alike, *En vacances dans le Système solaire* (On Holiday in the Solar System) is an eight-episode CNES series available on the Merlin audio-speaker.

DIARY

OCTOBER 2026:
LAUNCH OF THE MMX MISSION, led by Japan, to explore the moons of Mars. It will be carrying the French-German IDEFIX rover, tasked with collecting samples from the surface of one of these moons, Phobos.

DECEMBER 2026:
LAUNCH OF THE PLATO SCIENTIFIC SATELLITE by Ariane 6. Designed to gain new insights into planet formation and explore the planetary systems of the Milky Way, PLATO will spend four years detecting and characterizing thousands of exoplanets of all sizes, some of which could well resemble Earth.

LATE 2026:
EUROPE'S BEPICOLOMBO SPACECRAFT TO REACH MERCURY after an eight-year voyage. Once in orbit, JAXA's MPO and Moi satellites will map the planet's vicinity as well as its composition, inner structure and magnetic field.

LISA on the lookout for waves from the universe

LISA is a gravitational wave detector set to launch within the 2030-2040 timeframe on a mission to observe low-frequency signals and obtain precious data on black holes and galaxy evolution. A consortium of 200 research laboratories is providing scientific expertise for the project.

FRANCE

CNES, in partnership with the national scientific research centre CNRS and the French atomic energy and alternative energies commission CEA, is tasked with verifying performance on the ground. The agency is notably testing the system's optical bench. It is also developing the Distributed Data Processing Centre (DDPC) that will be handling the mission's science data.

ITALY

The University of Trento's contribution concerns development of the Gravitational Reference Sensors (GRS), each consisting of a free-fall test mass sensitive to gravitational waves. There are two GRS in each of the three LISA satellites.

UNITED KINGDOM

The University of Edinburgh is in charge of developing the optical systems for LISA's instruments. Scientists from the University of Birmingham will be working on science data processing, alongside their Italian and German counterparts.

GERMANY

Germany is the lead for the Interferometric Detection System (IDS), the key measuring system for the three LISA satellites' instruments. The Albert Einstein Institute is closely involved in designing this system.

ESA

The European Space Agency is the main contributor to the mission, which it is coordinating. It is developing the spacecraft buses, will launch the satellites and check that all space segment hardware is operational.