CNES MAG

EN FR

SPACE • INNOVATION • SOCIETY

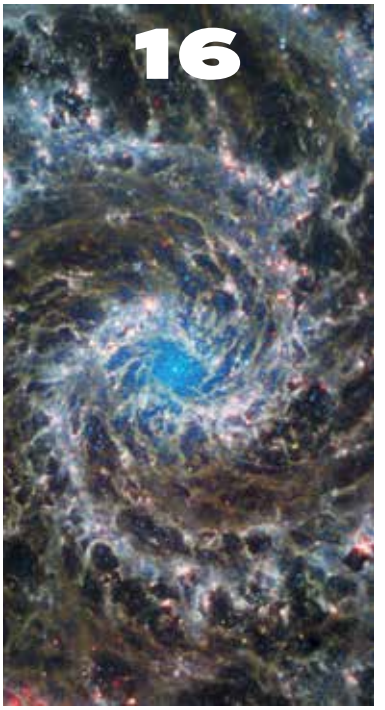
#94
November 2022

FRANCE-USA

IN SPACE WE TRUST

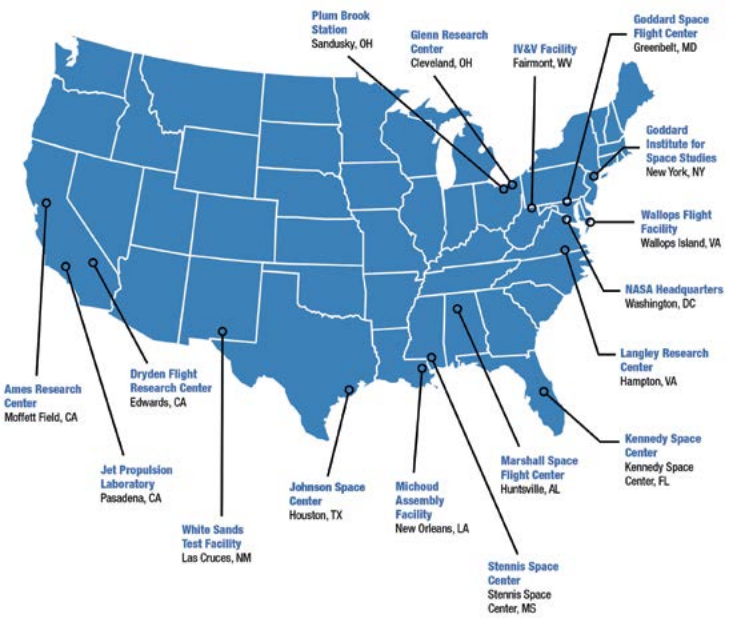
cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

INSIDE



INSIDE

NASA CENTRES IN THE UNITED STATES



PARTNERS

In this issue: NASA p. 3/7/9/10/11/14/18/20/23/25/26/28/29/31/34/35, ESA p. 9/20/24/25, NOAA p. 8/14/29, IRAP astrophysics and planetology research institute p. 17/23, Los Alamos National Laboratory (LANL) p. 23, Airbus Defence and Space p. 23, CNRS p. 16/18/23, LATMOS atmospheres, environments and space observations laboratory p. 10/26, JAXA p. 7/27, CSA p. 16/24, JPL p. 18/26, Thales Alenia Space p. 25, French Embassy in Washington D.C. p. 30/34/35, Business France p. 18, ONERA national aerospace research centre p. 4/18, Goddard Space Flight Center p. 10/18/35, SpaceX p. 7/9/24/36, CEA p. 16/18, Paris Observatory p. 16, CLS p. 34, Kineis p. 34, Rocket Lab p. 34, Exotrail p. 36, Federal Communications Commission (FCC) p. 29/34, DoD p. 7/14/29, Blue Origin p. 7, Virgin Orbit p. 7, Virgin Galactic p. 7, United Nations p. 8, COPUOS p. 8, Connect by CNES p. 36, SCO p. 8/9/14/20, LESIA space and astrophysics instrumentation research laboratory p. 10, LISA inter-university laboratory for the study of atmospheric systems p. 10, LGPM process engineering and materials laboratory p. 10, French Space Command (CDE) p. 11/29, U.S. Space Force (USSF) p. 11/29, Ministry for the Economy, Finance and Industrial and Digital Sovereignty p. 28, Ministry for Higher Education, Research and Innovation p. 28, Ministry of Armed Forces p. 28/32, National Space Council (NSpC) p. 28/13/15/28, French defence procurement agency (DGA) p. 29, National Reconnaissance Office (NRO) p. 29, National Geospatial-Intelligence Agency (NGA) p. 29, Federal Aviation Administration (FAA) p. 29, IFRI international relations institute p. 32, European Union p. 32, NATO p. 14/32, U.S. Geological Survey (USGS) p. 14, White House p. 13/15.

Cover: © Isabel Espanol

CNES.FR
More content in this new issue online at cnes.fr/cnesmag

CNESfrance
@CNES
YouTube CNES

CHRISTOPHE VENET

CNES's Director of European and International Affairs

Christophe Venet has always maintained a dual focus throughout his career on international affairs and space. With his background as a researcher in spatial analysis and then as space attaché at France's Mission to the European Union, and his role behind the publication of a number of books, he has been closely involved in executing France's space policy. For this issue, he gives us the benefit of his expert insight.

NICOLAS MAUBERT

Driven by his firm belief that space cooperation is a fantastic tool for diplomacy, Nicolas Maubert has crossed the Atlantic to head up CNES's office in Washington D.C. Working out of the French Embassy, he deciphers for us the causes and effects of the momentum behind the U.S. programme and how it's influencing CNES and NASA's longstanding relationship. He was a precious source of information in putting this issue together.

MATTHEW KOEPPE

Appointed in August 2021, Matthew Koeppe is NASA's representative in Europe, based at the U.S. Embassy in Paris. A man of experience who likes to keep in touch with grassroots, he has taken time to meet with the key French space players, at CNES, ONERA and the Cité de l'espace space theme park, as well as New Space start-ups. His role is an undeniable asset that can only strengthen French-U.S. ties.

BRIGITTE ALONZO-THOMAS

As editor-in-chief of this magazine, which she created in 1998, Brigitte Alonzo-Thomas has made Cnesmag what it is today. With her widely hailed professionalism and perseverance, she has done a fantastic job showcasing CNES's teams and what they do, taking the "Mag's" readers inside the ropes to reveal the agency's rich talents and expertise. Today she is handing over the reins to Mélanie Ramel, who will be perpetuating these same values.

CNESMAG

CNESmag, the magazine of the Centre National d'Etudes Spatiales, 2 place Maurice Quentin. 75039 Paris cedex 01. For all correspondence, write to: 18 avenue Edouard Belin. 31401 Toulouse cedex 9. Tel.: +33 (0)5 61 27 40 68. Internet: http://www.cnes.fr. This review is a member of Communication&Entreprises. Subscriptions: https://cnes.fr/reabonnement-cnesmag. **Publication director:** Philippe Baptiste. **Editorial director:** Marie-Claude Salomé. **Editors-in-chief:** Brigitte Alonzo-Thomas and Mélanie Ramel. **Proofreading:** Céline Arnaud. **Editorial staff:** Stéphane Boumendil, Liliane Feuillerac, Pierre Henriquet, Hortense Lasbleis, Mélanie Ramel, Valérie Ravinet, Guillaume Tixier. **Photos and iconography:** Marie-Claire Fontebasso, Orianne Arnould. **Photo editor:** Thierry de Prada. **Photo credits:** p.4 CNES/C.Peus - CNES/L. Le Carpentier - NASA - CNES/T. De Prada; p.5 CNES/C.Peus; p.6 CNES/Distribution Airbus DS, 2016; p.7 NASA/Keegan Barber; p.8 NASA/Landsat; p.09 NASA/Aubrey Gemignani, 2021; p.10 NASA; p.11 (haut) NASA; p.11(bas) Canadian Armed Forces; p.13- p.15 NASA; p.16 ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team; p.17 ESA/DLR/FU-Berlin; p.19 Isabel Espanol/Gettyimages; p.20 AFP/L. Marin; p.21 NASA/Cory Huston; p.22 NASA/JPL-Caltech; p.23 NASA/JPL-Caltech/MSSS; p.24 NASA/Aubrey Gemignani; p.25 Getty Images; p.26 CNES/Mira Productions; p.27 CNES/T. De Prada, 2021; p.33 J.Arnould; p.34 CNES/O.Sattler; p.34 (haut) TwentiethCenturyFox,2017; p.34(bas) CNES/ESA/M. Pedoussaut; p.35 Ambassade de Fance; p.36 Exotrail. **Illustrations:** Isabel Espanol/Gettyimages, François Foyard, Robin Sarian (Idix). **Webmaster:** Sylvain Charrier and Marie Fesuick. **Social media:** Mathilde de Vos and Alice Thomas. **English text:** Boyd Vincent. **Design and pre-press:** Citizen Press – David Corvaisier, Fabienne Laurent, Hortense Lasbleis, Alexandra Roy, Guillaume Tixier. **Printing:** Ménard. ISSN 1283-9817. **Thanks to:** Jacques Arnould, Philippe Collot, Philippe Etienne, Matthew Koeppe, Zohra Mokadem, Samuel Mamou, Jean-Luc Maria, Nicolas Maubert, Pam Melroy, Guilhèm Penent, Christophe Venet.

PEFC 10-31-2690

IMPRIM'VERT

With the Comprehensive Dialogue on Space, a new chapter in the story of French-U.S. cooperation in space is today playing out before our eyes.

This dialogue between our two nations is of course not new; in fact, it began 60 years ago. It has since been crowned by many achievements together of which we can be proud, such as robotic exploration with marvels of technology like Curiosity and Perseverance, Thomas Pesquet's flight as the first European astronaut aboard SpaceX's Crew Dragon or the study of climate change from space thanks to altimetry satellites like TOPEX/Poseidon and the Jason series, whose mantle will soon be taken over by their successor SWOT.

It's often said that if you want to go fast, go alone; but if you want to go far, go together. This proverb applies to space more than anywhere else, especially within a fast-moving ecosystem opening up to new players on either side of the Atlantic, driven by both social and defence considerations.

In this changing world, cooperation between our two nations remains a strong pillar on which to build the future. I hope you enjoy reading CNESMAG.

MARIE-CLAUDE SALOMÉ
CNES DIRECTOR OF COMMUNICATION

The U.S. Capitol seen by the Pleaides satellite.

COMPREHENSIVE DIALOGUE ON SPACE

FEDERATING SPACE STAKEHOLDERS

Space is central to the close and longstanding ties that France has forged with the United States, and is a powerful tool driving the nation's diplomacy efforts. At their meeting in Paris in November 2021, U.S. Vice President Kamala Harris and President Emmanuel Macron agreed to lay new foundations to further strengthen our partnership. Among the actions put in place is a Comprehensive Dialogue on Space designed to get key stakeholders in the space sector from the two countries together around the same table every year to define priorities for collaboration in the civil, commercial and national security spheres.
Topics like tackling climate change and building a sustainable space economy will naturally be at the heart of these constructive discussions.
The first of these gatherings will be held in Paris this November, making France the second nation after Japan to engage in this U.S. initiative.

ARTEMIS ACCORDS

ON THE ROAD TO THE MOON, MARS AND VENUS

The next slate of space missions are headed for deep space, the Moon, Mars and the solar system. Crews and technologies are already gearing up, but the ethical and regulatory guidelines governing the use of outer space need to be reset. This is what the Artemis Accords initiated in 2020 by the United States are seeking to do. Drafted to support NASA's Artemis programme to send astronauts back to the Moon, these vital accords have dusted off and updated the principles of the 1967 Outer Space Treaty, paving the way for global multilateral discussions on establishing a new legal framework to guarantee peaceful and sustainable use of space. France signed up to the accords on 7 June in Washington D.C. on the sidelines of CNES's 60th anniversary celebrations, becoming the 20th signatory nation. As well as its contribution to this lunar programme, it is also involved in the future U.S. Mars Sample Return (MSR), Dragonfly (Saturn/Titan), Veritas (Venus) and JUICE (Jupiter) missions.

25

Bilateral agreements currently in force between the French and U.S. space agencies. CNES is thus NASA's second most prolific partner, behind the Japanese space agency JAXA (42 agreements).

NEW SPACE

INNOVATION AND INSPIRATION

The U.S. space industry, like France's, was long the preserve of contractors supported by orders from government agencies like NASA or the Department of Defense (DoD). In the 2000s, the U.S. landscape was transformed by the quest to do things "better, faster and cheaper", opening up in the process to private players and competition. Disruptive technologies, the explosion of digital, miniaturization and artificial intelligence, the evolution of fabrication processes, gains from new architectures, off-the-shelf products, new business models and NASA's routine recourse to service contracts have ushered in the golden age of U.S. New Space. Firms like SpaceX, Blue Origin, Virgin Orbit and Virgin Galactic have built their success in part thanks to the federal government's innovative industrial policy. This has served as a source of inspiration for our nation, with the France 2030 Plan[1] inviting economic stakeholders to invest in certain segments of the space industry and develop new applications. And through initiatives like Connect by CNES, the French space agency is helping to sustain this momentum within the space ecosystem in the domains of healthcare, the environment and mobility.

1. Launched in 2021 by the French government.

In 2019, the Landsat Earth-observation satellite captured this image of severe flooding along the Mississippi.

SCO

U.S. STEPS UP TO THE PLATE

In 2017 at the One Planet Summit[1], the Space for Climate Observatory (SCO) came into being at the initiative of France and CNES. Its goal is to use satellite date to develop operational tools for adapting to the effects of climate change—preventing flooding and wildfires, preserving coasts, promoting integrated farming and irrigation, and so on.
The observatory today counts 30 member nations and international organizations.
The new U.S. administration, which has made space policy a tool to serve its climate priority, recently joined the SCO.
The decision to sign up to the initiative, announced by Vice President Kamala Harris in November 2021 in Paris, was formally enshrined by the signature of the SCO's charter in June this year by NOAA[2].
This agency has been observing the world's oceans and atmosphere, assimilating meteorological and oceanographic data, monitoring ecosystems and disseminating information for the past half century. It is the prime U.S. source of information on greenhouse gas measurements and projected sea level rise, and its international network is nurturing operational tools for land planning and tracking of climate change at the local scale.

1. International climate change summit.
2 National Oceanic and Atmospheric Administration.

REGULATIONS

MAKING SPACE SUSTAINABLE

Space isn't somewhere where everything goes and nations or users can do as they please, carelessly littering it with debris and other objects.
As early as 1959, the United Nations grasped the issue of space pollution, establishing itself as the relevant framework for laying down technical and legal "rules of the road" through the COPUOS[1]. While its recommendations seek to regulate the use of outer space, they remain non-binding. Today, the number of spacecraft and orbital debris has increased exponentially, cluttering space and fuelling fears that low Earth orbit[2] may become saturated.
Anticipating this trend, back in 2008 France enacted its very own French Space Operations Act (FSOA) incorporating the UN's recommendations. This act governs both launch operations[3] and orbital operations for satellites built in France or launched from French soil.
Recognizing CNES's expertise in this domain, the government has delegated responsibility to the agency for applying this legislation and checking regulatory compliance. CNES also regularly updates the act's provisions as orbital systems continue to evolve. This innovative French initiative could serve in discussions with the U.S. government to use the FSOA and its evolving concept as a blueprint for improving international regulations.

1. Committee on the Peaceful Uses of Outer Space.
2. Between 500 and 1,000 km.
3. Notably launches from French Guiana.

CREW-2

CLIMATE OF TRUST

On 23 April 2021, Thomas Pesquet set off for the International Space Station (ISS) aboard a SpaceX Crew Dragon, a testament to the close ties that bind France and the United States. The launch marked the first flight in 10 years of a European astronaut to the ISS from American soil. France's ESA astronaut and former engineer working on space mission autonomy at CNES (2002-2004) confided before his flight: "I'm proud to be representing my country up there." Now back on Earth after his six-month mission, he's eyeing the Moon and hoping to be on active duty for the Artemis programme's future lunar missions.

€9 billion

Investment in the space sector over three years announced by Prime Minister Élisabeth Borne at the International Astronautical Congress (IAC). The Prime Minister advocated "strong investment" and "cutting-edge research".

54.6 BILLION DOLLARS

Budget allocated to space by the United States for 2021, representing more than half of the total global space budget, with $23 billion appropriated to NASA.

1st

In 2021, Thomas Pesquet became the first French astronaut to command the International Space Station.

1961-2022: SIX DECADES OF COOPERATION

21 MARCH 1961

NASA and France sign first long-term cooperation agreement through the Space Research Committee, the forerunner of CNES.

23 NOV. 1979

Memorandum of Understanding to launch the Cospas-Sarsat project and signature of an agreement by four institutions, including CNES and NASA. The MoU was officialized in 1988 and Cospas-Sarsat has since helped to save 50,000 lives.

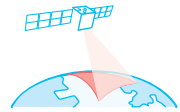
10 AUG. 1992

TOPEX/Poseidon is launched by an Ariane 4 from French Guiana, paving the way for a 30-year partnership in the field of oceanography.

7 FEB. 2011

Cooperation agreement on monitoring of space debris.

8 SEPT. 2011



Cooperation agreement on three Earth-observation missions—Calipso, Megha-Tropiques and SWOT—providing reference data for climate models.

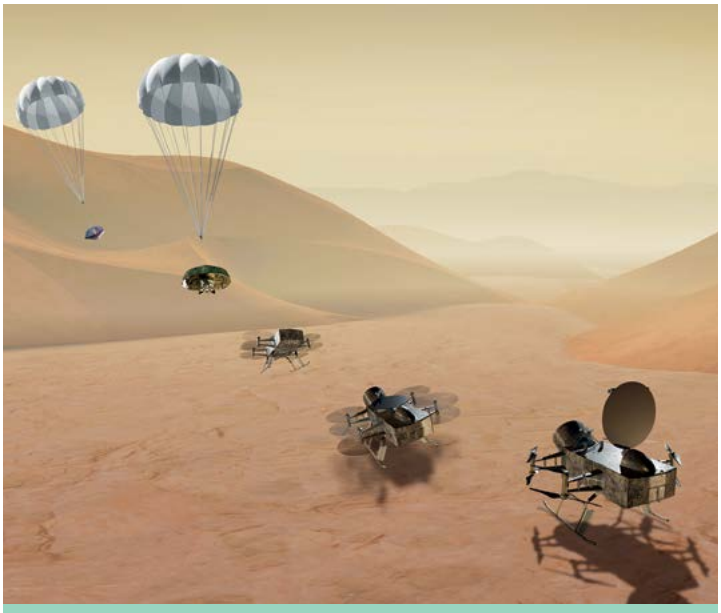
7 JUNE 2022

France signs Artemis Accords and U.S. joins SCO in Washington D.C., on the sidelines of CNES's 60th anniversary celebrations.

DECADAL SURVEY

MOVING FORWARD TOGETHER

A great deal of planning goes into defining space research programmes and determining the science value of their missions. Before engaging its own programmes, CNES draws on the findings of its Space Science Survey (SPS), which brings together the space science community every five years to fix the priorities that will shape the major space missions submitted to the agency's Board of Directors.
In the same vein, the United States' Planetary Science Decadal Surveys map out key science goals for NASA's space missions in the fields of planetary sciences, astrophysics and Earth sciences (climate characterization, planetary processes, searching for signs of life and habitability, etc.). These roadmaps serve to justify budget requests to the U.S. Congress, which is thus able to adjust budgets accordingly.
Although working on different timescales, France and the United States proceed in a similar manner with respect to science foresight, which makes it easier for them to envision future partnerships on certain programmes, to define their scope, the responsibilities of each party and to craft budgets for them. France is thus able to embark on very ambitious projects like lunar and Martian missions that it could never undertake alone.



DRAGONFLY

INVESTIGATING TITAN

The Dragonfly mission won't be quite as lightweight as its name suggests. Tipping the scales at 450 kilograms, the instrumented rotorcraft-lander will be launched by NASA to Titan, Saturn's largest moon, in 2027 and reach it in 2034. Once on the surface, it will visit a dozen or so sites. Like the Cassini-Huygens mission (2005-2017), this fourth mission in the U.S. New Frontiers solar system exploration programme will be chiefly dedicated to exobiology. Titan is an active body with rivers and lakes fed by a methane cycle similar to Earth's water cycle. Could this mean we might find organic compounds and potential traces of life there? During its three-year mission, Dragonfly will collect the broadest possible range of samples of the moon's atmosphere and soil for analysis. For the soil samples, CNES is working with four French research laboratories[1] to supply the gas-phase chromatograph for the DraMS[2] system designed by NASA's Goddard Space Flight Center (GFSC), drawing on technologies employed for the SAM instrument on the Curiosity Mars rover and the MOMA instrument on the ExoMars rover.

1. LATMOS atmospheres, environments and space observations laboratory, LESIA space and astrophysics instrumentation research laboratory, LISA inter-university laboratory for the study of atmospheric systems, LGPM process engineering and materials laboratory.
2. Dragonfly Mass Spectrometer.

FSS

A FRENCH SEISMOMETER ON THE MOON

The French SEIS seismometer on the InSight mission has been detecting surface 'quakes' on Mars since 2018. But on the Moon, we've heard nothing since the Apollo missions (1972-1977). The U.S. Farside Seismic Suite (FSS) project is set to change all that, aiming to deploy a seismometer to which France will be contributing on the lunar surface. CNES will be supplying NASA with the core of the instrument designed from a spare of SEIS. The lunar and Martian environments are substantially different, so the mission's Very Broad Band (VBB) seismometer will be tuned to optimize its performance on the Moon. It will also be deployed on the far side to learn more about the seismology of this relatively unknown region. The autonomous seismometer will be able to operate for four months. To take advantage of its observations, CNES will be giving NASA access to the mission centre designed for SEIS and adapting it to process data from FSS—a new harvest for the scientific community to look forward to.

DEFENCE

SHARED VISION AND INTENT

French General Michel Friedling signs up France to the CSpO on 11 February 2020.

French-U.S. cooperation also extends to the military realm, where the two nations have closely aligned visions. In standing up its Space Command (CDE) in 2019, France sought to acquire additional resources in response to increasingly frequent potential threats in space, such as eavesdropping, jamming, espionage and hostile manoeuvres. The same year, the United States re-established its own Space Command and stood up the U.S. Space Force. In February 2020, France also joined the Combined Space Operations (CSpO) initiative set up by the United States in 2014. Bringing together the United States' longstanding partners Australia, Canada, the United Kingdom and New Zealand, and now France and Germany, this initiative aims to coordinate space defence efforts, share data and develop technical solutions to counter the profusion of potential attacks and tighten security.

#COMMUNITY

Every day, CNES engages with you on social media and you share your thoughts and questions with us.
Join the conversation!

@EMMANUELMACRON

President of France.

Mars viewed from the Perseverance Rover and its SuperCam. So proud of this fine example of French excellence on the red planet studying Martian rocks! Congratulations to the teams at @NASA, @CNES and @CNRS. #CountdownToMars

@SENBILLNELSON

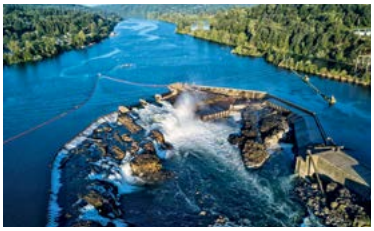
14th NASA administrator

It was an honor to meet with President @EmmanuelMacron today. The partnership between our nations is as strong in space as it is here on Earth. @NASA's collaboration with @CNES has been key to accomplishing our shared goals—in science, exploration, climate and more.

@DR_THOMASZ

Associate Administrator, @Nasa Science Mission Directorate

Water is life, but only ~1% of it is accessible to us. @NASAEarth's & @CNES' SWOT mission will measure over 95% of Earth's freshwater of lakes, rivers, & reservoirs, providing a better understanding of how climate change affects these important systems. https://t.co/qdfGXGBP3O



@VP

Vice President of the United States.

Great news: France became the 20th nation to sign the Artemis Accords. I applaud France for affirming its commitment to the peaceful, responsible, and sustainable exploration of outer space.

Q & A

CHIRAG PARIKH

SPACE IS CENTRAL TO THE CLOSE RELATIONSHIP THAT BINDS FRANCE AND THE UNITED STATES. Vice President Kamala Harris chairs the U.S. National Space Council (NSpC), the structure at the White House that formulates and implements U.S. national space policy. Chirag Parikh is the Deputy Assistant to the President and Executive Secretary of the NSpC and works for Vice President Harris.

In November 2021, Kamala Harris announced the establishment of a Comprehensive Dialogue on Space between France and the United States. What range of topics does this dialogue cover?

Chirag Parikh: The longstanding and fruitful cooperation between our two nations encompasses every aspect of space. We're working together on technical aspects, equipment, operations and technologies, as well as on space policy and its strategic ramifications. Such wide-ranging cooperation makes the U.S.-France partnership unique. President Emmanuel Macron and Vice President Kamala Harris both understand that in space, there is increasing overlap between civil, commercial, and national security space activities. The Comprehensive Dialogue aims precisely to break down silos and get all space players on both sides of the Atlantic around the same table. The goal is for us to draw upon each other's' ideas, experiences and capabilities in order to strengthen cooperation by engaging in a regular bilateral dialogue between U.S. and French agencies. That means our experts at the National Space Council, National Security Council, Department of State, Department of Defense, Department of Commerce, Department of Transportation, the Office of the Director of National Intelligence, NASA and all other relevant national departments and agencies will be working more closely with their counterparts in France.

How will this dialogue advance efforts to tackle the climate crisis, for example?

C. P.: The Comprehensive Dialogue isn't focused on one specific topic. For example, space science and Earth observation have long underpinned CNES and NASA's

> "Space underpins our national security and contributes to the defence of our interests and those of our allies."

partnership. As announced by Vice President Harris, the United States has signed up to the Space for Climate Observatory (SCO), a CNES initiative federating government and scientific agencies and corporations to provide decision-support tools for observing, assessing and anticipating the impacts of climate change. The SWOT satellite is set to be launched in December. This joint CNES-NASA mission to measure surface waters and ocean topography has also brought the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) on board. When talking about missions like SWOT, we generally focus on what's going on up there in space. But what we're doing together on analysing and utilizing the data flowing from current and future sensors in orbit is equally essential. One of the key points of our common policy is to give people all over the world open access to civil satellite data.

What about in the areas of defence and security?

C. P.: Our two governments believe that space underpins our national security and contributes to the defence of our interests and those of our allies. Last 18 April, Vice President Harris announced that the United States is committing not to conduct destructive, direct-ascent anti-satellite missile testing. The reason is simple: such tests generate significant amounts of orbital debris with the potential to damage Earth-observation, communications and military satellites, as well as endanger lives on the International Space Station.
Coming back to our bilateral partnerships in the national security domain, France is contributing in a number of areas, including the Schriever space wargame.
Our two nations are also engaged in multilateral military cooperation through NATO. Obviously, security is one of the pillars of our Comprehensive Dialogue.

CHIRAG PARIKH

DEPUTY ASSISTANT TO THE PRESIDENT AND EXECUTIVE SECRETARY OF THE NSPC AT THE WHITE HOUSE

"TOGETHER, WE'RE WORKING TO ENSURE WE USE SPACE SAFELY, SUSTAINABLY AND RESPONSIBLY."

Can the ties between our two nations benefit from the momentum of New Space in France?

C. P.: New Space activities are enjoying strong growth all over the world. This is driven in part by the fact that it's now cheaper to get into space, which is enabling more and more governments, private corporations and investors to join the adventure. That's something we should welcome. The trend is benefiting the economy, jobs, security and science, as well as space exploration. But we also need to channel these burgeoning efforts. We need to step up international cooperation and the United States is already working to define a framework to support the development of novel space activities. France and the United States are both signatories of the Outer Space Treaty, which requires authorization and continuing supervision of the activities of non-governmental entities in outer space. Previously, this mainly concerned communications and Earth-imaging satellites, and launchers. Now, the scope of these activities is being extended to in-orbit servicing, in-space manufacturing and even activities around and on the Moon. Part of this effort is to ensure that new space activities are conducted in a responsible manner to preserve the space environment. France's signature in June of the Artemis Accords is a testament to the importance it attaches to preserving the space environment, from low Earth orbit to the Moon and beyond. Together, we're striving to ensure we use space safely, sustainably and responsibly.

Which of the crop of current and future missions are you most excited about?

C. P.: We're all very eager to see the launch of the Artemis programme and to go back to the Moon. It's hard not to be carried along by this fantastic momentum we've created. But from my perspective, and probably because of where my career has taken me, what I'm most excited about is how we can best exploit the phenomenal amount of data we're collecting for Earth from space with multiple civil, commercial and military sensors. I'm expecting great things from advances in computing, analytics techniques and artificial intelligence. I really believe the great discoveries of the future lie hidden somewhere in the data we already or soon will have.

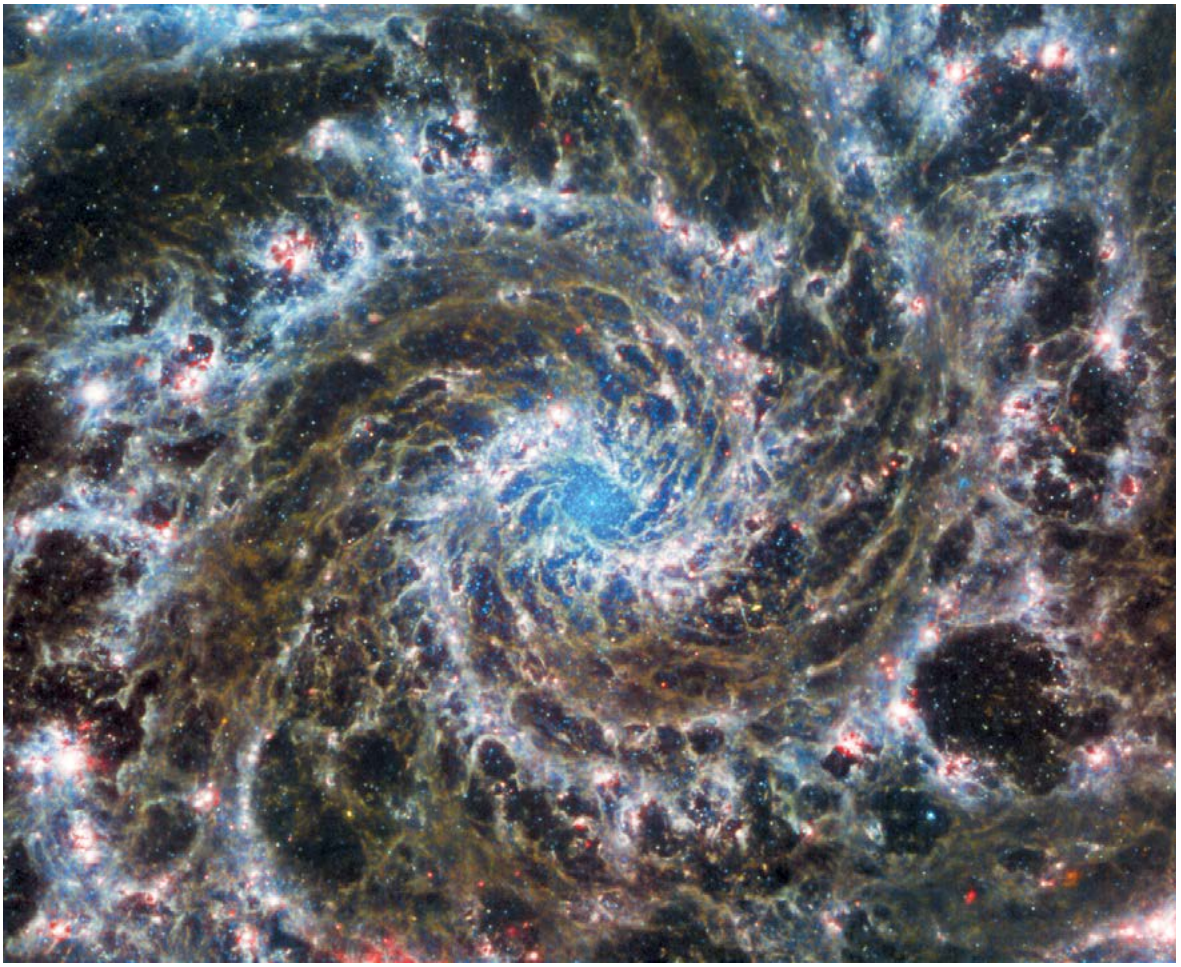
PROFILE

1997-2008
Aerospace engineer, National Air and Space Intelligence Center, United States Air Force

2010-2016
Director of Space Policy overseeing national security strategy and policy at the National Security Council

2016-2019
Senior Executive at the National Geospatial-Intelligence Agency (NGA)

SINCE AUGUST 2021
Deputy Assistant to the President and Executive Secretary of the National Space Council



STARS IN EVER CLOSER DETAIL

This stunning picture is one of the first images sent back by the James Webb Space Telescope (JWST), built by NASA in partnership with the European and Canadian space agencies. It shows a galaxy—M74, also called the Phantom Galaxy—some 32 million light-years from Earth in exquisite detail. The successor to the Hubble Space Telescope is enabling the international scientific community to see the universe at it has never been seen before. Images containing more than 150 million pixels have been generated from a thousand files. As lead for the French contribution, CNES provided technical support and funding to research laboratories attached to the national scientific research centre CNRS, at CEA[1] and the Paris Observatory, who designed the camera and coronagraph for JWST's MIRI infrared instrument.

1. French atomic energy and alternative energies commission.

FULL MARKS FOR MARS 2020

Perseverance, the rover on the U.S. Mars 2020 mission, set down on the surface of the red planet on 21 February 2021 in Jezero Crater. Drawing its heritage from ChemCam[1], the rover's SuperCam instrument was defined and conceived by IRAP[2] with the aid of research laboratories and funding from CNES. This Swiss Army knife of an instrument combines the ability to analyse rocks and the atmosphere with its laser. It's the support instrument most used by the mission. To operate it round the clock and host the scientists and engineers responsible for programming SuperCam's work plan, CNES has also set up the FOCSE[3].

1. Instrument on the Curiosity rover (launched 2012). 2. Astrophysics and planetology research institute.
3. French Operations Centre for Science and Exploration.

118

NASA has signed 118 agreements related to the environment and its preservation through the GLOBE (Global Learning and Observations to Benefit the Environment) science and education programme for schools and teachers.

Business France

With a budget of around $55 billion in 2021, the United States represented some 60% of global expenditure on space. It is sustained to a large extent by federal government orders (90% of the U.S. space budget came out of federal funding voted by Congress) and national preference—a factor that might dissuade the French ecosystem of start-ups and SMEs from looking to do business across the Atlantic. Opportunities nevertheless exist. At the French Embassy in Washington D.C., CNES's office is pulling out all the stops to make the American dream a reality for these fledgling French firms. A fact-finding trip to the United States was organized for them this June in partnership with Business France[1], taking in Florida and California, to give 15 French space players the chance to immerse themselves in the U.S. scene. The three-day trip included site visits, meetings and conferences. CNES has set up its own new structure this year dedicated to supporting this ecosystem and is fully committed to helping firms export their know-how.

1. National agency working to develop French business around the world.

8.3%

Proportion of ISS funding from Europe. This contribution guarantees seats for European astronauts on U.S. flights to the station and time for European scientific experiments.

56

NASA HAS TO DATE 56 PARTNERSHIP AGREEMENTS WITH FRANCE: 25 with CNES, 21 with research establishments and universities, 6 with the national scientific research centre CNRS, 3 with the national aerospace research centre ONERA and one with the atomic energy and alternative energies commission CEA.

13

LE GODDARD Space Flight Center (GSFC) is NASA's main field centre, devoted to scientific research. France is its number one partner with 19 partnership agreements, including 13 with CNES (see map p. 3). With 8 bilateral agreements, the Jet Propulsion Laboratory (JPL) is CNES's second most important U.S. partner.

1965

Based in Washington D.C. since 1965, CNES's office has maintained the 60-year relationship between France and the United States in space.

62,000

Shots fired in a year by the laser on SuperCam, the French-U.S. suite of instruments aboard the Mars 2020 mission's Perseverance rover, which is notably analysing the chemical composition of Martian rocks.

UNITED SPACE

OVER THE COURSE OF THEIR SHARED 60-YEAR LEGACY IN SPACE, FRANCE AND THE UNITED STATES HAVE FORGED A CLOSE RELATIONSHIP BUILT AROUND MULTIPLE PARTNERSHIPS. NOW, WITH NEW SPACE EXPLORATION AND EARTH-OBSERVATION PROGRAMMES IN THE OFFING AND THE ARRIVAL ON BOTH SIDES OF THE ATLANTIC OF A HOST OF NEW SPACE PLAYERS, THEY ARE MOVING FORWARD TOGETHER AND BOOSTING RESEARCH, INDUSTRY, THE ECONOMY AND DIPLOMACY.

In November 2021, the meeting in Paris of U.S. Vice President Kamala Harris and President Emmanuel Macron further strengthened the two nations' already close relationship. Less than one year on, their cooperation in space is stepping up a gear, building on the solid foundations of a partnership begun 60 years ago, as shown by the slate of cooperation agreements signed (see p. 7). France is also the United States' oldest partner in space. U.S. sounding rockets began flying French experiments as far back as 1959, while in 1963 a first memorandum of understanding sent a dozen people from the fledgling French space agency to receive training from NASA. Backed by their governments' proactive policies, the two agencies have been working together ever since.

CLOSER DIALOGUE

The newly signed agreements are going to "commit both partners in key areas", notes Christophe Venet, CNES's Director of European and International Affairs. In signing up to the Artemis Accords (see p. 7), France "is confirming its support and participation in the ambitious mission to send human crews to explore the Moon." Besides the expected benefits for science, this firm commitment to the project opens up interesting partnership prospects for the French space ecosystem. In the meantime, the United States has ratified the charter of the Space for Climate Observatory (SCO), a key commitment at a time when climate disruptions call for all resources to be marshalled. The two partners have also agreed to extend the scope and frequency of their contacts. The Comprehensive Dialogue on Space (see p. 13) will enable a more responsive, fluid and regular approach to dealing with common issues. The message is clear: space is now central to diplomatic efforts.

447

billion dollars

Revenues generated worldwide by the space sector were estimated at $447 billion in 2020, up 176% since 2005.

SHARED AREAS OF INTEREST

Such strong ties have given—and continue to give—France the opportunity to join some ambitious programmes. In the 1980s, human spaceflight was too costly for the nation's budget, but NASA offered it the chance to come in on the adventure with a French astronaut[1] on the crew of the Discovery space shuttle mission in 1985. Since 2000, through ESA, France has been an active crewmate for the United States on the International Space Station. Four French astronauts[2] have sojourned on the orbital outpost, where they have conducted biology, physiology and fluid and material sciences experiments, helping to gain deeper insight into how microgravity affects humans and their environment to lay the groundwork for deep-space exploration missions. The Artemis lunar programme—a first stepping stone to Mars—in which France is participating also holds out exhilarating prospects.
Collaboration in the field of Earth observation has also proved fruitful. The French-U.S. TOPEX/Poseidon (1992-2006) and Jason missions (2002 onwards) both marked decisive steps for operational oceanography. And from next year, SWOT will survey the globe's oceans and surface waters, crucial to tackling climate disruptions, while the AOS[3] mission still in the design phase will seek to characterize Earth's atmosphere.

The Space Launch System (SLS), here on the launch pad in Florida, is the cornerstone of the Artemis mission.

KEY FRENCH EXPERTISE

France brings to all these partnerships its world-renowned expertise in robotic technologies for guidance, navigation and control. CNES is regularly called upon for the excellence of its space systems and subsystems, constantly fuelled by innovation. Over the last decade, the agency has demonstrated its prowess in spectrometers, cameras, seismometers and other technologies for Mars infrastructures. It has also shown its appetite and skills for deep-space exploration missions, such as Juno to Jupiter and Veritas to Venus. In this endeavour, CNES is backed by a solid ecosystem of partner laboratories, manufacturers and start-ups that it has federated and in which it is a key player.

Sixty years after the United States and France signed their first accord, space has become a global market driven by multi-form technologies, encompassing a huge variety of domains and scientific knowledge, and models have evolved, but cooperation between the two nations remains a strong pillar on which to build the future.

1. Patrick Baudry, the first French astronaut to fly on a U.S. space mission.
2. Léopold Eyharts, Claudie Haigneré, Philippe Perrin, Thomas Pesquet.
3. Atmosphere Observing System.

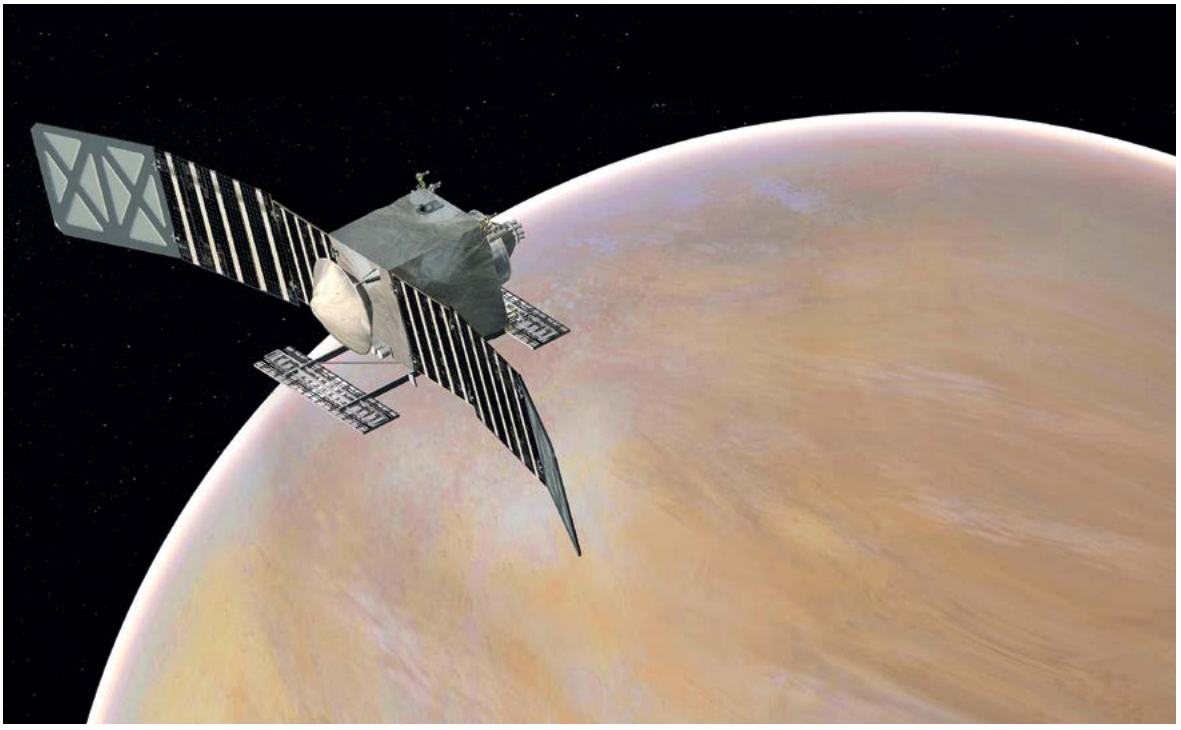
U.S. space

MAINTAINING LEADERSHIP

The United States is the world's leading space power, with unrivalled levels of investment, a strong stimulus policy and a solid ecosystem. This leadership position is sustained by the two pillars of crewed space exploration and the development of military space. To retain this position, the U.S. administration committed in 2017 to "reinvigorate America's human space exploration programme", aided by the development of New Space, which has greatly increased space's accessibility and attractiveness (see p. 7). Since that date, a series of Space Policy Directives have imposed a tight schedule to restructure the sector and reaffirmed the desire to maintain this leadership, notably through human spaceflight missions. Since 2020, U.S. policy has remained aligned with these directives while strengthening the space component dedicated to climate science.

Technological EXCELLENCE

The United States and France share the ambition of exploring space to better understand Earth. France is contributing to this quest with cutting-edge instruments.



Artist's impression of Veritas, the satellite planned to study Venus.

France cannot on its own marshal the huge sums needed to fund large-scale robotic missions. Where it adds value is in the innovations and technologies it brings to the table, like the lasers that have become a French specialty seen on Mars missions. The ChemCam laser camera, controlled notably from the FIMOC[1] at CNES, is on the MSL/Curiosity mission launched in 2011 and still studying the texture of Martian rocks and soil. In 2021, the same technology was enhanced to equip the Perseverance rover (see In Pictures p. 17) with SuperCam, its "eye" designed by the IRAP astrophysics and planetology research institute and controlled on either side of the Atlantic from the FOCSE[2] at CNES and Los Alamos National Laboratory (LANL) in the United States.

Another cutting-edge technology in which France excels is seismometry. In 2018, the French SEIS instrument on the InSight mission was the first to "take the pulse" of Mars. The research undertaken to develop this instrument 20 years in the making has paid off handsomely, since a new French seismometer was recently selected by NASA to fly on its future FSS lunar mission.

FLYING HIGH FOR SAMPLE RETURN

Such technological advances are also enabling other challenges like bringing back samples from Mars to Earth. This is the goal of the Mars Sample Return mission (MSR) planned for 2031, which will be accomplished in several stages. The first will send a lander developed by NASA to Mars carrying a Mars Ascent Vehicle (MAV). To collect samples and get them to the MAV, two options are envisioned: two small rotorcraft derived from the Ingenuity model that has demonstrated powered flight on Mars, or the Perseverance rover. The sample canister will then be lofted into Mars orbit for retrieval by a European satellite and return to Earth inside a capsule. France is closely involved in this adventure, as the return orbiter will be built and assembled by Airbus Defence & Space in Toulouse and launched from Kourou by the future Ariane 6. France's expertise will also be called upon to analyse and curate samples on the ground.

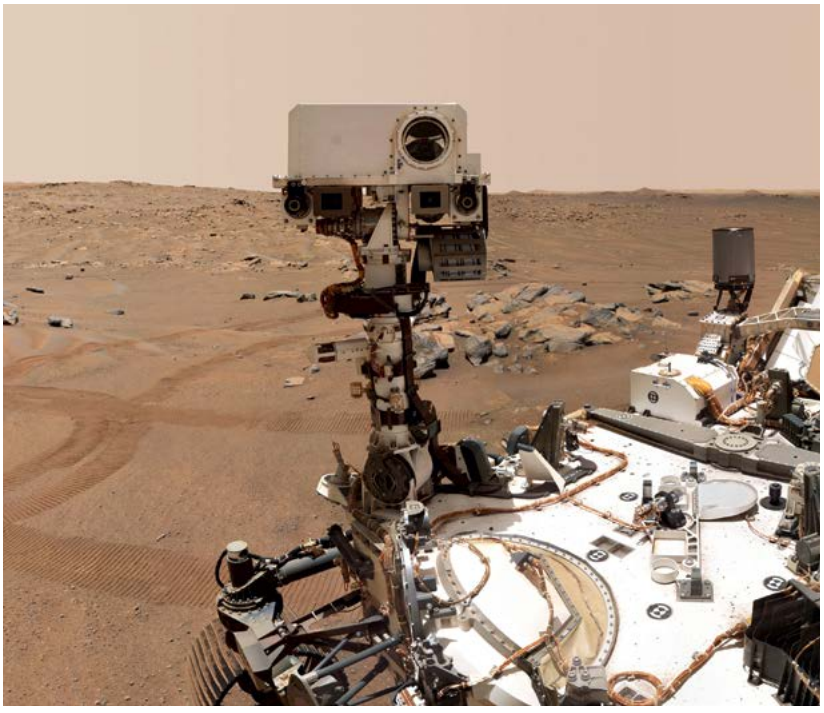
DESTINATION TITAN AND VENUS

The Moon and Mars aren't the only terrains where France and the United States are working together. France will be contributing to Dragonfly, a U.S. mission set to launch in 2027 to explore Titan, Saturn's largest moon. It will be carrying a chromatograph designed by French research laboratories. Venus, Earth's nearest neighbour, hasn't been visited by a spacecraft for 30 years. The Veritas mission is lining up to fill this gap. France will supply the optics for a German infrared camera, as well as the amplifiers for the spacecraft's K_a-band telecommunications subsystem. Lastly, asteroids are also under study. Launched in 2016, the U.S. OSIRIS-REx probe visited asteroid Bennu and brought back rocks and dust from its surface to Earth. CNES and four laboratories attached to the national scientific research centre CNRS worked on this mission.

80%

of joint NASA-CNES programmes concern Earth observation (11 accords) and space science (9 accords).

1. French Instrument Mars Operations Centre.
2 French Operations Centre for Science and Exploration.



Selfie of the Perseverance rover on the surface of Mars taken on 10 September 2021.

NASA Administrator Bill Nelson meets the crew of the SpaceX Crew-2 flight on 6 June 2022.

The benefits

OF SPACE SCIENCE

On 21 July 1969, humankind set foot on the Moon. Today, crewed space exploration is seeking more to delve deeper into the universe than to renew this feat.

Space exploration isn't the preserve of robots; human spaceflight missions are also playing a key role, with crew health and safety a prime concern.

HUMAN-CENTRIC VISION

In 1983, to better understand, analyse and measure the environment outside Earth's gravity, the U.S. administration conceived a project to operate a permanent orbital laboratory dedicated to scientific research and open to international partners. This would become the International Space Station (ISS), built by the U.S., Russian, European, Japanese and Canadian space agencies. NASA is the main contributor of modules used on the station by the partners in proportion to their investment. France has conducted many experiments there, supervised on the ground by the CADMOS centre for the development of microgravity applications and space operations, through ESA like for the Aquapad experiment with support from NASA, or through bilateral accords with the U.S. space agency like for DECLIC (see over). The ISS has enabled new insights into physiological conditions and astronaut health, delivering results that benefit general medicine here on Earth.

30

years.

At IAC Paris 2022, CNES and NASA celebrated their 30-year collaboration in space altimetry, which all began with the launch of TOPEX/Poseidon in 1992.

FROM EARTH TO THE MOON

Experiments on the ISS are helping us to understand what will be needed for crews to live and survive in space. How will they be supplied with energy, water, food and oxygen? How will they manage waste? The results will feed into the next phase of crewed space exploration through the Artemis programme, which aims to land a crew on the Moon by 2025 to explore its environment and test technologies. The Moon can thus be seen as a stepping stone to more-distant destinations, notably Mars.

KEY LIFE-SUPPORT MODULES

Through ESA, France is actively involved in the Artemis project. The European Service Module (ESM), derived from the ATV[1], is a key component of the programme, supplying propulsion, power, avionics, water and oxygen for the Orion capsule. Without it, crews would never be able to reach lunar orbit and return safely to Earth. France will also be contributing to the design and construction of the Gateway lunar station, which will have a module called Esprit dedicated to communicating with crews and resupplying them. Esprit will be built by Thales Alenia Space, which will also be leading development of the I-HAB pressurized habitation module in partnership with Japan.

1. Europe's Automatic Transfer Vehicle, which resupplied the ISS from 2008 to 2014

DECLIC

FLUID STATES HOLD KEY TO WASTE MANAGEMENT

At high pressure or temperature, certain materials like water become a supercritical fluid, which is something that's difficult to observe on Earth due to gravity. Gaining closer insight into how fluids behave in this state could lead to real-world applications like clean combustion, reduced atmospheric pollution or emission-free final waste processing. Designed jointly by CNES and NASA, the DECLIC[1] mini-laboratory has been flown on the ISS, developing three types of experiment: one on the liquid-solid interface and two on supercritical fluids and directed solidification. By paving the way to new ways of burning waste without emitting toxins, DECLIC could solve the problem of how to eliminate waste on interplanetary missions.

1. DEvice for the study of Critical LIquids and Crystallization.

Serving CLIMATE SCIENCE

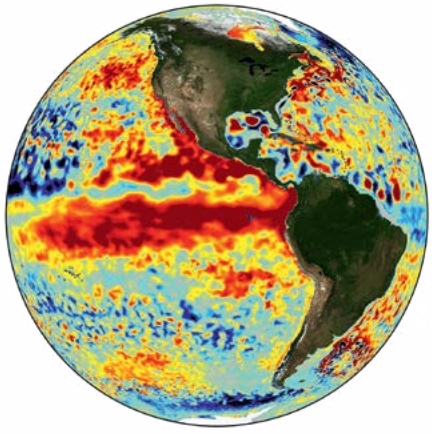
While space science is a major focus of the French-U.S. tandem, observation of Earth and its oceans hasn't been left aside.

NASA and CNES have combined satellite altimetry and ocean topography to measure variations in sea level around the globe—a world first. From a scientific perspective, operational oceanography has identified the role of tides, tracked ocean currents and eddies, mapped the oceans' bottom topography and delivered deeper insights into climate episodes like El Niño.

FROM TOPEX/POSEIDON TO SWOT

Thirty years after its launch, TOPEX/Poseidon—the first ever space oceanography satellite, succeeded by the Jason series—remains an emblematic mission. It drove development of operational oceanography and its real-world applications like measuring wave height, wind speed and ocean topography, for the benefit of sailors, fisheries management, shipping and oceanographers alike. By giving public stakeholders, citizens and decision-makers reliable information, this cooperation has breathed life into the space ecosystem and proved its utility.

This December, drawing on the same altimetry technology and the same French-U.S. partnership framework, the SWOT mission will be taking flight to observe 90% of the planet's water: not only its oceans, but also its rivers and lakes.



Heat content in the first 300 metres of the Pacific Ocean on 29 September 2015. Red areas are where heat content is higher than average. Blue areas are where it is lower.

ATMOSPHERE OFFERS NEW TERRAIN FOR RESEARCH

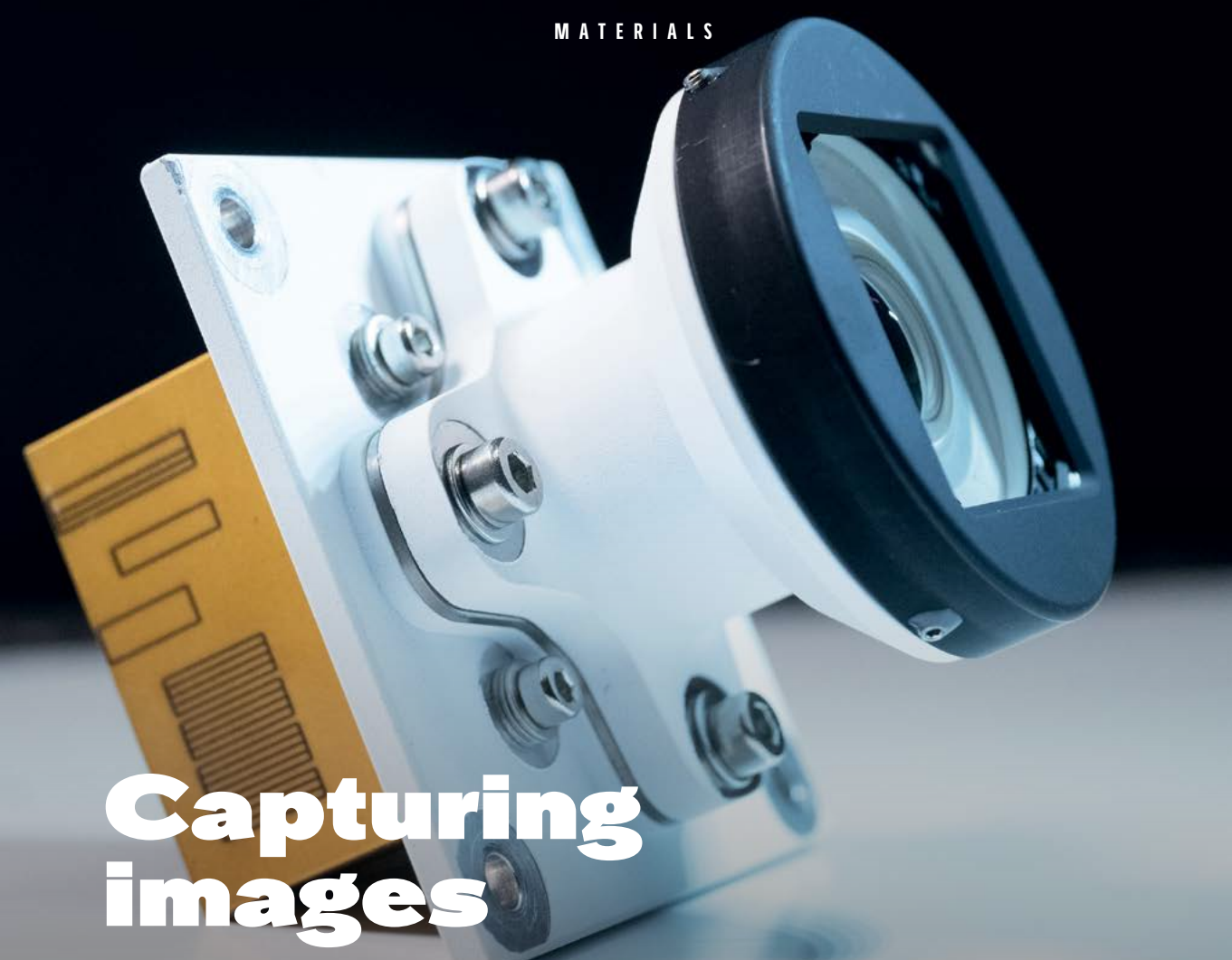
Water isn't the only thing focusing scientists' and decision-makers' attention. AOS[1] is the atmospheric component of NASA's new Earth System Observatory announced in May last year. Constellations of satellites will study clouds, microparticles, atmospheric convection and precipitation with a range of instruments including lidars, radiometers and spectrometers. The goal is to collect data to improve weather forecasts and devise actions to tackle air quality and climate change. How? By providing a snapshot never seen before of the vertical structure of the atmosphere from space down to the ground. Such measurements could reveal how ice and water move vertically inside clouds. Four years after the start of negotiations, the French proposals led by the LATMOS atmospheres, environments and space observations laboratory and CNES have been selected. "In July 2022, NASA confirmed its selection of France's contribution in the final four," says Nicolas Maubert, CNES's representative in the United States. France is expected to supply two passive microwave radiometers that will fly on two of the constellation's satellites. It will also be working on the project's architecture alongside other partners like Japan and Canada, with the common goal of mitigating climate disruptions.

1. Atmosphere Observing System.

JPL

A PERENNIAL PARTNER

Curiosity, InSight and Perseverance on Mars, Cassini and Europa for space science, Jason and SWOT for oceanography... CNES and the Jet Propulsion Laboratory (JPL) have achieved many successes together. JPL traces its origins back to 1936 and was transferred to NASA when the U.S. space agency was formed in 1958. Today it has world-renowned expertise in robotic space missions, notably developing Mars probes and rovers. It also manages space telescopes like Kepler.
JPL is one of France's oldest partners, with 10 bilateral agreements in place and some 40 French scientists working there on site. With a budget of $2.4 billion (2021), it shares its time between Mars exploration, solar system exploration, astronomy, Earth observation and management of ground communications stations in the Deep Space Network (DSN). Fired by the same pursuit of excellence, CNES and JPL have forged a unique and longstanding relationship that is set to continue with missions like the Farside Seismic Suite (FSS) planned to land on the Moon in 2024.



Capturing images

DEVELOPED IN JUST FOUR YEARS, THE CASPEX CAMERA IS REVEALING THE SURFACE OF MARS IN FINE DETAIL. With its CMOS colour sensor similar to those employed in smartphones, this 2.5 x 3.5-centimetre instrument tips the scales at just 64 grams and each image packs a resolution of four million pixels. This French technology is operating on the SuperCam instrument aboard the Perseverance rover that set down on Mars last year, capturing images for spectrometric analysis. By breaking down the light spectrum of a scene, we can ascertain the composition of a rock or gas, and possibly determine if water once flowed on Mars... After the red planet, the CASPEX technology is planned to fly to the Moon on United Arab Emirates missions starting this year. And in 2024, no fewer than four CASPEX cameras will be dispatched to Mars' moon Phobos on MMX[1], a joint JAXA, DLR and CNES mission.

1. Martian Moons Exploration.

1 INCEPTION

Formed on 19 December 1961 by the French government at the initiative of President Charles de Gaulle, CNES succeeded the Space Research Committee (CRS). The agency is today overseen by three ministries: the Ministry for the Economy, Finance and Industrial and Digital Sovereignty; the Ministry for Higher Education and Research; and the Ministry of Armed Forces. It employs 2,350 people.

Passed in the midst of the Cold War by the U.S. Congress, the bill enacting the inception of NASA was signed into law by President Dwight Eisenhower on 29 July 1958. The agency executes the nation's civil space programme, which until this date was spread across different branches of the armed forces. It manages 10 field centres (see p.3) and employs 17,500 people.

2 POLICY

CNES helps the French government to shape its civil, commercial and military space policies. This wide-reaching responsibility is an asset in an increasingly dual-use and cross-cutting space sector. The agency conducts science and technology programmes for the benefit of all user communities. Its activities are structured around the four pillars of sovereignty, climate, scientific cooperation and economic competitiveness. It has responsibility for regulatory and legal provisions governing launches and orbital systems in France (through the French Space Operations Act or FSOA). In the United States, this role is not held by NASA but by the National Space Council chaired by Vice President Kamala Harris (see p.13).

CNESMAG SHINES A LIGHT ON THE RESPECTIVE ROLES OF THE U.S. AND FRENCH SPACE AGENCIES, FROM THE CONTEXT OF THEIR INCEPTION TO THEIR MISSIONS, PEOPLE AND AREAS OF ACTIVITY.

3 DEFENCE

In France, CNES is in charge of space defence programmes, liaising with the French defence procurement agency DGA and Space Command (CDE) formed in 2019. In the United States, NASA remains a civil government agency. Military programmes are therefore overseen by federal departments like the Department of Defense (DoD, for armed forces), the National Reconnaissance Office (NRO, for development and operation of intelligence satellites) and the National Geospatial-Intelligence Agency (NGA, for collection, analysis and distribution of intelligence from satellite imagery). In 2019, U.S. Space Command was re-established and the U.S. Space Force formed as the sixth branch of the armed forces.

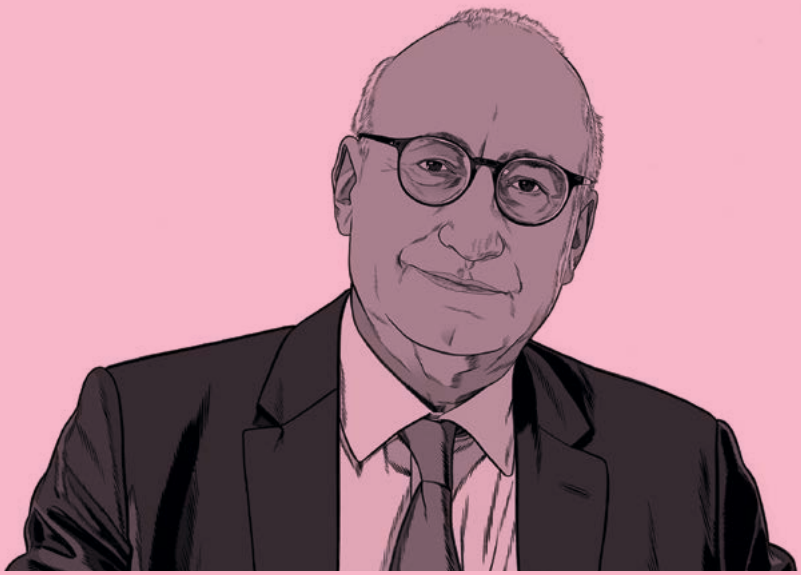
4 REGULATION

The French Space Operations Act (FSOA) sets since 2008 the regulatory and legal framework for controlling technical risks pertaining to space activities (launchers and orbital systems) conducted by public and private players. CNES contributes to this framework by drafting regulations, checking compliance of operators, systems and operations, and addressing new requirements like sustainable development. In the United States, regulation and responsibility are not within NASA's remit but covered by three government agencies: the Federal Aviation Administration (FAA) for commercial space transportation, the Federal Communications Commission (FCC) for telecommunications satellites and the National Oceanic and Atmospheric Administration (NOAA) for Earth-observation satellite licensing.

PHILIPPE ÉTIENNE

French Ambassador to the United States

"International cooperation is vital for the future of humanity..."

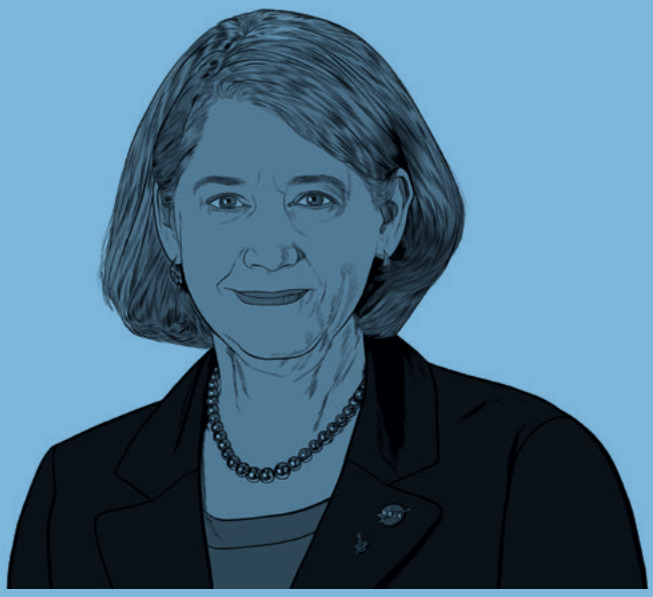


Philippe Étienne is a happy ambassador. Since taking up his post in Washington D.C. in 2019, he's delighted to have attended some "fantastic events". Referring to Perseverance's landing on Mars, the launch of the James Webb Space Telescope and Thomas Pesquet's flight to the International Space Station from Cape Canaveral—undoubtedly the memory that moved him most—he talks about the attraction that space holds for him and his excitement at being part of the adventure. Indeed, this interest has marked his career. Posted to Moscow in the 1990s, he attended the launch of a crewed mission from Baikonur. In Berlin, then in Brussels, he observed the sector's progress and helped shape decisions on major programmes such as Ariane and Galileo. Today, he thinks space is "essential to the strategic and political relationship between France and the United States". The official visit to Paris in November 2021 by Vice President Kamala Harris, also Chair of the U.S. National Space Council, led to "new cooperative ventures—from America joining the Space for Climate Observatory (SCO) to France signing up to the Artemis Accords to send humans back to the Moon". The CNES teams in the United States, based at the French Embassy in Washington D.C. since 1965, have a longstanding relationship with NASA, and with their expertise play a "highly valued supporting role," says the diplomat. "International cooperation is vital for the future of humanity. And space has a major role to play as we address the climate, environmental and health challenges we face". The bilateral dialogue initiated between the two countries is a significant part of this closer cooperation and proof of "great momentum, political will and shared awareness of the challenges ahead in space, with a growing number of public and private-sector players and the emergence of new risks, but also opportunities".

PAM MELROY

NASA Deputy Administrator

"France is our oldest partner in space"



"If she could do it, then so can I!" That's the message that Pam Melroy, NASA Deputy Administrator, former astronaut and retired U.S. Air Force officer, hopes to pass on to young women. "I drew my inspiration from the Apollo programme. When I told my parents I was going to be an astronaut too, they gave me their unwavering support. With hindsight, I realise now how important it is to have role models. So, I'm delighted to be back at NASA working on the Artemis programme to land the first woman on the Moon," she confides. Last July, she was discussing this project with President Emmanuel Macron in Paris, one among many other equally exciting endeavours including the extension of the International Space Station through to 2030, CNES-NASA partnerships in space science and climate science, and a whole host of joint initiatives between our two nations over the next 20 years. "I was able to appreciate just how closely we share the same vision of space as a powerful tool for education, science and industry helping to shape a nation's future," she says, recalling that with a shared 60-year heritage "France is our oldest partner in space." According to Pam Melroy, the main asset of the French-U.S. relationship—besides our know-how in launchers, cutting-edge technologies like the ocean altimeters operating on missions such as TOPEX-POSEIDON and SWOT, or the Perseverance Mars rover's super-sophisticated optical sensors—is above all the French mindset. "France is a strategic and political ally playing a driving role in crafting the legal framework for space exploration, based on transparency, data sharing, non-interference and cooperation," she concludes.

GUILHÈM PENENT

Space Advisor to the Directorate General for International Relations and Strategy (DGIRS) at the Ministry of Armed Forces

"Some challenges call for a joint response..."

"The space sector is undergoing a strategic transformation," says Guilhèm Penent. A specialist in space policy, he was a researcher—his PhD thesis won him the Clément Ader prize—and then an expert at the French Institute of International Relations (IFRI). Today, he focuses on space defence issues: the militarization of space, its regulation and France's relations with its allies and partners. "Space has become a priority focus." A priority reflected in the 2019 publication of France's military space strategy, which CNES plays a key role in implementing. Guilhèm Penent says the document stresses the need for cooperation between space players at national and international level and with allied countries, the European Union, NATO and the Combined Space Operations (CSpO) initiative. "Some challenges call for a joint response. With the United States, our understanding of the threat and our analysis of the evolving strategic environment are closely aligned. We're learning to work together, coordinate our policies, share information and promote the peaceful and responsible use of space."

Author of the article *"L'espace au XXIe siècle : à la recherche d'un nouvel équilibre"* (Space in the 21st century: in search of a new balance), published in 2020 in the journal *Politique étrangère*, Guilhèm Penent describes the emerging trends: "With the arrival of new public and private-sector players—what we call New Space—space heralds new opportunities, but it also brings renewed risks and threats". A place of strategic rivalry and potential confrontation, space is the object of "irresponsible, ambiguous and provocative behaviour. Russia's launch of an anti-satellite weapon in 2021 is a case in point". The sharp increase in the number of satellites and players coupled with dual civil-military capabilities, which are now mature, mean we must "improve our surveillance systems so we know who's doing what and coordinate with others at international level".

Jacques Arnould, science historian and theologian, CNES ethics officer.

ETHICS CORNER

J. A.

JACQUES **ARNOULD**

AS IT WILL BE

As we commemorate CNES's 60th anniversary this year, we recognize the importance of international cooperation in the French space agency's inception and development—and by extension its future. And there's no doubt the United States has a special place in our story.

It's good form and undoubtedly quite right to consider cooperation and competition as vital drivers of the space adventure. Certainly, tying them together is as much a matter of will as of chance, since human affairs depend, even in space, on circumstances, influences and events, which are sometimes entirely independent of each other.
This explains the central and often predominant role the human factor plays in these matters.
Not surprising therefore that, when it comes to cooperation between France and the United States, the first thing that comes to mind is the names and faces of colleagues who, with their total commitment to this endeavour, talk about it with such enthusiasm and excitement. Besides all the technical, strategic, legal and diplomatic aspects, they always reminisce about an evening at a Paris restaurant, or a drive into the California hills or along the Florida coast. Surnames, job titles and roles gradually give way to first names. Professional respect always remains, but with time comes friendship, which often endures long into retirement, like the bedrock of future cooperations.

NEW HORIZONS

One such colleague, now no longer with us, had the habit, somewhat undiplomatically, of talking about past cooperation with our "American big brother"—albeit an appropriate expression for space activities—with a nostalgia that seemed like a criticism compared to what we can achieve today. I read into it a twofold encouragement. First, we must not rest on our laurels, as real as they are. And second, we must not lapse into a kind of debilitating nostalgia.
Any cooperation should assume the same attitude as that described by a traveller after a trip to the United States in 1830. "Americans," he wrote, "love their country not as it is, but as it will be. They don't love the land of their forefathers, but they're sincerely attached to the land their children will inherit." Isn't this mindset particularly apposite to space cooperation, not least between France and the States? It will only be effective to the extent of the commitment we attach to it and, above all, provided we set a goal to be achieved, a frontier to be reached for. Together, we must love space as it will be!

KINEIS

A PROMISING START STATESIDE

Back in 1978, a French-U.S. partnership between CNES and the National Oceanic and Atmospheric Administration (NOAA), with NASA's support, resulted in the pioneering Argos satellite-based location and data collection system. Forty years later, with its subsidiary CLS[1],CNES founded Kineis in Toulouse, which has made an emphatic entry into the Internet of Things (IoT) market. With 20% growth in 2021 and a Next40[2] label for the second year in a row, the company is keen to export its know-how internationally, especially to the United States. Heir to the Argos system developed by CLS, Kineis provides IoT services based on a constellation of nanosatellites. In October last year, it gained the key to business on the other side of the Atlantic, securing its licence from the Federal Communications Commission (FCC), the American telecoms regulator. In March this year, Kineis formed a subsidiary in Washington D.C. Its local team, managed from France, markets its applications to the logistics, transport, environment, maritime, utilities and infrastructure sectors. Just as the company is developing its range of services, so it's expanding its asset base. In the second half of 2023, U.S. company Rocket Lab will perform five successive launches for Kineis. By commissioning 25 new satellites in record time, the company is taking its current level of IoT connectivity to a new level.

1. Collecte Localisation Satellites.
2. Label created by the French government to support 40 promising young companies.

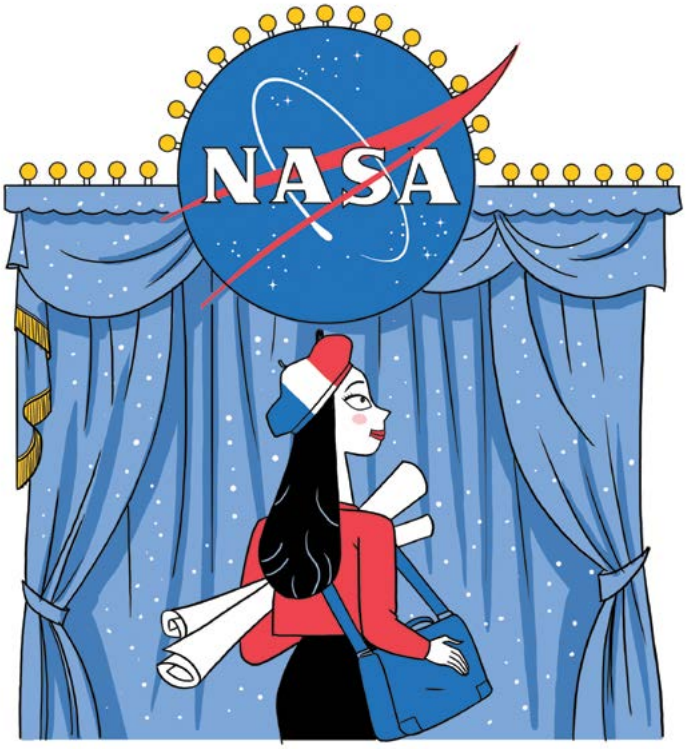
EXHIBITION

WOMEN IN THE SPACE AGE

Where are all the women? While films like *Gravity* (2013) and *Proxima* (2019) portray the role of women in the space age, their involvement in the industry has long been understated or overlooked. A few female pioneers have made their mark on history, however, like Valentina Tereshkova of Russia, the first woman to fly a crewed mission (in 1963), and Sally Ride, astrophysicist, astronaut and the first American woman to fly in space (in 1983). CNES's Washington D.C. office wanted to pay tribute to these heroines and the Hidden Figures—another great movie—of the space adventure with an exhibition at the French Embassy in the American capital. The event was also a chance to make an encouraging observation: in space and behind every space mission the number of women is growing.
At CNES, for example, 39% of the agency's engineers today are female. In the United States, NASA has appointed former astronaut Pam Melroy as Deputy Administrator. And another giant leap will be taken in 2025 with the Artemis 3 mission, which will fly the first woman to the Moon. To date, only 75 women have flown in space, compared to over 500 men.

1

France's only female astronaut is Claudie Haigneré. On 17 August 1996, Claudie André-Deshayes (later, Claudie Haigneré) began a 16-day mission on the Mir space station, becoming the first—and to date only—Frenchwoman to fly in space.



PEOPLE

EXPAT EXPERIENCE

In the last six decades, NASA has regularly had French professionals on its teams in a partnership hailed by both sides as rich and constructive. But what's it like for these expatriates? Mass spectrometer specialist Victoria, who joined the Goddard Space Flight Center's planetary atmospheres department in 2019, is struck by how open her American colleagues are: "The scientists I work with are passionate and always ready to share their knowledge and expertise," she says. "They quickly entrusted me with important responsibilities. There's a strong sense of teamwork." Cédric, a researcher in terrestrial hydrology on the SWOT team, is equally enthusiastic and emphasized the difference in approach to research: "Here, researchers are responsible for their own funding. It makes you more entrepreneurial—always looking for the best idea for the next call for projects. This competitive spirit encourages new teams to form around new ideas." Thanks to SWOT, Cédric is involved in the development of new concepts for space hydrology missions. "SWOT is just the start—the SMall Altimetry Satellites for Hydrology programme, or SMASH, will hopefully be the continuation," he explains. The partnership between French science and NASA isn't ending anytime soon!

HAPPY BIRTHDAY!
FLASHBACK ON 60 YEARS OF COOPERATION

CNES's 60th anniversary was also celebrated in Washington D.C., with fireworks, birthday cake and astronauts in spacesuits. On 7 June, the residence of the French Ambassador to the United States welcomed a host of prestigious guests, including representatives from NASA and the U.S. government and key figures from the American private space sector. CNES's local office, based in Washington since 1965, took the opportunity to mount an exhibition on the highlights of French-U.S. space partnership, encompassing robotic exploration, Earth observation, space sciences, defence, space transportation and applications. A fantastic shared legacy, which deserves to continue long into the future!

FRENCH SPACE TECH
EXPANDS ITS HORIZONS

With support or funding from CNES, French start-ups like Exotrail are beginning to make their mark across the Atlantic in the world's largest space market.

Far from being the preserve of haulage firms on land, logistics is also becoming vital in space. Spacecraft mobility is a key requirement throughout their mission, from separation from the launcher and reaching operational orbit to management of collision risks and end-of-mission de-orbiting. According to Jean-Luc Maria, co-founder and Chairman & CEO of Exotrail, that's why we need space logistics. Delivering to the right place, at the right time and at the right price is the mantra of the start-up's founders. To achieve this, it offers a range of products and services built around software (for design and monitoring of space missions) and hardware (electric motors and an orbital transfer vehicle).

SPACE VAN

Formed before Connect by CNES rolled out its panel of services for start-ups, Exotrail has nevertheless cultivated a close relationship with the French space agency from the outset. Today, this has led to the creation of SpaceVan™, able to convey 500-kilogram satellites, with 400 kilograms of "hold" space to take micro- and nanosatellites to orbit. SpaceVan™ is currently being readied for its first spaceflight in October 2023 on a Falcon 9 launcher operated by U.S. company SpaceX. The United States remains the world's premier space market, and to gain a foothold there Jean-Luc Maria knows that Exotrail will need "the right products and a stainless reputation". Let's wager that Exotrail will blaze a trail for other French start-ups on the road to success.

70

Current number
of employees at Exotrail, working at two sites in Paris and Toulouse.