



THE SPIRIT  
OF SPACE



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## THE SPIRIT OF SPACE

**“Working with scientists, industry and international partners is central to CNES’s strategy.”**

**INTERVIEW WITH JEAN-YVES LE GALL**  
CNES President



***The space sector is seeing far-reaching transformations driven by digital technologies, miniaturization and new players in the public and private spheres. How is CNES adapting to stay ahead?***

CNES is constantly adapting to change. As early as 2016, we created a new Directorate of Innovation, Applications and Science, followed by two more for Digital Technologies and Operations and Orbital Systems in 2017. This reorganization has spawned new approaches to enable us to grasp and respond to these challenges.

***Burgeoning applications are helping to revolutionize the way space is used, and CNES has made***

***developing such applications a priority. How is it doing that?***

CNES has always fostered very close ties with users of space applications, forming several companies that are today world-renowned to serve their needs. Building on this success, we’re now setting up an investment fund called CosmiCapital with the aim of nurturing start-ups with a connection to the space sector. This fund will be coupled with a technology booster to provide stronger support to such initiatives. We’re also developing new tools like Federation, Space’ibles and Connect by CNES to give us a direct line to the very many potential users of space applications. More broadly, we’re encouraging uptake of space technologies by big groups like SNCF, Total and Renault, because demand for data from space systems is strong.

***How is CNES working to sustain the French and European space industry's competitiveness in this shifting landscape?***

We're forging multiple new partnerships with industry and moving from a customer-supplier relationship to one that's based on genuine collaboration. A good example is the ANGELS nanosatellite being developed with Nexeya, whose engineers are working closely with our teams at CNES. Working together more effectively is just as important as developing disruptive technologies to drive innovation.

***Ariane 5 is a testament to the technological and commercial success of Europe's space effort that completed its 100<sup>th</sup> flight a few weeks ago. How is CNES laying the groundwork for Europe's future launchers?***

We have a very clear roadmap to develop Ariane 6 and Vega-C. And in response to the disruptive innovations that are emerging all over the world, in the United States, China, India and Japan, our Launch Vehicles Directorate is playing a key role preparing for that future through the Prometheus low-cost engine and the Callisto demonstrator.

***With the Guiana Space Centre (CSG), Europe undoubtedly has one of the best launch bases in the world. How does CNES intend to sustain its excellence? And what is the agency doing to support French Guiana's development?***

I've always said the CSG is one of the European space programme's most valuable assets and we've engaged a programme to modernize it that will be on the table at the next ESA Ministerial Council meeting at the end of 2019 in Seville. We also decided, on the occasion of the French President's visit to French Guiana in 2017, to redefine how we collaborate with the region's authorities. That means reshaping the Guiana Mission so that CNES works hand in hand with French Guiana in a win-win relationship.

***Climate is central to everything CNES does. How are satellites helping to respond to the urgency of climate change and what projects is the agency pursuing to meet this challenge?***

Satellites are vital to highlight global warming and rising sea level, and to keep a check on greenhouse gas emissions. Out of the 50 essential climate variables (ECVs) defined by the IPCC, 26 can only be measured from space. Building on the momentum of the COP21 conference three years ago, many decisions have been taken. Among those was the decision to develop the

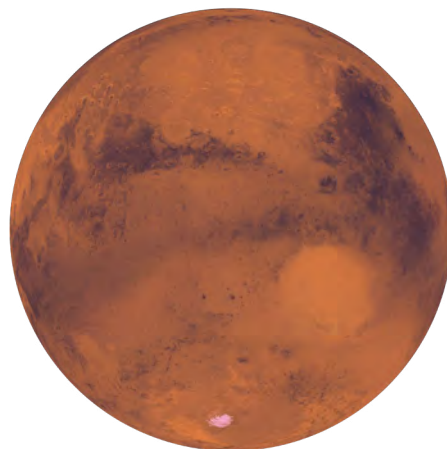
MicroCarb and MERLIN satellites. Today, we're working to set up the Space Climate Observatory (SCO), a hub giving scientists access to data from space that we hope will be as broad in scope as possible. More than ever, we're making satellites a pillar of efforts to tackle climate change.

***After a stellar year for science missions in 2018, what can we look forward to in the domain of space exploration in the years ahead?***

Our partnership with the scientific community is accomplishing great things. We recently landed on Mars with the Insight-SEIS mission and we're already looking ahead to 2020 with ESA's ExoMars mission and NASA's Mars 2020, for which CNES is working closely with both agencies and coordinating development of several French instruments. For Mars 2020, we're supplying the SuperCam instrument that is an enhanced version of ChemCam, which has been probing the Martian surface on the Curiosity rover since 2012. And like the ambitious BepiColombo mission launched in October 2018 to study Mercury, we're involved in all the big exploration projects of ESA's Cosmic Vision programme.

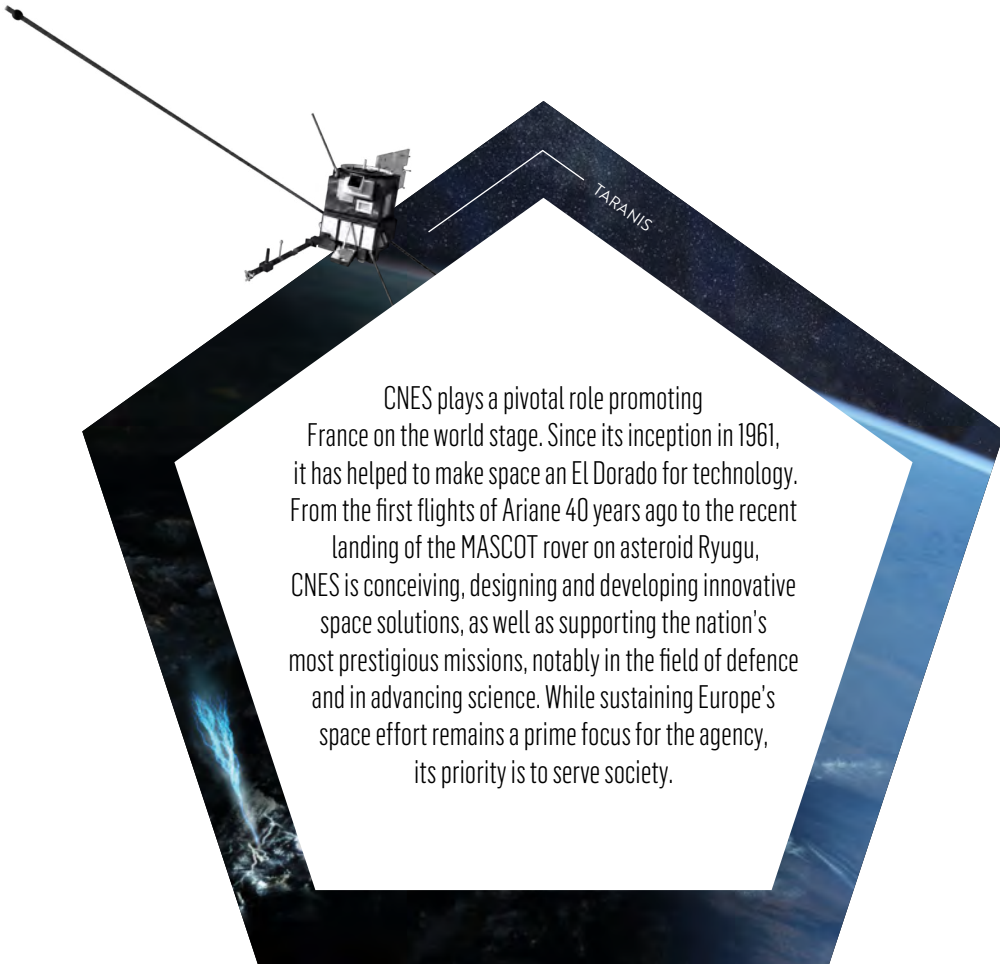
***In short, CNES is going from strength to strength. How do you explain its success?***

In France, we're fortunate to be able to count on very strong political support for what we're doing at CNES and on remarkable budget growth given the circumstances of which we're all aware. Buoyed by such a favourable context, we're reaching out across the board to multiply our actions. Working with scientists, industry and international partners is central to CNES's strategy. But when all's said and done, the agency's success is down to the amazing talents of its people.



# CNES

*“Our vocation is  
to drive innovation for jobs.”*





## ANTICIPATING

CNES is constantly pioneering in its five fields of focus—Ariane, Science, Earth observation, Telecommunications and Defence—and it is also the space agency that has established the most international partnership agreements. Its goal is to develop disruptive programmes and to innovate with cheaper and better solutions geared to the needs of tomorrow. By anticipating the challenges ahead, it is federating Europe's space efforts and working closely with institutions, industry and scientists at the best research laboratories.

## IRRIGATING

80% of CNES's budget is devoted to funding development of new technologies by French industry and research laboratories, sustaining 14,000 jobs in France—40% of all space sector jobs in Europe.



## SUPPORTING

At the end of 2018, CNES took over the rotating six-month chair of the International Charter on Space and Major Disasters, of which it is a co-founder with ESA. Since it was first activated in 2000, this satellite-based emergency support organization has sprung into action nearly 600 times around the globe in the wake of storms, hurricanes, earthquakes, wildfires, volcano eruptions and aviation accidents. Among the 25 participating Earth-observation satellites operated by the charter's 16 partner agencies, SPOT and Pleiades deliver detailed imagery of disaster zones to enable more effective emergency response.

## FUELLING

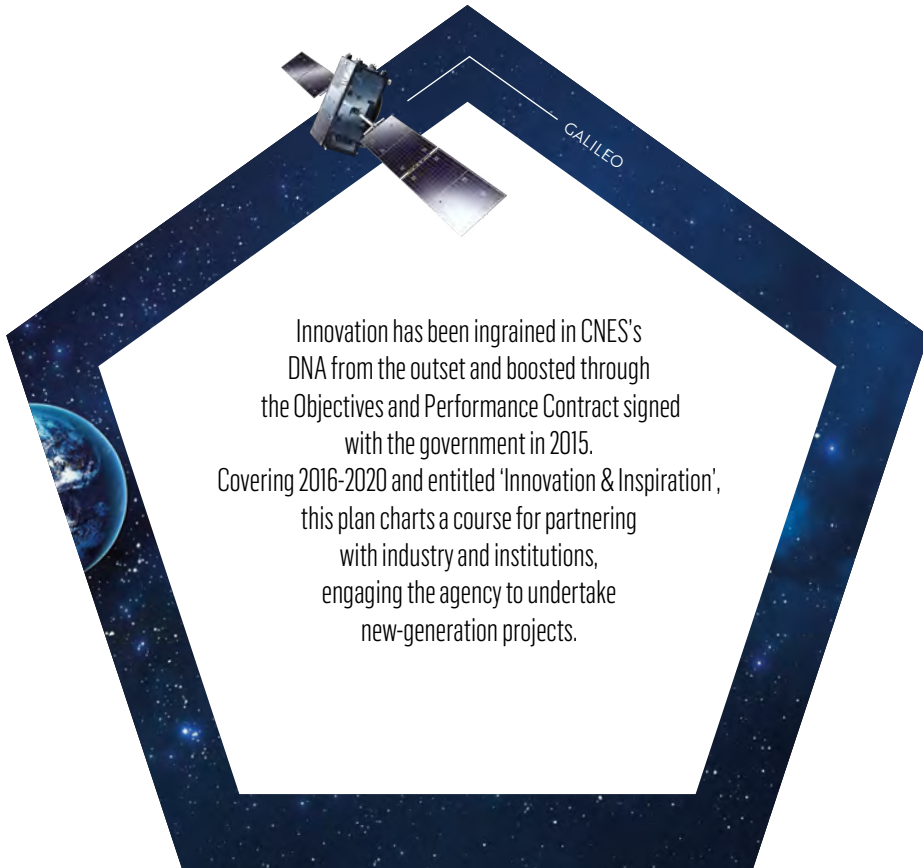
Healthcare, tourism, fisheries, urban planning, transport, environmental management and security are just some of the many sectors that rely on space. For several years now, CNES has been stepping up its actions towards communities by developing partnerships with large operators like SNCF and research organizations, as well as with start-ups.



BREEDING SUCCESS

# A POLITICAL COMMITMENT

*“Space is undergoing a transformation being driven by innovation, applications and digital technologies.”*



Innovation has been ingrained in CNES's DNA from the outset and boosted through the Objectives and Performance Contract signed with the government in 2015. Covering 2016-2020 and entitled 'Innovation & Inspiration', this plan charts a course for partnering with industry and institutions, engaging the agency to undertake new-generation projects.



## INNOVATION AND INSPIRATION

Every five years, the government renews its faith in CNES and sets specific objectives such as securing new industry partnerships, developing innovative solutions to meet current and future needs, and driving its digital transformation. Since 2016, the agency has undergone a deep transformation, branching out into artificial intelligence, biotechnologies and new energies to confirm its mission to invent. Leveraging a range of mature technologies, it is proposing new ideas, investing, connecting, nurturing and building the future of space. It regularly reports to its overseeing ministries on the strategic choices and directions voted by its Board of Directors.



Lucerne 2016

## DIPLOMACY IS THE KEY

International relations are all about diplomacy, and space is no exception due to its dual civil-military nature and clear strategic import. CNES develops a broad palette of cooperative undertakings from symposiums to major space missions.

CNES's advisors in Brussels, Berlin, Washington D.C., Moscow, Tokyo, Bangalore and now Abu Dhabi are constantly seeking to consolidate cooperation with the agency's longstanding partners. Working every day in close contact with their local contacts, they assist France's ambassadors in all matters pertaining to space.

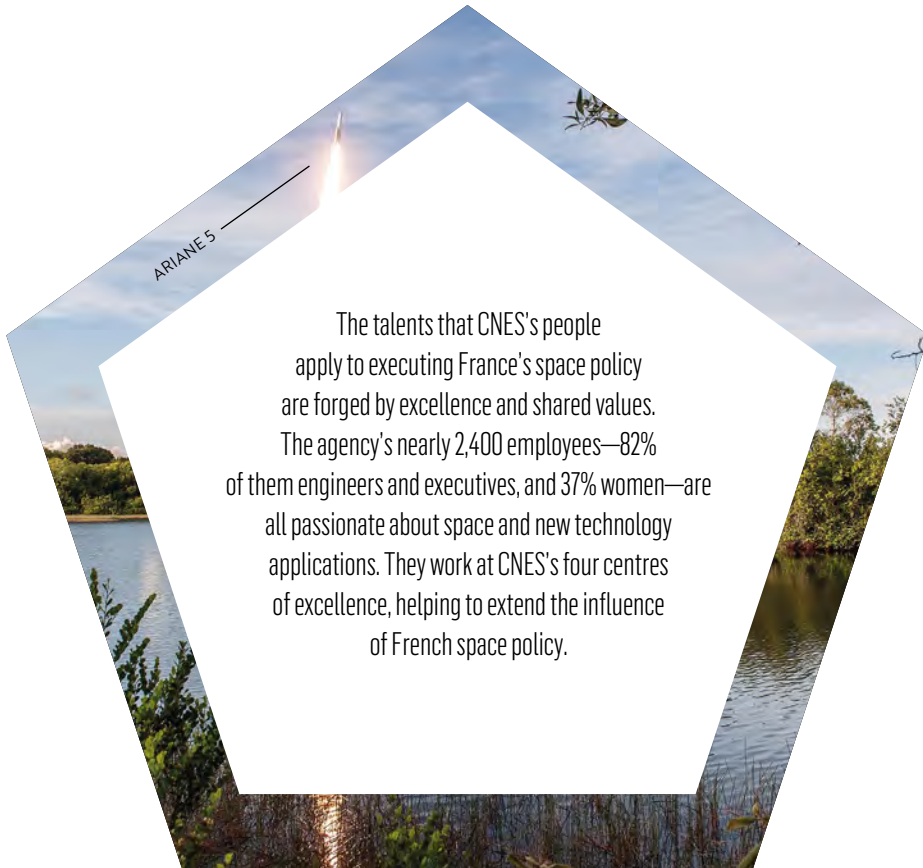
## NUMBER ONE IN EUROPE

The Space Strategy for Europe, adopted in 2016 by the European Commission, was shaped to a large extent by France's proposals, and CNES continues to play a driving role through the substantial French contribution to ESA's budget.

BREEDING SUCCESS

# FOUR CENTRES OF EXCELLENCE

*“We are team space France, devoted to innovation, inspiration and anticipating future needs.”*



The talents that CNES's people apply to executing France's space policy are forged by excellence and shared values. The agency's nearly 2,400 employees—82% of them engineers and executives, and 37% women—are all passionate about space and new technology applications. They work at CNES's four centres of excellence, helping to extend the influence of French space policy.



## HEAD OFFICE: space policy (179 employees)

Paris Les Halles is CNES's Head Office, responsible for mapping out French and European space policy and crafting and coordinating CNES's national, European and international programmes. Every year, CNES signs tens of international agreements, laying the foundation for new science and technology partnerships. The agency also works of course with a broad spectrum of academic, scientific, industrial and business partners in France.

**HEAD OFFICE** • 2, place Maurice Quentin, 75039 Paris Cedex 01 • Tel.: +33 (0)1 44 76 75 00



## LAUNCH VEHICLES DIRECTORATE (DLA): launch systems (206 employees)

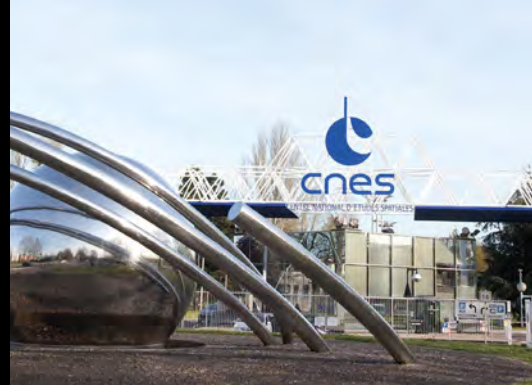
Paris Daumesnil is home to the Launch Vehicles Directorate (DLA), which is instrumental in operating Europe's Ariane 5 and Vega launchers and Soyuz in French Guiana. CNES is prime contractor for all of the launch facilities in French Guiana. Ariane 6, designed to bring down operating costs, is the next major challenge it is now working on. Drawing on its 40-year heritage, DLA's experts are working to invent tomorrow's launchers.

**LAUNCH VEHICLES DIRECTORATE** • 52, rue Jacques Hillairet, 75612 Paris Cedex • Tel.: +33 (0)1 80 97 71 11

## TOULOUSE SPACE CENTRE (CST): orbital systems (1,738 employees)

The CST in Toulouse is the agency's largest technical and operational field centre. Its engineers conceive, design, develop, build, position, control and operate orbital systems. Their work also involves fostering uptake of satellite data for the benefit of all and innovating and creating to imagine tomorrow's space systems. The CST's teams are tasked with supporting all potential space user communities and encouraging adoption of space applications where they are most needed in our daily lives.

**TOULOUSE SPACE CENTRE** • 18 avenue Edouard Belin, 31401 Toulouse Cedex 9 • Tel.: +33 (0)5 61 27 31 31



## GUIANA SPACE CENTRE (CSG): launch operations (268 employees)

The CSG guarantees Europe's independent space launch capability. The 1,700 people at the launch base come from 40 European firms and are working to get ready to operate the launchers of the future. At the space base, CNES coordinates launch operations, prepares satellites and is responsible for range safety and ensuring compliance with environmental regulations. With its modern facilities, three operational vehicles and regular launches, the CSG is a key plank of Europe's space strategy.

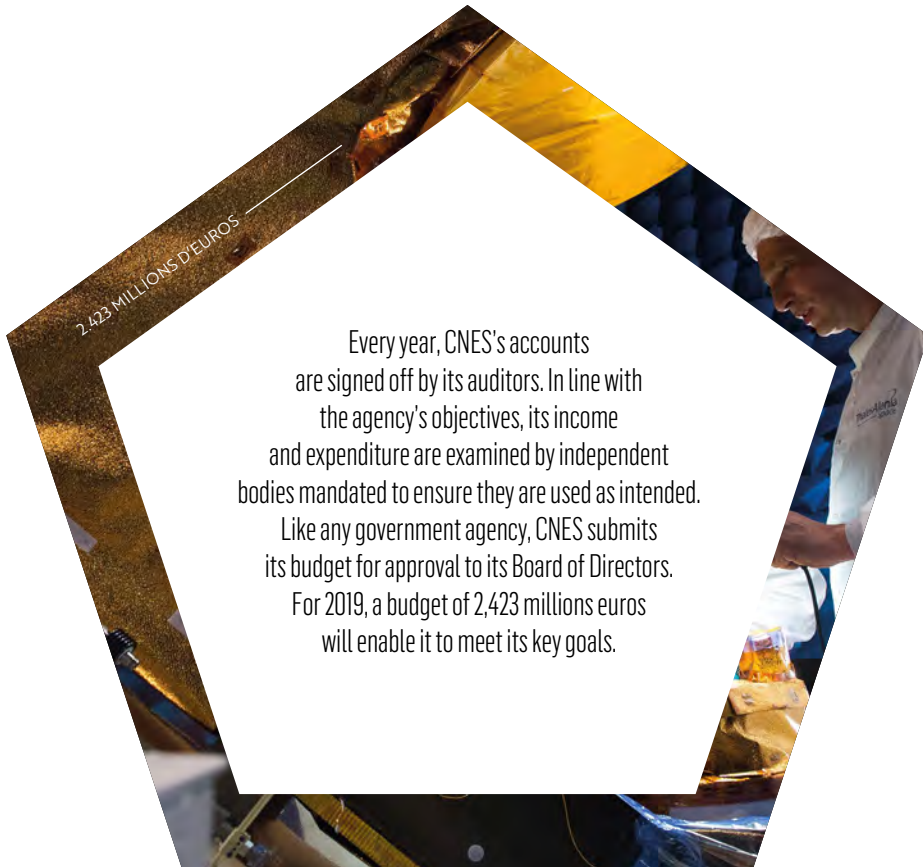
**GUIANA SPACE CENTRE** • BP 726, 97387 Kourou Cedex • Tel.: + 594 (0)5 94 33 51 11



BREEDING SUCCESS

# A SUBSTANTIAL BUDGET

*“Efficiency is our calling card:  
we very often do more and better with the same  
budget than most other space powers.”*



Every year, CNES's accounts are signed off by its auditors. In line with the agency's objectives, its income and expenditure are examined by independent bodies mandated to ensure they are used as intended. Like any government agency, CNES submits its budget for approval to its Board of Directors. For 2019, a budget of 2,423 millions euros will enable it to meet its key goals.

## WHO FUNDS CNES?

To accomplish its missions on behalf of the government, CNES receives funding from the budget lines provided for in its Objectives and Performance Contract, from the PIA future investment programme and from external sources for programmes where it has delegated responsibility (DGA, ESA, Eumetsat, etc.).

### 2019 BUDGET

# 2,423 million euros

CONTRIBUTION  
TO ESA:

**1,175**  
million  
euros

NATIONAL  
PROGRAMME:

**717**  
million  
euros

PIA FUTURE  
INVESTMENT  
PROGRAMME:

**48**  
million  
euros

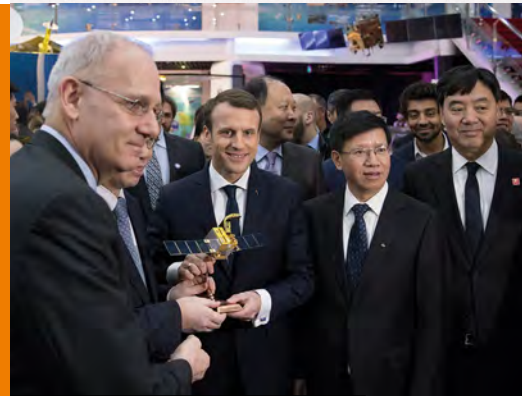
OWN  
RESOURCES:

**484**  
million  
euros

# 359

FRENCH FIRMS WHOSE CORE BUSINESS IS SPACE WERE CALLED ON BY CNES IN 2017. OF THESE, 111 ARE SMALL OR MEDIUM-SIZED ENTERPRISES (SMEs).

**IN ALL, CNES WORKS WITH 2,306 SUPPLIERS TO WHICH IT DEVOTES A BUDGET OF €987.1 MILLION.**



President of the Republic Emmanuel Macron with Jean-Yves Le Gall, CNES President, in China.

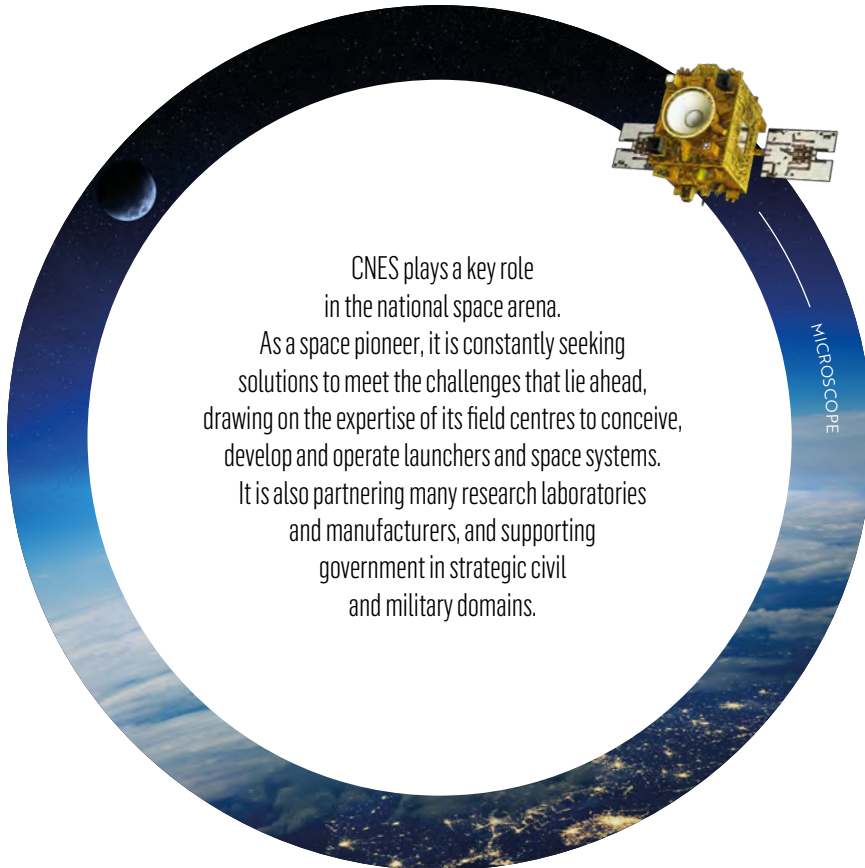




A PIVOTAL PLAYER

# IN FRANCE

*“Space-related disciplines need more engineers, research scientists and entrepreneurs inspired by space.”*





## SME PACT

2019 will see the roll-out of a new action plan in support of small and medium-sized firms (SMEs). This plan covers 30 actions to promote SMEs, in line with CNES's strategy of supporting industrial development to meet the needs of institutions and society. It will focus on four main areas:

- > Spinning off innovations from SMEs into the field of space
- > Making it easier for SMEs to work as government suppliers
- > Forging closer ties between SMEs and CNES
- > Helping SMEs to develop other business outside contracts with CNES



## RESEARCH EXCELLENCE

The French scientific community is renowned as one of the best in the world. Its collaboration with CNES is therefore vital to resolve the remaining mysteries of science. Already a partner of centres of excellence like CNRS (the French scientific research centre), CEA (the French atomic energy and alternative energies commission) and ONERA (the French aeronautics, space and defence research laboratory), CNES has signed new formal partnership agreements with organizations like INSERM, the French National Institute for Health and Medical Research (to study human physiology in space), the INRA agronomy research institute (to monitor the carbon budget of vegetation in Africa), BioMérieux (in the field of microbiology) and Lyon Biopôle (for space and health). Others are set to follow in 2019.



## SPACE INVESTMENT FUND

Under its Objectives and Performance Contract signed with the government in 2015, CNES committed to setting up a space investment fund. This project is now on the rails with the CosmiCapital fund looking to attract €80-100 million from institutional and industrial investors. This fund will be providing support in 2019 to start-ups based in the European Union and fostering uptake of space applications. A dedicated team is managing the fund from Paris and Toulouse.

A PIVOTAL PLAYER

# IN EUROPE

*“More than ever before,  
we are assuming our role as the backbone  
of spacefaring Europe.”*

Since 1975,  
the European Space Agency (ESA) has been  
conducting European space policy.  
ESA today has 22 member states and its leading  
contributors are France and Germany,  
represented by their respective agencies CNES and DLR.  
Alongside its partners, CNES guarantees Europe's  
independent space launch capability and is helping  
to ready new generations of space systems.  
The next key milestone is the ESA Ministerial  
Council meeting to be held in Seville  
on 27 and 28 November 2019.

STATION SPATIALE INTERNATIONALE





## SHARED COMMITMENT

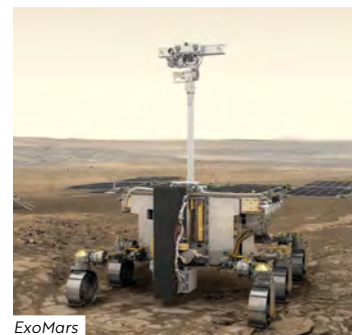
Europe is the world's number two space power, a position it owes to its member states and national agencies, ESA and the European Union. Over the years, they have succeeded in translating their close cooperation into political action.



Emi Koussi volcano - Sentinel-2B (Copernicus)

## VENTURING FURTHER AFIELD

ESA is currently developing its future launchers. To this end, it is working with CNES and industry to develop the future **Prometheus** reusable low-cost engine and the **Callisto** demonstrator, scheduled to undergo its first tests in 2020. Other planned missions include **Euclid** to study dark energy (2021), **JUICE** to explore Jupiter and its icy moons (2022), **Athena** to discover galaxy clusters and black holes (2030) and **Lisa** to confirm the existence of gravitational waves. CNES and its European partners also approved funding in Lucerne in 2016 for the **ExoMars** rover and its science payload, as well as the continued operation of the **International Space Station** through to 2024.



ExoMars

## PREPARING FOR POST-2019

On 27 and 28 November 2019, the next ESA Ministerial Council meeting will be held in Seville. Among the many challenges facing spacefaring Europe are:

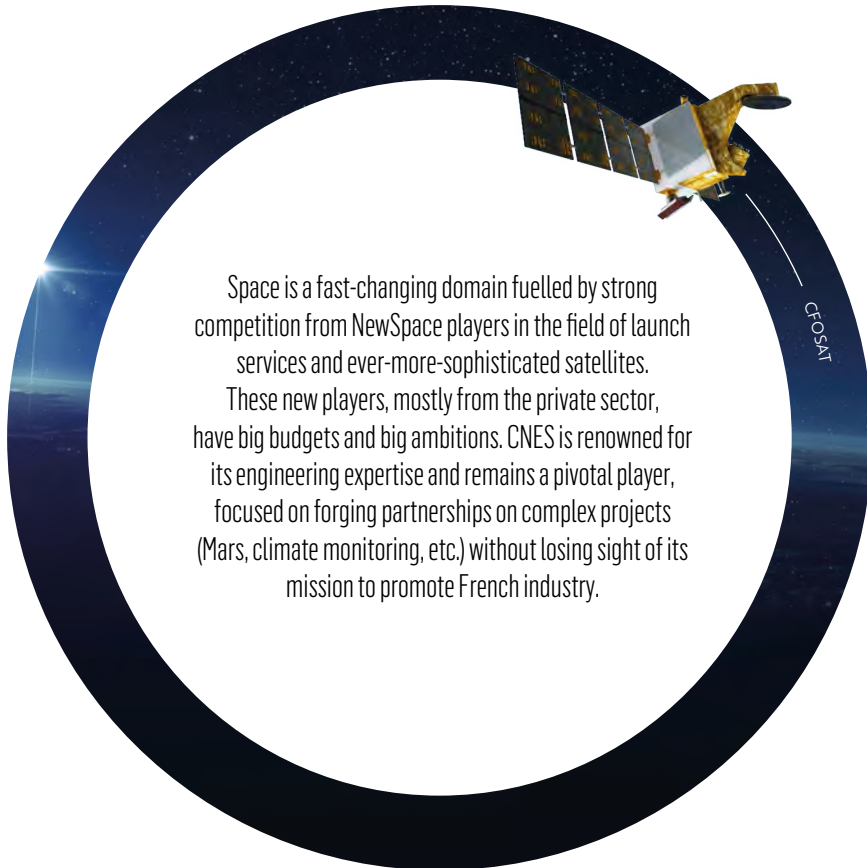
- > Planning ESA's mandatory science programme activities while sustaining its excellence and basic tasks.
- > Committing to optional programmes, i.e. launchers (Ariane 6 and beyond), Earth observation (Copernicus), space exploration (International Space Station), telecommunications, navigation and space surveillance and tracking, to step up ESA's role serving society.

ESA is also looking to work more closely with European industry to boost its competitiveness in the fast-moving NewSpace landscape, while pursuing activities on behalf of the European Union and its member states. One of the key issues at stake for spacefaring Europe in the years ahead will be the adoption of the EU space programme regulation ahead of the next Multiyear Financial Framework (MFF) for 2021-2027, which will cover Galileo, EGNOS, Copernicus and GovSatCom.

A PIVOTAL PLAYER

# ON THE WORLD STAGE

*“CNES is constantly adapting to the new challenges of space and maintaining France’s position as a linchpin of international scientific cooperation.”*



Space is a fast-changing domain fuelled by strong competition from NewSpace players in the field of launch services and ever-more-sophisticated satellites. These new players, mostly from the private sector, have big budgets and big ambitions. CNES is renowned for its engineering expertise and remains a pivotal player, focused on forging partnerships on complex projects (Mars, climate monitoring, etc.) without losing sight of its mission to promote French industry.





## A GO-TO PARTNER

With some 40 agreements signed every year, CNES is a partner of choice. Besides the world's leading space powers—the **United States, China, Russia, Japan and India**—CNES is cementing ties with new entrants like **Peru, Singapore, Vietnam, Indonesia, Morocco and Thailand**, working together on actions that France has initiated to promote economic diplomacy or tackle climate change. The agency is not only providing its technology know-how and expertise for technical missions but also supporting and developing national projects like a hyperspectral satellite for the **United Arab Emirates**, developing space learning with **Senegal and Tunisia**, and building the Colibri telescope in **Mexico**. Many more agreements are already in the pipeline for 2019.

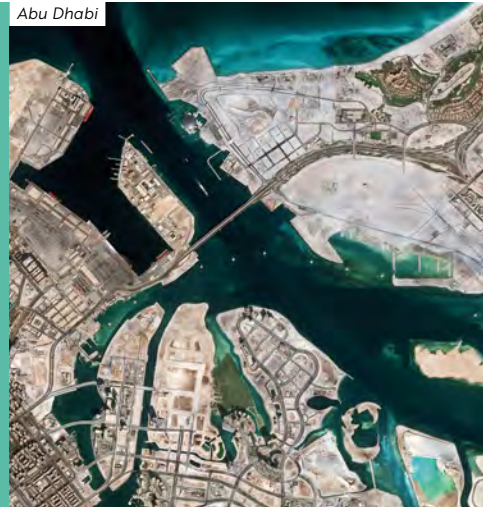


CNES and the Canadian Space Agency (CSA) sign a cooperation agreement.

## MAKING 'THINK FRANCE' A REFLEX RESPONSE

CNES is encouraging its international partners to 'think France' as a reflex response and turn to French manufacturers for their space applications, thus boosting their competitiveness.

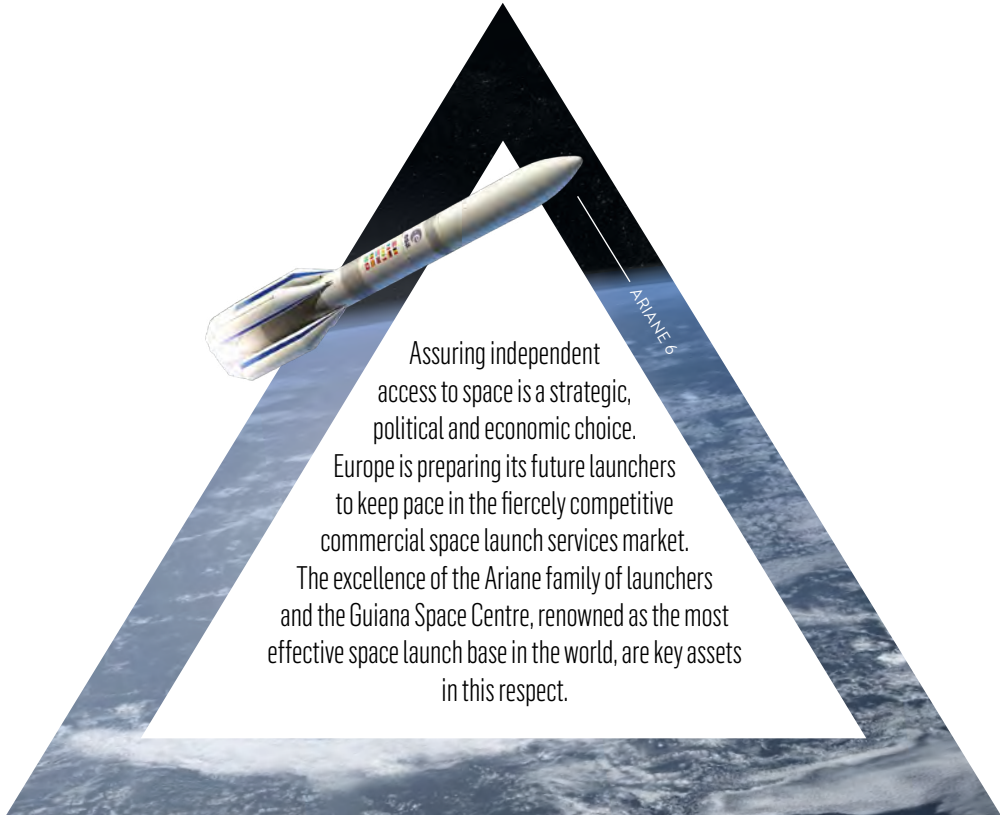
Abu Dhabi



THREE KEY SECTORS

# LAUNCHERS

*“Europe has become the world’s number two space power thanks to the reliability and availability of its launchers.”*





## COMBINING SOVEREIGN AND COMMERCIAL CONSIDERATIONS

The European model was based from the outset on developing a launcher to serve strategic and institutional needs first and commercial customers second. Current competition is increasing dependence on the commercial market and demanding a more economical launcher to drive down the cost of government launches.

## LAUNCHERS OF THE FUTURE

In the short term, Vega will be evolving with a new Vega-C version in 2019 and Ariane 5 will remain in service through to 2022 until Ariane 6 comes on stream and ramps up its launch rate. In the medium-to-long term, new launch vehicles are set to appear relying on innovative technologies like very-low-cost propulsion and simpler designs to stay competitive. For example, largely due to its methane propellant, **Prometheus** will deliver 100 tonnes of thrust 10 times more cheaply than current-generation engines. First tests are planned in 2021 to lay the foundation for the development of future launchers. Stages are the other main focus of attention: while Germany is studying how to make them lighter with composite materials, France is working on reusability with **Callisto**. This demonstrator being built in partnership with the German space agency DLR and the Japanese space agency JAXA, set to begin testing in French Guiana in 2021, intends to assess technical and economic issues related to reusability. The results from Callisto will subsequently feed into development of a much larger demonstrator powered by Prometheus engines.



Prometheus



Ariane's 1<sup>st</sup> flight

2019 marks **40 years** of independent access to space for Europe with Ariane (1979-2019). From the first Ariane vehicle (LO1) to the last Ariane 5 launch of 2018, it has completed 246 flights from the CSG.



Callisto

## EFFICIENT LAUNCH BASE

Covering an area of 700 sq.km and with three operational launch complexes, the Guiana Space Centre (CSG) is the cradle of Europe's launchers and, since 2011, a base for the Russian Soyuz. CNES is in the process of building the ELA4 complex for Ariane 6 and investing to accommodate future launchers, notably reusable ones. It is also preparing the CSG New Generation programme designed to modernize the launch base, topped by a new Operations Centre where all the information required by its teams will converge.

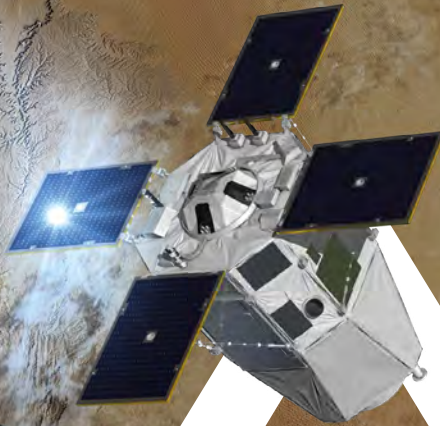




THREE KEY SECTORS

# SATELLITES

*“Space systems are a vital strategic asset.”*



CSO

The reason for going into space is to conduct missions with orbital systems. Today, it's hard to imagine a world without satellites. Working alone or with partners, CNES is a key player in the satellite ecosystem, developing disruptive technology projects and leading the way for a national industry renowned worldwide for its excellence.



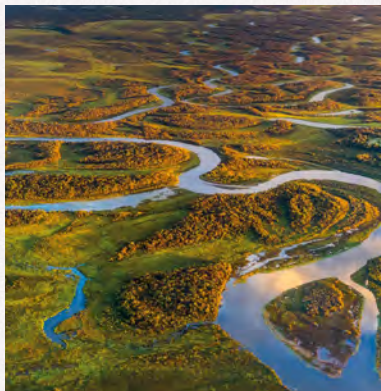
## SCIENCE

Space is a fantastic laboratory for science. Alongside leading research organizations, CNES is conceiving sophisticated space instruments like **Taranis**. Set for launch in 2019, Taranis will be the first mission devoted to probing radiative and electromagnetic phenomena generated at altitudes of 20 to 100 kilometres. The agency is also working on the international **PILOT** programme and the **Co-PILOT** programme that aims to map ionized carbon (C+) clouds in our galaxy from a stratospheric balloon.



## TELECOMMUNICATIONS

With demand for connectivity growing exponentially, satellite telecommunications is a sector in a state of flux. CNES is developing ever more new services, investing in fast broadband with **THDSat** as well as in small satellites for low-Earth-orbit constellations geared towards the Internet of Things (IoT).



SWOT



## EARTH OBSERVATION

Space is also the best vantage point for surveying our planet. As the conceper of the SPOT series of satellites, CNES has always set the bar very high and helped to establish French excellence in remote sensing. After the launch in 2018 of CFOSat, designed with China to study waves and ocean surface winds, several eagerly expected projects are now underway, notably to support climate actions. Among these is the French-U.S. **SWOT** mission that is set to revolutionize the science of hydrology with its altimeter capable of surveying Earth's seas, oceans, rivers and lakes.

## DEFENCE

Working alongside the Ministry for Armed Forces, CNES conceives tools that contribute to the peace and security of citizens while helping French industry to maintain its competitive edge. The launch of CSO-1 at the end of 2018 marks the start of a cycle to renew the nation's military space capability, with six launches from the Guiana Space Centre: three **CSO** optical reconnaissance satellites, a **CERES** signals intelligence satellite and two **Syracuse 4** secure telecommunications satellites.



## CHANGING WITH THE TIMES

With new technologies and innovative applications, CNES is adjusting to the new paradigm and banking notably on electric propulsion. In 2019, the first electric-propulsion **Spacebus** platform will be lofted into geostationary orbit. Electric propulsion will also be used from 2020 on the new **Neosat** spacecraft buses developed with European partners, to boost performance and serve new telecommunications requirements at lower cost.

THREE KEY SECTORS

# APPLICATIONS

*“We must promote the principles of 3G diversity:  
Gender, Generation and Geography.”*



Business, healthcare, agriculture, fisheries, the environment and security are among the many areas where space applications are delivering benefits. To encourage uptake of space technologies, CNES is engaging with all potential user communities. In line with European Union directives, it is making it easier for citizens to access data from major space missions.

CLS





## GALILEO

With 26 satellites now in orbit, Europe's navigation constellation is driving a revolution in the world of GNSS, delivering unrivalled precision of one metre anywhere in the world to more than 500 million users. A method devised by CNES to achieve centimetre precision is already being marketed under an agreement with French firm Geoflex. Galileo is thus finding immediate applications in autonomous vehicles, farming and geodesy, where it is helping scientists to study the motions of Earth's plates. The first service activated at the end of 2016 for search-and-rescue (SAR) applications receives signals from distress beacons and sends them instantaneously to emergency responders.

## COPERNICUS

The Copernicus Earth-observation programme delivers vital data to the international community for tracking socio-economic activities and preserving our environment, whether for topographic mapping in Ethiopia, monitoring water resources in Uganda or compiling agricultural statistics and predicting food crises in Senegal. Developed by CNES, the online PEPS Sentinel Product Exploitation Platform offers users free access to data from the programme's six families of satellites. New Data and Information Access Services (DIAS) are also set to be deployed in 2020 and integrated at European level to bring all of these data and processing capacity to citizens, scientists and manufacturers everywhere.

# +12 Tb

**OF DATA GENERATED**  
BY THE COPERNICUS FLEET  
OF SATELLITES EVERY DAY.

## A KEY STAKEHOLDER

In bringing space to citizens, CNES is seeking to meet the challenges facing us now and in the future. Working with firms, research laboratories, territories and institutions, it is honing its skills and proposing extraordinarily precise tools. In particular, the agency is positioning itself as a core player in autonomous vehicles. Other sectors like personalized medicine, telemedicine and e-health are also emerging in response to the lack of doctors in remoter regions. The performance of all of these applications is being driven by new satellite telecommunications systems.

### Telemedicine





THE CHALLENGES OF GLOBALIZATION

# DIGITAL

## DRIVING A TRUE REVOLUTION

*“This revolution in which we are all engaged is going to change how we live forever.”*



With the emergence of a data-driven economy, Earth-observation, positioning and communication satellites are today seen as vital cogs in the global digital infrastructure. Satellite data are fuelling development of numerous services for the environment, healthcare, mobility and more besides, so they are a key focus for the giants of the digital age. This revolution is also completely transforming management, business and industrial practices (Industry 4.0, agile approaches).

## WORKING FOR EMPLOYEES

To do its job more effectively, CNES is changing its working and management methods, and for that it can rely on its digital transformation team. Its approach is focused on people and the environment (paperless office) and on social issues (data protection, time saving, sharing of information, etc.). The agency's employees each have their own digital safe where documents can be held securely. Other applications like teleworking, digital signatures and digital forms aim to improve working conditions and make exchanging information easier. This culture shift not only concerns employees in their work environment, but also in their dealings with contacts outside the agency, for example for paperless procurement. Last year, CNES also adopted a new approach to hiring with dynamic after-work meetings held in the evening in a friendly and relaxed setting.



3D virtual-reality headset



## PLANET EARTH UNDER SURVEILLANCE

As a big producer and storer of masses of data and a precursor of big data technologies, CNES decided to look at how it could best share its heritage more widely. Tracking pollution peaks, polar ice melt and deforestation in the Amazon may be the first environmental protection imperative, but other sectors such as transport and mobility, security and agriculture are also calling for satellite data. SPOT paved the way in the 1980s and Copernicus, GAIA and Galileo are now following in its footsteps.

## LEARNING FROM SIMULATION

Basiles is a tool conceived by CNES that consists of software components able to create a faithful digital simulator of a satellite, putting the control centre and its operators in real-life space conditions. By simulating before they build, engineers can thus better project how a satellite will operate and anticipate possible failure points to boost performance. Today, all space missions go through Basiles, and in 10 years it has become the benchmark platform in its class. Downloadable for free, it is already branching out into other sectors outside space.

THE CHALLENGES OF GLOBALIZATION

# MINIATURIZATION

## DRIVING DOWN THE COST OF SPACE

*“Between agencies and start-ups,  
we are taking the best from both worlds.”*





## COSTS DECLINING FOR A PROMISING MARKET

Smaller is cheaper, so smaller satellites mean more space for all. Nanosatellites are accessible to all types of users and are great for developing applications and in-orbit testing. They are also an excellent tool for learning and partnering nations new to space. CNES is looking at a number of miniaturized payloads, for example to study cosmic rays, measure river levels by altimetry and retrieve Galileo signals exiting the atmosphere for weather observations.

# 580

SMALL SATELLITES WILL BE ORBITED EVERY YEAR BETWEEN NOW AND 2022.

## NANO CLUB

Created in 2016 by CNES, the Nano Club federates players from the public and private sectors focusing on satellites in the under-50-kilogram class. Through a dedicated platform for exchange, the club's 60 members are working together to develop and structure a French industrial ecosystem geared towards the highly promising nanosatellite market.



## ARGOS AND ANGELS

CNES's partnership with Nexeya on ANGELS, the first French nanosatellite demonstrator to be launched at the end of 2019, illustrates the momentum generated in this sector. ANGELS (Argos Neo on a Generic Economical and Light Satellite) is set to prove the reliability and performance of nanosatellites as part of the famous Argos fleet. CNES is also working with operator CLS on the next-generation Argos 4 Neo, which will be two times lighter and consume half the power of an Argos 4 instrument. Alongside this effort, the agency's R&T team is partnering industry to develop optimal electric propulsion systems for small satellites.



Eyesat nanosatellite

## JANUS

In partnership with universities, engineering schools, higher education institutions, research laboratories and industry, the Janus student nanosatellite project is working to get French students interested in space. CNES is helping them to develop their missions, from conception through to launch.



THE CHALLENGES OF GLOBALIZATION

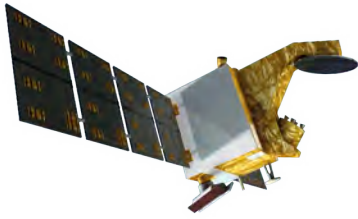
# INTERNATIONAL COOPERATION IS THE KEY

***“Space is a great builder  
of bridges between nations.”***

Competition aside, international cooperation in space remains a necessity. Many vital scientific and sometimes humanitarian projects are the result of partnership efforts. CNES is securing agreements all over the world, building technology bridges between nations by sharing its know-how.

INSIGHT-SEIS

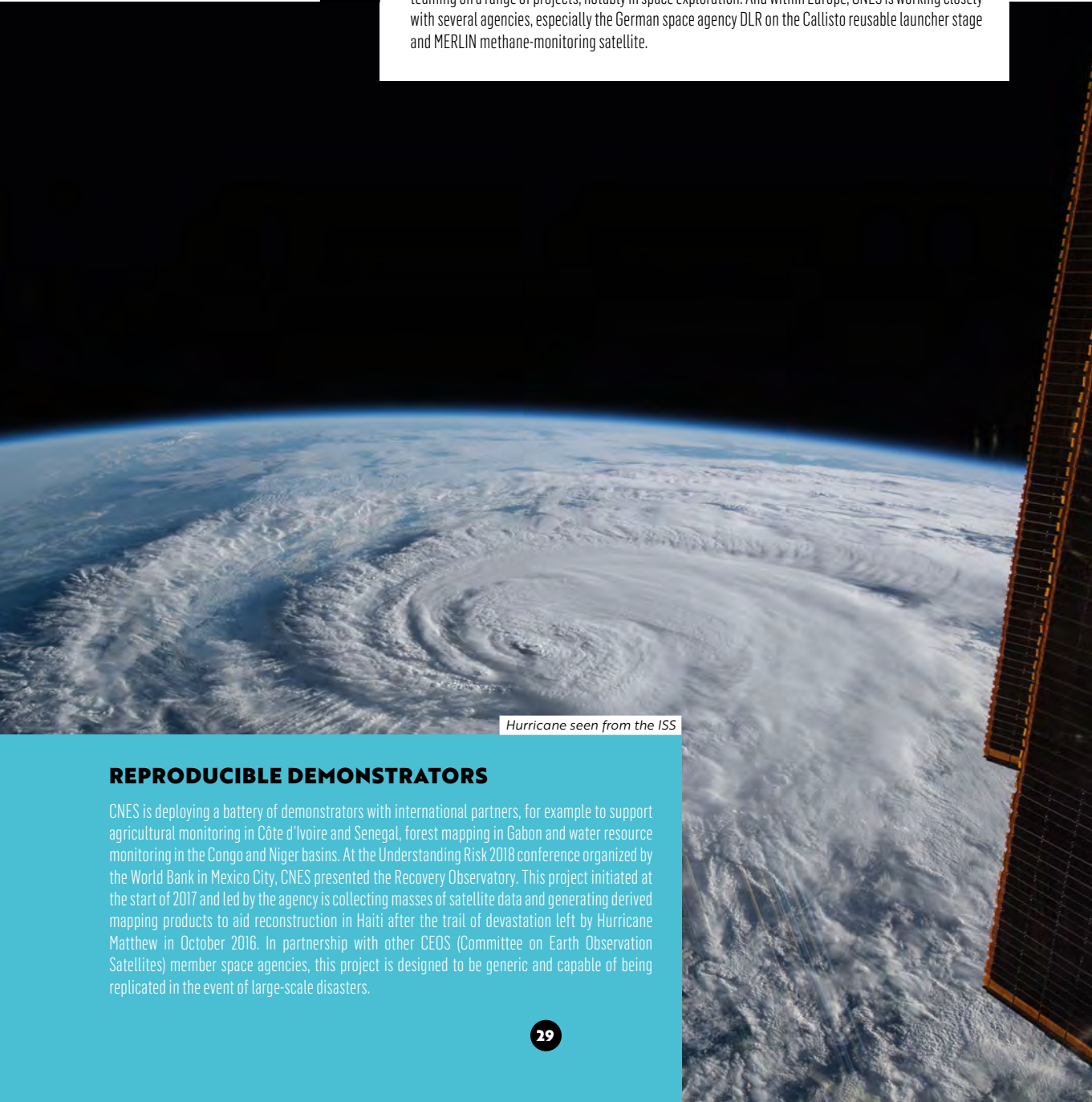




CFOSat

## COOPERATION ACROSS THE BOARD

CNES's partnerships with other agencies are founded on a relationship of trust built at the highest levels over many years. With the United States, this has led to a series of missions to the red planet like the Curiosity rover, and fine successes like the Jason ocean-surveying satellites. Cooperation is also in place on the International Space Station through agreements with ESA, and with Russia, a CNES partner for more than 50 years. Other longstanding partners are the Indian Space Research Organization (ISRO) and China, which is stepping up its cooperation with CNES. After CFOSat launched late in 2018, the two partners are laying the foundations of the Space Climate Observatory (SCO) and already working together on new projects. Besides exchanging space surveillance and tracking data, CNES and Japan are teaming on a range of projects, notably in space exploration. And within Europe, CNES is working closely with several agencies, especially the German space agency DLR on the Callisto reusable launcher stage and MERLIN methane-monitoring satellite.



Hurricane seen from the ISS

## REPRODUCIBLE DEMONSTRATORS


CNES is deploying a battery of demonstrators with international partners, for example to support agricultural monitoring in Côte d'Ivoire and Senegal, forest mapping in Gabon and water resource monitoring in the Congo and Niger basins. At the Understanding Risk 2018 conference organized by the World Bank in Mexico City, CNES presented the Recovery Observatory. This project initiated at the start of 2017 and led by the agency is collecting masses of satellite data and generating derived mapping products to aid reconstruction in Haiti after the trail of devastation left by Hurricane Matthew in October 2016. In partnership with other CEOS (Committee on Earth Observation Satellites) member space agencies, this project is designed to be generic and capable of being replicated in the event of large-scale disasters.



A NEW WORLD ORDER

# INNOVATION TECHNOLOGIES AND METHODS

*“Success will also come from start-ups innovating with space data and solutions.”*



CNES is continuing to innovate and positioning itself as the partner of choice for users. Applying a disruptive approach, it has been working for several years now to adapt to new uses and challenges. Today, space is seen increasingly as a business booster, be it upstream for legacy players or further down the line for applications. For big manufacturers, start-ups and local government alike, the agency is adopting new methodologies, proposing new ways of working and contributing its technology expertise across the board to spur creativity.

## FOR EVERYBODY, EVERYWHERE

Space isn't just for stargazers; it concerns all sectors, and CNES must be ready to enlighten users on the opportunities it affords. To reach out to them and encourage infusion of technologies, it inaugurated the **Space'ibles** space survey observatory in 2017 with 38 partners from all horizons working together to gauge prospects in areas such as space applications for business. In 2018, in partnership with French Tech, CNES is present at the **Station F** incubator in Paris and soon **B612** in Toulouse to help nurture start-ups.



ActInSpace held its 3<sup>rd</sup> edition in 2018.



## SPACE FOR EXPRESSION

In creating a new Directorate for Innovation, Applications and Science (DIA) in 2016, CNES clearly announced its intention to make space a booster of innovation for all by spawning new initiatives. To achieve this, it is applying a disruptive methodology which, while leveraging space expertise, is more broadly based. New spaces for expression and debate are emerging both inside and outside the agency, with expert communities, the FEDERATION trophy and Crealab to name a few. And to inspire innovation in citizen communities, CNES is helping to launch the FEDERATION non-profit association of fablabs, makerspaces, hackerspaces and other collaborative initiatives. It is also the co-organizer of the ActInSpace international hackathon in partnership with ESA, which in 2018 attracted more than 2,000 participants.

## INSIDE SPACE

Nanosatellites or electric propulsion would of course be impossible without innovation. CNES is striving to promote French businesses and expand their international reach, providing its resources and expertise to act as a facilitator, create synergies and build networks.

## OUTSIDE SPACE

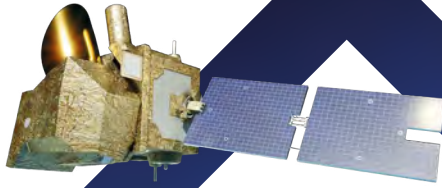
CNES is also developing a set of tools to nurture an ecosystem of new technologies, working with all potential users of space technologies and helping them with the space component of their projects. Cap Digital in the digital sector, Lyon Biopôle in healthcare and Boosters for applications and services are just a few examples.

A NEW WORLD ORDER

# CLIMATE

## A NEW ECOSYSTEM

*“Mobilizing all layers of society to secure the future of populations and the diversity of life on Earth is the chief priority of this century.”*



MICROCARB

Humans are both the cause and victim of the very real impacts of climate change—rising sea level, melting ice, coastal erosion, droughts and flooding to name a few. France is seeking to mobilize international efforts and resolutely committed to tackling climate change through the new Space Climate Observatory (SCO) designed to deliver data and impact studies to scientists and citizens alike.



**1** PERSON IN 10  
IN THE WORLD LIVES  
IN A REGION UNDER  
THREAT FROM RISING  
SEAS, WHICH HAVE  
RISEN 10 TIMES FASTER  
IN THE LAST 20 YEARS  
THAN IN THE 4,000  
PREVIOUS YEARS.



## SPACE CLIMATE OBSERVATORY

The SCO is a key international project of the utmost urgency. A global hub for space communities, it is seeking to pool satellite data on climate change and its impacts at national and local scales. Also encompassing social science and economic aspects, the challenge facing the SCO is to give scientists, NGOs and citizens regularly refreshed data to enable local and regional stakeholders to conduct their own impact studies.

## ONE PLANET SUMMIT



The 195 nations that signed the Paris Agreement in 2015 have committed to curbing their greenhouse gas emissions. Launched on France's initiative to gauge progress on implementing this agreement, the One Planet Summit at the end of 2017 endorsed the proposal of space agencies to set up a Space Climate Observatory (SCO). At the second such summit in September 2018 in New York, several applications that rely on satellite data were presented, including modelling of sea level rise along coasts, monitoring of ice melt and efforts to combat recurring drought.



## DEDICATED MISSIONS

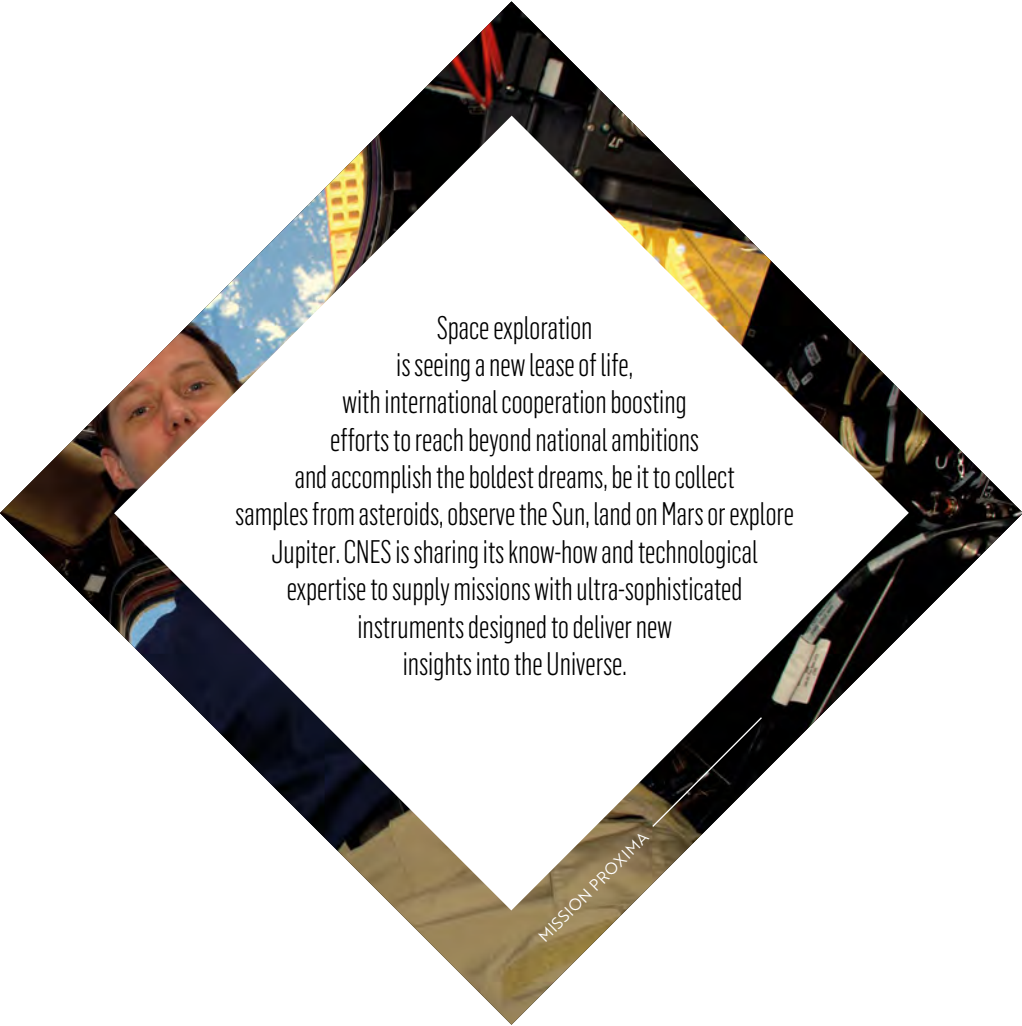
Satellites are the most effective tools for observing climate change and checking that commitments are being kept. To this end, space agencies are continuing to innovate to acquire vital new measurements required to meet the goals of the Paris Agreement. As a pioneer in Earth observation, CNES is bringing to the SCO its archive of more than 30 years of satellite data from the SPOT and Jason series, IASI, Megha-Tropiques and now CFOSat. And the **MERLIN** and **MicroCarb** missions are set to provide measurements of greenhouse gas emissions to gauge new climate variables.

A NEW WORLD ORDER

# EXPLORATION

## INSPIRING INTEREST

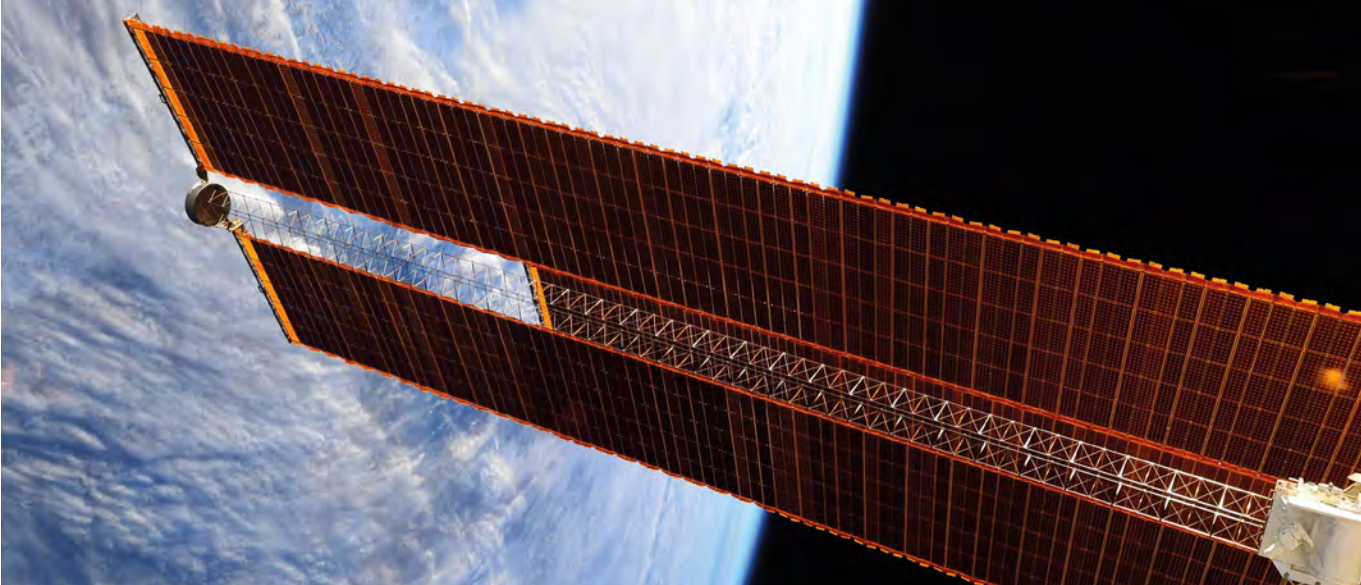
*“Space is without doubt inspiring the future of humankind.”*



Space exploration is seeing a new lease of life, with international cooperation boosting efforts to reach beyond national ambitions and accomplish the boldest dreams, be it to collect samples from asteroids, observe the Sun, land on Mars or explore Jupiter. CNES is sharing its know-how and technological expertise to supply missions with ultra-sophisticated instruments designed to deliver new insights into the Universe.

MISSION PROXIMA



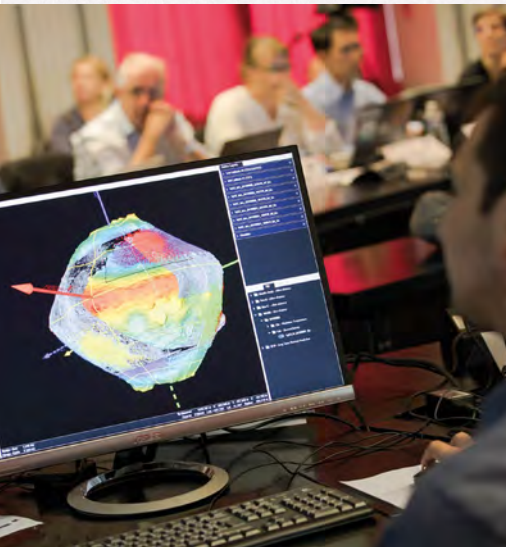
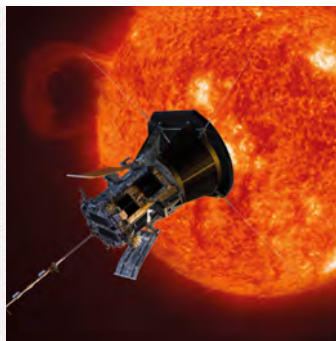


## PESQUET, GERST, CRISTOFORETTI, PEAKE

Deployed since 1999 by five space powers—the United States, Russia, Europe, Japan and Canada—and planned to continue operating through to 2024 at least, the International Space Station (ISS) is a laboratory like no other. The wealth of experiments conducted on the station by astronauts has advanced science, notably in the fields of physiology, biology and material physics. The Proxima mission flown by French astronaut Thomas Pesquet in 2017 was no exception. The United Kingdom's Tim Peake, Italy's Samantha Cristoforetti and Germany's Alexander Gerst are also the pride of their country and of Europe. In partnership with national and international research organizations, CNES's CADMOS operational centre is pursuing new science missions on the ISS.

## MASCOT

Following in the footsteps of Rosetta and Philae, the French-German **MASCOT** rover, carried by the Japanese **Hayabusa2** probe launched in 2014, landed in October 2018 on asteroid Ryugu. Hayabusa2 is now set to collect samples from the surface and bring them back to Earth late in 2020.



## ROBOTIC EXPLORATION

Missions accomplished in 2018 promise a rich harvest of unprecedented data in 2019 and years to come. Launched in May 2018, **InSight** landed on Mars in November to study the planet's interior structure with the SEIS seismometer developed in France. The French-U.S. **Parker Solar Probe** mission departed in August 2018 and will reach the vicinity of the Sun in 2024. And the European **BepiColombo** probe sent aloft in mid-October 2018 will go into orbit around Mercury in 2025. Other planned missions include **Mars 2020** with NASA, the **Bion-M2** recoverable capsule and **Interhelioprobe** to survey the Sun with Russia, **MMX** to study samples from the moons of Mars with Japan, and **SVOM** to probe gamma-ray bursts in 2021 with China. CNES is also involved in ESA's programmes through **ExoMars**, **Euclid** to study dark energy (2021), **JUICE** to explore Jupiter's icy moons (2022), **Athena** to probe the mysteries of black holes (2030) and **Lisa** to study gravitational waves.





# 1961

INCEPTION OF CNES.



# 2nd

**THE WORLD'S SECOND SPACE BUDGET**  
WITH €35 PER CAPITA PER YEAR, FRANCE'S SPACE BUDGET COMES SECOND ONLY TO THE UNITED STATES, CONFIRMING THE GOVERNMENT'S STRONG INTEREST IN SPACE ACTIVITIES.

# 3rd

**1965: FRANCE BECAME THE WORLD'S THIRD SPACE POWER** AFTER THE UNITED STATES AND THE SOVIET UNION, LAUNCHING DIAMANT WITH THE ASTERIX SATELLITE.



# x4

**THE OCEANS WARMED FOUR-TIMES** MORE QUICKLY FROM 1992 TO 2015 THAN FROM 1960 TO 1991. THIS ISSUE IS A KEY CONCERN FOR CNES.



# 2016

**FIRST GALILEO SATELLITE NAVIGATION SERVICES LAUNCHED.**  
THE SYSTEM NOW HAS MORE THAN 500 MILLION USERS AROUND THE WORLD.

THE SPIRIT OF SPACE



# 44

**PROBES, SPACECRAFT AND ORBITING OBSERVATORIES FOR SCIENCE** HAVE BEEN LAUNCHED FROM THE GUIANA SPACE CENTRE. FROM GAIA AND ROSETTA TO SPOT, PLANCK, HERSHEL AND THE ATV, CNES HAS HOSTED NUMEROUS EMBLEMATIC PASSENGERS.



# 497

**PATENTS (FOR SYSTEMS AND LAUNCHERS)** HAVE BEEN FILED IN THE LAST 10 YEARS BY CNES AND MADE AVAILABLE TO USERS FREE OF CHARGE.



# 700,000

**PEOPLE FOLLOWED THOMAS PESQUET'S PROXIMA MISSION ADVENTURE** ON [www.cnes.fr](http://www.cnes.fr) IN 2017. THE MOST HITS CAME FOR HIS FIRST SPACEWALK IN JANUARY.



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January 2019 // **Organizations:** AdEchoTech, Airbus DS, Assemblée Nationale, CNES, CNES/ESA/Arianespace, CNES/ESA/Sentinel, Copernicus Sentinel data, ESA, ESA/ATG Médialab, Johns Hopkins University Applied Physics Laboratory, JPL, NASA, Ariane Groupe Holding, GettyImage, Fotolia // **Photographers:** Guillaume Berthier, Gwenewan Le Bras, Stéphane Corvaja, Romain Gaboriaud, Emmanuel Grimault, Frédéric Maligne, Alexandre Ollier, Christophe Peus, Hervé Piraud, Patrick Tourneboeuf, Optique Vidéo CSG-P.Piron, Soizig de la Moissonière/Présidence de la République. // **Illustrators:** Blackbear, David Ducros, Mira Productions, ATG Médialab // **Copywriting:** Karol Barthelemy and Eric Médaille // **Design and pre-press:** Communication // **Artwork:** CNES Photo Library, Photon, Orianne Arnould // **Printing:** Escourbiac // **Translation:** Boyd Vincent // **Published by:** Communications Directorate.