CNES MAG

EN FR

SPACE • INNOVATION • SOCIETY

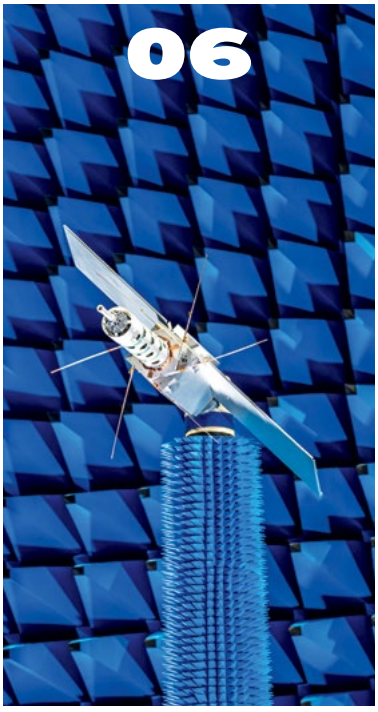
#91
February 2022

INNOVATION

BOOSTING FRENCH EXPERTISE

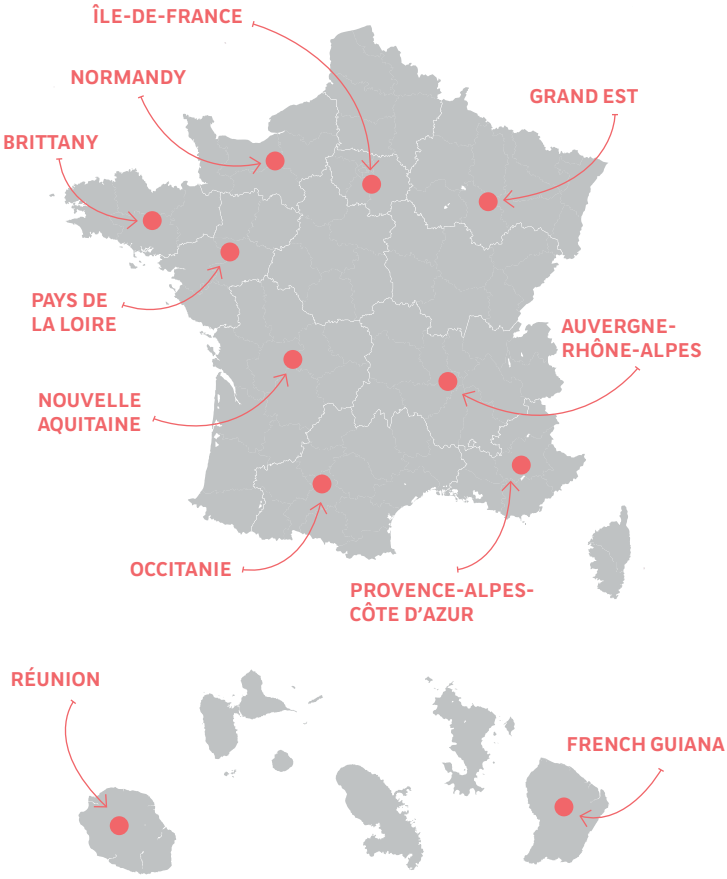
cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

INSIDE



INSIDE

STAGES OF THE FIRST SPACE TOUR



PARTNERS

In this issue: European Space Agency (ESA) p.9-15-25; Germany space agency (DLR) p.7; ArianeGroup p.9-23-27; French defence innovation agency (AID) p.11; French research and technology association (ANRT) p.11; Thales Alenia Space p.14-20- 22; Airbus Defence & Space p.9-14-20-22; Bpifrance (public investment bank) p.21-24-25.

Cover: © Fred Péault

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

CNESfrance
@CNES
YouTube CNES

CONTRIBUTORS

FRANÇOIS ALTER

With his background in applied mathematics, satellite imagery, innovation, public policy and technologies, François Alter, today advisor to CNES's Chairman & CEO and Deputy Director of Strategy, was just the right person to give us the keys to understanding the France 2030 Plan and space ecosystem funding mechanisms.

MURIELLE LAFAYE

As deputy head of CNES's space economy observatory, Murielle Lafaye's job is to understand and share trends, applying her sense of foresight to the transformations shaping the economy. In this issue's Timeline, she reveals the inner workings of this information nerve centre with its finger on the pulse of the space ecosystem.

DIDIER LAPIERRE

Creating and developing new projects and then spinning them off and expanding the community of space players is Didier Lapierre's vocation. This includes for example setting up incubators, developing the ActInSpace hackathon and instigating strategic partnerships with government—all initiatives led with conviction and crowned with success.

FRED PÉAULT

90% of information transmitted to our brain is visual. Fred Péault is so convinced that pictures are the best way of conveying emotions that he's made a career out of them. He draws his inspiration from artists like Edward Hopper and Edward Ruscha, and from photographers like Stephen Shore or William Eggleston. We gave him carte blanche for this issue of CNESmag.

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. Tél. : +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. **Editor-in-chief:** Brigitte Alonzo-Thomas. **Proofreading:** Céline Arnaud. **Editorial staff:** Brigitte Alonzo-Thomas, Liliane Feuillerac, Dominique Fidel. **Photos and iconography:** Marie-Claire Fontebasso. **Photo editor:** Thierry De Prada. **Photo credits:** p.4 F. Péault - CNES/T.De Prada - CNES/N. Tronquart - CNES/C.Peus ; p.5 CNES/C.Peus ; p.6 CNES/T.De Prada ; p.7 (top left) Venture Orbital Systems - p.7 (right) CNES/N.Tronquart ; p.8 (top) CNES/E. Grimault - p.8 (bottom) COMAT ; p.9 Copernicus Sentinel Data/ESA ; p.10 (top) Mersen Boostec ; p.11 (top) Getty Images - (bottom) CNES/A. Ollier ; p.13 and p.15 CNES/O. Pascaud ; p.16 Voltalia Guyane Caraïbes/A. Le Devehat ; p.17 Illustration: Les-Super-Héros ; p.18 Getty Images ; p.27 ArianeGroup Holding ; p.33 J. Arnould ; p.34 and p.35 CNES/A. Ollier ; p. 36 Getty Images. **Illustrations :** François Foyard, Robin Sarian (Idix), Jean-Marc Pau, Fred Péault. **Webmaster:** Sylvain Charrier, Mélanie Ramel. **Social media:** Mathilde de Vos. **English text:** Boyd Vincent. **Design and pre-press:** Citizen Press – Camille Aulas, David Corvaisier, Fabienne Laurent, Alexandra Roy. **Printing:** Ménard. ISSN 1283-9817. **Thanks to:** Céline Angélélis, Ursula Aniakou, Christèle Astorg-Lépine, Jacques Beas-Garcia, Typhanie Bouju, Eric Brel, Philippe Collot, Christiane Coute, Laurent Deroin, Emline Deseez, Michel Faup, Thierry Floriant, Philippe Guay, Didier Cauquil, Véronique de La Casa, Jerome Legenne, Anthony Le Letty, Delphine Leroux, Céline Marchesan, Jean-Youri Marty, Emmanuelle Meric, Jean-Michel Monthiller, Laurence Mossay, Bruno Vieille, Jerome Vila, Eric Werling.

PEFC 10-31-2690

IMPRIM'VERT

EDITORIAL

CNES's 60th anniversary last December bore testament to an extraordinary scientific and human adventure. Today, while continuing to fulfil its missions of excellence, our agency is taking on a new role as the linchpin of the nation's space industry policy. Our commitment to the economy is unwavering: right from the start of the pandemic, we put in place the emergency measures—notifying contracts, placing orders and so on—that were needed to cushion the impact of the crisis on all our partner firms. Since 2020, CNES has been expediting the government's stimulus plan as the agency with sole responsibility for executing its space strand (see p. 22-23). Likewise in 2022, working with the Ministry of the Economy, Finance and the Recovery, and in collaboration with public investment bank Bpifrance, we will be implementing the space budget line of the France 2030 Plan.
With the signature of the new Objectives and Performance Contract (OPC) for 2022-2025, under the banner "New Spaces", CNES is further consolidating its commitment alongside the government. In a fiercely competitive global landscape, the stakes will be to stimulate growth in the space economy through competitiveness and innovation. This issue of CNESMAG shows how we have rethought our role and documents the wealth of real-world solutions we are providing to spawn start-ups and nurture the French New Space industry, irrigating the wider space ecosystem. Through initiatives like pitch days, Connect by CNES, Space Ticket or CosmiCapital, we are embracing a new culture tailored to this new reality and setting our sights on these new spaces.

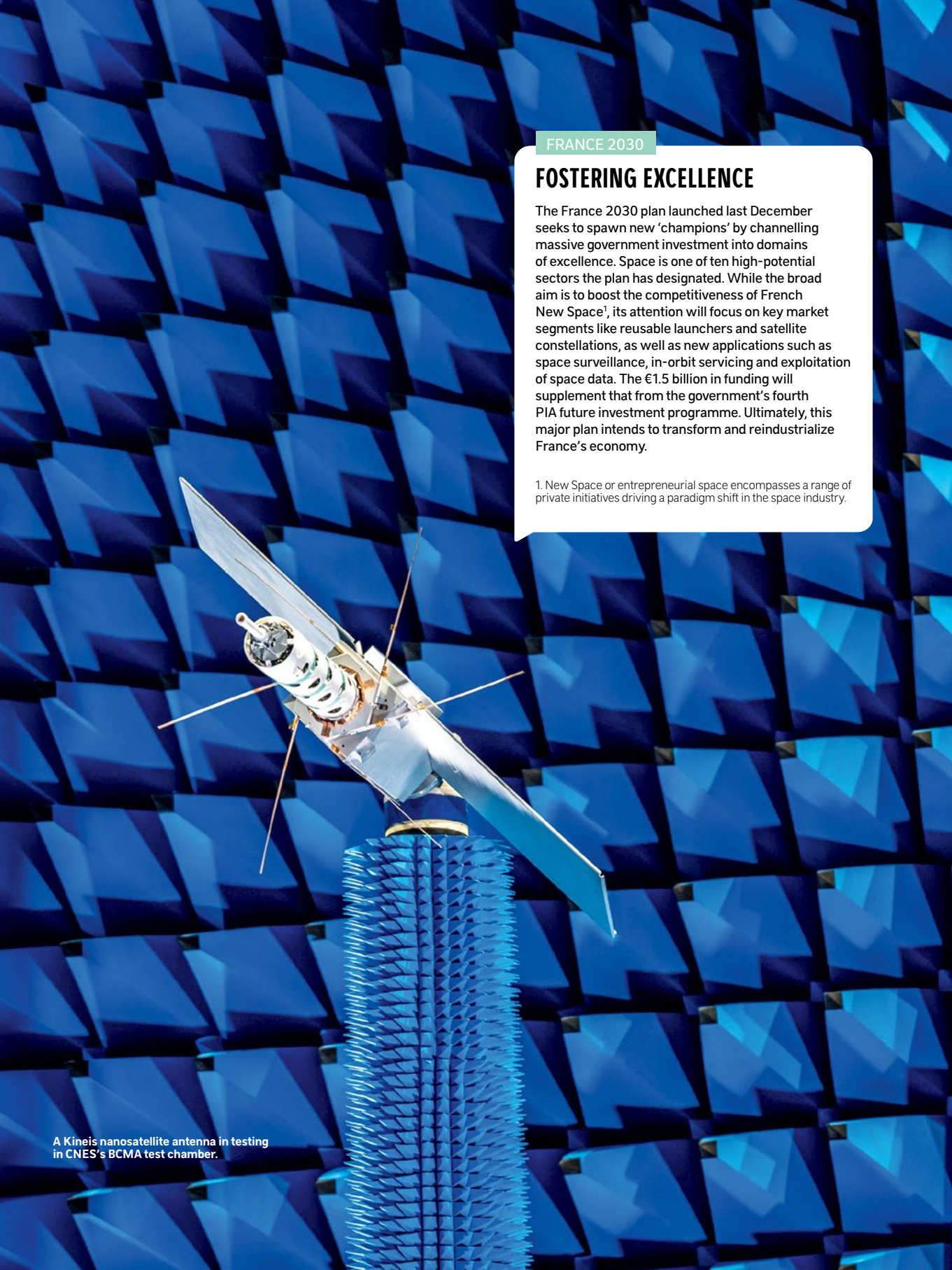
MARIE-CLAUDE SALOMÉ
CNES DIRECTOR OF COMMUNICATION

FRANCE 2030

FOSTERING EXCELLENCE

The France 2030 plan launched last December seeks to spawn new 'champions' by channelling massive government investment into domains of excellence. Space is one of ten high-potential sectors the plan has designated. While the broad aim is to boost the competitiveness of French New Space[1], its attention will focus on key market segments like reusable launchers and satellite constellations, as well as new applications such as space surveillance, in-orbit servicing and exploitation of space data. The €1.5 billion in funding will supplement that from the government's fourth PIA future investment programme. Ultimately, this major plan intends to transform and reindustrialize France's economy.

1. New Space or entrepreneurial space encompasses a range of private initiatives driving a paradigm shift in the space industry.



A Kineis nanosatellite antenna in testing in CNES's BCMA test chamber.

BLAST

TURBOCHARGING TALENTS

Make or break is the hard reality today facing French space tech firms. Unlike their U.S. counterparts, they have to contend with many obstacles when seeking funding. But BLAST[1], France's first accelerator for aerospace and defence technologies, is bucking this trend. The modular mentoring and training programme is supporting firms in early-stage development and research projects pursuing disruptive technologies. They are getting intensive training from the Starburst accelerator leading BLAST and a consortium of partners[2]. Every year, 20 selected start-ups are coached and then pointed in the direction of top investment funds and new customers. In 2020, Starburst clocked up its first space unicorn[3] with the stock market listing of California-based firm Momentus. With BLAST, it now intends to find its first French unicorn. The class of 2022 will be recruited this February, so the hunt for new deep-tech projects is on.

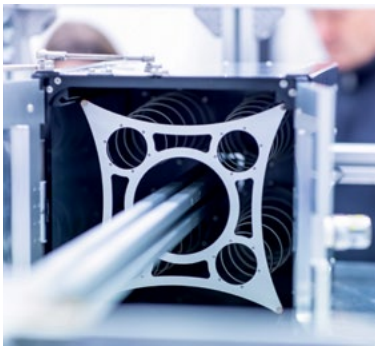
1. Boost and Leverage AeroSpace and defence Technologies
2. Starburst, French aerospace research agency ONERA, SATT Paris Saclay tech transfer accelerator and Ecole Polytechnique engineering school
3. A high-tech start-up valued at a billion dollars or more with very high growth potential

In the last 10 years, there have been
3 GOVERNMENT INITIATIVES
supporting space. The PIA future investment programme (2010) set out to develop French industry. The stimulus plan (2020) helped businesses through the Covid crisis. And this year, the France 2030 plan is going to boost innovation and make the French space ecosystem more competitive.

SPACEFOUNDERS

BREEDING EUROPEAN WINNERS

SpaceFounders' mission is clear: to make Europe's best and brightest space start-ups tomorrow's world beaters. Created by CNES in partnership with Bundeswehr University Munich (UniBw) and German space agency DLR, this resolutely European initiative is ultra-intensive and laser-focused on quality, federating more than 100 leaders from the space, digital and investment communities. The idea is to provide tailored mentoring and introductions to investors for fast-growing start-ups that have already achieved market success, spanning the entire value chain from space tourism, space surveillance and reusable launchers to downstream services, nanosatellite components and in-orbit servicing. At the end of the programme pursued through Connect by CNES, the start-ups will quite simply be ready to take on the world!



Prototype cubesat deployer.

SPACE TOUR 2021

ON YOUR MARKS… INNOVATE, PITCH!

Adding balconies or chimneys to 3D maps of properties derived from satellite imagery for greater realism is one of the projects pursued by Luxcarta in Southeast France that is set to come to fruition in 2023 thanks to Space Tour 2021. This call for projects is also supporting services based on nanosatellite constellations conceived by Brittany-based Unseenlabs to enhance ship monitoring, and Var, Southeast France-based Prométhée to mitigate pollution-related health risks, alongside 30 other projects of social interest. Executed by CNES, funded and coordinated by DGE, the French enterprise agency, with support from 11 French regions[1] through regional councils, DREETS[2] and Boosters[3], Space Tour 2021 is moving fast and with a purpose. Selected start-ups are given five minutes to pitch their projects. Each of the 11 pitch days designated three laureates with whom CNES signed contracts worth €50k to €100k a week later. Some regions—Occitanie, Sud, Nouvelle Aquitaine and Brittany—are providing additional funding, while others are considering this option. In light of the great response to this first Space Tour (see p. 9), a second one is envisioned.

1. French Guiana, Réunion, Normandy, Grand Est, Nouvelle Aquitaine, Ile de France, Pays de Loire, Provence-Alpes-Côte d'Azur, Auvergne-Rhône Alpes, Occitanie, Brittany
2. Regional directorates for the economy, employment and solidarity
3. Project accelerators led by competitiveness clusters

PROOF OF CONCEPT

A MATTER OF MATURITY

Whether it's a simple nut or a nanosatellite ejector, research or pre-production engineering, the road to success for space systems, equipment and materials is long and hard. No matter how big or small, no matter their domain or function, technologies must be qualified on the ground and often flight-proven before finding their market. The major stumbling block is proving their maturity, measured on a scale of nine technology readiness levels (TRL). This is because TRLs 5 to 8—ominously dubbed the "valley of death"—can end up being very costly for space tech start-ups. With funding from the government's PIA future investment programme, CNES has put in place a tool to help them overcome this obstacle. The proof-of-concept (PoC) stage enables them to gain maturity with a demonstrator, to avoid pitfalls and hasten time to market while limiting the risk to the customer.

Plasma Jet Pack 80W electric thruster.

Phytoplankton (or algal) bloom in the Baltic Sea seen by the European Sentinel-2 satellite.

ESA BIC

QUALITY AND VISIBILITY

Have the ESA BIC[1] incubators in France pulled off the challenge of spawning space start-ups? The figures (see p. 9) from the ESA BIC Sud and ESA BIC Nord centres formed in 2008 and 2013 suggest they have. The success of young firms like HyPRSpace, which has developed a micro-launcher engine technology based on hybrid propulsion, or Spacesense, offering services that combine satellite imagery and artificial intelligence, speak for themselves. Funding is provided up to €50k and may be topped up by equivalent loans, and this financial assistance comes with expert advice. Via its Connect by CNES initiative, the agency and its partners in research and industry—ArianeGroup, Airbus, Meteo-France, Ifremer, etc.—are helping these budding firms to get their products and services to market quicker and fostering their development.

1. ESA Business Incubation Centre.

€550,000

Budget envelope devoted by CNES to laureates of the advanced launcher concepts R&D challenge (see p. 10). Each laureate thus receives €50,000 to €100,000 to advance their solution.

98

Number of candidates for the first Space Tour call for projects in 2021 (see p. 8). All projects submitted focused on themes set by the regions: shipping, logistics, agro-ecological transition, pollution, preservation of resources, safety, land planning, smart cities and more.

151

A report compiled in 2020 shows that three to five years after being incubated, almost all start-ups are still in business. Since the inception of the ESA BIC incubators, 151 start-ups or firms have been spawned, 32 in 2021 alone.

CNES'S ACTINSPACE HACKATHON

2014	2016	2018	2020 (virtual format)	2022 (projected)
National event	12 countries	32 countries	35 countries	50 countries
5 host cities	24 host cities	54 host cities	60 host cities	100 host cities
200 participants	900 participants	2,200 participants	3,600 participants	5,000 participants
4 start-ups created	14 start-ups created	18 start-ups created	35 start-ups created	>50 start-ups created

LAUNCHERS

COMPETING FOR TAKE-OFF

CNES's R&D Launcher Challenge designed to ready future space launchers built around disruptive technologies for the 2040 timeframe has scored its third success. This competition is open to start-ups, SMEs, non-profit associations, research laboratories, universities and large manufacturers not specializing in launch systems. Its goals are to federate the French space ecosystem and cultivate synergies with other sectors. Laureates gain immediate access to funding and technical expertise from CNES, taking home a signed contract at the end of the event's pitch day. The 2021 edition focused on the theme of disruptive technologies and advanced concepts designated 10 laureates, four of which—CES Works, Flight Level and Orbital Deployment, Open Space Makers and Opus Aerospace—had never worked with CNES before.

Among the topics covered were new types of nuclear, laser and anti-matter propulsion and new challenges such as deep-space exploration and orbital transfers.

The Gaia satellite's mirrors on display for an exhibition at the Palais de l'Élysée in Paris in July 2021.

SME LABEL

STANDING OUT FROM THE CROWD

CNES's SME label[1] rewards the excellence of products or services with economic growth potential and is a great asset for firms looking to make their mark in a highly competitive global market. Awarded for three years to key French SMEs supplying the space sector, it covers a wide spectrum—launchers, orbital systems, ground segments, satellites and balloons—and concerns numerous innovations in mechanisms, space telescope mirrors, actuators, processors, ground support equipment, radiofrequency systems and more. The SME label complements the French space industry catalogue[2] released by the agency in 2020, a practical tool designed to foster "think France" as a reflex response. If you're looking for a supplier of stratospheric balloon envelopes in France, they're just a few clicks away.

1. https://entreprises.cnes.fr/fr/entreprises-partenaires/label-cnes-pme
2. https://cnes.fr/fr/french.space.industry.catalogue

DEFENCE
NEW PARADIGM

Our military space capability has to constantly stay ahead of the curve and remain fit for purpose while gaining in speed and precision to assure the nation's defence. For this it relies on intelligence, positioning and communications, a rationale based on anticipation underpinned by "planned innovation", a process of progressive evolution that takes the long-term view. But the armed forces also need to be able to take advantage of disruptive technologies from new and very agile players offering solutions and services in diverse domains. The defence market affords new opportunities for these emerging players and CNES is supporting the process of "open" innovation alongside the French defence innovation agency AID. Its role is to detect start-ups likely to add value, make sure they fully meet military requirements and send them on their way towards the economy of the future.

Testing on the OTOS innovative optical technologies demonstrator.

MOONSHOT INSTITUTE
IN THE LUNAR WAITING ROOM

Establishing a lasting human presence on the Moon is no longer merely the stuff of dreams. Attention is now focusing on pragmatic details like how to build infrastructures, generate power, manage waste and ensure logistics. Since July 2019, the Objectif Lune (Destination Moon) working group initiated by the French research and technology association ANRT, ESA and CNES has brought together public and private stakeholders to address these crucial questions. To find the right answers, its priority is to seed an entrepreneurial ecosystem around the lunar economy. As an active member of the working group, CNES is also leveraging these strategic efforts to support the Moonshot Institute, another ambitious initiative started with ESA last year. The institute is open to entrepreneurs, explorers, start-ups, scientists and big firms inside or outside the space sector but all with an interest in this lunar economy. It is laying the groundwork for this adventure through the four pillars of education, ideation, research and development, and commercialization to make this lasting human presence on the Moon a reality.

#COMMUNITY

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

@ACTINSPACE

International space hackathon co-organized by @CNES and @ESA.

The International winners of @ActInSpace 2020 are all set for their ZeroG flight! Thanks to our international sponsor Novespace. Good luck to our astronauts for a day! ✈️👨‍🚀 @AirZeroG

@SNT_UNI_LU

The Interdisciplinary Centre for Security, Reliability and Trust @uni_lu. Pioneering ICT research in Luxembourg and beyond.

Congratulations to the 41Space team on winning the ActInSpace hackathon!
A total of 15 teams took part in the 24-hour challenge to design an application for configuring rovers to look for resources on the Moon.
➡️ow.ly/IjMc50GA7Wq @Technoport_Lux

@KLEYNHOFF

Business leader - Regional Councillor - President of #RISINGSUD - Chair of Economic Development and Digital, Industry, Export and Attractiveness Board

This morning, on behalf of @RenaudMuselier, at the #SpaceTour2021 Sud region Pitch Day, I awarded the 2nd prize to Hydroclimat. Well done our region's start-ups @LuxCarta (1st prize) and ACRI IN (3rd prize). @CNES @FranceRelance @MaRegion Sud @risingSUD @Safe_Cluster all working together for space!

@PAYSDELALOIRE

Welcome to the official Twitter feed of the Pays de la Loire Regional Council. Keep up with the region's latest news here

The Pitch Day organized by @CNES and @paysdelaloire under the #francerelance stimulus plan on the theme of the agro-ecological transition was held today. Well done @AGC_Robotics, @kermap_info and @yesitis_startup for their pitches and prizes awarded in the presence of @franguyo

Q & A

THOMAS COURBE

TAKING IN THE HEALTH CRISIS, STIMULUS INITIATIVES, NEW MARKETS AND PLAYERS, Thomas Courbe, head of DGE, the French enterprise agency at the Ministry for the Economy, Finance and the Recovery, and the government's commissioner for CNES, gives us his perspective on a sector at the crossroads.

Where does the French space industry stand right now?

Thomas Courbe: The pandemic has had a tangible impact on order bookings, production schedules and sourcing, even if its effects haven't been felt as hard as in the aviation and automotive sectors, for example. The big original equipment manufacturers haven't been forced to cut working hours, which shows their great resilience. Government support mechanisms and the sector's solidarity initiatives to protect players most at risk have worked well. After addressing the most urgent demands, the stimulus plan rapidly kicked into gear and has been effective in supporting the recovery. Under the impetus of the Ministry for the Economy, Finance and the Recovery, whose remit covers space, we've led this plan hand in hand with regional councils to ensure nationwide coverage. CNES had sole responsibility for executing the plan, which has already funded 93 firms from start-ups to big manufacturers. In fact, the stimulus plan seeks to do much more than just weather the crisis; above all, it's looking to provide a big boost for the future.

How do you see this future taking shape?

T. C.: Two years after the start of the pandemic, forecasts for the space sector point to a strong upward trend, with Bank of America betting on the space industry tripling in size by 2030. But it's also a sector in transformation. Burgeoning new applications and markets, particularly in the fields of space data production and exploitation, are opening up huge opportunities for players in areas as diverse as precision agriculture, transport, commerce, banking and finance, and of course the environment. With programmes like SWOT, MicroCarb and Trishna, CNES is a trump card for France as it seeks to gain a foothold in these new market segments. The other major shift is the revolution in access to space, with a move towards multiple private launch service providers and constellation projects leveraging smaller satellites and lower launch costs to cater to new entrants. We're thus entering a new era of mass production with all its attendant challenges, not the least of which will be capacity in low Earth orbit and our ability to curb space debris.

> "CNES is a trump card for France as it seeks to gain a foothold in new market segments."

But isn't increased competition for legacy players the biggest challenge of all?

T. C.: It's true that space is attracting many players, some of them with very aggressive business strategies. SpaceX and soon Amazon are well-known examples, but they're far from alone! This competitive pressure is being felt by both launchers and satellites, where we still have a solid footing. Late last December, the successful departure of the James Webb Space Telescope provided a fine illustration of Europe's launch capability spearheaded by CNES. As for satellites, let's not forget that our two leading European manufacturers Thales Alenia Space and Airbus Defence & Space have cornered between them nearly 60% of the geostationary telecommunications market. They also have valuable experience in LEO constellations with Iridium and OneWeb. Every day, our industry is proving its ability to take the right turns. In recent months we've seen the announcement of the project to build the Maïa reusable mini-launcher and the signature by our minister Bruno Le Maire of major agreements with Germany and Italy on future European launchers. Lastly, two key rendezvous await us this year with the informal meeting of European space ministers in Toulouse in February and the ESA Ministerial Council meeting in November in Paris, where a number of fundamental issues will be addressed.

You're also in charge of the France 2030 investment plan. What are the stakes of this plan for the space sector?

T. C.: With €1.5 billion, two-thirds of it for emerging players, the space budget line of France 2030 is focused on three key priorities: reusable launchers, new constellations for broadband Internet, 5G and other

THOMAS COURBE

HEAD OF THE FRENCH ENTERPRISE AGENCY AT THE MINISTRY FOR THE ECONOMY, FINANCE AND THE RECOVERY, AND THE GOVERNMENT'S COMMISSIONER FOR CNES.

"Every day, our space industry is proving its ability to take the right turns."

connectivity applications, and development of new market segments like space surveillance, in-orbit servicing and downstream exploitation of space data, all items identified through the France Relance economic stimulus plan. A first series of actions is already underway, for example a call for projects open to start-ups geared towards spawning French micro- and mini-launchers. And with France 2030, the government is looking to nurture future world leaders in a strategic market for our economy and sovereignty.

What role does an agency like CNES have to play here?

T. C.: Working with public investment bank Bpifrance, CNES will have a key role executing the space strand of France 2030, providing funding through calls for projects and government orders, leading the sector, spinning off expertise and galvanizing innovation. It will also be working alongside the government to assist it in making the right choices to support innovation. These missions are unprecedented in terms of the scale of the budget involved, but the agency already has the skills and tools to get the job done, starting with Connect by CNES. This year CNES will also be moving up a gear with its Objectives and Performance Contract (OPC) for 2022-2025, which confirms the importance attached to its scientific and defence missions and affirms the stronger priority given to industrial policy. We mustn't oppose science and industrial policy, quite the contrary in fact: easing access to space offers more opportunities to science and, conversely, we have commercial credibility because our government-funded space research is top level and irrigating start-ups and industry. CNES's new OPC is the perfect illustration, since it's devoting more resources to science while driving the shift of industrial policy towards New Space. On the strength of its 60-year heritage, CNES is more than ever one of France's greatest assets to write an exciting new chapter in its space history.

PROFILE

1995
Graduates from the ISAE-SUPAERO aerospace engineering school, joins the aeronautical programmes department at French defence procurement agency DGA as an IGA armaments engineer

2002
Joins the Directorate General of the Treasury

2010
Deputy Chief of Staff to Christine Lagarde and Chief of Staff to the Secretary of State with responsibility for Overseas Trade

2012
Secretary General at the Directorate General of the Treasury

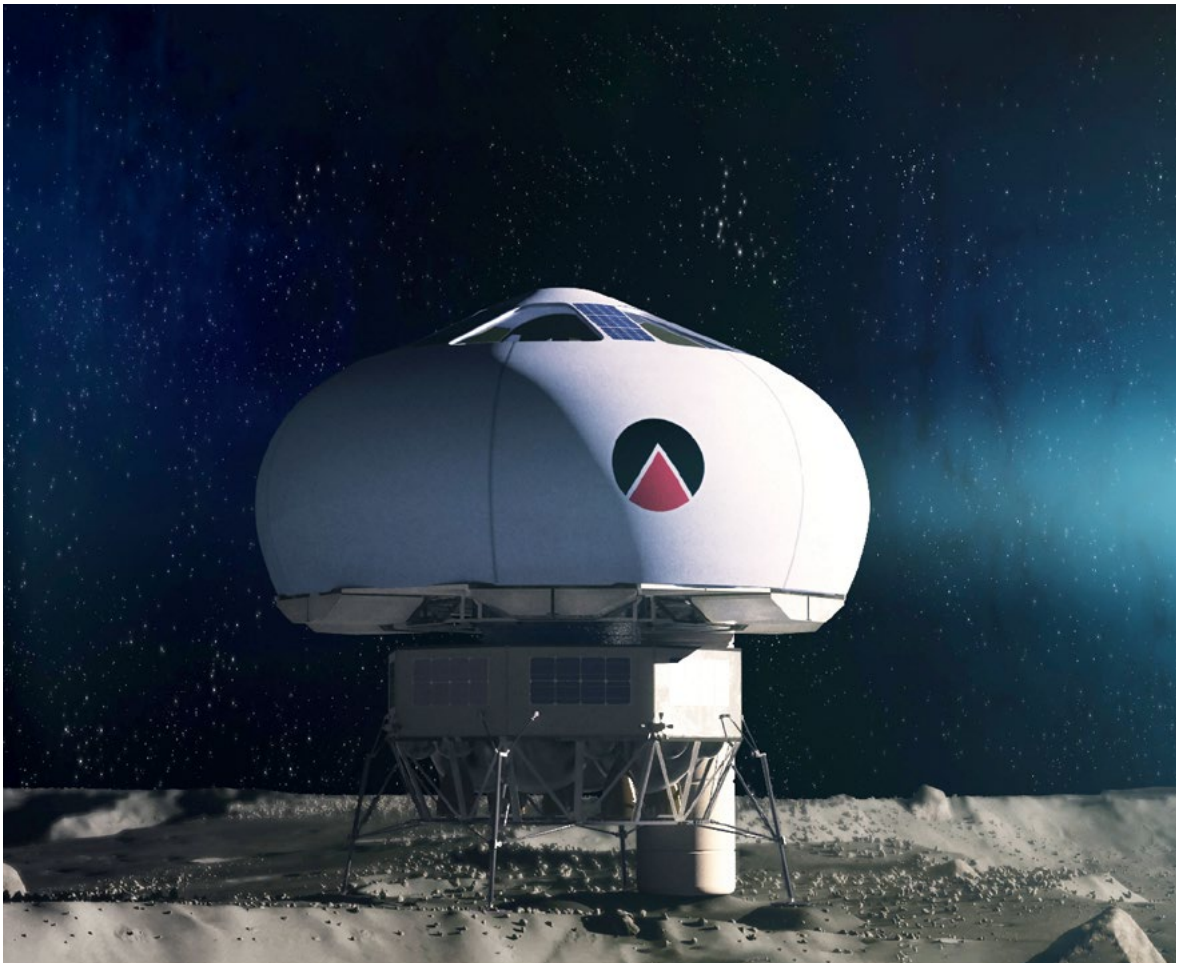
2015
Deputy Director General of the Treasury

2018
Head of DGE, the French enterprise agency, and commissioner for strategic information and economic security

SOLAR FARM

French Guiana has great potential for solar energy[1] that the Guiana Space Centre (CSG) is set to start harnessing in 2023 thanks to two five-hectare solar farms with an installed capacity of 4.4 megawatts. Planned by CNES and accelerated by the government's stimulus plan, the first farm[2] is in the process of being erected. Local firm Voltalia, the winning bidder from the request for proposals issued in July 2021, a renewable energy specialist and already a CSG partner, will be "planting" the high-performance solar panels this year. From 2023, 7,000 megawatts will thus be supplied free every year from French Guiana's sunny skies.

1. 1,222 kWh/m² per year on average
2. The other farm is being funded by ESA and CNES



LUNAR DESERT

Conquering the Moon may no longer be a pipe dream, but we'll need to create an environment to support a lasting human presence there. What type of habitat will be needed? What kind of protection against radiation? Led by CNES and Nubbo[1], TechTheMoon, the world's first lunar incubator, brings together a broad spectrum of start-ups to work on these issues. Five[2] have been selected and are receiving support during their maturation and prototyping phase. An extra challenge for the laureates is that their products or services will first have to prove they can be spun off into innovative solutions on Earth.

1. The Occitanie regional council's start-up incubator and accelerator
2. Anyfields, Metis, Orius Technologies, Spartan Space (see p. 31) and The Exploration Company

Thinking applications

In the 1990s, CNES was already working from the very early stages of the SPOT programme, and then later with Pleiades and SWOT, to optimize the range of future user applications. Today, with Downstream Ambition, it is systematizing this approach to conceive operational services even before satellites are launched. For example, applications like assessing landslide risks in the Alps or managing crop irrigation at individual field level could be tested with the CO3D and Trishna (thermal infrared) satellites well before their planned launches in 2023 and 2025. The Downstream Ambition phase is already underway to broaden the range of services and ease uptake of space data for users via platforms such as the Theia land surfaces data and services hub or the Dinamis[1] platform for institutional stakeholders.

1. French national facility for institutional procurement of satellite imagery.

400

THROUGH CONNECT BY CNES, the agency is providing more than 400 of its patents and software ready for use in the space sector or to be spun off into new processes outside space.

40%

SMEs play a pivotal role in the French space landscape, making up some 40% of its key supplier base. This is no accident, as they combine cutting-edge technologies with a strong capacity for innovation and great agility.

CALL FOR IDEAS

The future of space is a team endeavour being pursued through CNES's R&T call for ideas, covering orbital systems and space transportation (launchers). Once selected and validated, ideas from manufacturers, start-ups, research organizations and public stakeholders feed into the agency's multi-year R&T actions programme. And for even greater flexibility and agility, the 2022 call will involve three successive selections in February, June and October—so there's no excuse not to take part!

They were 9

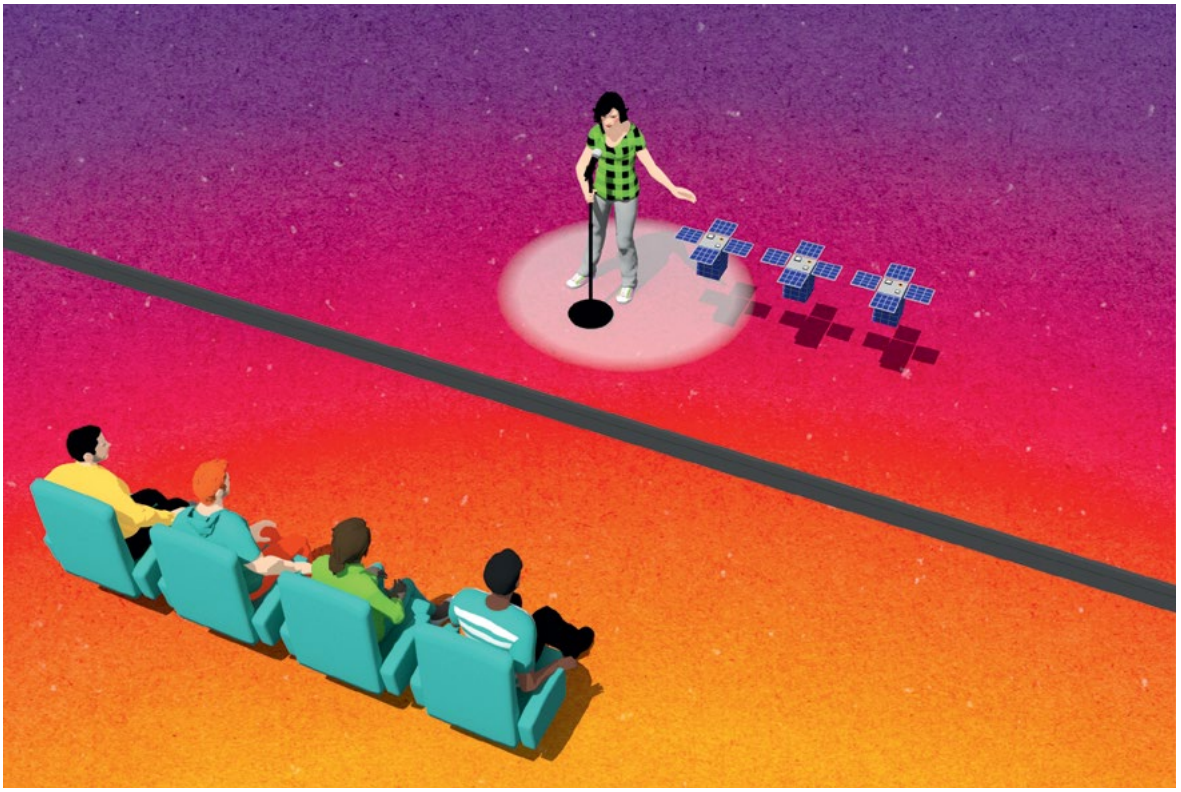
THE LAUREATES OF THE OCTOBER 2021 LAUNCHERS R&D CHALLENGE ARE:

- Absolut System SAS
- Air Liquide Advanced Technologies
- Blackleaf
- CEA, the French atomic energy and alternative energies commission
- CLESSE electronic systems
- Hybrid Propulsion for Space
- IRFM magnetic confinement fusion research institute
- Pangea Aerospace SL
- PIMM mechanical and material processes and engineering laboratory

CONDUCTING

CHANGE

AS A GOVERNMENT AGENCY, CNES IS ACCOMPANYING THE GAME-CHANGING SHIFTS IN THE ECONOMY. IN RESPONSE TO INITIATIVES LIKE THE PIA FUTURE INVESTMENT PROGRAMME, THE STIMULUS PLAN AND THE FRANCE 2030 PLAN, IT IS HONING ITS STRATEGY TO MAKE LEGACY PARTNERS AND EMERGING PLAYERS MORE COMPETITIVE.



When CNES was formed in 1962, France had no space industry to speak of. It was without infrastructures, satellites, a ground segment or launchers. Defence, aerospace and electronics manufacturers were the fledgling agency's first partners, motivated by space and the confidence that came with government orders. As they gained in maturity, they were charged with developing product lines of excellence led by CNES, like the Telecom series begun in 1984 and SPOT in 1986. Aerospatiale would build France's very first satellite. Through a series of transformations and mergers, these large manufacturers have since become Airbus Defence & Space and Thales Alenia Space, today the leaders in Europe. A solid network of SMEs and SMIs grew up alongside, among them Sodern, Europropulsion, Matra (satellites), SEP and Air Liquide (launchers). These early stages followed a simple, vertical model.

The 1980s marked a turning point. "The European dimension was a game-changer," notes Jean-Marc Astorg, CNES's Director of Strategy. Ariane and the first international partnerships brought a new business model, with four French firms[1] leading the programme involving 52 European manufacturers. For Ariane 5, this number would grow to 1,200.

NEW MODEL

By the 2000s, low-cost space had started to arrive from across the Atlantic, partly funded by private interests and developing constellations and application services. This direct threat to Europe's space industry "dictated the need to drive down the cost of

accessing space, by building smaller, cheaper and faster," says Astorg. Space thus harnessed the so-called fourth industrial revolution fuelled by miniaturization, digital technologies and artificial intelligence. According to Astorg, "this rationalization of costs sparked a move to a market-driven model with players unknown to us." CNES brings these players mostly from the digital sphere the space culture and expertise they lack, through feasibility studies, R&D launcher challenges, innovation days, technology days, the government's PIA future investment programme, support for the nanosatellite product line and much more besides. A new era of collaboration beckons, benefiting not only the ecosystem but also the space industry, which these new players are supplying with composite materials, smart systems, electronics, technology building blocks and other new developments conducive to its business. The vertical model sustained 100% by government orders is now a thing of the past.

INSPIRATIONAL BREW

The France 2030 plan launched in 2020 heralds a new revolution that is taking the long-term view and focused on innovation. To execute this plan, CNES has created a new Strategy Directorate. "Space is set to bring together fledgling and often fragile new entrants." The new directorate's role is therefore "to support disruptive projects and detect agile and promising players—possibly future unicorns—to get them started, but above all to secure their long-term future and be up there with the best in the global market," says Astorg. This approach is simply seeking to continue what's gone before. As with every such transformation, new players will find the resources they need, be they financial (CosmiCapital, Space Ticket, calls for projects with purchase offers), methodological (pitch days), technological (patents) or strategic (Connect by CNES, see p. 25).

Alongside these new initiatives, legacy partners are not forgotten and are also receiving support. Formed under the impetus of CNES and European contractors, Arianespace is for example today the European leader in launch services. At the Vernon testing facility outside Paris, work on the Prometheus engine (see Materials p. 27) is picking up pace under the stimulus plan. A test stand will be up and running this year for engines built by start-ups and new investments will enable recovery of evaporated hydrogen. Under the France 2030 plan, the network of SMEs and mid-tier firms will be able to take advantage of competitive purchase offers. Legacy players are also likely to benefit from the windfall effect from creative, agile start-ups shaking up the space ecosystem.

1. Aerospatiale (overall design), SEP (engine prime), Matra (equipment), Air Liquide (tanks)

of the space budget line

of the France 2030 Plan is designed to encourage emulation and spawn start-ups. 30% of this budget will go to legacy players in the space ecosystem.

Launchers

KOUROU GOES MINIATURE

New Space players are going to need new launchers. Micro- and mini-launchers will be required to send flotillas of small satellites weighing 1 to 1,500 kilograms into low Earth orbit and extend Europe's offering. With its range of azimuths for launches into all orbits from the equator to the poles, the Guiana Space Centre can accommodate them. The Diamant launch pad, in disuse since 1975, is going to be refurbished to provide shared facilities—power, access roads, etc.—and specific facilities for each operator—assembly buildings, launch tables and so on. A call for expressions of interest open to operators in all ESA or EU member nations has been issued. CNES has also issued a call for projects designed to solicit proposals for launch services. Young business players could thus break into this market, with funding from public investment bank Bpifrance.

Stimulus plan

STEPPING UP TO THE PLATE

SARS-CoV-2 hit hard and fast, threatening human lives and bringing growth to a halt. The government stimulus plan to reboost the economy, voted in 2020, is designed to do just the same. As the agency with sole responsibility for the plan's space strand, CNES has also acted quickly to execute exceptional measures.

75

laureates
of calls for projects, covering all domains from launchers and orbital systems to equipment and applications. While all kinds of firms are represented, 80% are very small firms or SMEs.

Representing revenues worth €4.2 billion, 16,000 direct jobs, more than half of the European space industry and the world leader in launch services and satellites, France's space sector is to be reckoned with. While not the most affected by the Covid crisis, with an estimated 19% decline in sales, it has nevertheless seen a slowdown in launches with a knock-on effect all the way down the value chain. With €365 million of new funding injected into the space budget, the stimulus plan is thus aiming to support all of the ecosystem's players. But that's not all: this boost also offers the opportunity to prime bold and inventive start-ups to develop potential applications of space data.

PRAGMATIC APPROACH

Tasked by its overseeing ministries[1], CNES has orchestrated this funding allocation. A specific budget envelope of €165 million has been devoted to Europe's Ariane 6 programme developed by ESA, which has suffered from the sourcing issues and extra costs generated by the crisis. "In deciding where to allocate the remaining €200 million, we looked pragmatically at the situation in light of evolving market trends, global competition and the ecosystem's resilience," explains Lionel Suchet, CNES's Chief Operating Officer. Five lines of action have been defined with a view to revitalizing French space firms, but the priority is to protect manufacturers. Line A is thus supporting projects led by a single firm, with those deemed to offer the most relevant technologies being awarded government R&T procurement contracts. In all, several tens of novel technologies were selected, from configurable integrated circuits (NanoXplore) to manoeuvrable balloons (Cnim AirSpace) and flight radiofrequency systems (Erems).

Line B is seeking to encourage emulation and boost collaborative projects through consortia. Proposals selected were funded via subsidies, with criteria based on the ability to quickly implement solutions in five areas chosen by the government: development of technology building blocks for optical communications, more-flexible telecommunications satellites, satellite telecoms terminals, ground segments with reduced costs and infrastructures geared towards the data-driven economy. Spearheaded by leaders like Airbus Defence & Space, Thales Alenia Space and Dawex, five consortia comprising four to as many as 20 partners—including SMEs, mid-tier firms and start-ups—were chosen.

66

Contracts

awarded under the stimulus plan's five lines of action:

Line A - 22 projects, 62% led by SMEs and mid-tier firms;

Line B - 22 projects, 62% led by SMEs and mid-tier firms;

Line C - 33 projects selected for call of projects from 100 candidates (see Space Tour p. 8);

Line D - IOD/IOV; 3 projects selected;

Vernon Line - 3 activities funded at ArianeGroup's facility.

APPLICATION SERVICES APLENTY

Line C is fostering all kinds of innovation for application solutions, requiring CNES to adopt a different approach and culture with the type of pitch days illustrated by the Space Tour (see p. 8). "We're looking to get all regional stakeholders and the local industry base on board to create momentum locally," says Lionel Suchet. The results so far are excellent, with 11 out of France's 18 regions signed up, including overseas regions.

Line D is focused on nanosatellites. A first call for projects last year accelerated in-flight validation of technologies, systems or applications, alongside efforts to speed up structuring of the sector through support for technology concepts and demonstration of innovative nanosatellite-based services.

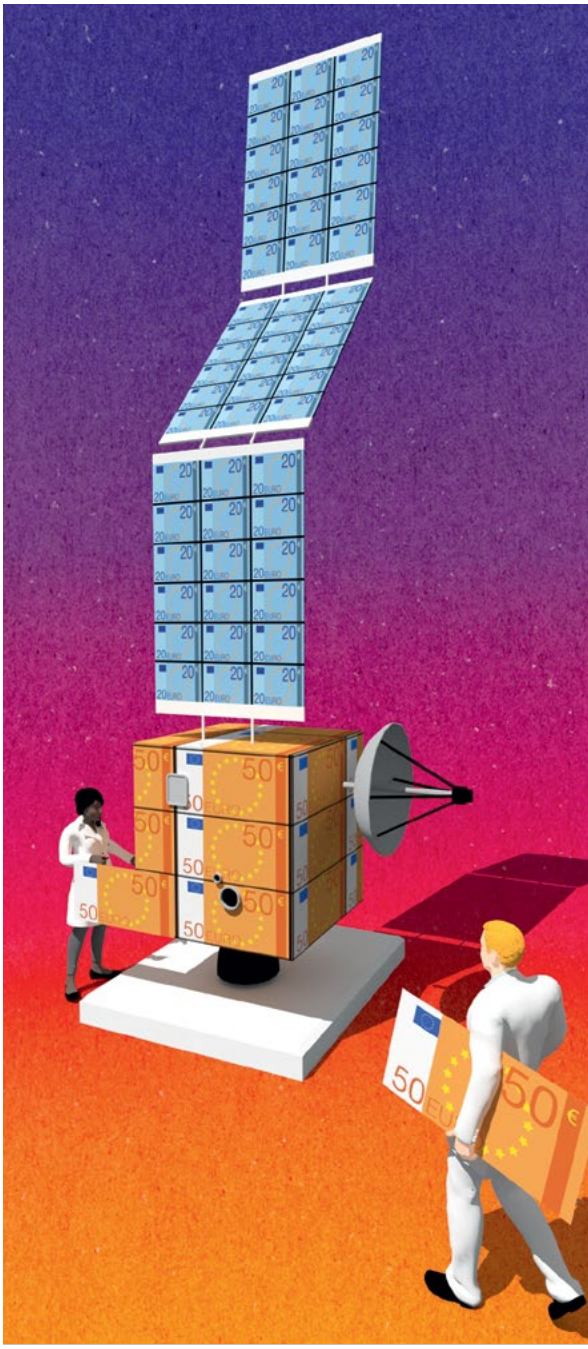
Lastly, the Vernon line—after ArianeGroup's Vernon facility—has extended test stands to new players. "We needed to move fast, and that's exactly what we did," notes Lionel Suchet with satisfaction. "End December 2021, we signed contracts for all the commitments made in 2021, covering more than 93% of the plan. Such remarkable speed and efficiency are largely down to the unwavering efforts of CNES's teams."

1. Ministry of the Economy, Finance and the Recovery, Ministry of Armed Forces, Ministry of Higher Education Research and Innovation.

Funding

MATCHING RESOURCES TO AMBITIONS

To gain a foothold in the highly competitive New Space arena, good ideas are not enough on their own; you also need the financial wherewithal to make them happen. The Space Ticket is one solution that CNES has devised to help. This year, it will be joined by CosmiCapital.



Set up in 2019 in the wake of the government's PIA future investment programme, the French Tech Seed fund managed by public investment bank Bpifrance helps future tech start-ups find investors. Direct access to this fund comes with the Space Ticket, worth up to €500,000 in convertible bonds.

HOW THE SPACE TICKET WORKS

Future tech start-ups with strong potential get in touch with CNES or its five partners[1], which down-select candidates and may provide assistance in looking for additional interested investors. Candidates are required to meet strict criteria: they must have been incorporated recently (no more than three years ago), have fewer than 50 employees and be engaged in early-stage development and a first round of funding. Their proposed innovation must serve a domain of the space value chain, such as exploration, application development or big data, for example. Once a candidate is selected, CNES signs a letter confirming the innovative nature of the technology so that it can then file a funding application with Bpifrance. Firms like Prométhée, offering environmental and strategic intelligence services, Spaceable, which specializes in assessing and monitoring risks in low Earth orbit,

and Gama Space, focused on deep-space exploration using satellites with solar sails, are just some of the lucky laureates to have received a Space Ticket.

CALCULATED RISK

CNES has decided to go the extra mile to support start-ups and taken the risk of setting up a new fund called CosmiCapital. After a call for expressions of interest, it selected venture capital management firm Karista to assist it. Bpifrance and private investors—manufacturers, insurance firms, etc.—will also be helping to fund French and European start-ups. CNES has invested €12 million in CosmiCapital, which will be putting €40 million on the table in total. The selection criteria, however, are extremely tight, based on development prospects, value of technologies proposed, team strength and likely spin-offs. The first investments are expected to be announced shortly.

1. SAFE, ASTech and Aerospace Valley competitiveness clusters, Ouest BIC Technopole and Karista

€60k TO €2m

That's the amount

of additional funding that PULSER—the European equivalent of Space Ticket—can bring. Led by ESA, the initiative is funded by its member states and also affords access to expert assistance from CNES and the network of partners of Connect by CNES and ESA Business Applications.

€350m

Supporting

the space ecosystem's development is one of CNES's missions. In all, the start-ups it has accompanied have raised €350 million in funding.

Connect by CNES

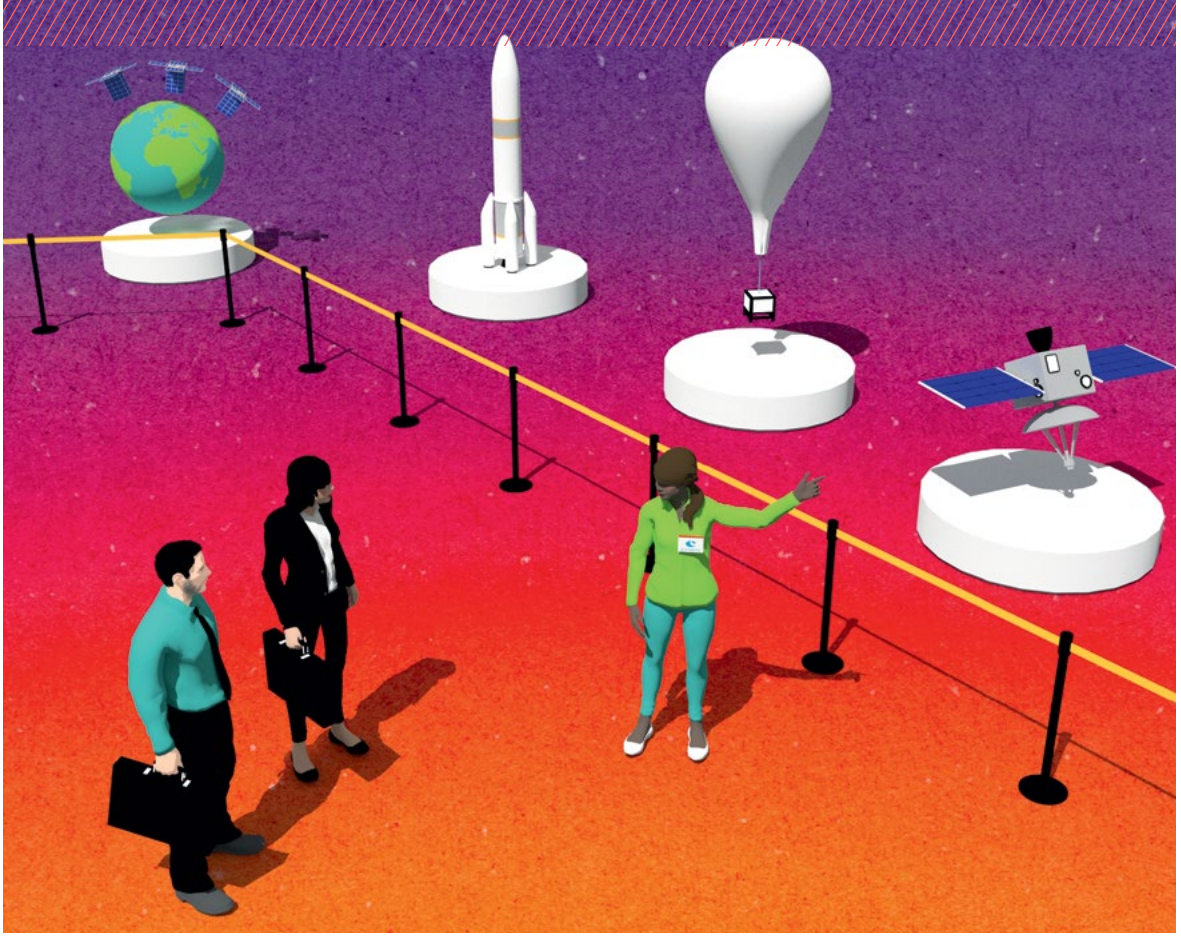
INSIDE A **VIRTUOUS CIRCLE**

If you have a project, product or service, space data might help to optimize its development. To find out, Connect by CNES is the place to look!

When CNES created Connect by CNES in 2018, the idea was "to open up space to ecosystems outside the sector," recalls Jean-Marc Charbonnier, deputy head of the agency's Competitiveness and Development sub-directorate. The success of dynamic programmes like the ActInSpace hackathon (see timeline p. 9) with students from all horizons had already shown the value of breaking down silos in this way. Three years on, Connect by CNES is stepping up a gear and aiming at economic stakeholders.

COMPREHENSIVE COVERAGE

Beyond data, Connect by CNES affords access to structures that are often under the radar and mediates between questions and solutions. It trains 'ambassadors', provides patents, organizes events, guides firms towards incubators like ESA BIC or competitiveness clusters, interconnects start-ups with accelerators like SpaceFounders, and points them to platforms like EOlab (Earth-observation data), CESARS (telecoms) or NavLab (geolocation) for technical expertise. If they need funding, Connect by CNES refers them to solutions like PULSER, Space Ticket and CosmiCapital. Through its ties with institutions[1] and regions, it offers a clear picture of territories' economic needs and identifies underlying synergies.



Space data

AN INFINITE POOL

What do macro-financial data analytics and monitoring of greenhouse gases (GHGs) have in common? The answer is space data, today the raw material for two French start-ups operating at the cutting edge in the New Space market: QuantCube, which conceives macro-economic prediction algorithms, and Kayrros, which converts satellite imagery into GHG indicators. Through satellite series like SPOT and Pleiades, CNES has access to a wealth of data collected over decades, and it is leveraging this "black gold" for the benefit of new players. The agency is engaged in modernizing its data infrastructure, underpinned by a data lake into which it is feeding its own data and those of its partners for processing, analysis and sharing. Orange Business Services is heading an industry consortium[1] working to set up this data storage system with a capacity of 50 petabytes.

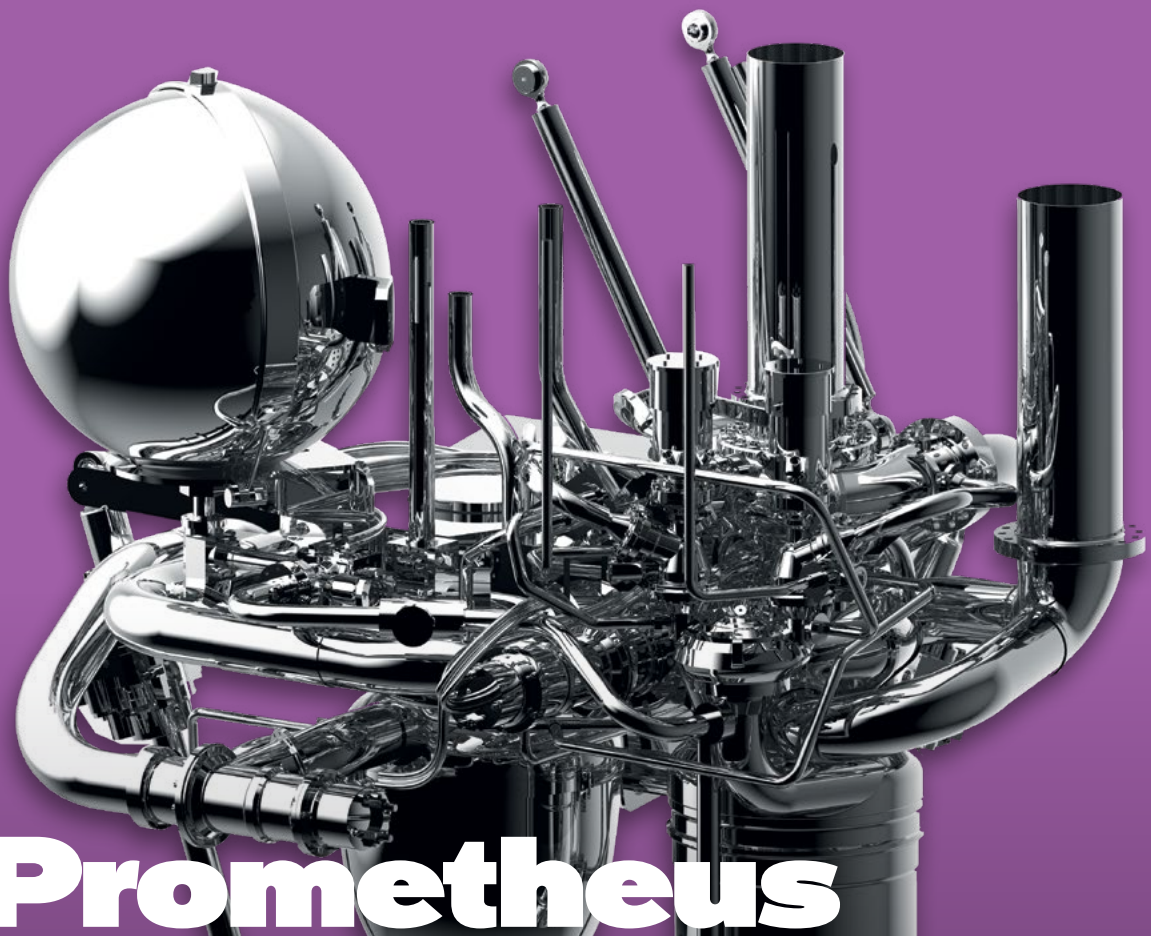
1. Composed of HPE, Scality and Tealenium.

THREE PRIORITY SECTORS

But the initiative is being careful not to spread its efforts too thinly. "Our efforts are focused on the three priority application areas of mobility, healthcare and the environment," says Jean-Marc Charbonnier. This is achieved through partnership agreements with organizations, trade bodies and clusters[2]. For example, Connect by CNES provided support to national rail operator SNCF for precise train positioning and altimetry-based monitoring of its network's quality. Shipping firm CMA-CGM is working to make its fleet 'smarter' (see Spinoff p. 36), while the MEDES space clinic helped to analyse early-warning signs of the Covid-19 pandemic. Precision agriculture is using robot solutions to control inputs and manage water resources. An infinite number of applications stand to benefit, backed notably by the government's stimulus plan.

1. Ministry for the Ecological Transition, Ministry for Territorial Cohesion and Relations with Local Authorities, Ministry of Agriculture and Food, French enterprise agency (DGE)

2. French Federation of Insurers (FFA), GICAN interprofessional shipbuilders and shipowners association



Prometheus

THE PROMETHEUS ENGINE INITIATED IN 2015 BY CNES AND DEVELOPED BY ARIANEGROUP IS A CORNERSTONE OF THE LAUNCHERS OF TOMORROW. Breaking from conventional engine technologies, it aims to reduce costs tenfold—a feat made possible notably by 3D printing of certain volume parts. The engine features an electronic controller and will be fuelled by liquid oxygen and biomethane. With a helping hand from the government's stimulus plan in 2021, Prometheus was able to complete its first firings at the Vernon test facility at the start of this year. Even before these combined tests with the Themis reusable stage demonstrator and well before the future ArianeNext launchers, the engine has attracted the attention of the burgeoning small launcher market and will be powering the reusable mini-launcher that newly formed company Maïa Space plans to develop by 2026—a significant return on investment for the French space agency's reputation.

VIGIL

1 DETECTING DIFFICULTIES

As it undergoes a deep transformation, the space market may ebb and flow between feverish activity and lethargy, and both these states need to be analysed objectively. This is what the SEO does. Created in 2020, it monitors the market's health and analyses the situation, a need confirmed by the concerns that have arisen out of the Covid crisis and highlighting the difficulties of certain firms that it has steered in the direction of digitization, aid measures and other support solutions.

2 ORGANIZING DIALOGUE

Through the SEO, regular rendezvous[1] are set up with key players in the space ecosystem: manufacturers, SMEs, mid-tier firms, start-ups, laboratories, academia and so on. Competitiveness clusters, boosters and DREETS[2] are also stepping up their cooperation in executing Line C of the government's stimulus plan (see CNES In Action p. 22). These discussions are a good indicator of the impact of support provided by CNES through consultations, contracts and supplier payments. Regular reports are also published at https://entreprises.cnes.fr/fr/observatoire-economie-spatiale.

1. Weekly during the Covid crisis, monthly in cruise phase
2. Regional directorates for the economy, employment and solidarity

LED BY CNES'S ECONOMIC INTELLIGENCE HUB, THE SPACE ECONOMY OBSERVATORY (SEO) TAKES THE PULSE OF FRENCH FIRMS WORKING IN THE SECTOR TO ESTABLISH THEIR BILL OF HEALTH. A NERVE CENTRE DESIGNED TO INFORM AND ANALYSE, IT HAS ALSO ASSUMED THE MISSION OF ALERTING THE AUTHORITIES WHERE NEEDED.

3

INFORMING DECISIONS

In response to the crisis that has paralyzed the economy, the SEO has served as the space sector's barometer for ministries. The picture on the ground reflects a shared and real vision, providing an excellent indicator and informing policymaking decisions (emergency measures, crisis resolution, stimulus plan, etc.).
This proactive approach has been much appreciated by government and space players alike.

4

SETTING THE STANDARD FOR THE FUTURE

While the SEO's scope of action is national, monthly status checks also look at wider competitive trends in the global market, highlighting global issues such as component shortages, the need to digitize production, restructurings and the health situation, or reasons for hope and signs of recovery.
The SEO has become the gold standard, with a sub-directorate all to itself within the agency's Strategy Directorate, aiming to engage foresight and help the space ecosystem find its place in the future.

PIERRE-OLIVIER JAY

CEO of 97PX, selected for Space Tour 2021 in French Guiana

"A satellite imagery service for easy access to a little-known source of publicly available data..."

In 2004, Pierre-Olivier Jay arrived in French Guiana to oversee production of a local tree identification guide for ONF, the French forestry commission. Little did he know he'd still be there 17 years later. Today, he lives in Cayenne and is publication director at Boukan, the only magazine devoted to France's overseas territories. **His career so far has had little to do with space. Yet, he applied for the Guianese stage of the Space Tour 2021**, a call for projects under the French government's stimulus plan for space. "I'm also an amateur photographer, and four years ago I created 97PX, a photo library with geolocation tags to provide opportunities for overseas photographers and showcase the local landscapes," he says. Aimed at public-sector stakeholders and businesses, the platform's clients include the French Guiana regional authority (CTG), the European affairs cluster (PAE) and soon the University of French Guiana. **"Recently, I had the idea to expand 97PX with a satellite imagery access service.** The goal is to make it easier to access this little-known source of public data, which could be useful for monitoring infrastructure projects or detecting illegal activities, for example." The service is called 97PX Sat, and it impressed the Space Tour selection committee. **The €50,000 grant at the end of the challenge will allow the young company to develop and market its solution.** "To this end, we're working with Jeobrowser, a Toulouse-based start-up founded by former CNES staff member Jérôme Gasperi, which offers SnapPlanet, an app for sharing satellite imagery." In the next few months, 97PX Sat users will be able to enter a specific location and a radius around it to access images from space as well as photos taken on the ground. "Initially, the platform will give access to Sentinel data," says Pierre-Olivier Jay. "Then, if all goes well, we'll add SPOT World Heritage imagery, in the longer term Pleiades and possibly even Pleiades Neo."

PETER WEISS

Founder and President of Spartan Space

"We're developing autonomous inflatable habitats for lunar crews..."

Fascinated by space for as long as he can remember, Peter Weiss did a PhD in lunar sampling systems at Hong Kong Polytechnic University. However, he has devoted much of his career to the underwater world, with 10 years at Comex, a Marseille-based company specializing in deep diving. "I had close links with space, because Comex provides underwater training for astronauts," he says. **Twelve years after his doctorate, Peter Weiss returned to his first love and founded a start-up called Spartan Space.** Its main project is EuroHab, an autonomous habitat system for lunar missions and, ultimately, Mars. "We developed this concept with astronaut Jean-Jacques Favier, who's also Chief Science Officer for Spartan Space," continues Peter Weiss. "Our idea was to create inflatable shelters as a payload on a lunar lander. This will make it possible to **position the modules in uncharted areas of the Moon, where they would serve as outposts for crews of two to four people.** Provided automated probes replenish them with water and oxygen, the EuroHab shelters could be used for multiple missions. It would be the first permanent habitat on the Moon!" For now, the project is being matured at CNES's TechTheMoon incubator (see p. 17 and 32) with the support of the agency's Spaceship France base (see CNESMAG #87). A prototype was built and presented at the World Expo in Dubai in October 2021. "Speed of development is key to success when it comes to the Moon. Since the announcement of the future crewed flights, teams all over the world are rushing to be part of it. **We believe EuroHab could be one of France and Europe's contributions to the Artemis mission, i**f we can keep up the pace. And for that, our collaboration with CNES is crucial."

THOMAS FOUQUET

Head of CNES New Space and Ecosystems sub-directorate

"TechTheMoon is the world's first incubator dedicated to the Moon..."

For several years now, the global space community has been gearing up for the Artemis human spaceflight programme. Its first goal is to reach the Moon by 2030. With this in mind, **France has already begun structuring a European ecosystem to meet the challenges of a sustainable human presence on the lunar surface.** "It's a matter of sovereignty—unless we want to be content with a secondary role in the supply chain for these missions," says Thomas Fouquet. Building on the work of the Objectif Lune (Destination Moon) working group overseen by ANRT, the French research and technology association, and the launch of the Moonshot Institute by CNES (see Roundup, p. 11), the world's first start-up incubator dedicated to the Moon was created in June 2021. Thomas Fouquet is fully familiar with the world of start-ups. After his PhD in physics, he was an entrepreneur and business angel for a decade before joining CNES. **"With TechTheMoon, we want to foster innovation in three crucial areas of lunar life:** the resources for producing energy, infrastructure for future crews working on the lunar surface, and their health in this hostile environment." The companies involved will need to propose solutions that can also help meet challenges here on Earth. So far, five have joined the incubator, including Spartan Space (see Horizons, p. 31). "Since October, they've been following an intense programme taking in space law, how to build a business model, business strategy and preparing to raise funding. They also benefit from being nested with CNES's technical teams and from the contributions of Connect by CNES and Spaceship France, a model lunar base being developed at the agency's field centre in Toulouse." Train, inspire, interact—**the goal is to help start-ups gain the maturity they need to meet and convince investors** who can put them on the launchpad to the Moon!

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

ETHICS CORNER

J. A.

JACQUES **ARNOULD**

THE GIRAFFE AND THE ASTRONAUT

The giraffe and the astronaut share the same destiny: reaching for the sky. But how they adapt to and are selected for this mission is not the same.

Think about the giraffe's long neck. In the 19th century, naturalists agreed that its superlative length allowed the giraffe to reach the highest branches of the savannah trees and live longer. This fuelled endless debate about what mechanisms could have led to such a result. Darwin successfully proposed it was nature's exuberant capacity to produce differing individuals combined with selection processes based on their survival. In other words, the giraffes with the longest necks could find more food than their shorter-necked relatives, so they reproduced more easily. Nature was the arena of a genuine fight for survival. It was a throw of the dice; it was no grandiose endeavour or sublime raison d'être, argued the British naturalist. How individuals or species adapt to the conditions of a place or time is simply a matter of chance.

NATURAL SELECTION AS A TEST OF WILL

Belonging to nature is part of what it means to be human. But we're also creatures of culture, with the ability to make tools, conceive plans and pursue dreams—beyond the simple need to adapt to conditions or immediate circumstances in order to survive. If not, would we have built the Pyramids, erected the great cathedrals or sculpted the giant statues of Easter Island? The ability of life—at least as we know it on our planet—to adapt has its limits. The range of possibilities is bounded, but the human mind has the ability to think outside these limits, imagine other possibilities and achieve them. The history of space exploration—which CNES has been contributing to for 60 years—is an example of this "human culture". But it functions not only according to the mechanisms proposed in Darwin's *Origin of Species*, but also by those advanced by his French predecessor, Jean-Baptiste de Lamarck and his ideas on the inheritance of acquired characteristics. The dreams and endeavours, the successes and failures of one generation can be passed on to the next. A human being or society isn't adapted to a context simply by random circumstances or selection. We also adapt by our own free will and our ability to determine our own destiny among the stars.

TRAINING

STAYING **AHEAD**

The space ecosystem and technologies are evolving. And to move with the times, CNES has expanded its range of programmes enabling everyone to stay ahead of the curve, with Connect by CNES, collaboration with universities and courses focusing on New Space.

The TTVS training course on spacecraft techniques and technologies was initially delivered in-house on a recurring basis. But it's now open to anyone wanting to expand their knowledge, especially in orbital mechanics and telecommunications. Some courses can be adapted to meet specific needs or for organizations keen for their staff or students to engage with space, such as the Ecole Polytechnique engineering school and a company in the optics sector, for example. A new need has arisen recently in emerging companies that don't have a space culture or related training infrastructure.

CNES has also engaged with the Nanolab Academy through its relationship with CSU university space centres in France. A dozen CSUs have joined forces to design operational nanosatellites for launch. The technical and financial support provided has led to the creation of a start-up called U-Space, which is now developing new-generation nanosatellites. Not a bad start!

STATION K

A FABLAB IN KOUROU

Guyane Connect has set some lofty goals: a modern, shared workshop, technology projects jointly pursued with a broad community and skills shared freely on a non-profit basis. In April 2021, these goals were achieved with the opening of the Station K fablab in Kourou. The primary reason Guyane Connect set up this dynamic facility is to foster projects devised and led by French Guianese people. And there's a wealth of inspiration for projects, with the country's industry, digital transformation, land-planning initiatives, energy sector, forest-timber sector, sustainable development and rich culture. Station K will offer an introduction to digital tools, masterclasses with professionals from the Guiana Space Centre (CSG), thematic workshops and lectures.

SPACE AMBASSADORS

A unique qualification for your CV

Space Ambassadors is the short course you need if you want to learn about the spectrum of space technologies with applications in everyday life. Designed by CNES, it's simple, practical and flexible. Seven modules[1] give an overview of the key space concepts, tools and solutions for society, industry, healthcare and the environment. Once registered, you can access the course 24/7 on the Connect by CNES platform. It's free, takes just 5½ hours, and you have three weeks to complete it. At the end is an interactive session with the educators on each module, followed by validation and award of your qualification. You can then join the community of Ambassadors and promote all the potential of space applications. The course was originally designed for local authorities, business/engineering schools and other specific communities, but it has met with such success it's now open to everyone (see Diary, p. 35).

1. Connect by CNES – Satellite geolocation – Satellite communications – Space imaging – Space oceanography – Business – Future.

INNOVATION

A DAY TO CHANGE EVERYTHING

Innovation may be a prerogative of New Space today, but here at CNES it has been a major focus for decades. And it's having a galvanizing effect. For example, CNES's Innovation Day[1] in Toulouse is a continued success, with 600 to 700 people taking part each year. Innovation also resonates widely across the national space ecosystem and internationally, from institutional players and research laboratories to industrial partners and start-ups in the downstream sector. Responding to feedback from participants and evolving contexts and needs, the format of the event is revised slightly every year. Focusing as always on space, sustainable development and a topical issue in the media spotlight, this year's gathering has been put back to mid-May due to the pandemic. It will look at efforts to prepare the launchers and orbital systems of the future and give new start-ups a platform to pitch their projects. New features this year will include a session on the results of actions to promote disruptive innovation.

1. Previous events have focused on fundamental research and innovation (2018), scientific exploration of the solar system (2019), technology and disruption (2020) and risk management (2021).

DIARY

UPCOMING SPACE AMBASSADORS COURSES OPEN TO ALL:

4–22 APRIL 2022
6–20 JUNE 2022
7–21 NOVEMBER 2022

Sign up here:
www.connectbycnes.fr/agenda-formation

INVENTING THE FUTURE OF SHIPPING

Together, Marseille-based shipowner CMA-CGM and CNES are looking to make maritime shipping smarter and greener. Here's how.

In June last year, CMA-CGM and CNES signed a five-year partnership agreement to combine their expertise for the future of shipping. "CMA-CGM might be a world leader, but we still have a strong entrepreneurial spirit and the desire to keep serving our customers better," says Marc Bourdon, CMA-CGM Executive Vice-President in charge of its training and innovation centre. "Our Chairman & CEO Rodolphe Saadé sees in space technologies the opportunity to cement our innovation strategy while also helping to ease shipping traffic and make the sector greener."

TOWARDS SMART SHIP ROUTING

Through their respective R&T, spin-off and innovation support structures—Connect by CNES on one side and Zebox and CMA-CGM Ventures on the other—the partners will be working to optimize ship routes throughout their voyage, with an ultimate eye on enabling gains in time, safety and fuel consumption. Space technologies will supply data to ships on currents, waves and winds. "We'll be working in particular with two of CNES's start-up partners: eOdyn, which correlates ships' geolocation signals to satellite data to deduce surface currents, and Amphitrite, which augments measurement precision by detecting ocean eddies in optical satellite imagery," explains Eric Brel, Connect by CNES's maritime development expert. "More broadly, we expect this partnership to tie into the agency's work on developing new space infrastructures for near-real-time oceanography." For now, the two partners have started joint projects "focusing on port management (shipping traffic, infrastructures, pollution), the use of hydrogen fuel and in-orbit logistics, a domain where CMA-CGM is looking to invest in the years ahead," concludes Marc Bourdon.

77%

In Europe,
77% of trade with the rest of the world is conveyed by sea. In 2018, maritime shipping accounted for 13.5% of transport emissions, behind road transport (71%) and aviation (14.4%).

(Source: European Environment Agency, 2021)