

CNES MAG

EN
FR

SPACE • INNOVATION • SOCIETY

#75

February 2018



DIGITAL
BOOSTING SPACE


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CENTRE NATIONAL
D'ÉTUDES SPATIALES



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PARTNERS

Mentioned in this issue: p.6 and 20 European Space Agency (ESA); p.11 Thales Alenia Space, Syrlinks; p.20 NASA, JAXA and DLR.

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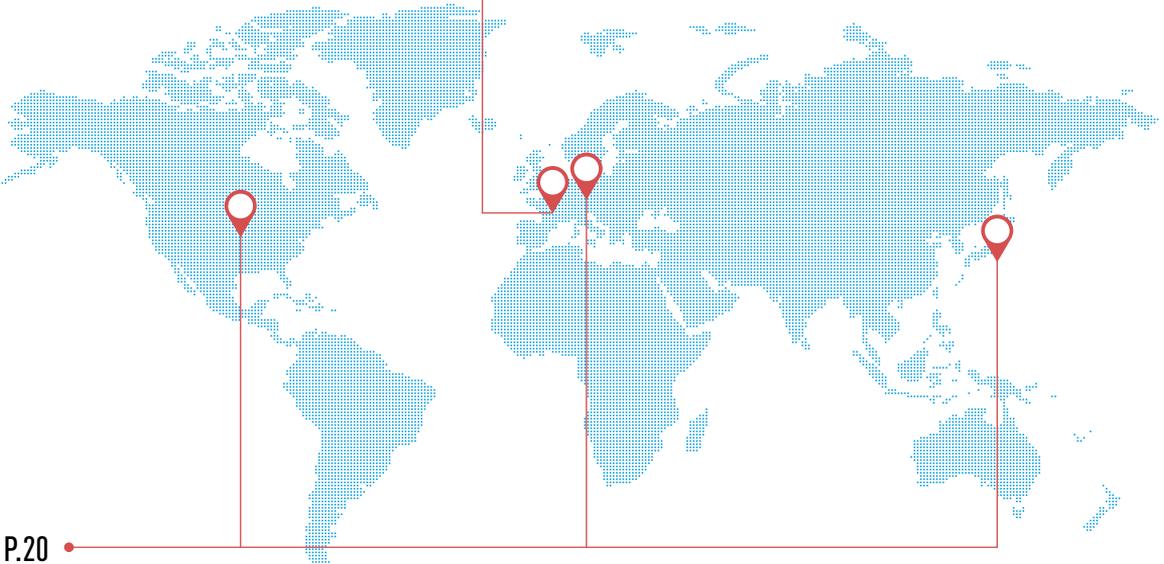
CNES



P.09

EUROPE

25 European nations are in the Gaia Data Processing and Analysis Consortium (DPAC). Its six processing centres are located in five countries: Spain (Madrid and Barcelona), Italy (Turin), United Kingdom (Cambridge), Switzerland (Geneva) and France (CNES in Toulouse).



P.20

UNITED STATES, JAPAN, GERMANY

Five of the world's leading space agencies—ESA, NASA, JAXA, DLR and CNES—meet twice yearly to compare notes on the effects of easing flows of data. While space agencies only generate public data and scrupulously safeguard people's privacy, they still keep a close eye on regulatory and ethical issues.



CONTRIBUTORS



CATHY LACOMME-VERBIGUÏÉ

CNES's Chief Digital Officer

Cathy Lacomme-Verbiguie is an 'executive woman' in the proper sense of the term, driven by a dynamic, 'can-do' approach. Attentive to the well-being of those around her, she has a keen sense of team spirit matched by her extensive knowledge of digital technologies. Her secret weapon is her conviction in charting the agency's digital future.



JEAN-PIERRE GLEYZES

As the agency's Deputy Director of Digital Technologies and Operations, Jean-Pierre Gleyzes is at ease in the world of petabytes and zettabytes.

His involvement with space data processing systems over many years means he knows just how precious those data are and how important it is to preserve them. In this issue, he gives us the benefit of his sharp, expert insight into data systems and artificial intelligence.



GWENEWAN LE BRAS

Photographer Gwenewan Le Bras entered CNES's universe with stars in his eyes. For CNESMAG, he used all his expertise to illustrate the additive manufacturing process and the new careers coming with the big data revolution, highlighting the human aspect in the face of the fantastic technological advances it promises. His secret is to add a touch of magic to evoke the emergence of new skills.



TINO

We gave carte blanche to Tino, who from his base in Tinoland projects images of a not-so-distant future. This illustrator with a style all his own works for the press, public institutions and corporate clients alike. In his lab, he invents a host of projects, heroes and books for younger generations, while also finding time to create a collective Internet platform and virtual furniture. In this issue, he gives us his take on big space data.

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: Jean-Yves Le Gall. **Editorial director:** Marie-Claude Salomé. **Editor-in-chief:** Brigitte Alonzo-Thomas. **Proofreading:** Céline Arnaud. **Editorial staff:** Brigitte Alonzo-Thomas, Karol Barthélémy, Liliane Feuillerac, Sophie Lherm, Marianne Quiles. **Photos and iconography:** Marie-Claire Fontebasso. **Photo editor:** Nicolas Tronquart. **Photo credits:** p.04 CNES/F. Maligne, CNES/N. Tronquart, CNES/G. Le Bras, Tino; p.05 CNES/O. Pascaud; p.06 Y. Beletsky (LCO)/ESO; p.07 top VR2planets; p.07 top right CNES/G. Le Bras; p.07 bottom CNES/D. Ducros; p.08 left ESA/J. Mai; p.08 right CNES/E. Grimault; p.09 ESO/A. Duro; p.10 CNES/G. Le Bras; p.14-15 P. Matsas/Opale/Leemage; p.16 CNES/G. Le Bras; p.17 CNES/S. Godefroy; p.27 GettyImages; p.33 J. Arnould; p.34 S. Soriano, Hasselblad H5D; p.36 Icare Technologies/J. Neyrou. **Illustrations:** François Foyard (p.11), Robin Sarian (Idix) (p.28-29), Tino (p.1-19-20-22-24-26), Jean-Marc Pau (p.30-31-32). **Webmaster:** Sylvain Charrier, Mélanie Ramel. **Social media:** Mathilde de Vos. **English text:** Boyd Vincent. **Design and pre-press:** Citizen Press – Camille Aulas, Stéphane Boumendil, David Corvaisier, Alexandra Roy, Aurélien Saublet. **Printing:** Ménard. ISSN 1283-9817. **Thanks to:** Caroline Amiot-Basile, Laurence Amen, Antoine Barnache, Jacques Béas-Garcia, Dampier Blanco, Christelle Boustié, Meritxell Clanet, Emline Deseez, Candice Foehrenbach, Philippe Guiral, Jean-Pierre Gleyzes, Cathy Lacomme-Verbiguie, Gabriel Liabeuf, Nadine Ladiette, Patrick Landrodie, Frederic Manon, Romain Mathieu, Eric Morand, Christine Monsan, Véronique Palatin, Chantal Panem, Killian Pfaab, Pierre Spizzi, Jérôme Vila.



EDITORIAL



In recent years, space has become part of our daily lives and kept the world on the edge of its seat. Be it in the field of climate science and the satellites constantly surveying our planet, in the field of exploration with planned missions to the Moon, Mars and asteroids, or in the field of innovation through disruptive technologies that are making world headlines, space is everywhere we look. And what ties all of these things together is that they are being boosted by the digital transformation of our society to which space is contributing at both ends of the scale. At one end, space systems have fuelled the development of extremely sophisticated technologies now finding their way into sectors outside space. CNES has pioneered big data systems for especially ambitious missions like Gaia, which is mapping the skies and deploying prodigious computing power to process huge amounts of data. Space has also conceived artificial intelligence algorithms for robotic probes exploring the outer reaches of our solar system. This expertise developed over the years is now being applied at the other end of the scale in driverless vehicles exploiting the extraordinary precision of Galileo, and to enable spectacular advances in medicine made possible by correlating an almost infinite number of experimental results. This digital revolution in which we are all intimately involved is about more than just being able to buy ever-more-sophisticated smartphones—it is changing the way we live forever, and space is central to this new society now coming into being.

JEAN-YVES LE GALL
CNES PRESIDENT



GAIA

The Milky Way in 3D

Gaia Data Release 2 (DR2) is the second version of the Gaia catalogue set for release this April, two years after the first. This catalogue will offer access to more than one billion celestial objects mapped in 3D. Gaia is an astrometry mission designed to deliver comprehensive data on the positions, distances, velocities and movements of stars. Launched in December 2013 for a planned five years, it is the sixth cornerstone mission of ESA's scientific programme. The sheer scope of Gaia is driving a radical shift, taking CNES into the realm of big data¹.

1. Often described as the 5Vs: volume, velocity, variety, veracity and value.



ROUNDUP

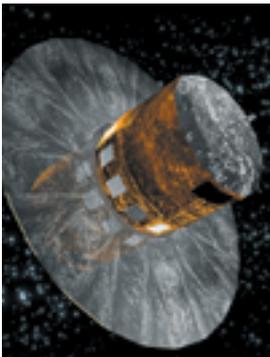


IMMERSION

MARS AS IF YOU WERE THERE

Imagine a room with 3D screens on three sides and two benches. You're in CNES's Martian CAVE¹ or 'cellar' [Editor's note: the French for cellar is cave], a communication tool designed to promote uptake of virtual reality technologies. Simply don your 3D glasses and you're whisked away to Mars, in the tracks of the rovers on the red planet. This immersive experience is reserved for the agency's employees and official visits. The experience is in fact very realistic, as the images used are actual regularly refreshed images from Mars.

1. Cave Automatic Virtual Environment



6,000 BILLION

CNES hosts one of the six Gaia data processing centres, which receives, processes and archives between 5 and 40 terabytes of data every month. This year and next, it is expecting to handle three years of data in less than six months. And in 2020-2021, it will be processing five years of data at a rate of 6,000 billion operations per second.

VOLUME

GAUGING THE GIGANTIC



Welcome to the mind-boggling world of petabytes (Pb), a unit of data that Gaia has made famous. Eleven hours a day, reams of raw data from the satellite stream in to the French processing centre (DPCC¹). When it was planning how to handle such volumes, CNES looked in 2011 at competing big data technologies and selected the Hadoop system, reputed for its ability to store and process massive datasets. But Gaia has no easily understandable keywords: the raw data are in digital form, combining numbers, codes and cabbalistic signs decipherable only by highly sophisticated algorithms. By the end of the mission, CNES will have handled 3 Pb of data.

1. Data Processing Centre CNES



ROUNDUP



VERACITY

SCAN, SCAN AND SCAN AGAIN

The Gaia satellite spins slowly on itself as it scans the entire celestial vault on each pass, completing a full-sky survey roughly every six months. These repeat observations are crucial to enable data to be compared and verified. At the end of every two-year cycle, all of the data acquired are reprocessed and precise data counting, integrity and completeness analysis tools have been developed to ensure that each centre has the same dataset, which is checked before and after archiving, processing and transmission. A science team at the DPAC¹ is tasked with validating the catalogue before it is released to the world. One of the reasons the second catalogue is so eagerly awaited is that it details the methodology scientists used to reach their results.

1. Data Processing and Analysis Consortium

VELOCITY

NEW SPEED RECORD



If we observed each star for just one second, it would have taken 30 years to map what Gaia is set to map in five years. The satellite's slowest data transfer rate is one gigabit per second;

internal transfers are performed at a speed of 10 Gbps, the kind of speed required to store and exploit two years of mission data and turn them into catalogue products in less than six months. And as all data acquired since the start of the mission are reprocessed for each new release, the catalogue is getting larger all the time. Extremely fast processing speeds are therefore needed to handle increasing volumes of data ever more quickly, employing ever-more-complex techniques.

VALUE

PAVING THE WAY FOR GALACTIC ARCHAEOLOGY

With Gaia, there's no need to compromise on quantity or quality—it's providing both. By extrapolating data on mapped celestial objects, the mission is opening new avenues for science, with the tantalizing prospect of maybe taking us back in time to when our galaxy was born some 10 billion years ago to reveal new clues about how it formed and evolved. Until now, scientists were unsure about how fast stars are moving away from or towards Earth, a fundamental element of "galactic archaeology". The international scientific community is already making extensive use of the first Gaia catalogue released in September 2016. With its increased accuracy, the second—described by the Gaia consortium's scientists as "amazing"—will no doubt be used for decades to come.



VARIETY THE FULL GAMUT OF STARS

Gaia makes no distinction between single, binary or multiple stars, brown or white dwarfs, supernovas, galaxies, asteroids or exoplanets of all kinds and sizes. It scans all known and unknown celestial objects, locating and mapping them with an accuracy on the order of 10 micro-arcseconds, the width of a human hair seen from 1,000 kilometres away. The data are then analysed and converted into astrophysical values. CNES receives about 100 different types of relational database tables at its processing centre, from which it generates 70 products in binary or text form. And these data are changing all the time, since Gaia observes 50 million objects a day and will observe them 70 times over the course of the mission. These measurements are added to those of the previous catalogue to compile a more precise map.

< 1%

Mapping a billion objects sounds pretty impressive, but that's less than one percent of all the stars in our sky. Gaia's performance has exceeded expectations and at the halfway point it has surpassed its goal with 1.14 billion objects already recorded.

100 TB/YEAR

That's the volume of data recorded by the first Earth-observing missions. In the era of big data, this may seem quite a small amount. The archive built up by the five SPOT satellites in a little over 30 years is barely 15 Pb, about what the Copernicus Sentinel satellites have acquired in just three years.

25

European nations in the Gaia Data Processing and Analysis Consortium, represented by laboratories, observatories, universities and space agencies processing Gaia data. There are 450 people, some 100 in France, working on the mission, and six data processing centres in five countries. The consortium has defined common methods and standards to ensure the data are managed uniformly.

QUICK DIGITAL INNOVATION GLOSSARY

VIRTUAL REALITY (VR)



A virtual world viewed through a 3D headset.

AUGMENTED REALITY (AR)



Puts a person in an environment with real-life objects, like for example a mock-up, or overlays a virtual 3D or 2D model on the observed scene.

ASSEMBLY, INTEGRATION & TEST (AIT)



At CNES, 3D virtual reality supports the various stages of satellite assembly, integration and testing. Virtual reality and computer-assisted design (CAD) are combined on a touchscreen tablet.

3D PRINTING



Also called additive manufacturing (AM), this process builds physical objects by depositing successive layers of material (plastic, resin or metal), working from a 3D file.

CONNECTED OBJECTS (CO)



All connected wireless objects sharing data with a computer, tablet, smartphone or other device.

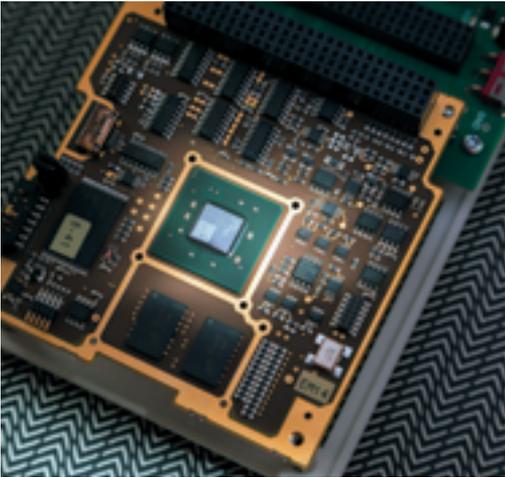
CLOUD OR CLOUD COMPUTING



Self-service, on-demand access via a telecommunications network to shared, configurable IT resources.

DARWIN

DISTRIBUTED PROCESSING AND SAFE SEPARATION



C NES is developing an avionics demonstrator called Darwin, designed to test new digital technologies expected to add value to space solutions. One such technology involves distributing processing units across different instruments. After the research and development phases, Darwin will test an innovative model of a group of processors. The system is built around a computer with a single circuit board that hosts the algorithms. But some obstacles need to be overcome first to be able to centralize the system's 'intelligence' in this way. Sharing memory and mixing memory is not the same thing, as applications must not be allowed to interfere with one another, and for this reason the system's specifications define how functions must be kept separate. This separation is guaranteed by software designed to ensure they co-habit safely, and by the processor's prodigious computing power. Darwin will leverage all of these features to combine high-level integration and versatility with compactness and low cost.



NEW CAREERS

FINDING THE RIGHT SKILLS

C NES knows all about data, but handling the huge volumes generated by big data is a quite different challenge, and to meet it the agency is seeking new career profiles like data scientists and data analysts. Having to compete with the private sector to attract this kind of talent, CNES is looking for candidates with a solid grounding in mathematics, databases and statistical and probability analysis (see Horizons p.32), and is providing special training in artificial intelligence, which is already being used for scientific disciplines like cloud detection and in the defence sector.



ROUNDUP

ARGOS NEO

NEW SOFTWARE-RADIO INSTRUMENTS

The reliability of space-rated electronic components is well proven, but with the need to bring products to market quicker and keep pace in an increasingly competitive environment, they have also become something of a luxury. That's why CNES has been preparing for several years now to use commercial-off-the-shelf (COTS) components for its future software-radio instruments. Argos Neo, the new satellite radiofrequency payload developed by Thales Alenia Space and Syrlinks, uses COTS components from the terrestrial radiocommunications and automotive¹ industries to save space, power and cost. CNES is working to characterize these components, list the potential risks of operating them in space and devise strategies to guarantee their efficiency. Scheduled to launch in early 2019, Argos Neo will be the first mission to operate these new software-radio technologies in space, paving the way for fully in-flight-reconfigurable systems.

1. Specifically, components used in managing autonomous transport systems

HUMAN RESOURCES

BIG DATA ADDS THE HUMAN TOUCH

CNES's human resources teams also rely on big data to tailor how they manage recruitment, careers, training and leave more closely to individual employees. The ability to cross-reference large volumes of data quickly really does add value, combining a human approach with consistency across the enterprise. For example, the Administrative Applications and Spin-off, Innovation and Products departments are working together to share experience and build bridges on topics of shared interest.



AFTER-WORK

A NEW WAY OF HIRING

In today's increasingly digital world, CNES needs new expertise that is proving hard to find on the market. So, it's targeting the younger generations fresh out of school and brimming with ideas. Shunning traditional hiring methods, the agency has turned to informal and friendly after-work events organized in the evening. The HR team first establishes a 'template' of the profile it is looking for with managers and then posts job offers on social media. Next, it down-selects candidates with the right profile and invites them. A cross between a punchy interview and a relaxed conversation, after-work events can reveal other qualities in candidates, such as their responsiveness, creativity and adaptability, the kind of values CNES is looking for to drive its digital transformation. No more than four or five candidates are identified for each post. Proof that the method works: the first gathering filled five of the six posts on offer in the space of only two months.



COMMUNITY

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



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Full house tonight at @Cap_Digital for the Space & Digital after-work event with @CNES_Techno !
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@FDOuest | #i4Emploi



#CWIN17 Paris roundtable
on space data (#spatial) How
they add value and support
new applications like
#agriculture #environnement.

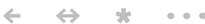


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space technologies?
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Science outreach
website devoted to
astronomy and space
#astronomie #aérospatial
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Thursday 14 December, NASA
is set to reveal new discoveries
by its Kepler space telescope.
We also know the data have
been processed using Google
machine-learning
technologies #espace
#astronomie #NASA
#MachineLearning #data





Q & A

CÉDRIC VILLANI

WINNER OF THE 2010 FIELDS MEDAL AND MEMBER OF PARLIAMENT FOR ESSONNE, Cédric Villani has been tasked by the government with producing a report on artificial intelligence (AI). For CNESMAG, he explains the current and future challenges this technology poses for France and the rest of the world.



Q & A

WHAT DOES THE TERM 'ARTIFICIAL INTELLIGENCE' ACTUALLY COVER?

Cédric Villani: In the 1950s, it referred to attempts to replicate human intelligence artificially, that is, using an algorithm. Today, artificial intelligence covers a set of algorithmic techniques accomplishing sophisticated, personalized tasks involving a large number of parameters. These techniques are built on ontological approaches, founded on logic, with causes and consequences; statistical approaches, based on examples; and approaches based on exploring all possibilities. The big revolution of the last 15 years has been the rise in statistical methods, which explains why data have become such a key issue. But AI is nothing new, as the main algorithms it employs have been around since the 1980s. What is new is that with the glut of data and the performance of computing systems, algorithms are now more powerful than ever before. Through their ability to calculate trajectories and shapes, and to optimize production lines and so on, these technologies are finding their way into all sectors of industry,

notably space with Europe's Galileo system fuelling applications related to geolocation and timing, and its U.S. equivalent GPS in astronomy and for automatic recognition in imagery of exoplanets or space debris.

THE GOVERNMENT HAS TASKED YOU WITH CONCEIVING A NATIONAL AI STRATEGY. WHAT PRIORITIES ARE YOU FOCUSING ON?

C. V.: Our six-strong team has auditioned 300 experts from all fields. With interest in the subject growing all the time, several reports have been released recently, notably one from the French technology academy. France is the premier ecosystem for start-ups in Europe, with its renowned scientific expertise and strong research culture in mathematics and algorithms. Many large foreign corporations have research labs here, like Facebook's in Paris. Our goal is to foster synergies between the world of research and the private sector, which historically have always been lacking. We're also working on data law and on the notion of trust and ethics, overseen by ad hoc institutions. Many other issues need to be

addressed, like the environment, employment and training, and increased resources for research. France's strategy will also take its cue from Europe. The United Kingdom already has a head start, with an effective institutional framework and significant resources. Europe is in the process of developing its own coordination strategy. It will be interesting to combine these strategies and identify where they differ and where they converge, through cooperation and exchange programmes.

WHAT PROGRESS CAN WE EXPECT GLOBALLY FROM AN AI REVOLUTION?

C. V.: Ten years ago, nobody was talking about investing big in AI. As the numbers involved are in the billions, the growth of AI could bring significant spin-offs that are hard to gauge precisely. Its impacts are already being felt in advertising and customer relations, notably through chatbots. In fact, we're using AI all the time, even for things like Google Translate. As I said, AI is nothing new. Before, people talked about 'operational research' or 'expert systems'. What is new is the recent and unexplained gains in performance from algorithms. Nobody expected the Alpha GO game would be so powerful or that neural networks would deliver such quick results. The same algorithms running on more-powerful machines are proving better than predicted. The transition we've seen in recent years is also opening new avenues in the defence sector,

"AI ALSO HAS ITS DARK SIDES: A NEURAL NETWORK ALGORITHM REVEALS VERY LITTLE ABOUT HOW IT ARRIVES AT A SOLUTION. SPACE IS ONE OF THE SECTORS THAT WILL MOTIVATE DEVELOPERS TO MAKE AI MORE RELIABLE."



Q & A



CÉDRIC VILLANI

2010 FIELDS MEDAL AND MEMBER OF PARLIAMENT FOR ESSONNE

“AI IS NOTHING NEW. WHAT IS NEW IS THE RECENT AND UNEXPLAINED GAIN IN PERFORMANCE FROM ALGORITHMS. THE SAME ALGORITHMS RUNNING ON MORE-POWERFUL MACHINES ARE PROVING BETTER THAN PREDICTED.”

which is putting a lot of effort into AI research. Nations are boosting their combat performance just by improving their algorithms, and that could alter geopolitical balances.

IS SPACE A SECTOR WHERE AI IS LIKELY TO DEVELOP?

C. V.: Space is seen as a laboratory for cutting-edge industries, so it's always pushing the envelope and providing the lead for other sectors in its

wake. The constraints of space are such that everything has to be optimized. Certification processes check that all code does exactly what it was designed to do. Making sure processes are reliable and finding bugs is crucially important, as any mistake could cost millions of euros. But AI also has its dark sides: a neural network algorithm reveals very little about how it arrives at a solution. One of the big challenges for AI is the ability to explain its answers to humans, for example when playing chess or buying shares on the stock market. Space is one of the sectors that will motivate developers to make AI more reliable. As a flagship agency, CNES's role is to embrace AI expertise and keep close track of technology developments to remain in the vanguard.

WHAT LIMITS AND DANGERS DO YOU SEE AS AI ADVANCES?

C. V.: Nobody knows how far we'll take it. We need to find the best way to use AI. Current techniques will reach their limit sooner or later and will need to be adapted. Scientists are hoping for a combination of statistical and logic-based approaches to make a leap in quality. As for potential dangers, they're inherent to all technology-related risks and will be down to humans, not machines. I don't think space is particularly at risk of that happening. In her book *Wagons of Math Destruction*, Cathy O'Neill shows how

evaluation systems, advertising and politics are already being manipulated. In the United States, for example, models are predicting the next crimes that will be committed or if prisoners on parole are likely to reoffend. Those kinds of applications are much closer to reality and down to earth than any 'Star Wars' scenario likely to occur as a result of the possible dangers posed by AI in the field of space.

Profile

1973

Born in Brive-la-Gaillarde.

1994

Obtains *agrégation* in mathematics.

1998

PhD on Contribution to the mathematical study of gases and plasmas.

2010

Winner of Fields Medal.

2017

Elected as La République en Marche (LREM) MP for Essonne, tasked by the government with producing a report on artificial intelligence.



IN PICTURES



ADDITIVE MANUFACTURING LIGHTENS THE LOAD

Making a satellite with lighter and cheaper parts can now be done, as CNES has proved with Taranis, the lightning surveyor microsatellite for which it has designed the star tracker's platform. The secret is additive manufacturing (AM), a simple process the agency has been working on for more than 10 years now. Here's how it works: fabrication parameters are optimized by algorithms and then fed into a computer-assisted design (CAD) model. Where traditional 'subtractive' machining would have required several elements to be joined together, the star tracker was built up layer by layer into a single solid unit. AM uses just the amount of material needed to make a part and doesn't have to rework it afterwards. And less material means less cost and weight. This sensor platform's mass was reduced by 40%.



IN PICTURES



HEADSETS MUST BE WORN ON THE LAUNCH PAD

Although it hasn't been built yet, it's already possible to view a detailed picture of the future ELA4 launch pad at the Guiana Space Centre, thanks to virtual reality technology. Ultimately, CNES teams will be able to use a digital model to visit the future facility and take decisions from the comfort of their offices. Whether in Paris, Toulouse or French Guiana, they will simply don their 3D headsets to take them there. No more plans, maps, paper documents or computer files, and no need to extrapolate to visualize the project's status. An associated tracking system even transmits the movements of each participant remotely.



IN FIGURES

13 TB

In terms of data volumes, today's Earth-observing missions are light-years from the legacy missions of the past. With its six families of satellites, Europe's Copernicus programme is expected to generate 13 terabytes (Tb) of data every day once it reaches cruising speed—that's five petabytes (Pb) a year. To give an idea, the Sentinel satellites deliver in one year the equivalent of 30 years of data from the entire SPOT series. And when associated services and downstream products are added to the mix, data volumes could reach as much as 10 Pb a year.

e-awareness

USING A SMARTPHONE APP IS AN EFFECTIVE WAY TO REACH YOUNG PEOPLE TODAY by speaking their language. At least that's what e-conscience, a start-up that grew out of the WoMixCity digital innovation marathon, is betting on. The app aims to give high-school pupils a new window on careers and the environment, teach them how to create new digital tools and apply techniques to enhance their well-being. How can we be smarter about using smartphone and tablet apps? How can we stay in control and not spend all of our waking hours surfing the web? With its learning-based approach, e-conscience is looking to encourage teenagers to become better consumers. CNES is supporting this initiative and more broadly all actions seeking to foster e-awareness.

5G

Telecommunications players are currently working on the next generation of standards for future wireless networks. Under the moniker of 5G (for 5th generation), these key technologies will need to support the exponential growth of the Internet of Things (IoT) and afford the kind of flexibility needed for new applications like connected vehicles. To meet the

goal of global coverage in particular, 5G is counting on satellite networks, meaning that the space community will have to show terrestrial network players where satellites can add value. For this long-haul effort—5G standardization is not expected before 2020—CNES is actively keeping track of developments to lend effective support to the satellite community and spin off space technologies.

11%

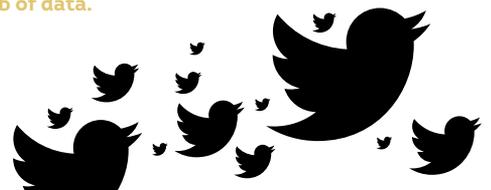
THE VOLUME OF INFORMATION INVOLVED IN BIG DATA and that produced from their use is simply mind-boggling. In France, firms are increasingly turning to big data, but they are still a minority: figures for 2015 show that only 11% of firms with 10 employees or more did an analysis of big data.

PEPS

The **PEPS** platform provides level 1-3 products from the Sentinel-1, Sentinel-2 and Sentinel-3 satellites. In service since 2015, the platform has already delivered five million products.

1 second

Every second, there are 100,000 Google searches and 5,900 tweets, representing 343 Mb of data.





CNES IN ACTION

DIGITAL

A CULTURE SHIFT

TAKING ITS CUE FROM PUBLIC POLICIES AND IN RESPONSE TO NEW EVERYDAY NEEDS, CNES HAS ENTERED THE ERA OF BIG DATA AS IT LOOKS TO BOOST ITS ABILITY TO DELIVER VALUE-ADDED SPACE DATA.



CNES IN ACTION

Big data is nothing new to CNES. Ever since its very first space missions, the agency is in the habit of handling large volumes of data. The Gaia project brought a step change and the opportunity to move to big data technologies (see Roundup p.6), but it had already been mulling this culture shift for some time. “CNES started looking as early as 2011 at the technologies the GAFAM¹ web giants were using,” explains Geneviève Campan, the Toulouse Space Centre’s director and CNES’s Director of Digital Technologies and Operations (DNO).

The challenges posed by the European Union’s Copernicus environmental-monitoring and security programme—set to generate 10,000 gigabytes a day of free, open-source data—were also already looming. “For CNES, the decision to adopt big data technologies was also paving the way for this step change in data access and applications. When you add to that the need to manage the three petabytes of data in our archives, making the digital transition was an obvious move.” This move ties in with a broader strategy engaged with the signature in 2015 of CNES’s objectives and performance





CNES IN ACTION

agreement with the government, which puts space data at the heart of the agency's defining innovation and inspiration lines of action. A year later, the new statute on digital technologies opened access to public data with a view to optimizing their use in the wider economy. This institutional context favours wider dissemination of space data and new forms of digital collaboration with businesses. At the same time, five of the world's leading space agencies—ESA, NASA, JAXA, DLR and CNES—now meet twice yearly to compare notes on the effects of this eased flow of data. While space agencies only generate public data and scrupulously protect people's privacy, they nevertheless keep a close eye on regulatory and ethical issues. ESA is working along the same lines with its Digital Agenda for Space.

SPACE SERVING CITIZENS

“Digital technologies are going to transform the way we work and operate,” notes Geneviève Campan. These technologies entail both constraints and opportunities for CNES. Today, the agency is seeking to make them an asset for its partners and employees through a human, social and citizen-centred approach. Previously the preserve of the scientific and defence communities and the telecommunications industry, space data must serve a diverse range of applications in every area of our daily lives, from home automation and robotics to finance, health-care, environmental management and transport. It is CNES's vocation as a government agency to share this treasure. *“We must spin off as much space data as we can to serve users, who we must listen to and support,”* says Geneviève Campan. And space is more than just a source of data, also inspiring innovative solutions. As result, like the start-ups it is working with and supporting, CNES has developed a dynamic and entrepreneurial approach with an eye on the future.

STEP BY STEP

In embracing big data and making the digital transition, CNES sees an opportunity to

HAPPY DIGITAL

DYNAMIC SHARING

Happy Digital is the name of the unit CNES has created to speed its digital transformation. The unit is built around a network of ambassadors that collect and report needs expressed by the agency's different teams. Happy Digital also owes its success to a very intuitive format. Over coffee, the project team and ambassadors discuss a new technology, service, product or experience

they would like to share. This informal setting also gives everyone the chance to propose new applications. Immersive virtual reality and audio-video exchanges are among those already being used. Digital visual management using the iObeya platform and collaborative meetings with the Klaxoon platform are some of those on the agenda for 2018.



Zb
Big data technologies are still in their infancy. In 2013, the world produced 4.4 zettabytes (4.4 thousand billion gigabytes) of digital data, an amount forecast to double every two years, reaching 44 zettabytes by 2020.

spin off its heritage and a chance to be seized. The challenge facing its teams is not so much to familiarize themselves with the terminology and tools, but rather to achieve a true change in culture. The agency is doing this through collaborative spaces, data sharing and autonomous access to information, driving its transformation via a holistic method and a new approach to innovation based on trust and more-flexible 'test-and-learn' and 'quick-win' models. Above all, the digital transformation demands agility and adaptability, and in this respect CNES will not hesitate to readjust its roadmap where needed. Whether big data is the issue or not, changing course when a project is leading to a dead-end isn't a failure, it's the wisest course of action—and that's something of which the agency is well aware.

1. Google, Apple, Facebook, Amazon, Microsoft



CNES IN ACTION

CORPORATE CULTURE BOOSTING PERFORMANCE

After coming third in the 2016 Happy at Work ranking, today CNES is grasping the opportunity that the agency's digital transformation offers to further enhance its employees' well-being.

“The digital transformation of business is coming, so it's better to build a project to embrace it by choice rather than having to play catch-up,” says Cathy Lacomme-Verbigu , CNES's Chief Digital Officer. “Our project will make us more agile, more fluid. It will boost our performance and will succeed if teams truly buy into it.” The agency is using all the technical, strategic and managerial levers at its disposal to ensure the project's success.

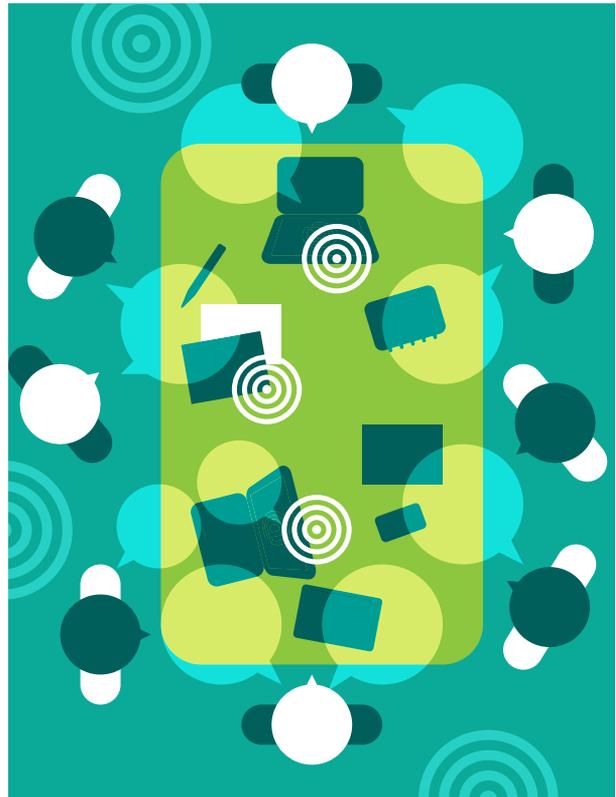
CULTURE CHANGE

CNES has thus chosen the path of a collaborative enterprise, and it's not alone in doing so. Many of its partners in the space supply chain have engaged their own digital transformation, realizing that it's the only way to maintain their excellence and keep pace. The first task is to remould the corporate mindset, break with traditions and move to a digital culture. This involves more than just adopting new tools, as the human aspect is paramount. The key is to replace vertical lines of reporting with practices based on experimentation, a cross-functional perspective and autonomy.

Instead of traditional concepts like control, sedentary postings and expert intelligence, the digital culture swears by encouraging responsibility, mobility, community and sharing. Making this transformation can be tricky and doesn't happen overnight, but embracing the new culture is a vital step towards more collaborative ways of working.

MODERNIZING TOOLS

New tools of the trade are obviously needed to nurture this shared intelligence. The digital 'toolbox' has much to offer, from collaborative corporate portals and chatbots to virtual meetings and collaborative digital spaces to name a few. All of these tools become part of employees' daily routine. CNES also intends to look at solutions like





CNES IN ACTION

VIDEO



Behind the scenes at CNES's data centre

machine learning to free them from repetitive tasks so they can concentrate on adding value. Massive online open courses (MOOCs) are another springboard to future careers (see Roundup p. 10), and at CNES an action plan is already in place.

WHY GETTING IT WRONG IS OK

While it can boost performance, “going digital is nonetheless a complex process that calls for a pragmatic approach,” notes Cathy Lacomme-Verbiguie. “You mustn’t be afraid to experiment and allow people to make mistakes!” To achieve its digital transformation, CNES is employing methods like ‘test and learn’ and ‘quick wins’ to build incrementally towards success.

Last and by no means least, a successful transformation will be predicated on a shared approach across the enterprise, both at management level and on the front line. A strategic committee has been set up to define guidelines this year and a network of digital ambassadors is already up and running (see box). Communication goes through subtle threads like an intranet news channel, new technology bulletins and digital events that help everyone to buy into the same digital culture.



Quick wins

recorded since the start of the experiment.

These wins involve things like simplifying procedures, designing new workspaces or going paperless—the opposite of seemingly insurmountable, energy-sapping challenges.

They achieve simple and effective improvements, as they can be quickly applied.

DATA BIG DATA CHANGING THE GAME

CNES generates, stores and uses huge amounts of data. As a prime big data player, it has an extensive archive ready to bear fruit, but for that the agency is having to rethink how it operates.



NES has been receiving, processing, exploiting and archiving mission data for 30 years, so data are deep in its DNA. “It’s what’s left when a satellite has completed its mission, the legacy we leave for future generations,” says Jean-Pierre Gleyzes, CNES’s Deputy Director of Digital Technologies and Operations. “What’s more, every mission launched is built with its own technological or scientific purpose, but we never know what data might prove useful in the future, so we keep everything we can.”

REFERENCE REPOSITORY

Right from its first Earth-observation programmes, CNES paid close attention to storing and preserving their data, to processing, analysing and visualizing these data to make them meaningful, and to protecting them. It began by investing to archive all this imagery and render it readily usable, which involved transferring the data from old magnetic tapes to digital media. This valuable heritage is backed up and carefully preserved, so that scientists know where to look if they want, for example, to study the impact of pollution peaks, the extent of deforestation in the Amazon or melting of polar ice caps. The agency’s data ‘library’ holds a host of time-series providing all the objective, reference information they need.

PARADIGM SHIFT

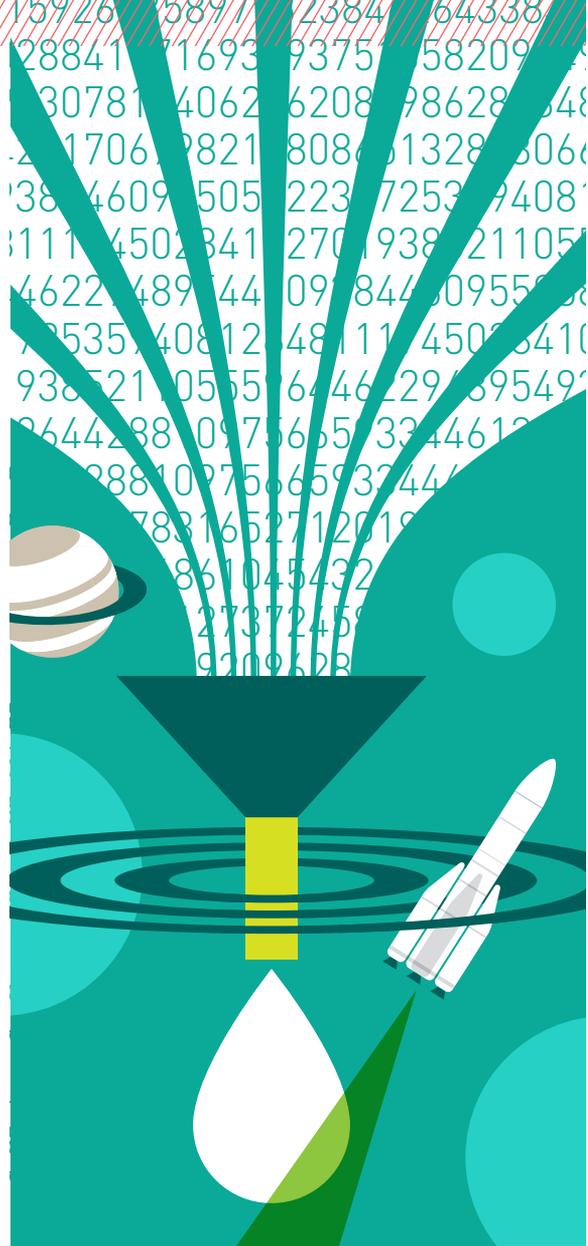
But CNES is more than just a custodian of these reserves of ‘black gold’; it’s also keeping its eye on the

— CONTINUED P. 24

fast-evolving requirements of the digital market. "What's new is the pace of change. What limited how data are used before was the capacity of processing systems on the ground," explains Jean-Pierre Gleyzes. "Now, with the Internet, communications are much faster and data can be cross-referenced. They're more accessible, and that's what's driving big data technologies." The way data are used is also changing. Processed products like SPOT satellite images of Earth are no longer the name of the game. "We're not selling imagery anymore; we're selling information," notes Gleyzes. The focus is shifting from data distributors to those capable of selling information mined from data with associated services—a paradigm shift that's being felt all the way down the space value chain.

DATA REFINERIES RESHAPING DATA PROCESSING

The Internet of Things, social media, nomadic devices, scientific instruments and location-based services are all grist to CNES's mill. But while it can store this glut of data, does it have the capability to analyse them all? Data volumes are now reaching a level where traditional 'human-in-the-loop' systems are becoming obsolete. The value of data lies not in how much we have, but in our ability to sort them meaningfully and the quality of information they deliver. The next step is therefore to employ artificial intelligence (AI) to 'filter' data and tease out substantive, actionable information. New systems based on data refineries or big data analytics are doing just that. By automating this process of distilling raw data to extract information, data refineries provide users with effective support for their decisions. These compute-intensive mass-processing systems are capable, for example, of counting and locating cars, aircraft, ships and ship containers, or gauging water stocks and urban growth. Where these new tools hosted in the cloud shine is in their ability to offer an all-in-one solution combining comprehensive analytics, quality, multiple sources and near-real-time processing of all the data being generated every day. And that will take CNES into the realm of tomorrow's world.



Data volumes

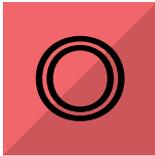
aren't the only area where the numbers involved are mind-boggling. The world market for big data systems, software and associated services is just as impressive, growing at a rate of 23.1% a year. This market is expected to be worth \$4.6 billion in 2019.



CNES IN ACTION

FUELLING A BURGEONING ECONOMY

Space data and digital technologies are feeding off each other to encourage new applications across all sectors of the economy, creating a virtuous circle in which CNES is playing a prominent part.



nce the preserve of scientific communities, space data are now on the cusp of a golden age as digital technologies bring them squarely into the world of business.

For example, satellite geolocation systems are enabling banking transactions to be time-stamped to within a billionth of a second, giving a huge boost to the finance sector, while satellite imagery combined with artificial intelligence is helping analysts and investors alike to keep close track of market health indicators. Space data and digital are proving increasingly valuable to a wealth of applications from mobility, environmental monitoring and crisis management to tourism, insurance, agriculture and telemedicine.

INEXHAUSTIBLE SUPPLY

With Copernicus, the European Union has embraced this coming digital revolution and chosen to make the programme's data easily accessible and free of charge. The six families¹ of Sentinel satellites are going to deliver a floodtide of information. Open-source policies have already spurred businesses to get creative and nurtured start-ups in varied domains. Countless new operational applications are coming on stream, like measuring the thermal efficiency of buildings, tracking land occupancy

or planning tourist activities.

ESA has created its Copernicus Data and Information Access Services (DIAS) to make it easier to exploit data through an on-line IT architecture. To enhance efficiency, these services will be able to reference their data on platforms in other member states, like the PEPS platform set up by CNES in 2015 to support public and private initiatives. PEPS has already spawned new applications in sectors as varied as agriculture, environmental management and land planning.

HAND IN HAND WITH START-UPS

Through initiatives like this, CNES is fulfilling its role to provide the added value required to develop services for citizens. A case in point is the partnership the agency signed with French national rail operator SNCF in 2016 to help it monitor the rail network, control trains and connect passengers.

– CONTINUING P. 26

VIDEO



Pixstart, from space data to the swimming pool

CAP DIGITAL

DISRUPTOR AND FACILITATOR

Cap Digital is a competitiveness cluster based in the Paris region that defines its role as a 'disruptor and facilitator'. Its vocation is to help public firms and agencies make the digital and high-tech transition. Set up in 2006, it today counts more than 1,000 members and federates a great many innovation stakeholders, from research laboratories, SMEs and start-ups to big corporations, mid-tier

firms, schools, universities and investors. CNES and Cap Digital have joined forces to bring space technologies to the attention of players in the digital economy. In November last year, they organized a matchmaking evening between CNES experts, start-ups familiar with space applications and the cluster's network.

LEARN MORE:
[HTTP://WWW.CAPDIGITAL.COM](http://www.capdigital.com)



CNES IN ACTION

“But big data and artificial intelligence open up a whole new realm of possibilities,” says Jacques Beas-Garcia, in charge of downstream industrial policy at CNES. And the digital realm is a vast one indeed, occupied by a host of vibrant nurseries, incubators, boosters and other structures serving industry. CNES is partnering or actively contributing to many of them. For example, Station F is a campus opened last June in Paris whose development the agency is supporting. It’s also working with artificial intelligence specialist QuantCube Technology (see Horizons p. 31), whose algorithms won an award at the Start-ups Forum in Paris. Lastly, the agency is involved in national and international initiatives and events like Cap Digital (see box). While

1,000

The largest digital

start-up campus in the world, Station F offers 34,000 sq.m. of flexible office space in Paris and is looking ultimately to accommodate 1,000 international start-ups of all sizes.

LEARN MORE:
[HTTPS://STIONF.CO/FR/](https://stationf.co/fr/)

remaining a faithful partner to the scientific community, it’s nonetheless pursuing a new ambition to support and sustain players driving the new economy.

1. Land, marine, atmosphere, emergency management, security and climate change





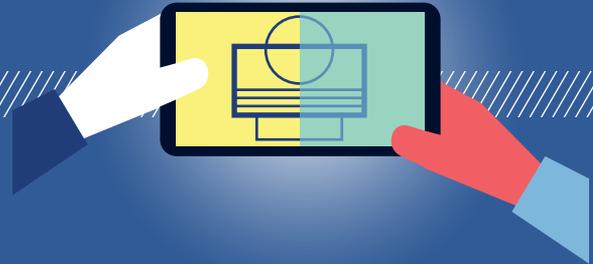
MATERIALS

LEARNING BY SIMULATION

BASILES IS THE MUST-HAVE TOOL FOR TESTING a satellite control centre and training teams. Conceived by CNES, this platform of software components is able to create a faithful digital simulator of a satellite. *“For pre-launch testing, Basiles plays the role of the real satellite, simulating all of its systems as well as the orbit, stars and any perturbations, putting the control centre and its operators in real-life conditions,”* Patrick Landrodie, head of the agency’s Systems Validation department, explains enthusiastically. Basiles, which is downloadable free, can be used to model a satellite, replicate thousands of Argos transmitters or deploy connected electric meters—in short, no challenge is too hard and the software is enhancing its capabilities and adding to CNES’s software heritage all the time.



TIMELINE



VIRTUAL REALITY **A GUIDED TOUR** WITH A DIFFERENCE

A launch base is a set of complex facilities, including satellite preparation buildings, radar units, telemetry systems and launch pads. To optimize their design and operations, virtual reality (VR) is proving a valuable ally. No matter where you are, the 3D VR headset takes you as if by magic inside the digital model of the building (see In Pictures p. 17), where you're free to collect data in situ. Let's say you want to install a travelling crane, gauge accessibility to a platform or plan network wiring. All of these parameters are recorded automatically and fed into the model, saving precious time at every step.

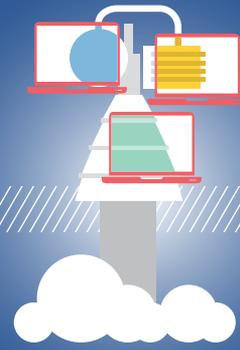
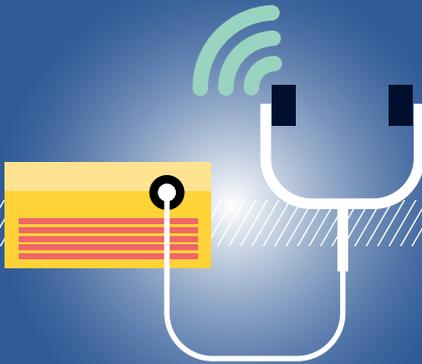
AUGMENTED REALITY **COMBINING** REAL AND VIRTUAL

Computer-assisted design (CAD) has replaced the drawing board in engineers' offices. And today, augmented reality is enhancing CAD, making it possible to interact with a real environment by embedding virtual objects on screen along with their associated data sheet, configuration history and performance parameters. It's more intuitive to use than a computer mouse. In a demonstrator, for example, augmented reality lets you work out how to install or fit a part. It also makes communicating with people who don't speak your language easier, as they can see the same thing as you and everything can be explained with your hands using the virtual components in the demonstrator.



TIMELINE

WHETHER FOR CRAFTING VIRTUAL DESIGNS, OPTIMIZING THEIR POWER CONSUMPTION OR DEVISING PREDICTIVE MAINTENANCE STRATEGIES, CNES SEES DIGITAL TECHNOLOGIES AS A MEANS TO ASSURE THE CONSISTENCY OF A SPACECRAFT'S DESIGN FROM CONCEPTION THROUGH TO LAUNCH.



INTERNET OF THINGS (IoT) ANTICIPATING FAILURES

The Guiana Space Centre in Kourou covers an area of 1,200 sq.km., so the surveillance of its buildings, spacecraft and networks is a particularly complex task. The task can be made easier by connected objects. For example, any malfunctions of the extensive and power-hungry heating, ventilation and air conditioning (HVAC) system prove costly. By fitting each HVAC element with autonomous connected sensors, the slightest hitch is immediately detected and analysed, and an alert sent before a failure occurs. As a result, maintenance is precisely targeted and predictive, allowing everyone to focus on what matters most. CNES is looking at interfacing multiple sensors with one of the two commercial networks already operating in the Amazon region.

FACTORY 4.0 A COMMON, CONSISTENT PICTURE

Europe's space programme involves many stakeholders spread far and wide. A space engine may be conceived in France and mated with a launcher in French Guiana using parts designed in Belgium and tested in Germany. Such diversity has its plus and minus points, entailing complex interfaces, extensive data transmission and so on. Factory 4.0 or the 'smart factory' concept offers a way to optimize such disparate elements. By automating transmission of part data, enabling collaborative engineering on a single, shared digital model and providing real-time production status information, the connected factory facilitates teamwork from the production floor to the launch pad. A 'call a friend' support system also kicks in automatically in the event of a hitch.



HORIZONS

FABRICE CRASNIER

Computer forensics expert at Scassi Conseil

“Artificial intelligence won’t be a threat, as long as it’s not modelled on humans!”



Serving 10 years in criminal justice and 17 in cybercrime investigation, Fabrice Crasnier observed a “huge rise in offences committed in cyberspace” between 1995 and 2000, which he blames on a “corruption of the tools, not a lack of them”. Today, the information vampires are everywhere—even in our inboxes, trying to steal our private data. And space data isn’t above such misappropriation, like the guy who used Google Earth to plan his escape after a robbery. **“Satellites are just another weapon of war for cyber-criminals,”** says Fabrice. “A recent mass attack reached 25% of the web, via 100,000 connected cameras. And you can do exactly the same with satellites, since the data

travel via the same nodes as terrestrial networks. So, it’s vitally important to protect the processing facilities on the ground.” **Fighting back with the same weapons, Fabrice undertook regular training in the core fundamentals of digital.** “To ensure the digital evidence of a fraud or other offence is admissible in court, we need to be as expert in the technologies as we are in the legal process,” he explains. In 2017, this former ‘cyberpoliceman’ joined security consulting firm Scassi Conseil and the IT research institute in Toulouse (IRIT), where he completed his PhD in AI and its impacts on cybersecurity. Individuals and companies alike need to “restrict data to their primary intended use, not

post them on any and every network,” says the researcher, who’s developing his own home automation system with AI, interconnecting a whole host of devices in a secure, self-contained network. **Asked about the risk of self-learning AI systems taking over the world, Fabrice is optimistic:** “If they’re programmed with positive rules of conduct, they can be collaborative and selfless. AI won’t be a threat, as long as it’s not modelled on humans!”



HORIZONS

THANH-LONG HUYNH

CEO of QuantCube Technology

“With our blend of business savvy, technology and AI, we’re thinking big!”



Paris today, London tomorrow, Bahrain next week... Thanh-Long Huynh is a business globetrotter. “Planes are my second home,” he says. A French national of Vietnamese origin, he travels the world to negotiate with banks, private investors and supranational institutions—all keenly interested in the financial forecasts of his start-up, QuantCube Technology. **Trader and investment strategist from 1998, he formed the company in 2013, inspired by the rise of social media.** “Basically, we capture data in real time to get a lead on the financial markets. By harvesting commodity prices as they emerge, for example, we can predict inflation rates a month ahead of the official

announcements. Other information derived from these big data sources isn’t structured into figures as such, so we use artificial intelligence to analyse it.” **QuantCube can produce immediate satisfaction or social instability metrics, extracted from social media data in a given country,** or predict which cities offer the highest growth potential, based on satellite imagery analytics. All this 6 to 12 months ahead of the game. “We’re working with CNES to unlock the huge opportunities offered by the emerging NewSpace commercial space industry, creating apps to predict the sales figures of carmakers, for example, by counting the number of vehicles at their facilities.”

The visionary start-up already has the edge on the Silicon Valley giants—a success Thanh-Long directly attributes to the 20 data scientists he works with, set to double in the near future. And he’s proud of the team, a “close-knit family of diverse nationalities”. “We’re passionate about what we do and we’re moving forward fast. Strategic partners like CNES are helping us gain and maintain a competitive edge over our rivals.”



HORIZONS

GUILLAUME EYNARD-BONTEMPS

Big data engineer at CNES

“The issue isn’t the processing power needed, but the sheer size of the datasets we’re now handling...”



From gigabytes to tera, peta and now exabytes, data volumes continue to grow, calling for new skills and techniques. **IT engineer Guillaume Eynard-Bontemps owes his big data expertise to five years working on the Gaia project**, with its 3,000-terabyte dataset and Hadoop cluster (see Roundup p. 7). “I was keen to pursue my interest further, and the experience I’d gained seemed to tie in with the issues CNES was facing with the development of big data,” he says. In September 2016, he joined the High Performance Computing (HPC) unit. He describes his role as “a kind of data engineer developing new approaches to storing, handling and extracting usable information from

these unprecedented datasets”.

The HPC unit serves the entire CNES organization, providing engineers, scientists, project planning teams and operational programmes with the IT resources they need for all kinds of applications, from calculating launch trajectories to running complex image processing algorithms. Some of its 600 users consume as much as 3 million hours of CPU time in just six months! “To meet this demand, we have a highly versatile supercomputer, with 370 servers, 8,000 processing cores and 3 petabytes of storage shared between processing nodes and data,” he continues. From user support to operations, development and technology intel-

ligence, the job calls for a “high level of expertise in hardware infrastructure and software development, coupled with a broad background in science and mathematics”. **Looking ahead, Guillaume sees CNES streamlining its data storage infrastructure and working with the teams to address big data issues at an earlier stage in their projects.** “We’re also looking at the suitability of the cloud for outsourcing processing operations, plus the use of AI and machine learning. Because however impressive and popular these technologies might be, they’re not necessarily suitable for every application.”



ETHICS CORNER



JACQUES ARNOULD

WORLDS AS YET UNKNOWN

The world of digital technologies and big data is maybe not so different from space, with its huge dimensions and lack of any definable centre—unless we humans should occupy that place.

Back in the days of the Greek philosophers, Protagoras asserted that “Man is the measure of all things”. So, he might be concerned to see our lives today invaded by such a growing mass of data and information, knowledge and theories, threatening to drown us and sweep us away to an unknown destination. A tidal wave or ‘great flood’ so overwhelming that any effective resistance would seem futile, with no chance of a way out or rescue by virtual Noah’s Ark. We thus seem condemned to live in this floodtide of data, without even thinking about it. And maybe it’s better this way?

PURPOSE TO OUR EXPLORATIONS

This isn’t the first time humankind has faced such a situation. Astronomers in the early 17th century surveyed the skies, their eyes augmented by telescopes, their minds freed from arrogant geocentrism, daring to describe the world as a sphere, its centre everywhere, its circumference nowhere. Subsequent centuries have proved them right: billions of light-years separate us from the possible edges of a universe we call our own, not to claim possession of it, but to distinguish it from the multiple others that may exist in other

dimensions—other universes that will undoubtedly remain unknown to us. Yet, we’ve decided to explore our universe, devoid of centre and boundaries, starting with its nearest frontiers. Human and robotic explorers have ventured beyond our atmosphere to describe new worlds, at the same time looking back at our planet from a unique perspective. On Earth, laws have been passed to make space freely accessible and safe from any claims of ownership, its exploration a privilege for all humanity. Preserving such lofty principles will be easier said than done, however, especially in the face of corporate and private interests. Is the world of digital technologies, with its ever-growing mass of data, any less extensive? Should we not share the challenges and risks of space, as much as the dreams and values it inspires? We mustn’t think the unknown is something simply imposed on us: as we explore it, we also discover what we’d previously imagined, or even constructed. As such, a concern may remain with us: that of giving a sense of purpose to our explorations, that of keeping humankind at the centre of those worlds as yet unknown to us.



INSIGHTS

ASSOCIATION INTO THE DIGITAL FRAY

From talks to barcamps (open events) and participatory, quick-learning workshops, Toulouse-based non-profit association La Mêlée Numérique (lit. 'the digital fray') regularly focuses on the topic of big data. Formed in 2000, it facilitates a whole ecosystem of innovation and digital transformation across the Occitanie region of Southwest France. Its 600 members contribute to collaborative projects via working groups, share content on specific themes and discuss common issues, innovative solutions and practical initiatives. For CNES, it's a source of bright new ideas, networking opportunities and a great way to stay in tune with the region's digital ecosystem. CNES also supports initiatives to develop socially responsible applications, such as the French search engine Qwant, committed to protecting user privacy. La Mêlée also organizes the Homo Numericus festival, which attracted over 7,000 visitors in 2017. At the event, CNES Chief Operating Officer Lionel Suchet hosted a roundtable discussion on big data and the power of the web giants.



DIGITAL GIRLS Climate and equality

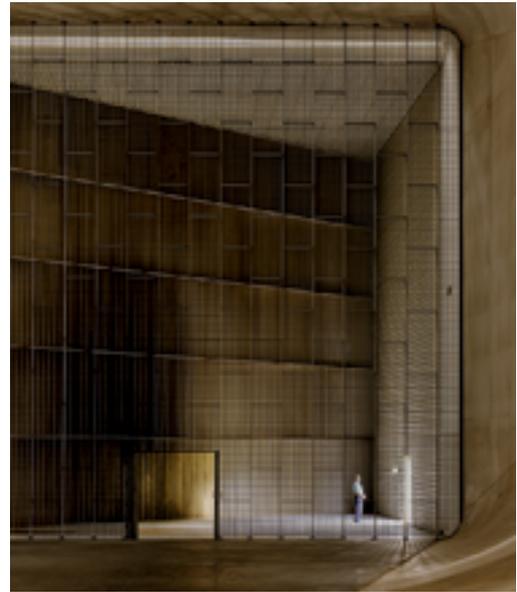
The Digital Girls movement promotes the key role of women in the digital sector, even though they currently account for just 25% of its jobs. The Wo'Mixcity innovation marathon organized by Digital Girls last September was a chance for female-led teams to design and develop solutions to protect the climate and speed the energy transition. CNES was actively involved in the event, which was sponsored by Geneviève Campan and Cathy Lacomme-Verbiguie from CNES.

SYMPOSIUM Big Data From Space

In November, CNES hosted the third Conference on Big Data from Space, organized by ESA, IRC and SatCen. BiDS17 was attended by over 700 delegates from 48 countries and focused on the growing importance of techniques to extract useful information from large datasets. Open access to these datasets is a key success factor and needs to be improved. The next BiDS event is in February 2019 and will be hosted by the German space agency DLR.

EXHIBITION

PAST FORWARD



Vincent Fournier's work combines documentary-style photography with a nod to the silver screen. His *Past Forward* exhibition in Toulouse explores two themes: *Space Project*, revisiting the iconic locations of space exploration, and *The Man Machine*, looking at the evolution of artificial creatures and their role in daily life.

18 January to 1 April at the Galerie du Château d'Eau in Toulouse, open Tuesday to Sunday, 1 p.m. to 7 p.m.



INSIGHTS



DIARY

26-28 JUNE 2018
Toulouse Space Show
France

FEBRUARY 2019
Big Data From Space
Germany

BOOK

ASTRONAUT J.-F. CLERVOY READS ENKI BILAL

13 December 2041. A planet-wide bug wipes out all data. Only one person escapes: an astronaut returning to Earth from a Mars mission... Bug is the new book from Enki Bilal, author of *La Foire aux Immortels* (published in English as *Gods in Chaos*). This sci-fi graphic novel impressed French astronaut Jean-François Clervoy, a veteran of three NASA space missions. *"I discovered Bilal when his first books came out. His drawings are fascinating, real works of art!"* So, what did he make of Bug? *"It's an artist's take on things, of course, but it's no head-in-the-clouds storyline. It*

insightfully shows just how dependent we've become on space, with no way of going back. In a hyperconnected world, what would happen if all data were lost? A few years ago at ESA, we made a short video explaining that a burst of solar activity, on a scale seen every 1,000 years or so, could fry all satellites in Earth orbit, disrupting communications and financial transactions and causing immediate chaos." So, the assumptions behind Bilal's plot aren't fanciful at all, but *"quite plausible"*.

ActInSpace® contest

Initiated by CNES and jointly organized with ESA since 2016, ActInSpace® is an international contest bringing together more than 60 cities around the globe. Participants have just 24 hours to solve a challenge, which involves finding everyday uses for space technologies. Designed for students but open to all, its purpose is to foster entrepreneurship and innovation. The third contest takes place on 25 and 26 May. Some 2,500 entrants are expected, resulting in more than 30 start-ups. The final will be held on 27 June at the Toulouse Space Show.



SPINOFF

CONNECTED RING

With its Aeklys smart ring, Corsican start-up Icare Technologies is set to connect us to the things we use every day in a totally new way. The product should be available in March.



Time to put away your car and house keys, public transport tickets and bank cards! Very soon now, you'll be able to do everything with just one finger. You'll no longer have to worry about losing all those precious things or having them stolen, as they'll all be combined in a ring that only works as long as it's in contact with the first phalanx of your finger. "The system to authenticate the wearer of the ring uses a smartphone app that lets you program and then activate it every time you put it on. After that, it works automatically, even if you forget your smartphone!" says Fabien Raiola, Vice-President Sales and co-founder of Icare Technologies in 2016.

RELIABLE, ETHICAL AND TRANSPARENT

The ring made of ceramic or polymer material isn't itself connected; it simply receives a code from a terminal to which it matches a response. "Aeklys is 95% compatible with all market devices, uses contactless technology and authorizes payments up to €600. Security and protection of your personal data are built in to guarantee a reliable, ethical and transparent system," adds Raiola.

To miniaturize the system, Icare drew inspiration from the technologies used in aircraft and satellites. "The next applications we're developing will be geared towards defence and healthcare. A partnership with CNES, who we met recently, would no doubt help us to further perfect the technology," Raiola affirms. Today, the start-up employs 11 people in Corsica and one in Paris. And as CNES's Directorate of Innovation, Applications and Science (DIA) is keen to nurture partnerships with such entrepreneurial start-ups, there's every chance that Aeklys' wish will be granted.



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Patents assure the ring's integrity