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EN FR

SPACE ● INNOVATION ● SOCIETY

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ISS

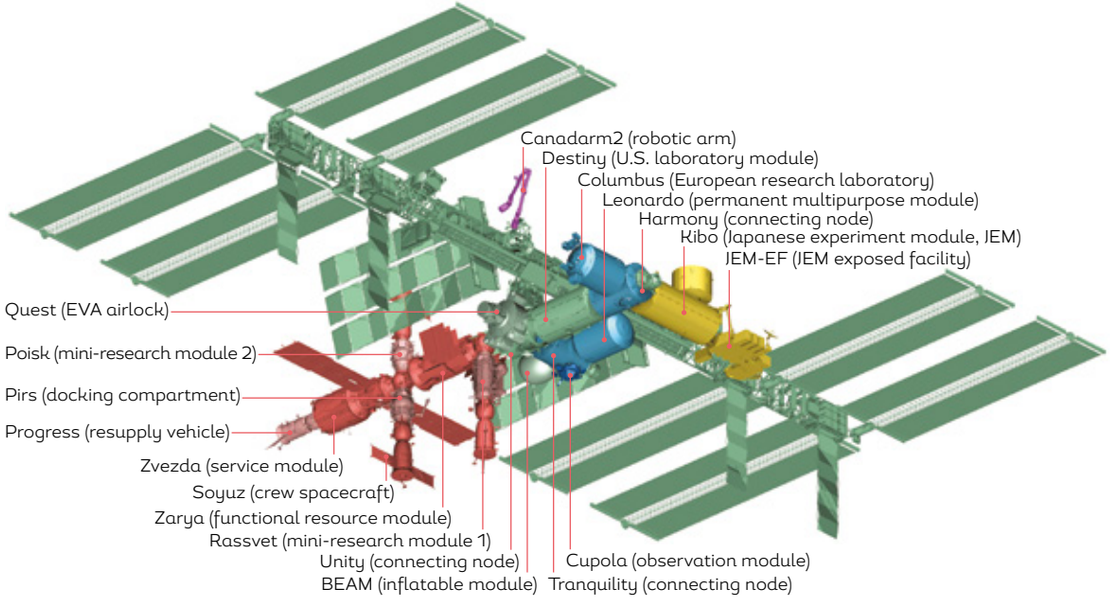
SCIENCE AND PEOPLE

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

INSIDE

THE INTERNATIONAL SPACE STATION

An assembly of modules developed by different partner nations, the ISS is a great example of successful international cooperation. Here's who does what on the station.



PARTNERS

Mentioned in this issue: p.08 – Novespace, the firm specializing in parabolic flights, microgravity and technology spinoff; p.09 – The MEDES space medicine and physiology institute; p.10 – IBMP Institute for Biomedical Problems, Moscow; p.31 – CNRS, the French national scientific research centre; p.36 – Telemedicine firm AdEchoTech and all of the space agencies involved in the ISS (ESA, NASA, Roscosmos, CSA).

More content in this new issue on line at cnes.fr/cnesmag

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CONTRIBUTORS

FRANÇOIS SPIERO

Head of human spaceflight, François Spiero is part of CNES's science, microgravity and exploration team. He's a member of the French delegation to ESA and represents CNES on various international groups. When it comes to astronauts, science on the ISS and preparing for human exploration of the Moon and Mars, there's not much he doesn't know. He helped us with this issue of the magazine and gave his insight into where France is positioned in a fast-changing environment.

SÉBASTIEN BARDE

Head of the CADMOS centre, Sébastien Barde coordinates preparations for microgravity experiments, working closely with scientists and partners. He also monitors operations from the control room and is responsible for data distribution. As project lead for France's contribution to Proxima, he gave us the inside track on how this mission came into being. He also brought all the experiments back to Toulouse for a photo session before they fly to the ISS.

DAVID DUCROS

A child of the Apollo-Soyuz generation, David Ducros has combined his passion for space and drawing. From observation satellites to space probes, he's depicted many spacecraft exploring our Universe for space agencies. For CNESMAG, he's produced a simplified reproduction of the ISS, based on an extremely detailed cutaway of each module that required countless hours of calculations.

CLÉMENT DEBEIR

Head of audiovisual and multimedia production at the agency SapienSapienS, Clément Debeir is passionate about human-digital interactions. A passion shared with the members of the Proxima France team, who he filmed at the CADMOS centre. You can see the video via the digital version 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. Tel.: +33 (0)5 61 28 33 90. Internet: http://www.cnes.fr. This review is a member of *Communication&Entreprises.* Subscriptions: cnesmag@cnes.fr
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EDITORIAL

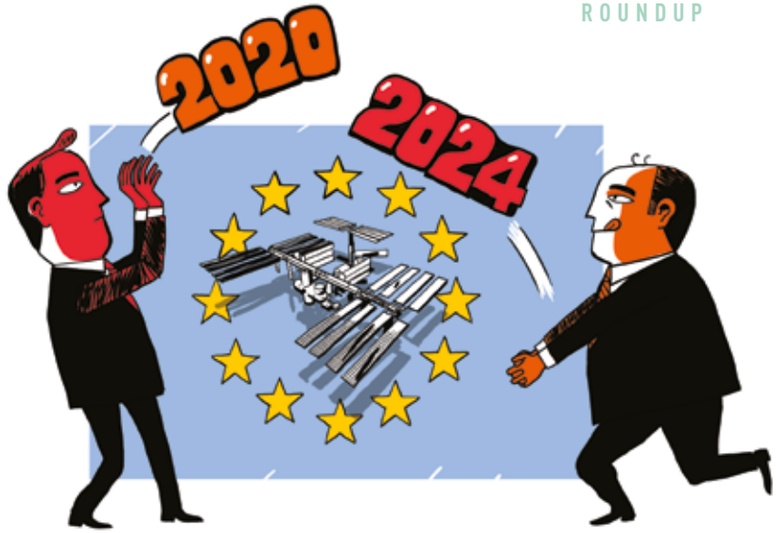
12 April 1961, the date of Yuri Gagarin's spaceflight, is a landmark in the history of humanity. For the very first time, a human being left our planet to explore a new element—space—generating an unprecedented level of excitement. Now, 55 years later, space is still a source of fascination and in a few weeks' time many of us will gather to watch Thomas Pesquet take off from the Baikonur Cosmodrome launch pad, the site of that momentous event in 1961. Space exploration still stimulates the imagination and our entire community is motivated by the possibility of one day landing on Mars. This is why Thomas and his co-astronauts are going to spend six months on board the International Space Station—to learn how to live longer and longer in space. CNES is of course at the forefront of this mission, with our teams hard at work to prepare its scientific experiments and health monitoring, as part of the agreement that we have just signed with Inserm, the French National Institute for Health and Medical Research. Because, while it's true that in our line of business everything usually runs like clockwork, space still remains the final frontier.

JEAN-YVES LE GALL
CNES PRESIDENT

2016

Key space events

Surveying Earth from its 400-kilometre vantage point in orbit, the International Space Station (ISS) is poised for two key events at the end of the year on which France will be casting a close eye. The first will see three new astronauts arriving, among them Frenchman Thomas Pesquet, who will be conducting the Proxima mission designed and planned by CNES and the CADMOS centre for the development of microgravity applications and space operations (see p. 8). And in December, a more strategic event will be taking place in Lucerne, Switzerland, where the ESA council meeting at ministerial level is set to decide on its future contributions to the ISS after 2020.



OUTLOOK

STATION'S FUTURE TO BE MAPPED OUT IN SWITZERLAND

Will ESA pursue its contribution to the ISS after 2020? The Council of Ministers, ESA's governing body, is set to answer this question at the end of the year in Lucerne. Every two years, the space ministers and representatives of the ESA member states meet to set the key objectives of their space policy. In Switzerland, there will be a busy agenda. The agency is already committed to supporting the ISS until 2020, so it may decide to leave it at that or follow the lead of the Russian and American space agencies in extending Europe's contribution out to 2024, in which case it will need to specify on what terms it intends to continue its effort. The Council will also need to think about its involvement beyond 2024 and establish the framework for a new crewed exploration programme.

200

More than 200 people have stayed on the ISS since it entered service 16 years ago. The next crew scheduled to fly to the station is Peggy Whitson (NASA), Oleg Novitskiy (Roscosmos) and Thomas Pesquet (ESA).

INSIGHT

CODENAME PROXIMA

Proxima Centauri in the Centaurus constellation is the star closest to our solar system, lying more than four light-years from Earth.

To find a name for his mission to the ISS, French astronaut Thomas Pesquet decided to solicit proposals via the web. Proxima, suggested by 13-year-old Samuel from Toulouse, came out the winner, continuing the tradition of naming European missions on the ISS after stars, following on from Altair, Cassiopee, Andromede and Perseus. The 'x' stands for 10, as Thomas is the 10th French astronaut to fly in space. The mission comprises 100 experiments the Frenchman will perform aboard the ISS, half of them devised by ESA, plus seven demonstrators conceived by CNES.

VIDEO

Behind the scenes at CADMOS

CADMOS
THE MICROGRAVITY EXPERTS

CNES created the CADMOS centre in 1993 to improve our knowledge of microgravity by planning missions and comparing astronauts' health on the ground and in space. Working closely with French astronauts aboard the Russian Mir space station[1], CADMOS played a key role. In 1998, when ESA became an ISS partner, it decided to deploy a network of platforms of excellence or USOCs[2]. Recognising the skills and expertise CADMOS had acquired, ESA made it the lead USOC for human physiology. France, with its huge investment in the ISS, helped make CADMOS one of the most influential USOCs in Europe. The French centre is involved in every stage of the experiments assigned to it, from planning to in-orbit monitoring and data gathering and archiving. On the ISS, it is in charge of operating the European Physiology Module (EPM). It also helps operate the fluid sciences and biology payload racks. CADMOS works with the astronauts during the mission preparation phase, contributing to their science training, as well as monitoring operations during the flight phase.

1. Launched 19 February 1986, de-orbited 23 March 2001.
2. User Support and Operations Centres.

MORE INFORMATION: **CADMOS.CNES.FR**

VIDEO

All aboard!

NOVESPACE
GOING WEIGHTLESS

Each parabola flown on the Airbus 310 Zero-G aircraft lasts only 22 seconds, but that's long enough to gauge the effects of weightlessness in areas of research suited to short observation times. CNES subsidiary Novespace has been operating this specially equipped Airbus to simulate space conditions since 1986, able to accommodate 40 researchers on each flight. Parabolic flights are cheaper and more flexible than the ISS, which is why they're much sought after by scientists. Experiments can thus be given a trial run on the aircraft before being flown to the station. For Proxima, the protocols used on the Matiss and Aquapad experiments (see CNES in Action, p. 25) and the techniques adopted for Everywear and Fluidics have been tested out. Thomas Pesquet has also spent many flight hours on the aircraft for his astronaut training.

MORE INFORMATION: **ZERO-G.CNES.FR**

VIDEO

Ever wondered what goes on at the space clinic?

ROUNDUP

MEDES
A UNIQUE SPACE CLINIC

They're young, fit and healthy, so you might wonder what possesses them to spend two whole months in hospital. In fact, they're all volunteers checking in to the MEDES[1] 'space clinic' for the cause of 'human science'. Based in Toulouse, this clinic runs regular bedrest campaigns that simulate the weightless conditions of space, with subjects lying in a tilted head-down position for up to two months. In 2015, MEDES innovated with a new technique termed 'dry immersion'[2], a first in Europe. This technique is faster, with immersion taking just three days, providing information about certain deficits that appear when gravity is removed. Created in 1989 on the initiative of CNES and Toulouse University Hospital, MEDES is the only space clinic in the world located on hospital premises, where it can draw on the full range of health expertise present on site. The results of its bedrest work are helping to develop new digital tools that benefit general health practice and e-health services.

1. Space medicine and physiology institute
2. Volunteers are floating in specially adapted baths in which they are isolated from the water

MORE INFORMATION: **MEDES.CNES.FR**

8,400 CANDIDATES

In 2008, ESA issued a call for candidates to join its astronaut corps and received 8,400 applications, a quarter from France. The rest is history, as Frenchman Thomas Pesquet was assigned, along with other Europeans, and since 2009 has been pursuing a full training programme to ready for his flight.

2.2 BILLION

Kilometres travelled by the ISS since 1998. NASA, which published this figure, says it's the equivalent of 10 return trips to Mars. In May this year, the ISS celebrated its 100,000th orbit of Earth.

50,000

Life in space requires astronauts to take good care of their health. Initiated by ESA, eXplore is an outreach and education programme designed to encourage young people to adopt healthier lifestyles, using astronauts as their role models. Classes of volunteers take part in challenges to improve both their health and their knowledge of biology. The mission supports school teachers and offers the opportunity to combat child obesity. More than 50,000 youngsters around the world, 3,000 from France, took part in this cross-disciplinary project this year.

FRENCH ASTRONAUTS WHO HAVE FLOWN IN SPACE

JEAN-LOUP CHRÉTIEN

The first astronaut from Western Europe
Missions:
PVH (1982) - Aragatz (1988)
STS 86 (1997)

PATRICK BAUDRY

Mission:
STS-51-G (1985)

MICHEL TOGNINI

Missions:
Antares (1992)
STS-93 (1999)

JEAN-PIERRE HAIGNERÉ

Missions:
Altair (1993)
Perseus (1999)

JEAN-FRANÇOIS CLERVOY

Missions:
STS-66 (1994)
STS-84 (1997)
STS-103 (1999)

JEAN-JACQUES FAVIER

Missions:
STS-78 (1996)

CLAUDIE HAIGNERÉ

Missions:
Cassiopee (1996)
Andromede (2001)
First French astronaut to fly on the ISS

LÉOPOLD EYHARTS

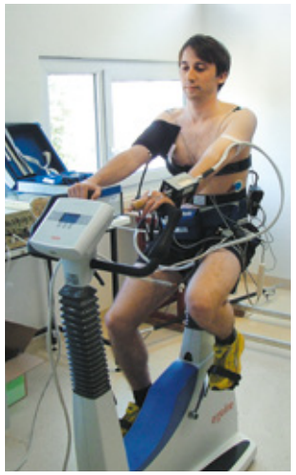
Missions:
Soyuz TM-27 (1998)
STS-122 (2008)

PHILIPPE PERRIN

Mission:
STS-111 (2002)

CARDIO CHECK-UPS

BLOOD CIRCULATION UNDER CLOSE WATCH



Weightlessness disrupts the normal way in which gravity 'organizes' our body's blood circulation. Studying such effects is the domain of CNES's trio of permanent 'cardio' devices on board the station:

• *Cardiomed* is operated on the ground and in space. This multi-data unit is a French-Russian collaboration[1]. CNES developed the main processor from which the instruments and two sensors are connected.

• *Cardiolab* is a French-German contribution comprising several instruments. Readings from each heart beat precisely monitor astronauts' cardiac parameters. Such data will help to gain new insights into fainting and the effects of a sedentary lifestyle in older age.

• *Cardiospace* is a set of instruments developed jointly by France and China to study micro- and macro-circulation. It will fly on China's TianGong 2 orbital module to refine investigations already undertaken with its sister Cardio units.

1. In partnership with the IBMP Institute for Biomedical Problems, based in Moscow.

MORE INFORMATION: **CARDIOMED.CNES.FR; CARDIOLAB.CNES.FR; CARDIOSPACE.CNES.FR**

PHARAO

DETERMINING UNIVERSAL TIME

The current timekeeping standard—the second—is defined by measuring the oscillations of a caesium atom. ESA's ACES instrument (Atomic Clock Ensemble in Space), soon to be installed outside the ISS's pressurized modules, will compare timescales on Earth and in space. France has built PHARAO, the first-ever laser-cooled cold-atom clock, delivered in 2014, for this programme. Scheduled to fly in 2018, ACES could shed new light on Einstein's theory of gravitation and new applications are expected in establishing universal time, navigation, positioning and geodesy.

EXPOSE R2

SUN EXPOSURE IN SPACE

The ISS isn't just a sealed laboratory; it also has the ability to accommodate experiments on its outside 'porch', like the European EXPOSE-R programme comprising nine experiments, among them CNES's EXPOSE-R2 designed to measure the effects of sunlight on certain chemical and biological compounds. EXPOSE-R2 was launched on 24 July 2014. Long-duration observations are set to shed new light on the astrobiology of Titan's environment. Initial results show lower methane consumption than expected (but no change in levels of carbon dioxide). New samples retrieved in June are in the process of being analysed.

DECLIC

WATER IN ALL ITS STATES

'Supercritical' water may offer a solution to the pressing issues of ultimately disposing of waste and reducing pollution, due to the properties it exhibits in this extreme state, and DECLIC[1] is helping scientists to find out. Here on Earth, gravity makes it impossible to precisely determine the interfaces between fluid states (liquid, solid and gas). What happens during state changes is easier to observe in weightless conditions, which is why in October 2009 the DECLIC mini-laboratory was installed on the ISS in an effort to find some answers. It has since been acquiring automatic readings on the behaviour of critical fluids at low and high temperature. Designed to accommodate a range of inserts, DECLIC is able to perform several types of experiments being monitored by CADMOS. Inserts can be returned to Earth on each crew rotation and replaced with new ones. After six years in space, DECLIC has been overhauled on the ground this year and is set to return to the station in January 2017.

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

MORE INFORMATION: **DECLIC-MISSION.CNES.FR**

GASTRONOMY

EATING WELL IN SPACE

After spending six months aboard the ISS, French astronaut Jean-Pierre Haigneré's assessment of the food was blunt: *"The packaged food certified for the station is pretty tasteless and always the same. It's a real downer..."* Because this can affect crew health, it's a more important matter than may first seem, as nutrition has a large bearing on how astronauts' bodies adapt to space. So 'space gastronomy' is more than just a gimmick. CADMOS has since worked with the Souillac catering school and then teams at culinary consultants Ducasse Conseil to devise menus for special occasions. While these meals are much tastier, preparation is no picnic and stringent procedures must be followed to avert all risk of food poisoning and make sure the food is the right consistency for microgravity conditions: too dry, and the astronauts could choke on the crumbs; too moist, and the liquid could cause short-circuits. Maturing the manufacturing process has been an uphill task, but the recipes produced with Brittany-based firm Hénaff have been certified by NASA.

ENERGY FOR THOMAS PESQUET

What are the precise energy needs of an astronaut on a long-duration spaceflight? For now, we don't know exactly, but the Energy experiment is hoping to find out by evaluating four menus. It will also seek to solve the practical problem of how much freight to ferry up to the station to avoid food shortages or, on the contrary, too heavy loads on board.

#COMMUNITY

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

@ THOMAS PESQUET
Astronaute européen français, décollage en Novembre 2016 vers l'ISS / Euro-french astronaut in training for 1st mission to space!

My dinner: calories and quantities measured... Thank you @CNES #CADMOS, and long live research on the ISS;)

@ ARISS PROXIMA 30
Pupils at Boissières and Saint-Dionisy will call the ISS using their amateur radio equipment. More here early 2017.

Pupils in Boissières and Saint-Dionisy will call @Thom_astro on the @Space_Station!

@ PIERRE BUHLER
Former French ambassador to Poland. Były ambasador Francji w Polsce. Autor Anatomia Oszustwa, Polska w czasach komunizmu

Innovation in France: scientists are doing experiments in weightless conditions @CNES on the A310 @AirZeroG.

@ JULIETTE DEMEY
Reporter for the "Le Journal du Dimanche" newspaper @lejdd

At the space clinic @CNES #Toulouse, 12 men testing weightlessness in a bath #MEDES

DEDICATED WEBSITE FOR PROXIMA FRANCE TEAM

Get the latest from Thomas Pesquet via the French-language website dedicated to the Proxima mission. The site also takes you behind the scenes with all the people working on the ground to ensure mission success.
> http://proxima.cnes.fr

YOUTUBE SPACE PARIS

As part of the Proxima mission, CNES is launching a long-term collaboration with YouTube Space Paris, an 80-sq.m. film studio with space backdrops where YouTubers can shoot videos in an exceptional French space industry location. Sign up now!
> http://proxima.cnes.fr/YouTubeSpace

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VIDEO

An out-of-the-ordinary career path

Q & A

THOMAS PESQUET

AT 38, THOMAS PESQUET IS ABOUT TO REALIZE HIS DREAM and will soon be flying to the International Space Station after eight years of hard work. With his departure only weeks away, he talks about his career and his vision for space exploration now and in the future.

YOU USED TO WORK FOR CNES BEFORE JOINING THE ESA ASTRONAUT CORPS. TELL US ABOUT YOUR CAREER PATH SO FAR.

Thomas Pesquet: I graduated from engineering school in 2001 and started out in space engineering at GMV in Madrid. I then joined CNES as a research engineer working on space mission autonomy. It was representing CNES at the Consultative Committee for Space Data Systems that my career began to take a more international direction. As an avid private pilot, I decided in 2004 to enrol on the Air France flight training programme. I logged 2,500 flight hours and became an Airbus A320 instructor. Then in 2008, when ESA began recruiting for a new class of astronauts, I put my name forward. I wasn't sure I'd make it, but I kept at it and passed every stage of the long selection process. And the dream came true when I was chosen in September 2009. At 31, I was the youngest of the six recruits, so I wasn't top of the list for assignment to the ISS. So I just got on with my basic training at the European Astronaut Centre in Cologne. And in March 2014 the news came: Proxima was my ticket to space!

WHAT DID YOUR TRAINING INVOLVE?

T. P.: Training for space is about preparing your body and mind for the extreme conditions of a long-duration mission. The physical preparation, i.e. daily sport and exercise sessions, enables us to endure the forces of the lift-off and re-entry phases as well as mitigate any subsequent effects on our muscles, which aren't used so much in weightlessness. Plus, I'll be involved in an extravehicular activity to perform maintenance on the outside of the station. To prepare for that, I've been doing underwater 'spacewalks' for 6 to 7 hours at a time in the pool at Houston, wearing an American spacesuit. This kind of training is really important, because spacesuits resist movement, so even closing your hand is like trying to crush a tennis ball. Then there's the mental side. Astronauts face a lack of privacy, disorientation as their normal 24-hour body clock is disrupted, plus the sense of isolation. To prepare, we recreate similar living conditions by spending days together as a team, cut off from the world in an extreme environment, such as underwater or in a cave, with an exploration task to carry out.

"I BELIEVE SPACE EXPLORATION IS ONE OF THE MAJOR DRIVERS OF HUMAN PROGRESS. IT CAN TAKE MANY FORMS FROM SPACE TELESCOPES TO THE COLONIZATION OF THE MOON OR MARS."

WHAT NEW SKILLS DID YOU HAVE TO DEVELOP?

T. P.: In terms of skills, basic training brings everyone up to the same level, because astronauts are recruited from a wide range of backgrounds, such as medicine, engineering or aviation. The two official languages on the ISS are English and Russian, so all astronauts must be proficient in both. For me, learning Russian was perhaps the biggest part of my initial training. I spent hours in my study learning my declensions, which isn't the kind of astronaut training you hear about in the media! And of course, you have to know all the elements of the station, memorize all the procedures and be able to correctly handle the 14 racks used for science experiments. The most difficult aspect is reaching the necessary level of proficiency in all these disciplines. It takes a huge amount of time and effort.

WHAT KINDS OF EXPERIMENTS WILL YOU BE CONDUCTING DURING YOUR MISSION?

T. P.: On the ISS, humans, i.e. the astronauts, are the main subject of research. The idea is to take advantage of the weightlessness and other physical parameters of space to conduct research that can't be done so effectively on Earth.

"OUR GENERATION IS REALLY FOCUSED ON THE FUTURE. WHAT CHARACTERIZES US IS THE DESIRE TO GO FURTHER."

THOMAS PESQUET

FRENCH ASTRONAUT

"OUR GOAL ON THE ISS IS TO HELP ACQUIRE THE KNOWLEDGE WE NEED TO INNOVATE..."

The goal for the station's crew is to help acquire the knowledge we need to innovate. And these innovations will apply to the space environment, but also to daily life on Earth. I'll be involved in experiments in a number of fields. Without going into detail, the technology demonstrators on the station will be used to test anti-microbial surfaces, evaluate a simple, low-cost water purification process and improve the way machines can be controlled remotely.

WHAT WILL BE THE MAJOR SPACE MISSIONS OF THE NEXT 20 YEARS? AND WILL YOU BE INVOLVED?

T. P.: I believe space exploration is one of the major drivers of human progress. It can take many forms, from space telescopes for better understanding the Universe to the colonization of the Moon or Mars. For me right now, it's all about this mission, so I haven't really thought about what's next. A lot of people—engineers, technicians, scientists and doctors—are working on the ground around us. The astronauts are at the end of the chain, but we want to be fully focused and do everything we can to ensure mission success. That said, if I was given the opportunity to go on a Mars expedition in 2030, I'd jump at the chance!

YOU BELONG TO A NEW GENERATION OF ASTRONAUTS. HOW WOULD YOU DEFINE IT AND WHAT DOES IT WANT TO ACHIEVE?

T. P.: I indeed belong to the first generation of astronauts born after the first lunar landing. I think our generation is really focused on the future, maybe precisely because we don't carry the weight of past achievements. What characterizes us is the desire to go further, beyond Earth's immediate orbit, and pursue new challenges. We're also more proactive about communicating our experiences, undoubtedly because, unlike our predecessors, we now have the technologies to do that. But we've also got a lot in common with those who went before. We have similar profiles, centred on science and technology, plus the slightly crazy explorer side to us. Since Gagarin, around 550 people have had the chance to see Earth from space. I'm about to join them, and it's really important for me to share this experience with the public. I want to inspire vocations and encourage young people to enter careers in science. Because you're not born an astronaut, you become one. There's no school, no courses. You have to pull all the pieces together yourself to stand a chance. It's like a jigsaw. I had to combine science and engineering studies, skills as a pilot and physically demanding sports. Everything's possible—if you believe in yourself—and it's this positive outlook that I want to promote.

Profile

2001
Graduated from ENSAE, the French national aerospace school in Toulouse.
2002-2004
Research engineer at CNES working on space mission autonomy.
2006
Completed training with Air France and obtained commercial pilot licence.
2009
Selected by ESA to become an astronaut.
2014
Assigned to the Proxima long-duration mission.

ORBITAL WORKSPACE

The Columbus laboratory attached to the ISS since 2008 is one of ESA's contributions to the station. This pressurized orbital workspace gives Europe's research scientists a permanent platform to perform their investigations. Several hundred experiments are conducted every year in fluid science (FSL), biology (Biolab) and human physiology (EPM). The cardiology series of units (see p. 10) is also operated by the CADMOS centre for the development of microgravity applications and space operations.

IN PICTURES

A STEPPING STONE TO MARS

The ISS is a first step in the Martian adventure. All around the world, the idea of establishing a base on the red planet is no longer science fiction but now a stated objective. There are still obstacles to overcome, not least the problems of trip duration, upmass to Mars and life-support systems. In 2010, Mars 500[1] gave a taste of what a long stay on the red planet would involve. Today, interest from private stakeholders in this scientific and human challenge could prove a real game-changer.

1. A Russian experimental programme simulating a return trip to Mars.

FIVE ATVs

The ATV cargo missions were bold in their conception, assembling a sophisticated and secure set of innovations. And of course, each mission was conducted in close collaboration with the ATV Control Centre (ATV-CC) in Toulouse, managed by CNES. The Jules Verne was the first, docking safely with the station. The four subsequent missions simply confirmed the vehicle's technical excellence and the expertise of the ground teams. The final flourish came with the flight of the Georges Lemaître, the fifth and last in the series, which also successfully took part in space debris collision-avoidance operations, without which the consequences could have proved dramatic.

MORE INFORMATION: ATV.CNES.FR

CUBESAT

With its JANUS[1] project, CNES is encouraging students to build nanosatellites and helping to fund them. JANUS is now part of the QB50 network, funded by Europe. Over 10 schools are taking part and two nanosatellites will soon be ready for release from the ISS. X-CubeSat, built by the École Polytechnique, has involved over 50 students in four years. The second, SpaceCube, is currently under construction at the École des Mines. QB50 has four goals: access to space, in-situ and multi-point measurements in the thermosphere, technology demonstration and education.

1. Jeunes en apprentissage pour la réalisation de nano satellites au sein des universités et des écoles de l'enseignement supérieur

AGREEMENT

Space is an extraordinary laboratory. Which is why, on 12 September 2016, CNES and Inserm opted to further their cooperation in the field of space and health. At the Elysée Palace and in the presence of the French President, Jean-Yves Le Gall and Yves Lévy signed their first ever framework agreement relating to advances in basic research made through the study of humans in space, and to the use of space assets for health issues. The purpose of the agreement is to develop methods, tools and services that draw on health-related space technologies, such as the development of connected devices created mainly for human spaceflight and of medical devices. The agreement will also give rise to a wide range of experiments during Thomas Pesquet's stay on board the International Space Station.

Rotation

ON THE ISS, EACH ASTRONAUT STAYS FOR AN AVERAGE OF SIX MONTHS, with half of the crew replaced every three months at each 'rotation'. Thomas Pesquet is part of Expedition 50-51. On arrival, he'll form Expedition 50 with the five other crew members. Then after three months, three of them will be replaced by three new astronauts, signalling the start of Expedition 51.

15,000

In 30 years, Novespace has flown 15,000 parabolas in CNES's Zero-G aircraft over 160 campaigns and observed the atmospheric re-entry of Ariane 5 main cryogenic stages on three occasions.

PROXIMA

PREPARING THE FUTURE FROM SPACE

FRANCE IS SOON SET TO RETURN TO THE INTERNATIONAL SPACE STATION, THIS TIME IN THE PERSON OF THOMAS PESQUET, THE YOUNGEST MEMBER OF THE EUROPEAN ASTRONAUT CORPS. THE FRENCHMAN WILL BE TAKING ADVANTAGE OF THE MICROGRAVITY CONDITIONS IN THIS ORBITAL LABORATORY TO PERFORM A WHOLE SERIES OF SCIENCE EXPERIMENTS, INCLUDING SEVEN DEMONSTRATORS CONCEIVED BY CNES, ALL WITH PRACTICAL REAL-WORLD APPLICATIONS.

France might have been expected to play only a bit part in the space adventure, but its boldness decided otherwise and it wasted no time getting on board with a significant human and scientific contribution. From the 1980s onward, working with the world's two space superpowers, the United States and Russia, it was closely involved in the first human spaceflights and in 1981 CNES selected Jean-Loup Chrétien and Patrick Baudry as the first two French astronauts. France and its space agency thus stole a march on the rest and began to develop undisputed expertise. In 1985, at the Rome Conference, European nations were still reluctant to commit to a European space effort. France, however, firmly believed that joining forces was the way to go and its proactive stance helped win over its more-hesitant counterparts. Europe's space programme thus began to take shape, including plans to get involved in the space station.

15

nations

The ISS is a vast science endeavour developed by 15 nations: Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Russia, Spain, Sweden, Switzerland, the United Kingdom and the United States.

PVH mission, 2 July 1982: Jean-Loup Chrétien returns to Earth in a Soyuz capsule.

EUROPE'S FIRST IS FRENCH

France took its first steps in space with Russia in 1982, when Jean-Loup Chrétien joined the crew of its Salyut 7 space station, in the process becoming the first western European astronaut to fly in space. Patrick Baudry would follow him in 1986, only this time with a new partner, flying on NASA's Discovery space shuttle. The previous year the U.S. space agency had unveiled its concept of a 'space laboratory', with the firm intention of engaging in microgravity science. ESA and the Canadian and Japanese space agencies soon joined the project, followed by Russia. At the same time, France continued its progress and in 1986 CNES created the MEDES space clinic (see p. 9) to monitor astronauts' health and spin off the results of its work in space to benefit public health. In 1993, it created the CADMOS centre (see p. 8) to give research scientists a high-level tool for preparing and keeping track of microgravity science experiments. CADMOS has since become a User Support Operations Centre (USOC) and is today the lead operations centre for the European Physiology Module (EPM), one of four European modules on the ISS. In 2000, Europe formed a single astronaut corps and Jean-François Clervoy would become the first French astronaut to fly under the European flag. Fast forward to 2016, and Thomas Pesquet has been assigned to the upcoming Proxima mission, confirming France's renewed involvement in human spaceflight and the advance of science. China is also making no secret of its lunar and orbital station ambitions and has already launched its first prototype space station. It could be a future partner for Europe.

STATION USE FAIRLY SHARED

Selected by ESA in 2009, Thomas Pesquet will be living the adventure from the inside as he passes over his home country up to five times a night. But his mission will be very much an international one, since the ISS is a broad scientific collaboration with carefully apportioned roles for each partner. The ISS in fact comprises two segments: the Russian Orbital Segment (ROS) and the U.S. Orbital Segment (USOS), connected by an airlock. The Russian segment consists of five modules, entirely controlled by the TsUP flight control centre in Moscow. The U.S. segment is supervised by NASA but with contributions from the European, Canadian and Japanese space agencies. The rules governing contributions to the station and its use are set out in a series of agreements. In return for their investment, the partner nations gain astronaut time, as with Thomas Pesquet's mission, or the ability to conduct experiments on the station. ESA's contribution is twofold. First, it resupplied the station with its five ATVs[1]. With the launch of the last ATV in July 2014, the Georges Lemaître, ESA fulfilled its contract. The agency's involvement also includes the Columbus laboratory, installed in 2008. Other contributions may be formalized through specific agreements such as that between ESA and CADMOS.

In the foreground, Europe's ATV-2 Johannes Kepler resupply vehicle berthed to the International Space Station.

8.3%

As the main contributor to the U.S. module of the ISS, NASA's potential share of its use is just over 76%. Europe gets 8.3% in line with its contribution.

1. Automated Transfer Vehicle

The French astronaut training in the pool at the Gagarin Training Centre in Russia.

INNOVATION ON THE ISS: HOW IT WORKS

The CADMOS centre has been working flat out to plan and develop the experiments for France's Proxima mission and provide Thomas Pesquet with the best possible 'tools' for advancing science and technology.

VIDEO

Science made in France

The moment France has been waiting for is almost here: eight years after Léopold Eyharts, Thomas Pesquet is set to fly to the ISS in mid-November. He has been getting ready for this mission at the astronaut training centre in Cologne since 2009. On the station, he'll be performing dozens of French, European and international experiments. This 'astronaut time' and the associated storage space, electricity and other services allocated to France by ESA are valuable and will enable Thomas Pesquet to make the most of his stay on the station.

FREE SPACE AND REAL-WORLD APPLICATIONS

With each new mission ferrying new supplies to the station, free space is at a premium. Thomas Pesquet will therefore be travelling light, with just 25 kg of 'upmass' allocated to CNES. Like the other science programmes, Proxima must make maximum use of equipment already on board. Another key constraint is the mission's objective as, like all others on the ISS, Proxima is expected to have spinoffs for society and not just do science for science's sake. "*With Proxima, France is playing its part in laying the groundwork for the future*," affirms François Spiero, in charge of human spaceflight programmes at CNES.

PRIORITY TO LIFE SUPPORT

Planetary exploration is a central focus of work on the ISS. In 2006, 15 of the most influential space agencies—among them NASA, Roscosmos, JAXA, ESA and CNES—came together to reflect on the value of the peaceful exploration of outer space and formed the ISECG[1] working group to establish an international roadmap. This authoritative document sets out a number of themes and offers the perspective of putting humans on Mars as an ultimate destination. But this isn't an end in itself; the value of the plan lies in the stepping stones to get there. To achieve these aims, life support is going to be a vital issue. "*The ISS is precisely a tool adapted to developing life-support experiments within the broader perspective of planetary exploration, and life support also holds great potential for applications benefiting society*," notes François Spiero. Here he echoes one of the recommendations of the report on space strategy[2] recently submitted to the French government by Geneviève Fioraso. In her report, the former Minister of Research advocates "*investing in niche technologies like life support where France has recognized expertise and innovations can be diffused to other sectors*." With the demonstrators Thomas Pesquet will be operating on the ISS, CNES has followed this line of thought and given priority to life support.

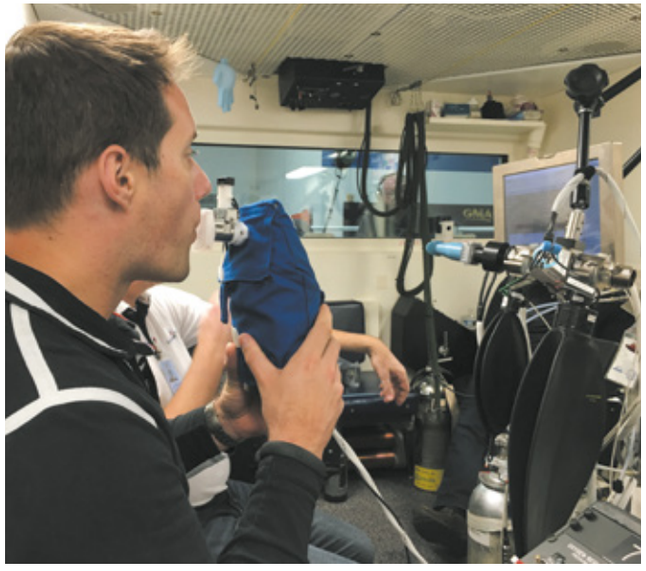
BROAD RANGE OF PARTNERS

Proxima is focused on conceiving innovative techniques and instruments. To devise the mission's experiments, CNES turned to MEDES and acclaimed academic partners like CNRS, the French national scientific research centre, and INSERM, the French national institute for health and medical research. It has also worked with leading French manufacturers in their field, especially Airbus Defence and Space and bioMérieux, and has created momentum within the SME and start-up community. More broadly, Thomas Pesquet is seeking to engage Europe's citizens as partners on his mission and share his adventure with them, since they will ultimately benefit from the results. He's been very active on social networks and across various media to establish contacts he'll be maintaining once aboard the station. His return next year will be awaited with the same eager expectation as his departure. ESA's youngest astronaut has succeeded in creating a real buzz around his mission with junior-high and high schools, and Proxima is set to produce a rich and exciting harvest of results for scientists and up-and-coming generations alike.

1,300

Thomas Pesquet maintains a high-profile presence on social media with lots of followers. The online call for ideas to name his mission attracted more than 1,300 entries.

1. International Space Exploration Coordination Group
2. Open space as a response to the challenges facing the space sector (26 July 2016)



Physiology experiment (respiratory tests).

DEMONSTRATORS
CONCEIVED BY **CNES**

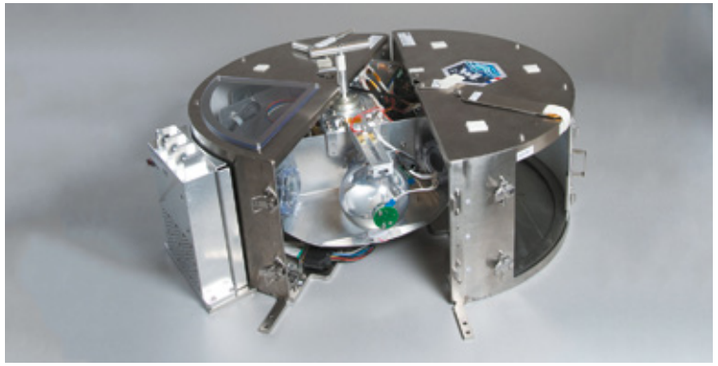
Thomas Pesquet will be kept busy on the station, with a whole host of science, technology and educational experiments to perform. Some of the experiments selected by CNES are directly derived from the world of research. Others have been devised by French laboratories at the forefront of technology. We look at some of the innovations ahead.

The ISS is the largest man-made structure ever built in space and took 13 years to assemble. It is above all a permanent laboratory and observatory watching over Earth. The initial three-strong crew when it began operating in 2000 has been increased today to six, and next year it will be extended to seven. Modules have been added progressively over the years to form a disparate but fully functional assembly. The crew has several laboratories at its disposal, including the U.S. Destiny, Japanese Kibo and European Columbus modules, where they handle experiments and gather data every day.

CADMOS will soon be adding the Proxima mission to the rota of experiments it's already working on. "*Out of 100 experiments, 22 will be managed from CADMOS on behalf of ESA and CNES. New technologies have been employed to enhance the interface with scientists and, if necessary, we'll be able to adjust experiments in real time*," says Sébastien Barde, the CADMOS centre's director. The French space agency is also contributing through seven demonstrators developed for the European ELIPS programme (see box p. 26). Several were inspired directly by the conclusions of the last future space science seminar at La Rochelle in 2014. These seminars are key events for the research community that give CNES the opportunity to issue calls for projects likely to lead to experiments being proposed for the ISS.

Inside the European Columbus laboratory.

CNES IN ACTION



Fluid physics

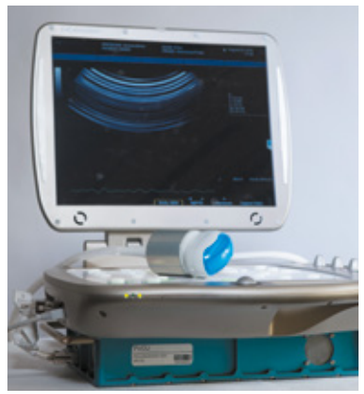
Fluidics: liquids in the engine

Despite the space sector's maturity, progress in two fields of study has so far been slow. CNES and Airbus Defence and Space are hoping to remedy this by studying certain phenomena like liquid sloshing in microgravity and wave turbulence. The results recorded by the Fluidics device are expected to be used in the space industry, notably to improve satellite pointing (see Materials, p. 27).

Physiology and health

Everywear: wearable health monitoring

Checking up on astronauts' health at the click of a mouse will now be possible. The Everywear garment Thomas Pesquet will be wearing is fitted with portable sensors. Using an associated tablet/iPad application, Everywear will send back data to CADMOS on the astronaut's nutrition and medication. The device was conceived in partnership with the University of Caen and INSERM, and the sensors by young and innovative French firms (Bodycap and Citizen Sciences). This system could find applications in monitoring chronic diseases.



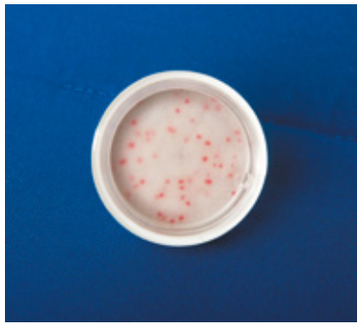
Echo for remote ultrasound scanning

The Echo tool developed by CNES will be used by the Canadian Space Agency (CSA) for its Vascular Echo experiment. Echo is built around telemedicine technologies, a field where the French space agency has extensive expertise. Via Echo, a physician on the ground will perform ultrasound scans on Thomas Pesquet and tele-operable probes will send back optimized images of his blood circulation and organs. This kind of tele-operability could resolve the problems associated with doing scans on patients in remote, hard-to-reach areas.

Perspectives: when the brain loses its bearings

When you can no longer tell up from down, or when you're unable to stand, the brain has to work overtime to keep control over your body. The Perspectives device has been built from a high-definition, virtual-reality occulting helmet with stereoscopic vision. A dedicated application immerses the astronaut in the chosen environment. A series of tests in microgravity conditions will provide new insights into how the central nervous system works and could benefit research into the effects of ageing.

Life support

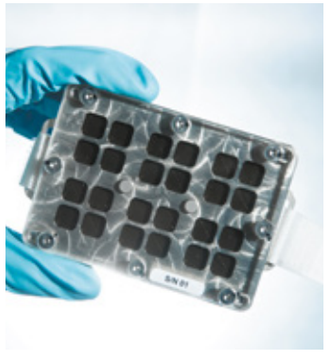


AquaPad for access to drinking water

Microbial contamination is an astronaut's worst nightmare and checking drinking water is a time-consuming but unavoidable task. Working with bioMérieux, CNES is going to test a simplified technique for quantifying bacteria securely and reliably. If validated, this technique could be used on a regular basis on the station to make the crew's daily life easier. Here on Earth, it could be used when supplying drinking water in the wake of natural disasters or in countries where access to clean water proves problematic.

Matiss for antibacterial services

Keeping the station clean is another unavoidable chore. The École Normale Supérieure in Lyon has devised an experiment for CNES to test innovative surfaces and coatings in microgravity designed to avert proliferation of bacteria. These new-generation surfaces would save time spent cleaning on the station. They could also be used in other places where cleanliness is paramount, such as hospitals and public transport.



Teaching

EXO-ISS: Getting youngsters on board

In recent years, the European and French space agencies have been proactively involving young people in various space projects. Proxima provided a fresh opportunity to get them interested in space. In 2015, CNES issued an unprecedented call for projects from schools and universities. Three experiments have been chosen and will be performed by Thomas Pesquet, under the acronym EXO-ISS (EXperiment in Orbit): Ceres (plant germination and growth), CrISStal (crystal growth) and CatalISS (enzyme growth). Partner schools and universities in France and Europe will be running the same experiments on the ground and comparing their results with those obtained on the station. CNES and ESA will be sending out kits to their networks of schools and universities.

ELIPS

A LONG-HAUL EUROPEAN PROGRAMME

In 2001, ESA conceived the ELIPS[1] programme to structure its microgravity science effort. This optional programme is quite separate from the ISS programme, so member nations are free to join or not. France is involved in both. ELIPS has two objectives. The majority of resources are devoted to supporting science work on the station. Thomas Pesquet will be operating a number of experiments for the programme. But ELIPS also funds other microgravity science activities outside the ISS, like parabolic flights, bedrest[2] campaigns run by the MEDES space clinic and certain missions at the French-Italian Concordia research base in Antarctica, where the extreme conditions are similar to those on a space station. Indeed, it's often used as an analogue by space agencies to conduct specific experiments.

1. European programme for Life and Physical sciences in Space and applications utilising the International Space Station.
2. See p. 8-9

DANCE OF THE FLUIDS

WHAT DO WE KNOW ABOUT HOW FLUIDS BEHAVE IN SPACE? We know they move about a lot. Freed from gravity, fuel forms bubbles that move around inside a spacecraft's cylindrical tanks, affecting satellite performance. The purpose of the Fluidics project is to better understand and control such phenomena. To this end, CNES and Airbus Defence and Space have devised an experiment based on three transparent spheres subjected to centrifugal force. Two cameras will continuously film the fluids inside the spheres at rest and when they're moving. The data obtained will then be compared against known models and analysed to help control fluid movements. Installed in the Columbus laboratory by Thomas Pesquet, Fluidics will also be monitored with interest by the Ecole Normale Supérieure in Paris to study wave turbulence in microgravity.

VIDEO

How Fluidics works

ONBOARD

DAILY LIFE

A METICULOUS **ORGANIZATION**

A normal day on the ISS starts at 7:00 UTC[1] sharp. A bell wakes the astronauts and they climb out of their rest compartments to inspect the station and hold a first briefing with NASA. After breakfast, they do science work up to the midday one-hour break. Work then continues in the afternoon, alternating with the mandatory exercise session. The crew usually have dinner together and Saturday evenings are a more social occasion when they take the opportunity to share a special meal.

1. Universal Coordinated Time, the global time standard.

OBJECTIVE #1

SCIENCE COMES FIRST

The ISS is first and foremost a science laboratory and the crew spend most of their time working on science and technology programmes. Each nation performs its own experiments but may also contribute to international collaborations. Some devices are permanently on station, like DECLIC and the Cardio series of units, which will be joined in 2018 by the PHARAO atomic clock (see p. 10-11). For safety-critical tasks like extravehicular activities or collision-avoidance manoeuvres, it's 'action stations' for all crew members.

THE ISS IS A CO-WORKING SPACE, NOT A HOLIDAY CAMP, AND EACH CREW WORKS TO A TIGHT SCHEDULE TO FULFIL THEIR MANY MISSIONS. WE TAKE A BEHIND-THE-SCENES LOOK AT LIFE ON THE STATION...

SAFETY

MAXIMUM **AUTONOMY**

The crew is also responsible for cleaning and maintaining the station. Any contamination on board would be disastrous, so this is a vital task. Since 2009, the station has been accommodating a permanent crew of six, which means that fungus, moulds and bacteria mustn't be allowed to take hold. From a maintenance viewpoint, glitches can sometimes develop on certain modules that have been on the station for 15 years and the crew has to resolve them with assistance from teams on the ground.

LEISURE TIME

WEEKENDS ON THE ISS

Astronauts work a five-day week and have two days off. At the weekends, they can spend some of their free time in the Cupola, a panoramic observation post that affords breathtaking views of Earth, or indulge in their usual hobbies and activities. They also take their role as ambassadors of our planet very seriously, finding time when they're not working to communicate with young people, schools and the public through radio link-ups or social media.

BRIGITTE GODARD

Thomas Pesquet's physician.

"Medically supporting an astronaut is a demanding role..."

Six months before astronaut Thomas Pesquet's departure for the ISS, Brigitte Godard has a busy schedule. Germany, America, Russia—providing medical support for an astronaut is a demanding role. Stressful at times, but exciting. It was an article in Ciel & Espace magazine about French doctor and former astronaut Claudie Haigneré that convinced Brigitte Godard, who'd always dreamt of space, that it *"might actually be possible"*. She studied medicine, furthered her knowledge of space medicine and held onto the dream. *"I was keen to join the MEDES space clinic in Toulouse and eventually the door opened, so I left the locum work I was doing in Paris and moved down for a three-month post."* **Brigitte Godard was involved in the Bedrest experiment in 2005, then became an astronaut physician.** Medical supervision of an astronaut covers three phases: two years before, six months during and up to a year after the mission. Although selection involves stringent physical evaluation, the training and stress can reveal weaknesses, which need to be monitored. In space, astronauts take part in human physiology experiments, supervised by their doctor. *"Once a week, I'll have a private medical consultation with Thomas for at least 15 minutes,"* she says.

The return to Earth is a particularly busy time medically and astronauts need continuous support while their bodies readjust to gravity. After three weeks, the doctor officially 'discharges' the astronaut, but will ensure everything has returned to normal after about a year. Most of Brigitte Godard's work with Thomas Pesquet is at ESA's European Astronaut Centre in Cologne. *"Outside the time spent with Thomas, I write a lot of reports and am taking German and Russian lessons as well as doing a medical degree in German,"* she adds airily. She also studies and practices Taoist and herbal medicine, just to keep her feet on the ground!

STÉPHANE BLANC

Research Director at the Hubert Curien Multidisciplinary Institute (IPHC)[1] in Strasbourg

"Space research is paving the way for new treatments..."

Since 1996, Stéphane Blanc has been working with CNES on energy and nutritional adaptation to microgravity in humans and animals. And astronauts aren't the only subject of his innovative research. **His central focus is the link between physical inactivity and physiopathology, with a particular interest in the Fula people of Africa, which are becoming increasingly sedentary, and bears, able to withstand all kinds of change during hibernation.** His work is seeking to answer such questions as how these living beings adapt physiologically to new environments and what strategies could reduce the effects of change. During a spaceflight, most physiological functions adapt, as reflected in muscle wasting, bone loss and weakening of the cardiovascular system. Effectively, the organism diverts resources away from what's no longer useful. *"To maintain the health and performance of astronauts, scientists have developed a set of protocols to mitigate the effects of life in space,"* says Stéphane Blanc. *"From the first missions, astronauts have been subject to a strict regime of physical exercise. Today, nutritional, pharmacological and even psychological countermeasures are being developed. But the body fully adapts to space, and almost all astronauts return in good health."* **Physiology studies on astronauts are benefiting research into the chronic conditions of our time, such as obesity and type 2 diabetes, as well as ageing** and metabolic, cardiovascular, muscle and bone disorders caused by sedentary lifestyles. Today, lack of physical activity is one of the leading causes of preventable death, on a par with smoking. *"Space research is paving the way for new treatment approaches for people around the world, with some programmes involving dozens of international teams,"* he concludes.

1. Part of CNRS, the French national scientific research centre

CLAUDE CARRIÈRE

Space upholsterer.

"I'd been asked to make a cap for a dog before, but a material kit for a space mission—that was a first!"

Claude Carrière, an upholsterer and registered guild member based in Toulouse, still smiles about that first space order. **In 28 years of working for CNES, he's produced boxes, cases and all kinds of containers** for the food, computers and science equipment taken into space. As a craftsman, now nearing retirement, he's guided by the principles of good relations, quality and meeting deadlines. "*In the early days, we would make five models of a product for testing, qualification and the flight. Today, we just make one.*" The upholsterer works from precise plans provided by CNES, which allow no room for error, giving him real peace of mind. **The materials are chosen to meet the specific requirements of space. They include a flame-resistant cotton called Nomex, used to make the suits worn by firefighters and racing drivers.** Another example is Plastazote foam, which lines the storage containers. It's light, comes in various thicknesses and has anti-static properties, making it ideal for space. For the Proxima mission, Claude Carrière and his employee Richard have produced 30 such containers. **Space orders account for 20 to 25% of production, depending on the year.** Most of his upholstery is for cars, motorcycles, boats, furniture, dentist chairs and physio tables. Asked whether working for the space sector is unusual in any way, he replied: "*We've never worried about that. What's most important is developing good personal relations.*" And it seems the relations he's forged with CNES through its CADMOS centre[1] couldn't be better.

1. CADMOS centre for the development of microgravity applications and space operations

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

ETHICS CORNER

JACQUES **ARNOULD**

ECCE HOMO

The highest vantage point for observing and monitoring our planet, and the first stepping stone to new cosmic frontiers, the International Space Station is also a unique place for contemplating our humanity.

We all find it useful to take a step back from situations and get some perspective, especially when things are complicated or we just can't find the answer. Yet the alchemy at work when we take a more 'elevated' view of our natural or social environment is equally effective when it comes to considering our human nature. When those few men and women take temporary leave of terra firma to enter terrestrial orbit, they not only experience the 'overview effect', the paradigm shift in awareness as they view our planet differently, they also embark on an incredible journey into the heart of their own humanity. Thus, the doctors and biologists who observe them, using ever-more sophisticated instruments, gain a first-hand insight into the secrets of the human body that only weightlessness can reveal. And strangely, such a pilgrimage into the ancient realm of the gods, far from affording eternal youth, actually makes our astronauts age faster. Researchers are working to figure out the extent of these changes as well as the processes by which they recover their abilities and return to normal after they arrive back home.

A STRANGE TRIBE

A microcosm of life on our planet, placed at the far edge of the atmosphere, the space station is home to an international human community, proud bearers of their respective flags, who form, with those who remain on the ground, a 'tribe' with its own culture and language. Though not necessarily unified, they're nonetheless made uniform through decades of cooperation. A strange tribe, more mosaic than homogenous mix, whose parts nonetheless need each other in the face of the vagaries of the cosmos, which could at any time stand in the way of the nations engaged in this unique adventure. I remember the picture of an astronaut, taken aboard Mir, Russia's famous orbital station. He was looking through the window of his space dacha, his face illuminated by the light from outside. I wondered what he was thinking about. The planets, stars and galaxies yet to be discovered? Or his family and friends, his fellow humans, from whom he was now separated? On the space station, confronted with the hostility of the cosmic environment and the lack of privacy inherent in any small group in a confined space, each astronaut, officially an 'envoy of humanity', is constantly faced with the age-old question: Who am I? Who are you? Who are the others? And ultimately, what does it mean to be human? Ecce homo: behold the man.

BOOK

WHAT IF YOU NEED TO PEE IN SPACE?

Pierre-François Mouriaux, aka Cosmopif, has brought out a new book, published by Fleurus as part of its *'Petites et grandes questions'* collection. Illustrated by Halfbob, *Comment on fait pipi dans l'espace ?* answers the questions children ask about life in space: work, leisure time, meals, contact with the outside, etc. Essential reading for any budding astronaut aged 8 or over!

Comment on fait pipi dans l'espace ?
by Pierre-François Mouriaux – Illustrated by Halfbob – Published by Fleurus – 48 pages – €8.90

PARTNERSHIP

Thomas Pesquet connects with youngsters

As part of the Proxima mission, CNES has teamed up with French publishers Milan to bring space culture to young people. A series of articles in *Géo Ado* magazine, a special edition entitled *Un Jour, Une Actu* (one day, one news story), published to coincide with the French astronaut's departure for the ISS, factsheets for teachers and a competition in *Wapiti*, *Julie* and *Géo Ado*: *"Imagine your life in a spacecraft and share your idea with Thomas Pesquet…"*—these are just some of the educational initiatives devised by CNES's Youth & Education department. On the ISS, Thomas Pesquet will announce the names of the three youngsters who most impressed the judges with their drawings, photos and words. He'll also talk about the highlights of the mission so far.

ANNIVERSARY

French Academy of Sciences turns 350

Two major events will mark the 350th anniversary of the Académie des Sciences: World Science Day on 27 September and a link-up with the ISS on 6 December 2016.

TUESDAY SPACE TALK

HEALTH IN SPACE

"The body and space travel" is the theme for the first Tuesday space talk of 2017. The speakers are François Spiero from CNES, astronaut Jean-François Clervoy and Franck Lehot from Novespace. They'll be talking about the physiological effects of microgravity on the human body (osteoporosis, muscle wasting, heart disorders, balance disorders, etc.) and their reversibility.

FIRST

SPACE POETRY ON THE ISS

During his stay on the ISS, Thomas Pesquet is set to perform, a highly original artistic experiment at the initiative of the Observatoire de l'Espace[1] called Télescope Intérieur (inner telescope), devised by American artist Eduardo Kac, inventor of the concept of 'holopoetry'[2]. Once launched and free from the shackles of gravity, two shapes cut out of paper will form the three letters of the word 'moi'. The text will become a mobile sculpture: depending on the angle, characters may or may not be visible as the shapes move, or people may see an abstract pattern or figurative representation. Télescope Intérieur will be an instrument of observation and poetic reflection to help us rethink our relationship with the world.

1. CNES's arts and sciences laboratory
2. Three-dimensional floating texts

DIARY

20 OCT. 2016 – 31 DEC. 2018
Astronauts
Temporary exhibition
Cité de l'espace, Toulouse

17 JANUARY 2017
The body and space travel
Tuesday space talk
Café du Pont-Neuf, Paris 1er
www.cnes.fr/mardisdelespace

SYMPOSIUM

Toulouse to host 30th World Congress of Astronauts

The 30th World Congress of Astronauts in 2017 will be held in Toulouse. Around 100 astronauts and scientists will gather from 4-8 September to discuss future exploration programmes. The 2017 event comes at a busy time, with the Proxima mission, 20 years of the Cité de l'espace and Toulouse chosen as the European Capital of Science 2017–18, as well as chairing the Community of Ariane Cities (CVA). Delegates will spend a day meeting students at schools and universities across France. The Cité de l'espace, which is hosting the event, will also hold an open day for the public.

ULTRASOUND
A TELE-OPERABLE PROBE

Research scientists and engineers sometimes use spaceflight conditions to develop solutions impossible to conceive on Earth. The tele-ultrasound scanning technology developed by CNES for medical practitioners is a good example...

With astronaut time at a premium, science experiments in space have to be conducted in record time. But ultrasound scans, vital for health monitoring, are too complex for astronauts to fit them into their already busy schedule. CNES's R&T team therefore sought ways to make them quicker. "*The precise positioning of the probe was where we found most margin for improvement*," explains Sébastien Barde, Director of the CADMOS centre for the development of microgravity applications and space operations. "*Positioning the ultrasound probe is difficult, particularly in space where the body's organs move about. So finding the right angle when using it on the ISS is particularly time-consuming.*" The solution is simple: hand control over to a physician on the ground to scan the astronaut on the station.
Tele-ultrasound scanning technology was designed for space, but it could also benefit the medical sector, which wouldn't have invested in costly research for such a small niche market. Hospitals could now offer ultrasound scans to patients in remote areas, with the sonographer guiding the physician holding the probe using tiny movements to achieve the right position.
The R&T work conducted in the tele-ultrasound scanning field by CNES's teams since the 1980s has enabled its subsidiary AdEchoTech to apply advances accomplished in space for the benefit of patients on Earth with its Melody robot.