CNES MAG

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SPACE ● INNOVATION ● SOCIETY

#73
July-August 2017

HEALTHCARE

NEW INSIGHTS FROM SPACE

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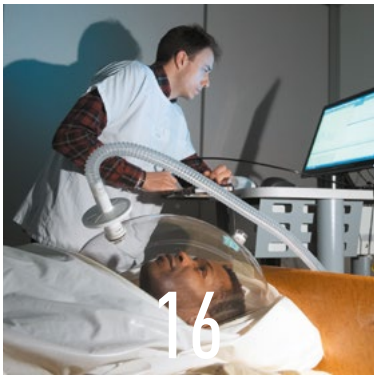
INSIDE



05
EDITORIAL

06
ROUNDUP
Cardiovascular complications, bone loss, nutrition and epidemics: how CNES is helping myriad health applications

12
#COMMUNITY
CNES's followers tweet about medical advances made possible by space

13
Q&A
Famous French doctor and radio/TV presenter Michel Cymes reveals how he's developed a special interest in astronauts' health

16
IN PICTURES
Bedrest and Emergesat serving healthcare

18
IN FIGURES
Space and public health make a great match

19
CNES IN ACTION
How CNES is using space as a research laboratory to derive health benefits on Earth

27
MATERIALS
MATISS cleaning up in space

28
TIMELINE
CNES's Diabsat diabetes screening truck comes to patients in the home

30
HORIZONS
• Christine Rozand, Head of the Innovative Programmes team at BioMérieux
• Raymond Le Moign, Director of Toulouse University Hospital and President of MEDES
• Elisabeth Rosnet, Psychologist and sports psychology lecturer at the University of Reims

33
ETHICS CORNER
In praise of family doctors, by Jacques Arnould

34
INSIGHTS
Exhibitions, books and events produced and supported by CNES

36
SPINOFF
ConsultStation® medical cabin validated by CNES

PARTNERS

Mentioned in this issue: p.07 Angers University Hospital and University of Strasbourg; p.08 University of Saint-Etienne and Paris-Descartes University; p.09 IMBP, the Russian institute of biomedical problems; p.10 University of Montpellier; p.11 Hubert Curien Institute (IPHC/CNRS) and Institut Pasteur; p.05-26-31 Toulouse University Hospital; p.27 LETI applied research centre for microelectronics and information and healthcare technologies (CEA), Saint-Gobain laboratory (CNRS); p.30 BioMérieux; p.32 University of Reims; and the U.S. (NASA), German (DLR) and European (ESA) space agencies.

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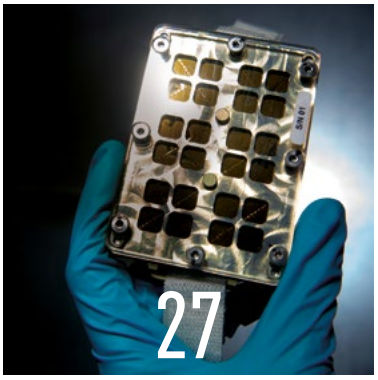


P.09

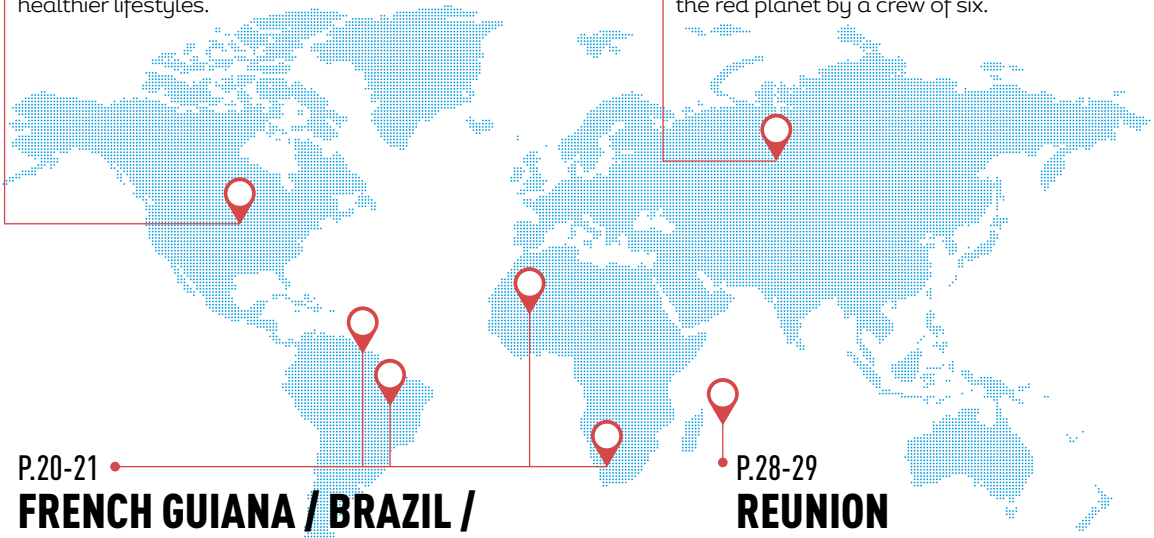
UNITED STATES

NASA is very active in combating obesity and sedentary lifestyles among the younger generations through its Mission X international health education programme for 8-to-14-year-olds. The programme encourages them to train like astronauts and adopt healthier lifestyles.

P.09

RUSSIA

The Russian institute of biomedical problems (IMBP) is working to probe the negative effects of weightlessness on the cardiovascular system. Recently, the Mars 500 experiment simulated a return trip to Mars and a one-month stay on the red planet by a crew of six.



P.20-21

FRENCH GUIANA / BRAZIL / WEST AFRICA / SOUTH AFRICA

Space remote-sensing is supporting early-warning systems to combat diseases like meningitis in West Africa, malaria in South Africa, dengue fever and Zika virus in French Guiana and Brazil, whose spread is fuelled by environmental conditions.

P.28-29

REUNION AND MAYOTTE

Diabetes is a major health issue on the Indian Ocean islands of Reunion and Mayotte, where two Diabsat trucks will soon be on the road bringing mobile screening services to their populations.

CONTRIBUTORS

GUILLEMETTE GAUQUELIN-KOCH

Guillemette Gauquelin-Koch has been instrumental in making CNES a leading expert in the domain of life science. Since Jean-Louis Chrétien's trailblazing spaceflight, she has been a prime mover behind an original biology and physiology programme involving research organizations, universities and hospitals, many of which are still on board today. She put us in touch with the programme's research scientists for this issue's Roundup feature.

MARINE BERNAT

She may appear quite reserved at first sight, but Marine Bernat has been creating a buzz around the MEDES space clinic for several years now. She's well-rehearsed in the demands of communication, opening the doors of the clinic for us in the middle of its 'bedrest cocktail' campaign. She even gave us the chance to interview two bedrest volunteers, who aren't usually so forthcoming, and the clinic's psychologist.

KAROL BARTHÉLÉMY

Formerly our correspondent in French Guiana, Karol Barthélémy now works back in mainland France as a free-lance copywriter. She knows all about space and health technology, an area where French Guiana is something of a showcase. For our Horizons feature, she went behind the scenes with research scientists and found that technology is to little avail without the human touch.

AMÉLIE BLANDEAU

Amelie joined the CADMOS team to promote the seven experiments performed by Thomas Pesquet on the International Space Station for the Proxima mission. She gave us the inside track on the expert health teams in Toulouse keeping a check on the French astronaut, as well as a glimpse of how they're helping to conceive new experimental devices like ECHO, EveryWear, Aquapad and MATISS.

CNES MAG

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EDITORIAL

Even before the first humans ventured into space, scientists were already striving to understand the effects of spaceflight on their health. Indeed, it was the chief concern. How would their bodies react when subjected to the acceleration and vibrations of launch, to weightlessness and space radiation? How would they cope with the constraints of the return to Earth? That is why, from the very beginning of crewed spaceflight, space medicine institutes were created to investigate the health risks to space travellers and define protocols to protect them. It didn't take long to realize that space, and in particular the weightless conditions it offers, could shed new light on how the human body works and how certain pathologies develop. And so it was that the focus gradually shifted from medical research for space to research in space for health, which now makes up a large proportion of experiments being conducted in orbit.
France and CNES were early pioneers in this field and space medicine experiments were already on Jean-Loup Chrétien's schedule when he became the first French astronaut to fly in space in 1982. CNES has been a continuing catalyst for research ever since, working with a range of partners in the field of health and developing multiple experiments that are now running permanently on spacecraft.
Far from the fears it inspired in the early years, space is today delivering new insights into health.

JEAN-YVES LE GALL
CNES PRESIDENT

For the GRASP neurosciences experiment, Thomas Pesquet donned a virtual-reality helmet and tested a multitude of targeted scenarios to delve deep into our brain.

SPACE

A lesser-known link in the health chain

CNES developed a close interest in the effects of microgravity from the early years of human spaceflight, because the space environment was still unknown and because its astronauts' welfare was paramount. It has been applying what it learns in space to health ever since. On the International Space Station (ISS), through its MEDES space clinic and CADMOS[1] service subsidiaries, it has pursued a proactive policy in training and monitoring astronauts and in experimentation. For half a century, it has been sharing its results with the public health sector in response to new issues like regions deserted by health professionals, assisted living and e-health.

1. Centre for the development of microgravity applications and space operations.

CARDIOVASCULAR SYSTEM

A TESTING TIME FOR VEINS

In microgravity, there's no up, no down, no lying or standing, but the loss of our usual bearings does affect the body, changing the way liquids flow, causing orthostatic disorders, puffy faces and cardiovascular malfunction on returning to Earth. Bedrest campaigns conducted by the MEDES space clinic or parabolic flights replicate the conditions of spaceflight to analyse these phenomena. Since 2010, the Cardiomed device developed by CNES and validated at Angers University Hospital has been continuously monitoring the cardiovascular systems of astronauts aboard the ISS. The astronauts' two-hour daily exercise regime isn't just for keep-fit fanatics, as research has also proved the link between physical inactivity and vascular risks. This kind of exercise could therefore improve the cardiovascular condition of patients who are bedridden or physically inactive for long periods. Looking further down the road, these observations will be put to the test of time on very-long-duration spaceflights.

2 x 45 MINUTES

That's how long and how often astronauts have to exercise on the ISS. Coached from the ground, they alternate between an exercise bike, a treadmill and weight-lifting exercises on a specially designed apparatus.

BEAR SERUM

HIBERNATION COULD HOLD THE KEY

When bears awake from several months of hibernation, they have lost almost none of their muscle. What's their secret? Researchers at the University of Strasbourg are trying to find out. It might be the answer to the problem of muscle wasting that affects astronauts and older people. Could the explanation be something to do with specific compounds in a bear's blood? If so, could they be transferred to humans? A "bear serum" was injected into human muscle cells grown in the laboratory.
All of the cells grew and all of the molecular processes observed in bear muscle during hibernation were reproduced in the human cells.
All that remains is to identify the active compounds or at least the family of compounds capable of reducing muscle wasting.

BONE DENSITY

HARD RETURN TO REALITY

We all have the picture in our mind of an astronaut floating in a capsule, but that floating isn't without its effects on the bone system, notably the load-bearing bones (femur, tibia, etc.). Pre- and post-flight medical imagery has confirmed that astronauts lose bone density fast. Another phenomenon that weakens a spaceflight crew's bones is fluid displacement from the lower to the upper body, which reduces bone marrow perfusion and causes the bone system to age prematurely. Two short- and long-term studies by ESA, CNES and DLR are planning to gauge the margin for post-flight recovery more precisely. In-vivo measurements of bone micro-architecture are also being conducted using the Xtreme CT scanner. The results obtained by the University of Saint-Etienne could prove very useful to cope with the effects of ageing.

MARS

MAKING THE DREAM REALITY

Ever dreamed of going to Mars? If so, you'll have to wait a while longer, as there are still some technical snags to be ironed out. None are insurmountable, but they're all fiendishly complex. The first is getting there and living there, but the hardest will be to ensure crews are operational when they arrive on Mars after a six-month journey in microgravity. Missions on stations in low-Earth orbit like the International Space Station (ISS) have laid the groundwork, but one area where we just don't have enough experience is mental strength. What psychological effects will such long-duration missions have? How will humans respond to being in isolation far from their home planet? How do we select crews? In 2010, the Mars 500[1] experiment sought to tackle this issue. Now, additional studies are needed. They could also deliver insights into certain situations here on Earth, like isolated populations and people working in extreme conditions.

1. 520-day confinement experiment conducted by IMBP, the Russian institute of biomedical problems.

INNOVATING FOR BETTER CARE

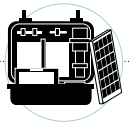
1982

AS DE CŒUR
The world's first Doppler scanner for studying astronauts' cardiovascular systems.

1996

PHYSIOLAB
Space laboratory designed to study the cardiovascular system.

2001



TELEMEDICINE KIT
Designed for medical diagnosis in remote areas or on the move (train, plane or boat).

NEUROSCIENCES

FROM BRAIN TO HAND

The central nervous system receives inputs from a range of sensory "assistants" such as the eyes, ears and our sense of touch. Removing some of these inputs affects how sensory information is interpreted. Paris-Descartes University is working to understand how gravity impacts our coordination. Does it act like a sort of reference frame for controlling our gestures, notably prehensile (grasping) actions? On Earth, it's hard to identify the separate effects of each sense, but in microgravity our sense of verticality is altered, making it easier to analyse the responses of the human sensorimotor system. This kind of research could also shed new light on sensory or motor disorders in common afflictions like Parkinson's disease.

16.2%

That's how much the lens clouded in the eyes of 48 out of 295 NASA astronauts examined for its Longitudinal Study of Astronaut Health (LSAH). Cataracts appear to be the most likely consequence of exposure to cosmic radiation. While astronauts are protected by their spacesuits, they don't wear eye protection.

81%

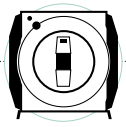
Astronauts experience particular sensations due to weightlessness. Specifically, 81% feel their face is puffy, 76% get headaches, 62% experience congestion and a stuffy nose, 39.4% report skin complaints and 22.9% sore eyes.

11,290

This figure clearly shows the success of NASA's Mission X health education programme relayed in France by CNES. The programme's aim is to encourage young people to adopt healthy lifestyles, taking astronauts as their role model. In 2017, 11,290 schoolchildren aged 8 to 14 took part in this space/health challenge. Among the range of materials provided for the 370 teachers who have signed up was a Web documentary explaining the effects of microgravity on the human body.

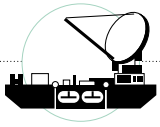
MORE INFORMATION: **PROXIMA.CNES.FR/FR/EN-MICROPESANTEUR**

2003-2006



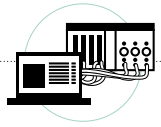
XTREMECT HIGH-RESOLUTION BONE SCANNER
to measure bone density and micro-architecture.

2007



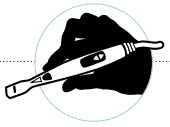
EMERGESAT
Humanitarian container fitted with satcom equipment for deployment in disaster areas (Haiti, Darfur, Chad, etc.).

2008



CARDIOLAB
European device on the ISS dedicated to studying the human cardiovascular system in microgravity. Replicated for Cardiomed (2009) in the Russian module and Cardiospace (2016) with China.

2016



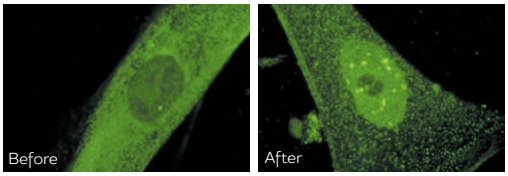
DENTAL CAMERA
Mini-camera inspired by technologies used on the Pleiades satellites to generate 3D images.

2017

ECHO
Tele-operable ultrasound scanner controlled from Earth.

RADIATION

ENEMY NUMBER ONE IN SPACE

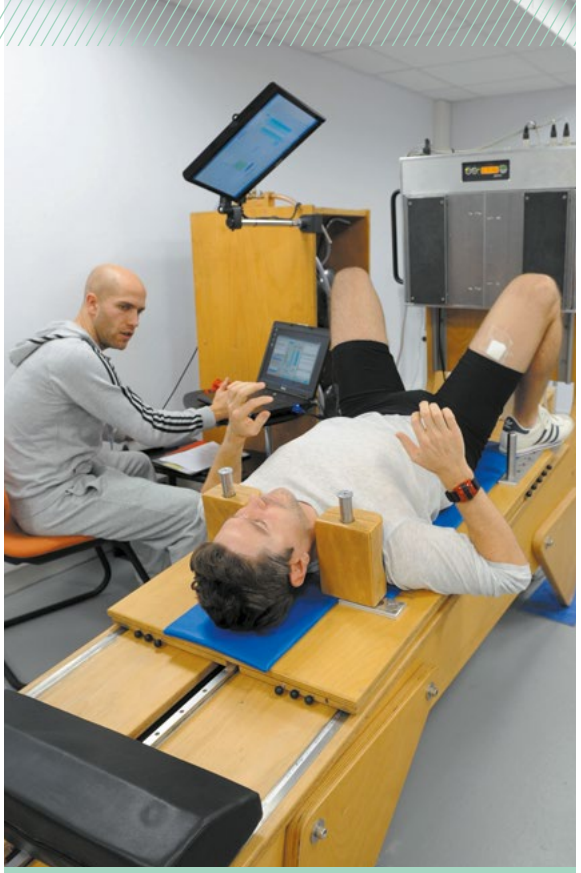


Before exposure to radiation, the protein (green) is in the cells' cytoplasm. After exposure, it finds its way into the nucleus, causing breaks in the DNA.

Journeying through the cosmos comes with radiation risks. Whether in the form of cosmic rays, solar particles or in the Van Allen belt, radiation is not good at all for astronaut health. INSERM, the French National Institute for Health and Medical Research, has identified two major risks: radiation-induced cancers and cataracts. Other factors that influence the impact on crews are individual radiosensitivity, hypersensitivity to small doses and repeated radiation exposure. Efforts to find effective radiation protection methods have encountered side effects. While less life-threatening, the issue of cataracts is nevertheless also being closely studied and is considered a likely consequence of exposure to cosmic radiation. Medical radiotherapies pose similar issues, so space radiobiology research will also help to address the clinical effects of X-ray diagnosis.

400 µGy/day

The radiation absorbed, in Grays, during space missions. That's 5,000 times lower than the dose received from an X-ray examination (2 Gy) and 10 to 20 times lower than a breast scan (2 to 4 mGy).



MUSCLES

PHYSICAL EXERCISE AS A TONIC

Exercising is recommended to preserve muscle strength according to observations conducted by the University of Montpellier during flights and prolonged bedrest. Muscular deconditioning is first noted in adults from the age of 30, but it happens faster as a result of lack of physical activity. The slow endurance and postural muscles are the most affected. Lack of activity also weakens the tendons that connect muscles to bones. In other words, it impacts the whole muscular chain. And what goes for astronauts goes for people who are bedridden or have a motor deficiency. It also applies to sarcopenia[1] and cachexia[2]. While studies have yet to discover a miracle cure, they do point to a combination of solutions involving medication, dietary supplements and mechanical stimulation. But physical activity still produces by far the best results.

1. Reduced muscle mass in older people.
2. Serious weakening of the body due to severe undernutrition.

METABOLISM

ARE ASTRONAUTS WHAT THEY EAT?

Pursuing research efforts ongoing for more than 20 years now, the Hubert Curien Institute (IPHC)—run jointly by the French national scientific research centre CNRS and CNES—is working to understand the role of microgravity and physical inactivity in the metabolic imbalances affecting astronaut health and performance. It has identified a metabolic syndrome very similar to that seen in overweight or obese humans. Physical-exercise countermeasures have already been tested before,

with mixed results, so scientists are now exploring other avenues, notably nutrition. Cross-disciplinary studies have confirmed the key role of micronutrients and vitamins (vitamin E, Omega 3, polyphenols, etc.) in mitigating the effects of microgravity on animals and humans. For example, astronauts eating more fish (rich in Omega 3) suffer less bone loss. In January this year, nutrition-cocktail tests were conducted during a bedrest campaign to verify a number of hypotheses and the results are currently being analysed.

TELE-EPIDEMIOLOGY

PREDICTING EPIDEMICS

A multidisciplinary approach is the only effective remedy against the global scourge of infectious diseases. CNES is playing its part in efforts to develop preventive strategies by helping to predict epidemics with satellite imagery. It is providing the World Health Organization (WHO) and regional health agencies with observation tools like entomological risk maps to detect larvae and measure mosquito densities. Such data have proved effective in combating dengue fever in French Guiana, for example. For the DETECT[1] project being pursued by the epidemiology laboratory at the Institut Pasteur in Cayenne, supported by CNES, a team of researchers is using satellite data on identified risk areas, a mine of information that is also saving time and money. CNES is also supporting efforts to combat diseases like malaria, meningitis and Rift Valley fever.

1. DEngue Transmission and Emergence Control using Tele-epidemiology.

#COMMUNITY

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

@ JULIETTE RAYNAL
Journalist #digitalretail #fintech @lusinedigitale. Ex @IT_technologies @LesClesDeDemain @frenchweb. #startup #innovation #numérique.

Artificial heart, surgical robots, respiratory therapy vest... Discover 3 health innovations spun off from space and defence at industrie-techno.com/comment-la-sante-innove-grace-a-l-aerospatial-et-la-defense.47298...

@ MARC GOZLAN
Doctor by training, journalist by vocation

Thomas Pesquet (@Thom_astro) undergoing a series of medical tests via @esa #medecinespatiale just minutes after landing back on Earth

@ CITYZEN SCIENCES
Specialized in the conception and developments of smart fabrics

Smart by @CityzenSciences tested in space to monitor the heart rate of @Thom_astro live for @CNES's #Everywear mission

@ ANGELINA BALLERINA
NASA ESA JAXA CSA CNES RSA

Research scientists from Jean Monnet University (UJM) are measuring the impact of spaceflight on @Thom_astro's skeleton univ-st-etienne.fr/fr/tous-les-faits-marquants/annee-2016-2017/zoom-sur/des-chercheurs-de-l-ujm-mesurent-l-impact-du-vol-spatial-sur-le-squelette-de-thomas-pesquet.html...

@ CNES
Latest news from CNES, the French space agency

PERSPECTIVES, CNES's latest #Proxima experiment, is up and running! Virtual reality here we come! #VR http://bit.ly/2rgWoQm

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Q & A

MICHEL CYMES

WITH HIS UNMISTAKABLE VOICE AND HUMOUR, the famous French doctor, radio and TV presenter takes the mystery out of medicine for the lay public. For CNESMAG, he tells us how he has developed a professional interest in space, particularly for astronaut health.

WHAT MOTIVATED YOU AS A DOCTOR TO START PRESENTING CURRENT-ISSUES PROGRAMMES ON RADIO AND TV?

Michel Cymes: I was a junior doctor at Chartres hospital. Every day, as I drove to work, I would listen to the two-minute health feature on France Info. I found it interesting because I'm obsessed with mediation and education. I've always liked developing an empathy with patients and explaining their illness and treatment to them, often with the aid of a sketch. One day I was on the medical team for a car rally and I reached out to some journalists at Europe 2 who offered me the chance to do a weekly feature called *La minute scientifique* (A minute of science). On TV, I started as a contributor on the *Télématin* breakfast show and on *Qui vive* when France 5 was launched. After that, I worked on *Attention santé* and then *Le journal de la santé* (Health Report), where the format has got progressively longer. On radio, I've done medical features for Europe 1 and France Info, and for RTL since 2011. The common thread between all of these programmes is that I try to explain health-related themes and how the human body works in words that everyone can understand. In fact, I remember that one of the first themes I addressed in *La minute scientifique* was orthostatic hypotension (low blood pressure) in astronauts returning to Earth.

SO YOU HAVE AN INTEREST IN SPACE?

M.C.: Space is the stuff of dreams. Like many people, I remember watching the first steps on the Moon in July 1969 on my parents' black-and-white TV set. I've always been really interested in the effects of space missions on astronauts' health and on the ageing process. These are themes that overlap with medicine. For *Qui vive*, we even put a sheep's brain in a centrifuge arm to see how it responded to g-force.

ONE OF YOUR PROGRAMMES IS ABOUT HOW THE HUMAN BODY FUNCTIONS IN EXTREME CONDITIONS, IN WHICH YOU PUT YOURSELF TO THE TEST. WHAT DO YOU TAKE AWAY FROM THAT EXPERIENCE?

M.C.: Some episodes of *Les pouvoirs extraordinaires du corps humain* (The extraordinary powers of the human body) on France 2 show how the human body responds when conditions get tough. We've been to the slopes of Mont-Blanc, to the jungle, to Australia, and we'll be shooting soon in Namibia. I'm afraid of heights, so walking at altitude or making a parachute jump from a helicopter gives me the chance to push my limits. It's a mix of science for the lay public and adventure and emotion. We also look at themes like hypnosis, Chinese medicine and acupuncture.

WHAT DO YOU THINK ARE THE LIMITS THE HUMAN BODY CAN'T EXCEED?

M.C.: The more I practise medicine (I see patients two mornings a week at a hospital in Paris) and the more I read, the more I wonder if there really are limits to what we can do. Everything we once thought impossible ends up happening within 10 years or later. Soon we'll be able to 'change out' cells and organs in the human body like we do parts in a machine, so we'll have to stop talking about limits, because no-one can say for sure that we won't live to whatever age or run the 100 metres at ever-faster speeds.

DO YOU SEE SPACE AS THE MOST HOSTILE ENVIRONMENT FOR HUMANS?

M. C.: It's obviously the most stressful environment there is. You find yourself in a confined space, with nobody to help you, nobody to fix mechanical or health problems. If you're on a boat or a submarine, rescuers can be sent out to save your life. But things are going to get even more complicated on a two-year mission to Mars. I of course watched Thomas Pesquet's return to Earth in June. During his

"ASTRONAUTS ARE LIKE 'GUINEA PIGS' LIVING LIFE IN FAST FORWARD. WHAT WE SEE IN ASTRONAUTS CAN THEN BE TRANSPOSED TO EARTH."

MICHEL CYMES

FRENCH DOCTOR,
RADIO AND TV PRESENTER

"THE MORE I PRACTISE MEDICINE AND THE MORE I READ, THE MORE I WONDER IF THERE REALLY ARE LIMITS TO WHAT WE CAN DO."

six-month stay, his brain got used to no longer feeling the weight of his body, and now he needs to readapt. I've personally flown in an Alpha Jet, when I was subjected to 6 g. Just lifting my little finger was a huge effort, because my brain didn't understand why all of a sudden my finger was so heavy.

WHAT BENEFITS DO YOU THINK MEDICINE CAN GAIN FROM SPACE EXPLORATION? AND WHAT ROLE CAN AN AGENCY LIKE CNES PLAY?

M. C.: First of all, telemedicine is already making it possible via satellites to operate, give advice or make a diagnosis remotely. Space exploration is shedding new light on things like osteoporosis, blood pressure and muscle wasting. Can humans live in space? That's a question we need to answer with all the talk about sending crewed missions to Mars. CNES is contributing to medical advances as it has the ability to perform a full range of experiments, notably to anticipate the kinds of medical problems an organism subjected to such constraints is likely to encounter. From a more personal standpoint, CNES has offered me the chance to go on a parabolic flight recreating the effects of weightlessness, so I'll be able to see what space sickness feels like for myself, as I have a sensitive inner ear. It may even feature in *Le journal de la santé*.

DO YOU THINK THE SPACE SECTOR COULD HELP TO SOLVE CERTAIN CURRENT PUBLIC HEALTH PROBLEMS?

M. C.: It's a shame that space can't do anything about the lack of health professionals in certain parts of the country (laughs)! More seriously, spaceflights can directly influence medical research methods. And as we've seen in the news recently, close observation of Thomas Pesquet's physical condition on returning to Earth after his six-month Proxima mission reflects the kind of concerns we have here on Earth with the ageing process and the functioning of the heart and muscles, etc. Astronauts are like "guinea pigs" living life in fast forward, as the effects of microgravity, confinement and space radiation lead to a 20 to 30% loss of muscle and 10 to 20% loss of bone mass. What we see in astronauts can then be transposed to Earth.

"I'VE ALWAYS BEEN REALLY INTERESTED IN THE EFFECTS OF SPACE MISSIONS ON ASTRONAUTS' HEALTH AND ON THE AGEING PROCESS. THESE ARE THEMES THAT OVERLAP WITH MEDICINE."

Profile

1989
Completes medical training at Chartres hospital

1991
Begins parallel career as TV and radio presenter

2012
Launches *Les Pouvoirs extraordinaires du corps humain*

2014
Voted France's most popular celebrity by *Stratégie* magazine

IN BED FOR POSTERITY

Staying in bed can also aid science, as 10 healthy volunteers proved during a bedrest campaign supervised by the team at the MEDES space clinic from January to April. Ten more will be following the same procedure this autumn. Bedrest studies simulating the effects of microgravity on the body enable specific countermeasures to be tested. This year's study, named "bedrest cocktail", is looking at the effects of taking an antioxidant and anti-inflammatory dietary supplement on mitigating the deconditioning induced by two months of bedrest. The results could point the way to treatments for sedentary patients.

IMMEDIATE RESPONSE

In the hours following a disaster, all conventional means of communication are down, so restoring contact with the rest of the world is the first priority. For this purpose, CNES has conceived humanitarian tools that are easy to transport to a disaster area. The PSMA forward emergency medical unit provides communications and first-aid equipment. Another example is Emergesat, a modular vehicle that can be equipped with a telemedicine kit and mapping software. These two tools can be deployed together, as shown here when French Guiana emergency responders assisted relief efforts after the earthquake in Haiti in 2010.

FEVER

The economic impacts of dengue fever are significant. Taking into account hospital admissions, sick leave and risks of dying, the disease is estimated to cost €100 million a year on the basis of about 10,000 people affected. And it's spreading, with some 390 million cases now being reported worldwide every year.

Guiana

AFTER TESTING OUT A ROBOTIC ULTRASOUND SCANNER IN 2011, French Guiana is set this year to start using particularly promising new scanners like the one used by Thomas Pesquet on the ISS. They will be operated at the three remote towns of Saint-Georges de l'Oyapock, Maripasoula and Grand-Santi. After a trial period of 18 months, the technology could be rolled out across other localities in this region of France where health professionals are most lacking and hospitals are large distances apart. CNES is funding 85% of this project costing €236,000. So far, the scanner has only been used in Spain and in Tours.

10 DAYS

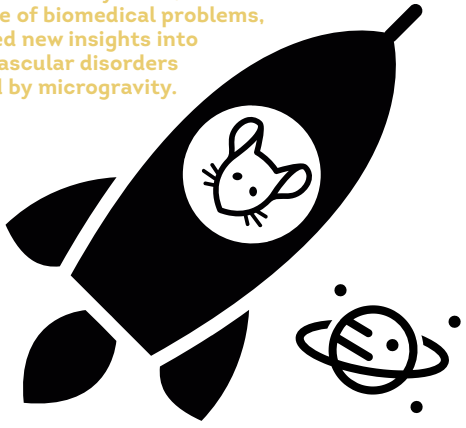
That's all it takes for muscles to lose 5 to 15% of their mass, which may not seem much but translates into 15 to 30% less strength in an adult subject. A five-year study on subjects aged 70 to 80 showed that they lost strength two to five times quicker than muscle mass.

5.3

MILLION. THE RESULTS OF BEDREST EXPERIMENTS could directly benefit Earth's populations, as it's thought nutrition could be used as a countermeasure for sedentary lifestyles, which cause 5.3 million deaths a year worldwide –as many as smoking.

15

In 2013, a hundred geckos, Mongolian gerbils, germs and 15 French mice spent one month in microgravity. The long timespan covered by this mission devised by IMBP, the Russian institute of biomedical problems, delivered new insights into cardiovascular disorders induced by microgravity.



VIDEO

Report at CADMOS on 22 April 2017

SPACE FOR HEALTH

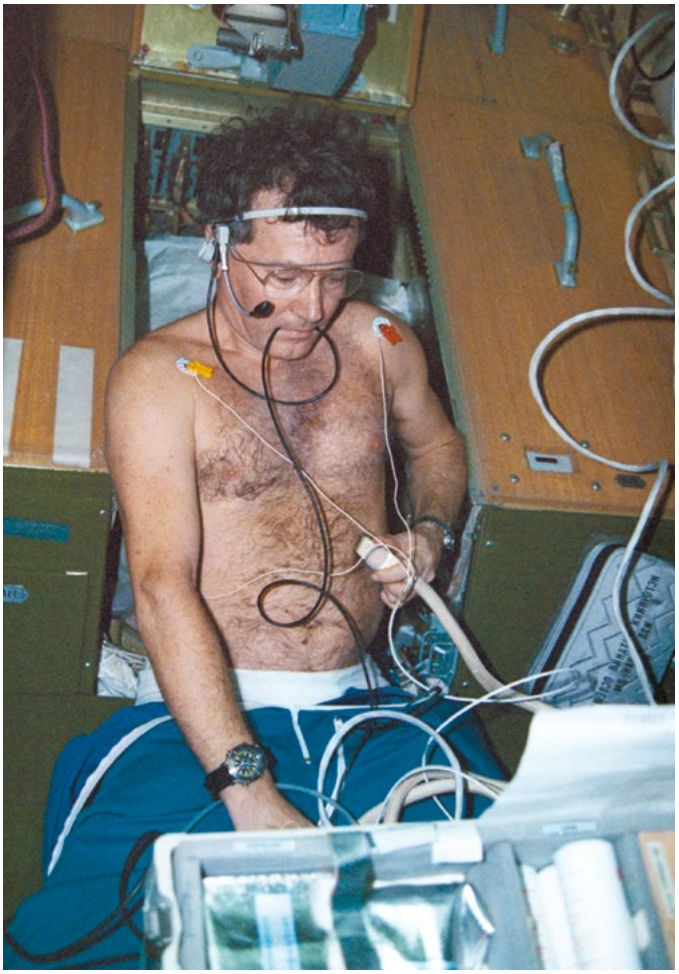
WHAT DO MAGNETIC RESONANCE IMAGING (MRI), MINIATURIZED HEART PUMPS AND TELEMEDICINE HAVE IN COMMON? ALL OF THESE MAJOR MEDICAL ADVANCES ARE THE RESULT OF DECADES USING SPACE AS A RESEARCH LABORATORY TO LEARN MORE ABOUT OUR HEALTH —A FANTASTIC ADVENTURE IN WHICH CNES IS PLAYING A LEADING ROLE.

The scanner to be tele-operated on the French astronaut from the ground is prepared at CADMOS.

Space travel may not be a formative thing for most youngsters (see Roundup p.8), but it is advancing science on the effects of ageing and sedentary lifestyles, and on the origin of chronic illnesses. And for good reason, because while gravity is vital to humans, shaping our cardiovascular, bone, muscle and nervous systems, microgravity is an unnatural environment for us. "*We previously knew nothing about its effects on living organisms*," explains Guillemette Gauquelin-Koch, Head of Life Sciences at CNES. It was the agency's belief in the value of research in this area that drove it to "*make space a microgravity laboratory*." Today, "*the goal of this space research remains of course to serve humankind*," confirms Laurent Braak, the former head of the MEDES space clinic now in charge of spinning off health applications of space at CNES.

JEAN-LOUP CHRÉTIEN, THE TRAILBLAZER

From 1975, before the great human spaceflight adventure had even begun, CNES was involved in specific biology and physiology studies. But it was with the flight of France's first astronaut, Jean-Loup Chrétien, on the Salyut 7 space station in 1982 that the agency really embarked on an original and ambitious programme. Two hundred kilograms of scientific equipment were waiting aboard the station for the astronaut to perform ultrasound scans and study hormonal changes, balance and posture. Laboratories, research organizations, universities and the university hospitals of Lyon, Tours, Saint-Etienne and Toulouse responded to calls for projects for the flight, enabling CNES to broaden the spectrum of its life science activities, now one of its areas of expertise. Most of all, the agency was able to draw on the key lessons of this first flight for those that would follow. Work to mitigate certain syndromes experienced by astronauts—like headaches, orthostatic intolerance, muscle wasting and bone loss—fostered an early link between life sciences and medicine that has got closer over the years. In 1989, with the help of Toulouse University Hospital, CNES formed its MEDES space medicine subsidiary (see p.25-26), and in 1993 opened a dedicated in-house department called CADMOS (see p.23-24).



Jean-Louis Chrétien operates As de cœur, the first ever Doppler scanner, on the Mir space station during his PHV mission.

Scientific knowledge has gained much from work on the relationship between space and health, especially in the field of chronic illnesses. Astronauts feel the same effects in space as seriously ill or dependent people do

as a result of prolonged bedrest, lack of physical activity or confinement. Equipment such as ultrasound scanners, postural platforms, bone scanners and telemedicine kits has thus proved of great benefit here on Earth. Insulin pumps are a direct spin-off from space medicine research. Thomas Pesquet's recent flight on the International Space Station (ISS) offered an opportunity to go one step further. By the end of his mission, the seven experiments conceived and prepared by CNES had all been completed and everything is looking good (see CADMOS p.24).

MONITORING AND EARLY WARNING

Besides spaceflight missions, Earth-observation and telecommunications satellites have become vital tools of health policy, playing a key role in developing telemedicine and health monitoring. In French Guiana, for example, satellites are enabling tele-consultations in remote regions. "*The system is simple*," explains Antonio Güell, the 'father' of telemedicine at CNES. "*All that's needed is a satellite dish, a terminal and an authorized referring health professional to make the right decisions and save lives.*" Today, space telemedicine is well established. It has proved its utility in monitoring certain chronic illnesses like diabetes (see Timeline p. 28-29) and is meeting new social needs such as monitoring of isolated workers, providing medical services in regions where health professionals are getting scarcer, support and care for the elderly and self-dependency.
Lastly, satellites are also a precious aid in identifying where climate, health and the environment overlap. Deforestation, urban sprawl and population growth have all fuelled environmental imbalances and are key factors in the emergence, spread and persistence of environment-dependent diseases like meningitis in West Africa, malaria in South Africa, dengue fever and Zika virus in French Guiana and Brazil. Space remote sensing is helping to set up early-warning systems, enabling epidemiological monitoring that ties in with current research on life-support systems for future space missions.

Red Plan exercise simulating a mass pile-up on the A68 motorway near Toulouse on the night of 14 June 2012, for which emergency response teams deployed the Emergesat humanitarian telecommunications and data-transmission container.

PUBLIC HEALTH

PRECIOUS PARTNERS

CNES is working with influential players to shape public health policy, a fact confirmed by three framework agreements signed in 2016. With the Institut Pasteur, the agency is helping to combat epidemics, in particular dengue fever in French Guiana. It signed a contractual partnership with the Department of Health (DGS) and the French armed forces medical office (SSA) as part of the Ministry of Social Affairs and Health's e-Health 2020 strategy. The aim of this partnership is to initiate programmes designed to modernize the health system. And with INSERM, the French National Institute for Health and Medical Research, CNES is developing space technologies for health including connected devices for astronauts.

SPACE EXPLORATION
THE ENDLESS POSSIBILITIES OF INNOVATION

How will we protect a crew's health and maintain their performance during deep-space missions? How will we come to their aid in an emergency? All stakeholders in space and terrestrial medicine must now come together to meet these future challenges.

Today, if medical assistance is required on a flight in low-Earth orbit or around the Moon, we can use telemedicine services or evacuate a crew member to a hospital back on Earth within hours. For missions to Mars, however, it will be a different story. Crews will be in space for anything from 500 to 1,000 days, with a journey time to the red planet of six to nine months, in extreme isolation and exposed to cosmic radiation. Given the 40 minutes or so it takes to receive a return signal from Mars, telemedicine is out of the question, and we won't be able to send up spares, food and water or medication. So the only solution is to make technologies more reliable and astronauts more self-dependent in all matters pertaining to health.

INNOVATION ON ALL FRONTS

As research in this area is still in its infancy, innovation is the only way to go. To cope with long space missions in isolation and in an extreme environment, that will mean inventing systems and tools for monitoring crews to mitigate any physiological and psychological issues that might arise.

We will need to innovate with new connected-health, diagnostic- and decision-support technologies like medical imaging tools compatible with the space environment, embedded mobile sensors and continuous training and assistance systems using robotics, virtual and augmented reality to manage health issues.

15

days

After 15 days in weightless conditions, our cardiovascular, bone, muscle and nervous systems undergo big changes.

And we will need to innovate to ensure a healthy environment and a suitable, autonomous habitat for crews, which means providing life support and optimizing use of water, air and food. Projects like Melissa in Europe are already focusing on a concept based on maximizing recycling and waste management. The Aquapad and MATISS experiments for the Proxima mission looked at controlling the physical-chemical environment and germs to avoid contamination of the crew and spacecraft systems.

The challenge is also to co-innovate with health stakeholders so that technologies developed for space exploration boost innovation here on Earth.

Shown here aboard the ISS, Aquapad is a new device for testing water quality on the station.

The PERSPECTIVES experiment designed to study how the nervous system responds and adapts to microgravity is prepped at CADMOS.

CADMOS
EXPERIENCE AND EXCELLENCE COMBINED

In 1993, CNES created its CADMOS centre for the development of microgravity applications and space operations, which supports scientific experiments performed in space. It prepares and monitors these experiments from its base at the Toulouse Space Centre, as well as archiving and distributing science data.

CADMOS's expertise runs the gamut from life and material sciences to the space environment, fundamental physics and life support. But it has earned special acclaim in the domain of physiology, working with an integrated team at the MEDES space clinic (see p.25-26). It all began in 1998, when the European Space Agency (ESA) embarked on the ISS adventure, for which it decided to create a network of User Support Operations Centres (USOCs). There are today seven such centres enabling scientists to tele-operate and track their experiments aboard the station. ESA has made CADMOS one of the three main USOCs in Europe and the success of the Proxima mission has further consolidated France's expertise.

– CONTINUED P. 24

VIDEO

Thomas Pesquet:
it's all about science

SIGHTS ON MARS

With Proxima, CADMOS has taken a new step towards Mars, but big challenges remain. The Toulouse-based team is working with laboratories and firms (large groups and start-ups)[1] on 20 experiments designed to lay the groundwork for this great adventure. Some of them—ECHO, EveryWear and PERSPECTIVES—are focused on human physiology, while others are looking at bio-contamination with the aim of building germproof barriers. For example, the Aquapad experiment is using a dry substrate that is easy to store for deep-space missions, combined with a tablet application able to screen for bacterial growth instantly. Such applications could be usefully transposed to hospitals and certain public places.

PROXIMA PROGRESSIONS

For CADMOS, Proxima is a total success. All of the experiments prepared, notably those for CNES, were accomplished and Thomas Pesquet was able to complete all planned work sessions. For some of the experiments, like ECHO, he even managed to perform additional tasks. Samples from MATISS (see Materials p.27) have been returned to Earth and will now be pored over by science teams. Patches used for Aquapad have also been brought back for analysis. Follow-ons to all of the experiments are planned either on the station or on the ground before processing the final results. Proxima is barely over and CADMOS has already received requests for authorizations to use equipment tested during the mission.

1. Laboratories: CNRS, INSERM, ENS Paris and ENS Lyon, CEA-LETI, MEDES; Firms: ADS, bioMérieux, Saint-Gobain; SMEs like Erems and start-ups like Bodycap and Citizen Sciences.

Thomas Pesquet tests out EveryWear, the tablet/iPad application designed to collect physiological data and relay them to ground for health monitoring during his mission.

WEIGHTLESSNESS

PARABOLIC FLIGHT PREPARATIONS

Parabolic flights on the Airbus A310 Zero G operated by CNES subsidiary Novespace offer a cheaper way than spaceflight to conduct experiments in weightless conditions. For Proxima, the aircraft was used to test qualification models of most of the experiments before sending them up to the ISS, and provided a training ground for Thomas Pesquet.

MEDES
CNES'S
HEALTH SUBSIDIARY

A pinnacle of biomedical research open to the scientific community, the MEDES space clinic is working to promote space medicine and its health applications.

Europe's astronauts have to stay fit and healthy to accomplish their mission. Maintaining their health and performance is one of the jobs of MEDES, which sent an integrated team to the European Astronaut Centre (EAC) in Cologne to keep an eye on Thomas Pesquet during his recent spaceflight. But that's not all MEDES does, as it also helps the CADMOS centre for the development of microgravity applications and space operations to prepare and keep track of physiology experiments aboard the International Space Station (ISS).

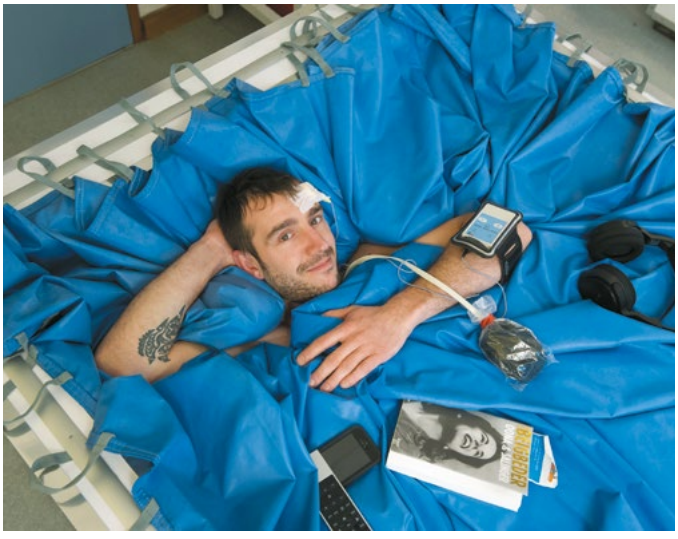
A CLINIC WITH A DIFFERENCE

Not all research can be done in space. There are relatively few astronauts and experiment equipment is hard to ferry up. So a structure able to conduct space medicine research on the ground was called for. In 1996, CNES and Toulouse University Hospital turned MEDES into a true "space clinic". It now has the capability to simulate the effects of weightlessness to study how the body adapts, prepare spaceflights and devise preventive strategies.
Putting this infrastructure in the hospital was CNES's choice. The space clinic thus benefits from all the advantages of a unique biomedical platform—with MRI, a scanner and biomedical testing facilities—and a network of highly qualified physicians to hand, making it one of the world's leading centres for simulating the effects of the space environment. ESA and CNES regularly issue calls for projects from the scientific community, which gets the chance to work on some extraordinary experiments. While bedrest is the most common simulation technique (see In Pictures p.16-17), MEDES is innovating with another model called dry immersion. It is also drawing on the expertise acquired in space to aid traditional medical research. For example, it conducts studies on confinement and sleep, and evaluates biomedical and life-support systems. It also receives outpatients from the University Hospital for specific tests.

A HELPING HAND FOR INDUSTRY...

But MEDES doesn't operate all alone. General medical practice is increasingly turning to new technologies like telemedicine, e-health and connected devices. Globalization is also driving mobility and closely dependent on space technologies, as satellite imagery is proving a key asset wherever there is an epidemiological risk. In this new landscape, companies in the medical and

– CONTINUED P. 26



Alongside its bedrest campaigns, MEDES is using a new 'dry immersion' model for simulating weightlessness. Subjects spend three days floating in specially adapted baths in which they are isolated from the water.

health sector are now joining the ranks of space technology users. By making its expertise available to this economic network federating big companies, SMEs, public bodies and incubators, MEDES is helping to shape the medicine of the future.

... AND SOLIDARITY POLICIES

Lastly, new ways of practising medicine and longer life expectancy mean that more will need to be done to support self-dependency in old age. Here, MEDES is acting as a mediator between technology and health. Philippe Hazane, MEDES's new director, is working on the concept of an 'extramural' hospital. Under the Government-Regional Council planning agreement, the Gers-Santé-Ruralité rural centre of excellence is experimenting with an original local health and social care model called ESPASS. MEDES's expertise will be employed to create networks for elderly people encompassing university hospitals, multidisciplinary practices, general practitioners and home services. Existing services like Diabsat also have a role to play in this model. ESPASS is a federating solidarity concept that should also make it easier for innovative firms to break into the 'silver economy' market. The still-experimental concept could ultimately be deployed in certain rural areas to check the exodus from the countryside.

25

Bedrest

campaigns conducted by MEDES since its inception. Bedrest subjects spend days to months lying in an anti-orthostatic position with their head tilted down 6 degrees.

Since 2007, MEDES also has a short-arm centrifuge funded by ESA to gauge the effects of artificial gravity.

VIDEO

MATISS goes after germs

SPACE GERMS

THIS GOLD OBJECT ISN'T A BAR OF CHOCOLATE, but rather a sample holder called MATISS. Developed by CNES and the ENS engineering school in Lyon, MATISS is designed to expose new test surfaces to the air inside the International Space Station (ISS). Conceived by LETI, the applied research centre for microelectronics and information and healthcare technologies (part of CEA, the French atomic energy and alternative energies commission), and the CNRS Saint-Gobain laboratory, the test surfaces have the rare ability to prevent bacteria from clinging to them and proliferating. During his space mission, Thomas Pesquet placed four sets of the surfaces in the Columbus laboratory module to gauge MATISS's effectiveness in microgravity, with the ultimate aim of reducing bacterial contamination in future spacecraft. Such bacteria-proof surfaces could also find applications here on Earth, especially in hospitals.

TIMELINE

DIABSAT

EDUCATION

SUPPORTING PATIENTS

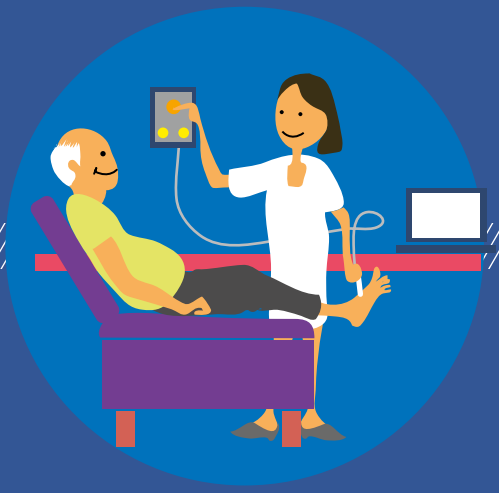
Can satellites help to improve health? CNES decided in the 2000s that they could and has proved it with Diabsat. One aspect of this novel project relying on satellite technologies involves educating patients through interactive terminals available in certain pharmacies to adopt dietary and lifestyle recommendations, and helping them with their treatment. Today, patients in the Occitanie region of Southwest France can also get this information at home through the DIAMIP diabetes network.

GEOGRAPHY

EASIER ACCESS TO HEALTHCARE

For patients who don't live close to a doctor, keeping track of their diabetes can prove difficult. Diabsat turns the problem around by going to the patient with a medical truck equipped with a dish antenna. The truck is packed with functional scanning devices thanks to the project's partners, the Occitanie regional council, Toulouse University Hospital, the DIAMIP network and CNES. Patients get eye, kidney, foot and vascular tests from local paramedics, who relay readings to hospital specialists where they are interpreted to enable doctors to recommend the right treatment.

€18 BILLION A YEAR IS THE COST OF TREATING DIABETES IN FRANCE. TWO-THIRDS OF THIS EXORBITANT SUM GOES ON DEALING WITH ITS COMPLICATIONS, MANY OF WHICH DEVELOP PARTLY DUE TO THE ISOLATION OF PATIENTS. THE DIABSAT MEDICAL TRUCK BRINGS DIABETES SCREENING TO THE PATIENT.



MONITORING

HELPING PATIENTS
KEEP TRACK FROM HOME

Diabsat screenings are free, with no need for an appointment. The project's success is due largely to the unsung but vital social welfare centres (CCAS) that handle all administrative aspects. Diabsat is aimed chiefly at fragile populations and therefore meets a key social need recognized by government. In response to the growing problem posed by diabetes in France, HAS, the high health authority, decided in 2014 to reactivate good practice guidelines concerning prevention and screening of type 2 diabetes and related illnesses. As of May this year, Diabsat has carried out 12,000 screenings.

COVERAGE

DIABSAT
REACHING OUT

The Diabsat truck has proved very popular in Occitanie, where its visits are now eagerly awaited, and is also attracting interest from the Provence-Alpes-Côte d'Azur region of Southeast France. The nation's overseas territories, where diabetes is particularly prevalent, have also expressed an interest in the mobile screening solution. Two Diabsat trucks are being fitted out in readiness to be sent to Reunion and Mayotte. Projects are also being studied for French Guiana. And Diabsat could soon be on the road again to screen jail populations, squatters or elderly people in nursing homes.

CHRISTINE ROZAND

Head of the Innovative Programmes team at bioMérieux

"With a rigour I admire, CNES is helping us cope with the tough conditions of space."

A woman with strong beliefs, Dr Christine Rozand sees a new era of humanitarian solutions in **CNES's collaboration with bioMérieux, which she describes as a "*marriage of biology and the stringent demands associated with space-rated devices*".** Under an agreement concerning astronaut health, the two partners have developed Aquapad, a solution as simple as it is clever. Use a syringe to place a millimetre of water in a dry Petri dish. Wait for the coloured dots to appear, which indicate the presence of microorganisms. Then run the EveryWear tablet app. Photograph the dish and read the result. "*Less than 50 bacteria colonies means the water is safe to drink!*" She's impressed by the results achieved with the technical demonstrator tested by Thomas Pesquet on the ISS: "*The solution is minimalist, keeps for a long time at ambient temperature and only takes 20 minutes to operate in weightlessness, compared to one and a half hours with the NASA test kit.*" **Building on these time, mass and volume savings, bioMérieux and CNES are already working on a 100-ml version.** They're also developing a space-rated molecular biology kit able to detect up to 25 pathogens linked to respiratory and digestive infections in under an hour. "*With a rigour I admire, CNES is helping us cope with the tough conditions of space with solutions so robust they'll also have a whole host of applications here on Earth,*" says Christine Rozand. To test a kit similar to Aquapad for its ability to detect cholera in public drinking water, "*a field trip to Haiti proved that anyone can use these diagnostic solutions—as demonstrated by our driver. I think the* ***EveryWear app from the MEDES space clinic, coupled with our kit, heralds a new era of telemedicine-type approaches*** *with real benefits for humanitarian organizations,*" she concludes. Now, Christine Rozand is looking forward to "*telling UNICEF about the positive results achieved.*"

RAYMOND LE MOIGN

Director of Toulouse University Hospital, President of MEDES

"Space research will find applications in dependence in ageing populations."

Raymond Le Moign is Director of Toulouse University Hospital and also President of the MEDES space clinic. The hospital isn't simply a member of the space clinic, it's also one of its founding organizations. CNES's base in Toulouse was also a factor in the decision to set up a space clinic at the hospital. It's a win-win arrangement. "*The hospital benefits from the pull factor of the space medicine research conducted here, and the medical researchers have easy access to the clinic's living lab*[1] *facilities*," says Raymond Le Moign. Conversely, MEDES has privileged access to the hospital's state-of-the-art technical facilities. Being at the same site also makes it easier to pursue collaborative projects drawing on the expertise of the two entities. Diabsat (see Timeline p.28-29) is one of these exemplary projects. Other potential projects could also have benefits for conventional medicine. One area of investigation is telemedicine. **"*Using remote diagnostic tools developed for space, issues can be discussed with patients and support provided without the need for teams and bulky medical equipment installed locally,* through tele-expertise and tele-consultation solutions**," he continues. The second is more directly related to the treatment of people on Earth, based on the similarities between the physiological disorders experienced by astronauts and the elderly. In space, the normal ageing process is accelerated, but its effects are reversible (see Roundup). After six months in orbit, age-related impairments progress by the equivalent of three to ten years on Earth. "*Space research has potential applications in the treatment of dependence in elderly populations.*" In addition, **"*medicine in the future will need to be preventive, predictive, personalized and participative,*"** he concludes. "*This will be achieved by bringing together aerospace and space companies, universities and start-ups via connected devices, for example.*"

1. A living lab is a research concept where citizens, user communities or residents in a home, for example, are involved in the research and innovation process.

Dr ELISABETH ROSNET

Psychologist and sports psychology lecturer at the University of Reims

"Astronauts must be up to the full range of tasks in orbit and able to cope with stress"

"Becoming an astronaut has nothing to do with merit—it's all about ability," says Dr Elisabeth Rosnet, who played an active role in the rigorous selection of Europe's last six astronauts. For to perform effectively in an extreme environment, astronauts need to be strong enough physically as well as mentally. *"I was chosen for the selection panel for the way I lead my research team and identify top candidates,"* she says. *"ESA's HR people were so impressed they decided to attend all panel sessions!"* she says with a smile.

To join ESA's life sciences working group, this extraordinary researcher began specializing in applied psychology when she started at the University of Reims in 1991. Her work on the effects of isolation and confinement in wintering groups in polar regions soon led to an involvement in simulations of long-duration space missions. While weightlessness influences our perception and thought processes, isolation can affect four key parameters of individual and collective function: mood (euphoria, gloominess), relations (irritability, withdrawal), somatics (headaches, stomach and back pain) and performance. So to ensure good team spirit, leadership on space missions is split between crew members and everyone has their own private space. But long before launch, it's *"vital to understand the importance of intensive training, because astronauts must be up to the full range of tasks in orbit and able to cope with stress. We also advise them to keep a journal as an outlet."*

This analysis enables Elisabeth Rosnet to provide support for bedrest candidates and insight for companies with employees working in isolation. As a lecturer, she draws on this rich experience and her ongoing research to captivate her students. And with Thomas Pesquet now back on Earth, she says she'd love to *"discuss the strategies he used to cope with the rigours of his mission."*

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

ETHICS CORNER

JACQUES **ARNOULD**

IN PRAISE OF FAMILY DOCTORS

The contribution of human spaceflight and space technology to terrestrial medicine is undeniable. But it mustn't detract from the vital personal rapport doctors have with their patients, or the importance of understanding each individual's background and culture.

"*I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth.*" NASA's medical staff thus weren't the last to be concerned by the challenge that President John F. Kennedy called on members of Congress to set before their country. And they did it—on 24 July 1969, three astronauts were picked up safe and sound in the middle of the Pacific Ocean, two of them having set foot on our lunar neighbour. Today, their successors, permanently living and working on the International Space Station, can draw on several decades of experience, while keeping an eye, we can be sure, on the health of their terrestrial fellows. And we should be grateful to them for it.

We must, however, keep our feet firmly on the ground. The conditions for returning astronauts 'safely', to use Kennedy's expression—in other words, in good health—aren't necessarily the same as for the rest of us mortals. I'm not thinking about the 'right stuff' or the reality of weightlessness, the ins and outs of which are well known to Thomas Pesquet's followers. Rather, I'm thinking of the medical supervision afforded to astronauts. Supervision administered by their very own 'family doctor', who knows them individually, shares their culture and understands the space environment, which while hostile is constantly monitored and, as far as possible, managed.

TECHNOLOGY IS NOT ENOUGH

There's no denying the advances in medical technology, particularly with the advent of tele-auscultation and tele-epidemiology. With the development of e-health, these techniques are a vital way of connecting patients with health professionals that are becoming scarcer, or perhaps simply a long distance away for people on a flight or at sea. As valuable as it is, the information these systems capture and convey shouldn't mask the fact that a human patient is more than just a set of values, diagrams and imagery. A person is a complex whole and part of a history and culture that shape their health, and which those responsible for their care should always seek to understand. In the space age, the family doctor not only has bright days ahead, but is more needed than ever.

EUROPE 1

ECHO AT THE PARIS AIR SHOW

Europe 1 radio has its finger on the pulse and always sends its top journalists to the Paris Air Show to bring listeners all the latest from the world's largest event dedicated to aviation and space. On the topic of space and health, Alain Cirou had previously covered the effects of microgravity on the human body and reported on the ECHO experiment from the CNES pavilion.

EVENT

30TH PLANETARY CONGRESS

From 16 to 20 October 2017, the Cité de l'Espace theme park in Toulouse will host the 30th Planetary Congress. This annual event is attended by around 100 astronauts and aims to promote educational initiatives and genuine international cooperation in space. Coincidentally, 20 October is also the Cité de l'Espace's 20th anniversary.

SPACE-GROWN VEGGIES

Spinach is good for you

The crew of a Mars mission would need enough food to last 400 to 900 days. Storing all that on a spacecraft is out of the question, so CNES is funding research into more sustainable solutions. The lucky subject of one study is spinach, with its hardy constitution, rapid growth and efficient photosynthesis. In 2015, a first lettuce was grown on the ISS. Due to the significant changes at cellular and molecular level, more research is needed into the effects of microgravity and cosmic radiation on plant growth in space.

DELICACY

Macaroons for the space age

Macaroons specially made by master confectioner Pierre Hermé for consumption in microgravity arrived just in time for Thomas Pesquet's birthday. They're smaller than usual so they can be eaten in one bite, and the cream centre has been replaced by fruit jelly so they keep longer. A space-inspired idea now available on Earth!

INTERVIEW

A BED'S-EYE VIEW OF MICROGRAVITY

At 10 years old, he was dreaming of far-distant planets. At 12, he was starstruck by Hubble. Laurent Brun is from a generation that *"grew up with rocket launches"*. Adventurous by nature, he braved the odds and applied for Bedrest 2017. His fears about the tests soon gave way to the excitement of being part of something extraordinary. *"There are 8 billion people on Earth, and I'm one of the chosen sample,"* he thought. Athletic, healthy and up for a challenge, he *"ticked all the right boxes"*. The working relations with scientists, the professionalism of the MEDES team and the psychological monitoring—everything impressed him. He rejects the word *'guinea pig'*, since the *'subject'* of the experiment is a fully-fledged member of the team and plays an active role. *"The Bedrest study took place while Thomas Pesquet was on his first space mission. To me, it was a sign. Our mission is to support research and help prepare for future spaceflights."* A trained photographer and social media fanatic, Laurent Brun contacted the French astronaut, who agreed to do a selfie with the bedrest subjects. He also made a connection with the terrestrial world. Aware this was a rare opportunity, he started a blog to chronicle *"the daily routine, the tests, their significance, life in a head-down tilt position and all the little joys and big questions that go with it"*. His life wasn't on hold during the two-month study—the experience has propelled him forward to new things.

NUTRITION

RECIPES UNDER CLOSE SUPERVISION

A decade ago, astronauts bored with the same old rations started pressuring their respective space agencies to provide higher-quality, more-appetizing meals for their long-duration missions. The CADMOS centre for the development of microgravity applications and space operations in Toulouse was quick to respond to this demand in Europe. Today, astronauts have a choice of 30 menu options. Each dish is not only mouthwatering but also meets a precise set of nutritional and energy intake criteria, the result of scientific testing. Specifications are stringent: they can't contain any traces of bacteria and they must look, smell and taste just right. Preparing these space meals is a well-rehearsed team effort. Detailed requirements are drawn up by NASA and the other ISS partner agencies. CADMOS is responsible for the science side. Alain Ducasse Formation prepares and tests the recipes. The meals are then packaged and sterilized by Henaff.

DIARY

20 SEPT. - 20 DEC.
Second phase of the Bedrest 2017 campaign on nutrition
MEDES, Toulouse (France)

10-12 OCT.
4th International Symposium on the system of radiological protection / 2nd European protection research week
Paris (France)

16–20 OCT.
30th Planetary Congress
Cité de l'espace, Toulouse (France)

BOOK
HARMONY IN SPACE

From the first handshake in orbit between three Americans and two Russians in July 1975 to Thomas Pesquet's Proxima mission, the authors of this well-researched and illustrated book tell the compelling story of how a small space civilization was built.

De Gagarine à Thomas Pesquet, l'entente est dans l'espace, by Éric Bottlanender et Pierre-François Mouriaux – Published by Louison Editions – 2017 – 173 pages – €17.

VIDEO

How the medical cabin works

GOING TO THE DOCTOR BY SATELLITE

With its ConsultStation® cabin validated by CNES's CESARS satellite telecommunications services and applications platform, French firm H4D is setting out to counter the exodus of health professionals from certain regions of the country—a human and scientific adventure, all made possible by satellite.

Step inside the ConsultStation® cabin and enter the era of telemedicine. After making yourself comfortable in this connected medical cabin, you have two choices: a tele-consultation with a doctor or an autonomous check-up that you can consult later on a secure Web platform.
The key is to make sure the system works everywhere, and that's where the CESARS team backed by CNES's telecommunications technologies and expertise comes in.

VALIDATED AND CERTIFIED SOLUTION

"The MEDES space clinic put us on to the concept and we contacted H4D and rapidly put together a solution with them," recalls Jérôme Moueza, who heads CNES's Satellite Telecoms Applications unit. An antenna and an Internet box were used to test the quality of the satellite link in and around Paris, to make sure the latency was adequate for the system to work, even simulating cases where both the patient and doctor are in a remote area. *"These tests validated H4D's solution, which is certified to deliver a prescription from the doctor remotely. The satellite link is proving really successful in metropolitan France and has great marketing potential for remote regions like French overseas territories,"* says Jérôme Moueza. The effective collaboration is described as an *"open relationship"* by H4D's CEO, Vincent Hillenmeyer: *"The very professional discussions with our engineering team sorted out the evaluation of our system in a few weeks. We now have a solution for customers with connectivity issues and a partnership of trust going forward."*

MORE INFORMATION: ENTREPRISES.CNES.FR/ACCUEIL-CESARS