alpha

2021

“I cannot wait to get to the International Space Station and to fly on a new spacecraft too. The work we do in space is preparing humankind for larger steps into the cosmos, while continuously bringing advancements for all on Earth”

Thomas Pesquet

THOMAS PESQUET

Cleared for liftoff

Thomas Pesquet is the first (civilian trained) commercial airline pilot to become an astronaut and his love for aviation and the stars shows in everything he does.

Leaving Earth for the first time in the middle of winter on a Russian Soyuz spacecraft, Thomas was launched from Baikonur, Kazakhstan, to the International Space Station for his Proxima mission in 2016.

During his first mission, Thomas and crew broke records for the amount of science conducted on the International Space Station, and Thomas conducted two spacewalks to maintain the Station.

His pictures from space and frequent updates make him one of the most followed astronauts worldwide, bringing spaceflight closer to Earth and sharing the unique experiences of living and working in Earth orbit.

Alpha

Now Thomas is returning to the International Space Station for a second mission called Alpha, after the star Alpha Centauri, located in the same system as Proxima.

Thomas is taking a new ride to space and will be the first European to leave Earth on the SpaceX Crew Dragon launching from Florida, USA. The crew of four includes NASA astronauts Megan McArthur and Shane Kimbrough, who was with Thomas on the International Space Station during his Proxima mission, as well as Japanese astronaut Aki Hoshide.

NAME
Thomas Pesquet

BORN
27 February 1978
Rouen, France

OCCUPATION
Astronaut
Airline and zero-g research pilot

STUDIES
Spacecraft design and control
Aeronautics
Air France flight school

MISSIONS
Proxima (2016)
Alpha (2021)

TIME IN SPACE
197 days

SPACEWALKS
Two, total time 12 hours 32 minutes

HOBBIES
Sports and mountaineering

ESA–N.Fischer

"The Alpha mission connects to my first mission, Proxima, as the stars belong to the same system close to Earth. Alpha, a Greek letter, is also widely used in mathematics, science and technology. And, as the first letter of the alphabet, it is often synonymous with the excellence we try to achieve in space exploration."

THE EUROPEAN SPACE AGENCY

Space for everyone

Established in 1975, ESA now has 22 Member States and cooperates with many others. These countries are home to more than 500 million European citizens. If you're one of them, then we're working for you.

Our mission is the peaceful exploration and use of space for the benefit of everyone. We watch over Earth, develop and launch inspiring and unique space projects, fly astronauts and push the boundaries of science and technology, seeking answers to the big questions about the Universe.

We are a family of scientists, engineers and business professionals from all over Europe, working together in a diverse and multinational environment.

ESA is a partner in the International Space Station along with the United States, Russia, Japan and Canada. The first European astronaut flew to space in 1983, and the European Astronaut Centre in Cologne, Germany, has been training men and women for missions since 1998.

Participation in the International Space Station allows thousands of Europe's brightest people at hundreds of universities and companies in ESA's Member States to work on the leading edge of science and engineering.

ESA patch floating in the International Space Station's European-built Cupola window (NASA/ESA)

CNES

France created its space agency, Centre National d'Études Spatiales (CNES), in 1961. With a budget of €2.3 billion in 2021, CNES is a major player in international space cooperation. It keeps close ties with its European partners through ESA and the European Commission as well as space agencies around the world.

With 2368 employees working in four centres in Paris and Toulouse in France, and Kourou in French Guiana, CNES represents France's ambitions in space and focuses on five strategic elements: Ariane rockets, science, observation, telecommunication and defence.

CADMOS control centre (CNES–T. De Prada, 2020)

Columbus Control Centre (ESA/DLR–G. Zoeschinger)

GROUND CONTROL

ESA's Columbus Control Centre, known by its call-sign Col-CC, supports the European Columbus space laboratory. It is located at the German Aerospace Center DLR in Oberpfaffenhofen, near Munich, Germany.

The Control Centre is the direct link to Columbus in orbit. The centre's main functions are to command and control the European space laboratory's systems, to coordinate operations of European payloads on the International Space Station and to operate the European ground communications network.

The Centre's operations teams provide support 24 hours a day, seven days a week. The centre has two control rooms: one for operations and one for preparations, such as training controllers and simulations.

USER SUPPORT AND OPERATIONS CENTRES

In 1998, ESA created the User Support and Operations Centres (USOCs) to support International Space Station users. Centres around Europe are responsible for the use and implementation of European payloads on the International Space Station. The Operation Centres conduct tasks needed to prepare and operate experiments. They act as the link between science teams on ground and the Space Station.

The Columbus Control Centre distributes data to the User Support and Operations Centres and receives information from them. The information is used to generate mission plans and timelines for the flight controllers and astronauts.

Belgian User Support and Operations Centre during Atmosphere-Space Interactions Monitor installation (ESA–J. Harrod)

CADMOS: MICROGRAVITY EXPERTS

Based at the CNES centre in Toulouse, France, CADMOS has extensive experience in international cooperation around space missions. Though established in 1993, the expertise of the engineers working at CADMOS goes back to the 1980s. French-Russian cooperation at the time sowed the seeds for an operational centre to prepare and operate the scientific experiments conducted for human spaceflight. The first steps toward this effort were taken in 1982 when the first French astronaut, Jean-Loup Chrétien, flew into space. Engineers at CNES made scientific programmes a reality for the extremely demanding domain of human spaceflight.

CADMOS became part of ESA's User Support and Operations Centres in 1998 based on its experience in physiological space experiments. CADMOS now works in three domains: preparing experiments, managing operations during flight and collecting and treating data returned. CADMOS accompanies microgravity research on the International Space Station as well as on capsules and in the Airbus Zero-G research aircraft run by Novespace.

For human spaceflight, CNES works with MEDES teams who support CADMOS for all physiological aspects of missions, such as the Space Clinic in Toulouse, where the effects of spaceflight on the body are simulated, and at ESA's European Astronaut Centre for astronaut training and health.

For the Alpha mission CADMOS has prepared a dozen scientific educational and technological experiments. Through this programme, CNES aims to improve on the world-class laboratory that is the International Space Station so that scientists can continue to advance technological progress in space, for Earth. French scientific research for Solar System exploration and human spaceflight is also a priority.

Thomas Pesquet running CNES Echo experiment on the International Space Station (ESA/NASA)

Thomas Pesquet training on SpaceX Dragon (SpaceX)

TRAINING FOR FLIGHT

Return to space on a Dragon

Never stop learning: after Thomas returned to Earth, he continued training to keep his skills fresh and ready.

As an airline pilot and astronaut, Thomas is an ideal candidate to fly the microgravity research aircraft Air Zero-G – a refitted Airbus A310 that flies in repeated arcs 600 m up and down to provide 'weightless' conditions for the scientists and passengers on board. This type of aircraft requires no less than three pilots to fly in these extreme parabolas, so Thomas gained the Zero-G pilot rating to allow more experiments and people to experience these conditions.

Thomas also took part in an underwater training course called NEEMO NXT, run by NASA off the coast of California. He tested new technology, tools, techniques and training programmes for space exploration in an extreme envrionment: underwater. The underwater world offers similar geological features as the Moon and enables ideas to be tested under high workload, real-world stress and the unexpected problems that come with field work.

Remaining on active duty, Thomas was assigned to his next flight just three years after landing, this time flying on a SpaceX Crew Dragon spacecraft. In addition to the usual refresher training, Thomas had to learn new procedures for a different launch vehicle, and a new spacecraft with different landing system.

Earmarked for his mission is the installation of the European Robotic Arm, part of a new Russian laboratory module. Thomas spent many hours at Star City near Moscow, Russia, learning new the robotic controls and how to assist spacewalks for installation.

Should the opportunity for a spacewalk arise, he is ready to go back out into space.

Thomas Pesquet takes a selfie during a spacewalk (ESA/NASA–T. Pesquet)

"A spacewalk is a showcase of human technology, engineering and collaboration – each detail during an activity needs to be planned and thought out in detail, there is little margin for error."

Thomas Pesquet flying Air Zero-G (Novespace/ESA)

RESEARCH FOR THE BENEFIT OF HUMANKIND

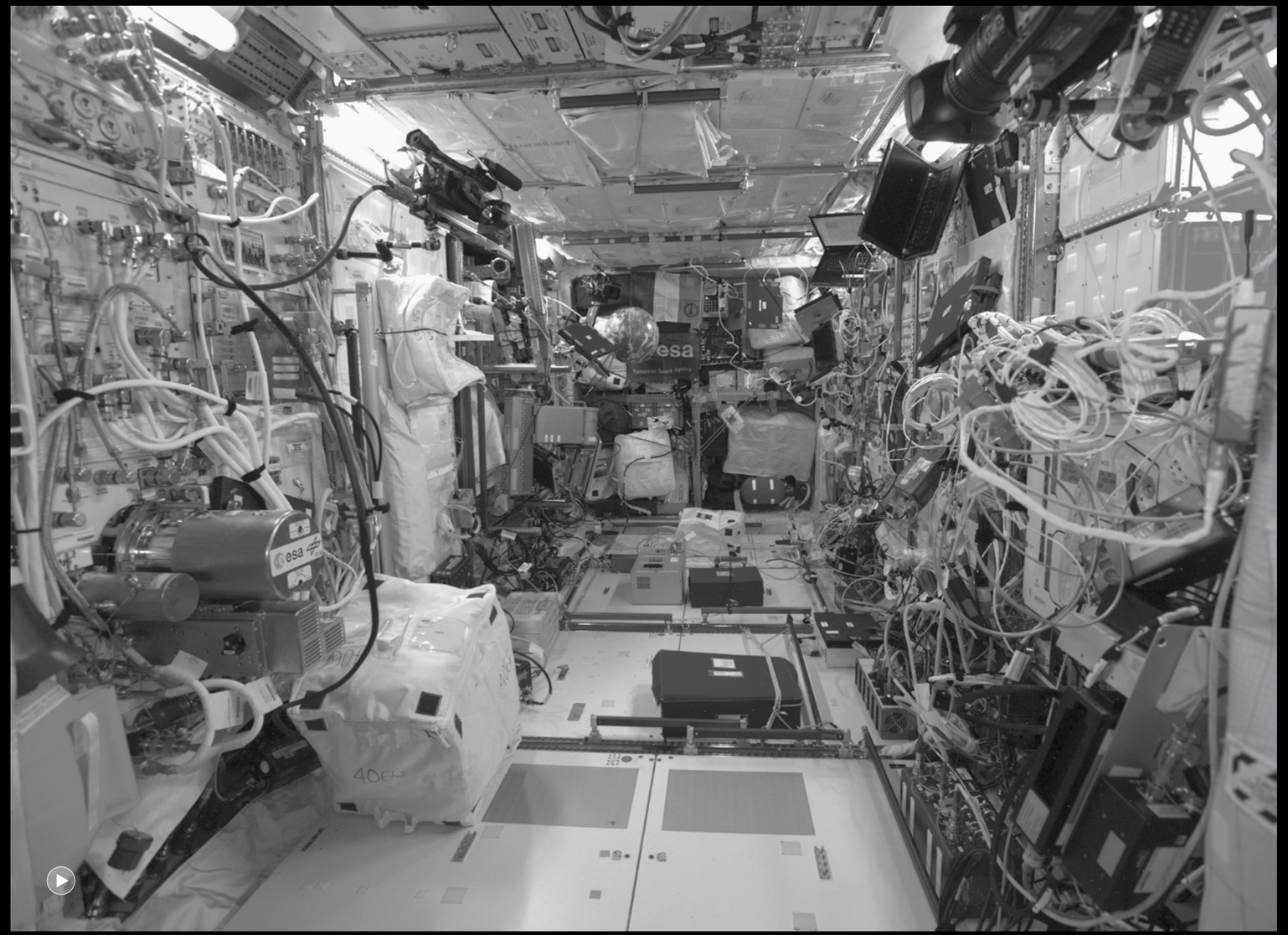
European science in space

Gravity affects almost everything we do. Remove it from the equation and we can improve our understanding of natural phenomena. The International Space Station is a place where the rules governing sedimentation, buoyancy and convection do not apply.

In 'freefall' around the planet, astronauts on the Space Station live in microgravity. This 'weightless' laboratory offers the opportunity to perform experiments that are just not possible on Earth. Up there, the crew carries out pioneering research, tests new technologies and pushes the boundaries of our knowledge. In this unique environment, Thomas will devote a lot of time to scientific activities, covering human research, physical science, biology and radiation, as well as demonstrating technologies that could shape the way we live and work.

"Every day is different on the International Space Station; we run so many experiments it is hard to keep track. One moment we will be incubating stem cells, the next moment launching satellites, and in the afternoon putting new cartridges in the Station's metal furnace to analyse and improve metal alloys. It is fascinating and I love the work we do for the researchers, benefitting all on Earth."

Thomas Pesquet during GRASP experiment on the International Space Station (ESA/NASA)



Europe's laboratory in space is packed with scientific equipment (ESA/NASA)

"Columbus was my home in space, a little piece of Europe on the International Space Station. I am looking forward to working in the laboratory again."

THE COLUMBUS LABORATORY

Where science happens

Columbus is the first and only European laboratory dedicated to long-term research in weightlessness. Europe's laboratory in space houses a wide range of scientific disciplines, from astrobiology and solar science to metallurgy and psychology. Inside and out, this complex and powerful module offers researchers the microgravity needed to unmask phenomena that cannot be observed on Earth.

Thomas's work station includes 16 experiment facilities that run 24/7. Each unit functions as an independent laboratory with its own power and cooling systems and communications links to scientists on Earth.

After a decade in orbit, circling our planet at 28 800 km/h, the versatile Columbus laboratory constantly breaks new scientific ground. More than 250 experiments have been carried out in this remarkable experiment facility.

Intensive use of this laboratory leads to new applications and benefits for people on Earth – from space to your doorstep.

Thomas Pesquet practising suturing during astronaut training (ESA)

EXPLORE FARTHER

Healing far from home

As humans travel farther from our home planet, we need to prepare for medical emergencies occurring where there are no hospitals. On the International Space Station, injuries are avoided at all costs but astronauts are never far from home; in a worst-case scenario they could land on Earth in hours.

Wound healing is a complex process and no one has adequately explained why mammals scar or heal imperfectly rather than regenerate fully.

The Suture in space experiment will look at how tissues heal in weightlessness. Living tissue from biopsies will be cut and sewn back together, before being sent to space where astronauts will activate the cells to monitor the healing mechanisms. The samples will be frozen at set times to track how they progressed in space.

The study will help understand how humans heal, but the preparations for Suture in space have already developed a new technique on Earth that keeps tissue biopsies alive for longer periods, aiding studies in laboratories on transplants, cell regeneration and surgical techniques.

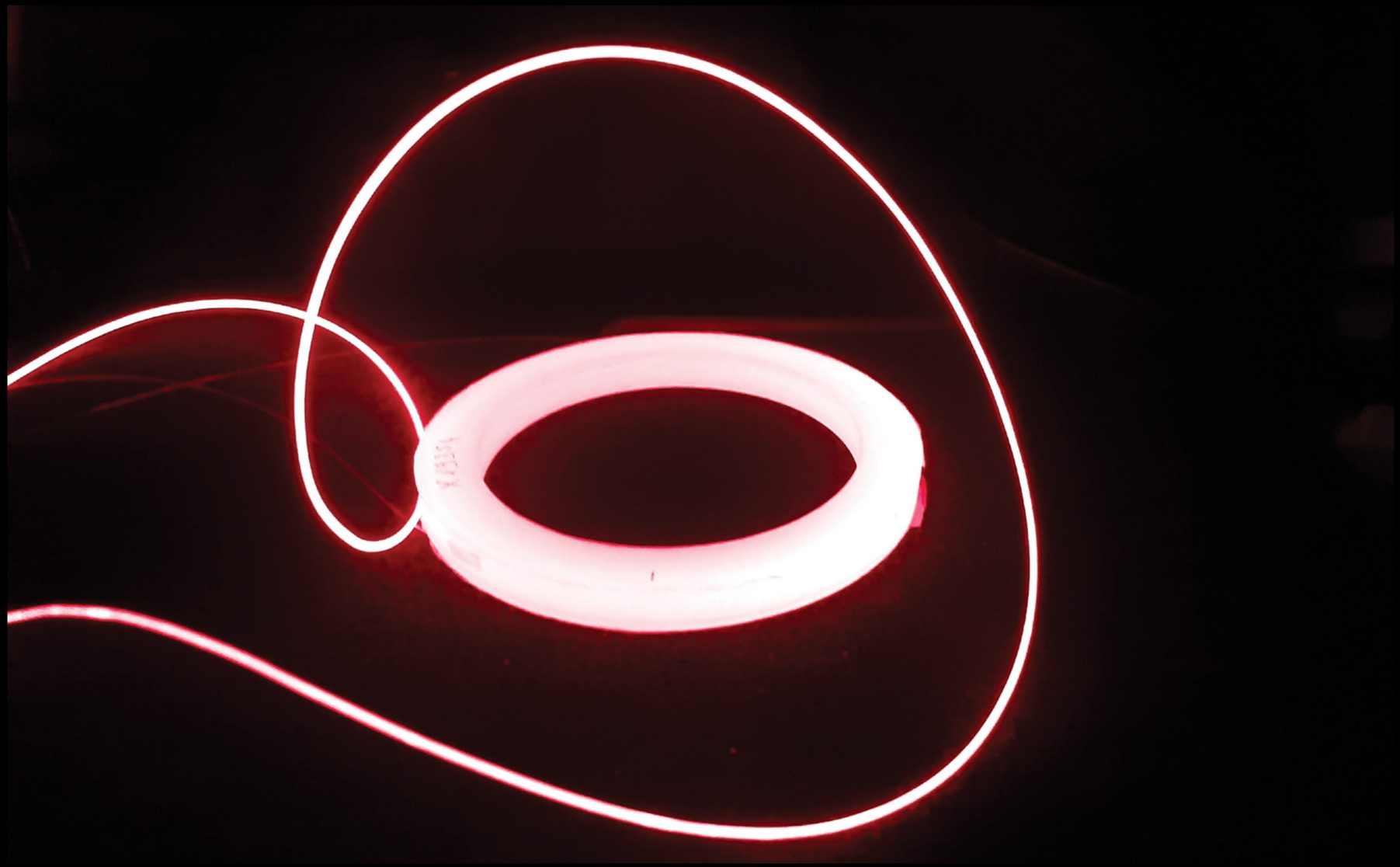
Recycling for life in space

Each kilogram launched into space is very expensive. For years, oxygen on the Space Station was extracted from water brought from Earth. As the Station welcomes larger crews at a time, thanks to new launch vehicles, ESA has designed a new system to recycle carbon dioxide into oxygen and reduce the amount of water that must be shipped into space.

ESA's Life Support Rack will move to the European-built Tranquillity module where it will produce oxygen for up to three astronauts. These operations are part of ESA's goal to create a closed life-support system, including water recovery and food production, that will eventually enable astronauts to stay in space indefinitely without costly resupply missions from Earth.

Advanced life-support systems are a huge step for human spaceflight as space agencies prepare to explore farther from Earth, such as to the Gateway, a staging post around the Moon for deep-space missions.

NASA's Jessica Meir working on Life Support Rack (NASA)



Lumina fibre optic cable (iXblue–P. heiney, 2020)

Preparing for the future

The Lumina experiment will demonstrate the reliability of a fibre-optic dosimeter in measuring radiation ionising inside the International Space Station. The Lumina technology demonstration features two spools of kilometre-long fibres that will improve our understanding of how fibre optic cables cope with long-duration spaceflight. This knowledge is essential as we prepare to protect astronauts and hardware on longer missions farther from Earth.

All hardware flown to the International Space Station travels in fire-proof foam-padded nomex bags. They are necessary to protect the hardware during launch, but once on board the bags are unnecessary and take up valuable space. With a total volume of 900 m^3, of which 388 m^3 is habitable, the International Space Station has no space to waste. Eco Pack is an experimental solution that is testing reusable, recyclable or even edible packaging materials.

The Dreams experiment hardware will be sent to the Space Station in this packing material that is made of recyclable and biodegradable blister strips.

Some of the Food Processor hardware will be packed in consumable materials such as gingerbread. Why throw away packaging when you can eat it and save precious fuel in the process? The Food Processor will fly to the Space Station in 2021 to demonstrate whipping up a chocolate mousse. The goal is to develop a tool that can allow astronauts to prepare their meals according to their nutritional needs and available stocks.

The Freshness Packaging demonstration aims to keep food on the International Space Station fresher for longer, moving from the current shelf life of one week to more than 15 days using a new permeable packaging technology.

WORK SMARTER

European Robotic Arm

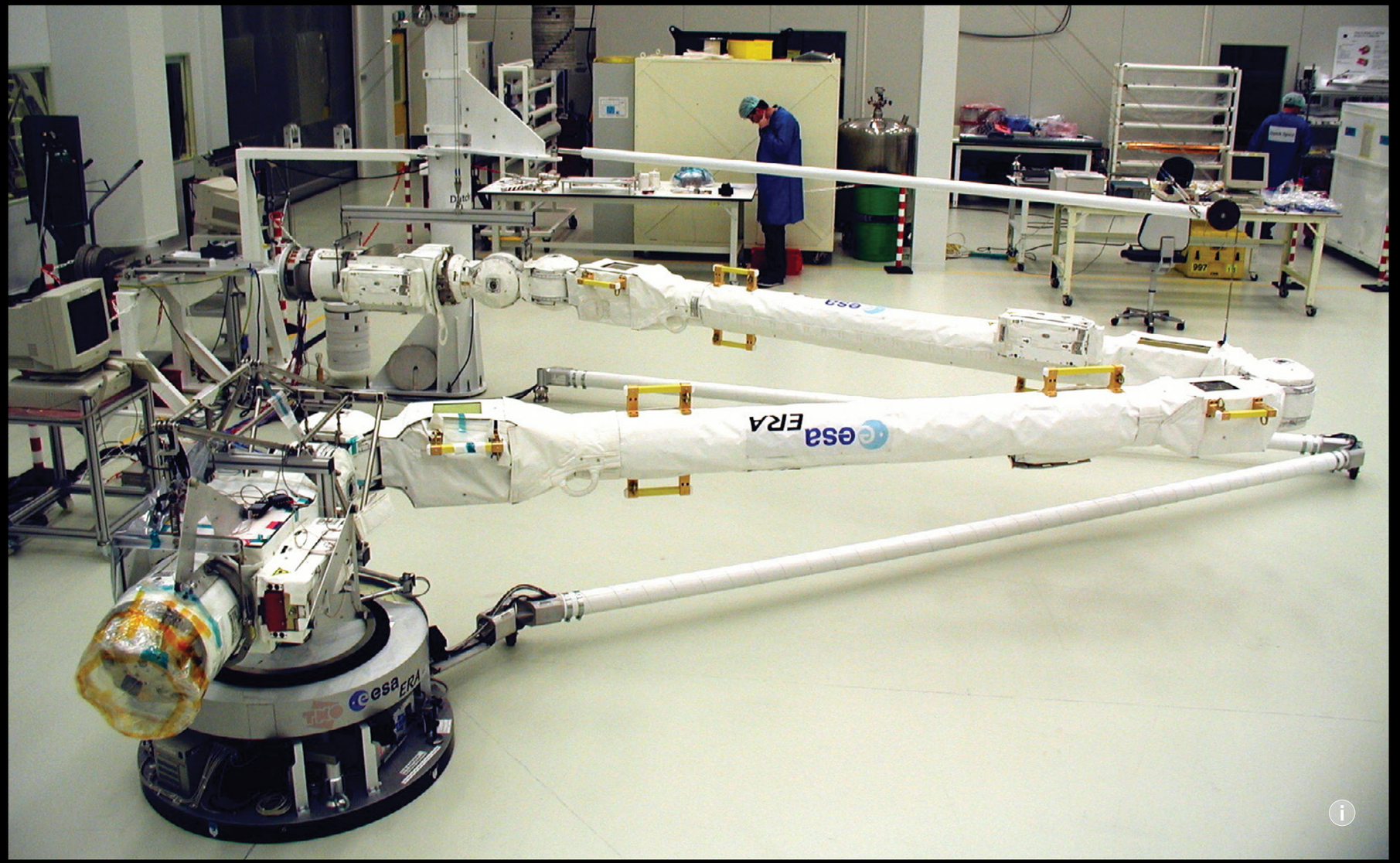
The European Robotic Arm (ERA) is the first robot that can 'walk' around the Russian segment of the International Space Station.

The 11-m-long robot has seven joints and can conduct assembly tasks with a large range of motion, working alongside astronauts to save time and effort during spacewalks.

The robotic arm can also transport astronauts to a position where they can work on the exterior of the Space Station saving time and effort during spacewalks.

Fully made-in-Europe, this intelligent robotic arm can perform tasks automatically and be controlled both from inside and outside the International Space Station.

Thomas is set to be on board when the European Robotic Arm arrives and is trained to help in its installation and setup.



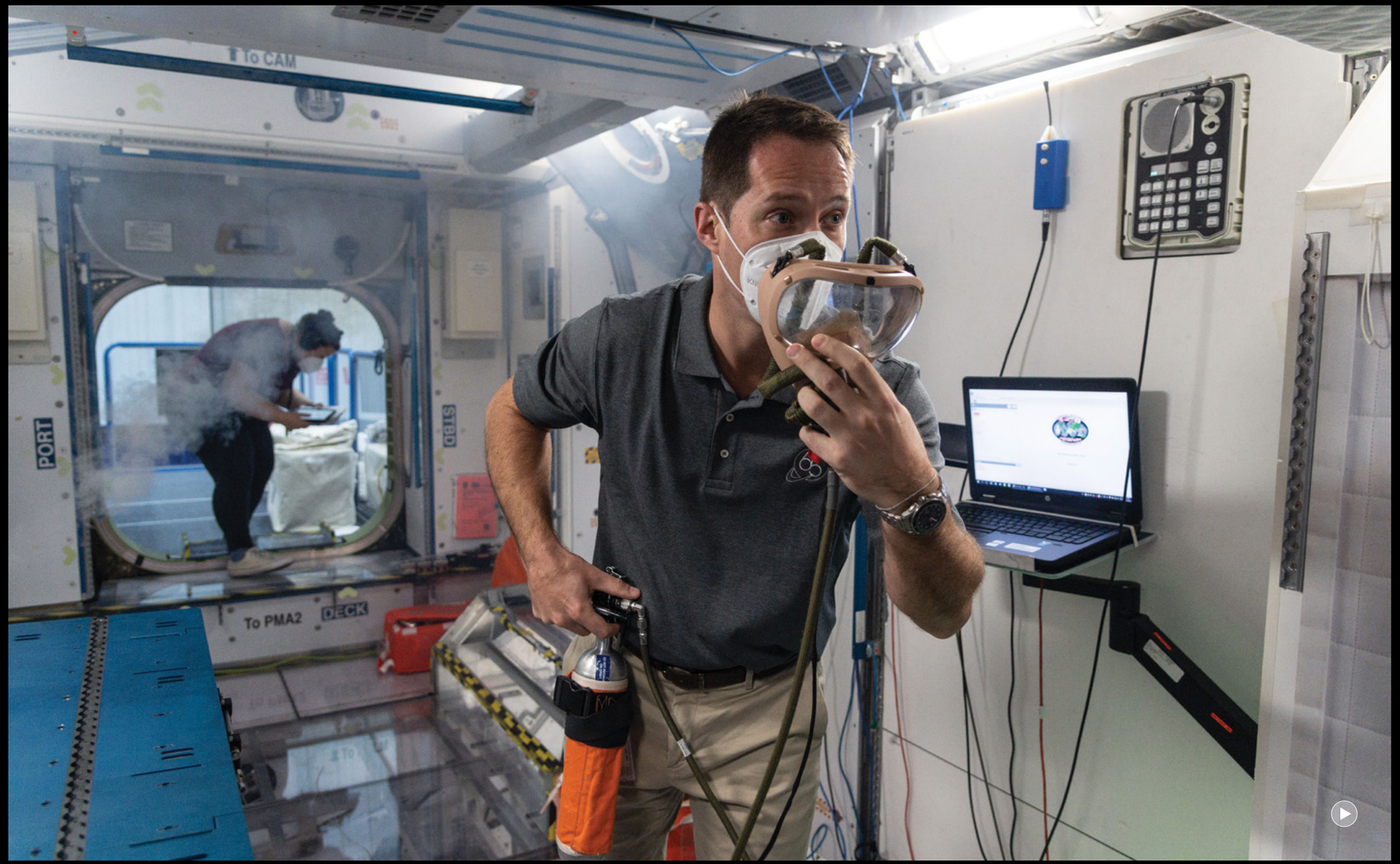
European Robotic Arm during testing in Leiden, the Netherlands (Dutch Space)

Safe air

Astronauts living on the International Space Station never get a breath of outdoor air. In their closed atmosphere, irritating, poisonous, and carcinogenic gas compounds emanate from materials, equipment, and the crew. As there is no window to open to freshen the air, astronauts must rely on the air revitalisation system.

Air quality is monitored continuously to assure the crew's health and well-being. A rapid response by the astronauts to any accidental release of harmful contaminants, or malfunction of the air system is essential, and air monitoring is even more important as missions last longer and samples cannot be taken to Earth for analysis.

ANITA-2 (Analysing Interferometer for Ambient Air) is an instrument that will constantly monitor air quality. Considerably smaller than its predecessor that flew to the International Space Station in 2007, and with improved software, the spectroscopy-based facility will run automatically in the background while astronauts get on with their work. The system is useful for all confined spaces such as in submarines.



Thomas Pesquet during emergency scenario training for Alpha mission (NASA–R. Markowitz)

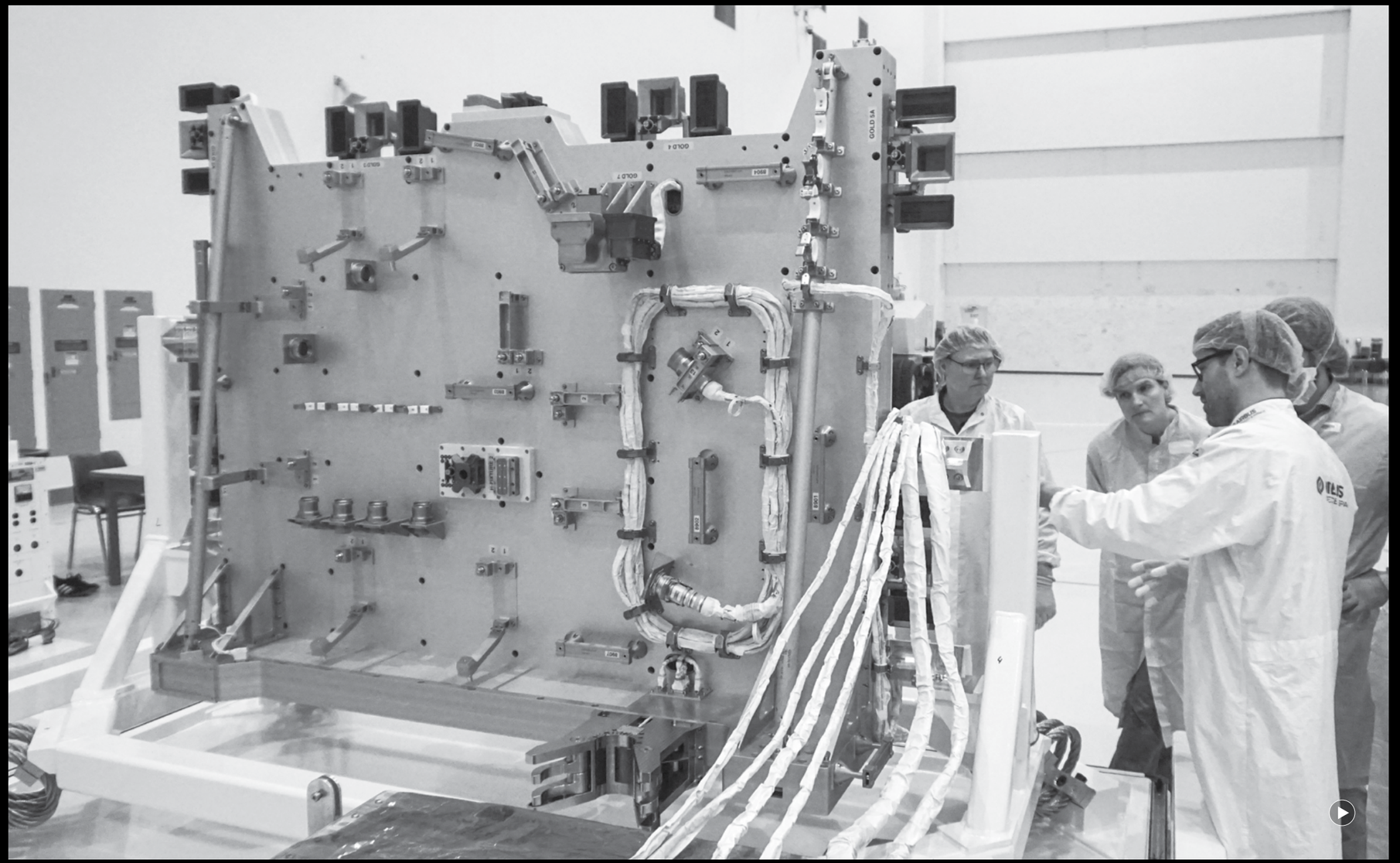
Commercial access to outside space

From idea to reality in less than a year, anyone's experiment can be launched to the Space Station.

Europe has a new commercial research facility outside the International Space Station called Bartolomeo, after Columbus's younger brother.

Bartolomeo offers a high-speed data link and a unique view of Earth and deep space, providing easy access to space for companies, organisations and research institutes with competitive pricing.

Humans cannot survive in space without a spacesuit, but some life forms can. ESA is planning to expose microorganisms, such as bacteria, seeds and lichens, to the harsh conditions of space for long periods of time – via Bartolomeo.



Bartolomeo getting ready for launch (NASA)

Ultrasonic tweezers and trapped object (CNES–T. De Prada, 2021)

Ultrasonic tweezers: moving objects without touching

Ultrasonic tweezers promises to move, manipulate and study objects or liquids without ever coming into contact with them. An acoustic tweezer uses ultrasound to trap objects. By moving the sound beam it is possible to move an object with great precision. The Ultrasonic tweezers experiment will evaluate how the technique can be used in microgravity to capture small plastic or glass marbles and move them over an obstacle course. Ultrasonic tweezers is a technology demonstrator that will stay on the International Space Station for use by scientists and astronauts to investigate other materials, gels and liquids and even hazardous materials or biological material without risk of contamination. Another use could be to capture water evaporation to better understand the physics at play. Other applications for the experiment lie in healthcare. Acoustic tweezers could be used to remove kidney stones or deliver targeted medicine.

"We run the experiments in space. We are the eyes and hands of researchers on Earth, but we are also experimented on as their test subjects... double science!"

Thomas Pesquet storing samples in the Space Station's freezer (ESA/NASA)

LIVE BETTER

DNA damage

As we age, our DNA sequences and structure changes and this can lead to cells and tissues functioning less well. Cosmic radiation damages DNA and can accelerate this process. A newly uncovered parallel mechanism called epigenetic ageing also changes DNA but not its sequence or structure. It involves modifications of specific positions of the DNA without altering its sequence. This modification changes very precisely with age, and has been called our epigenetic clock. Is this form of ageing also influenced by cosmic radiation? If so, by how much? On Earth we are protected from cosmic radiation by the atmosphere, but when astronauts live in space for months, they lose this protection and are exposed to greater amounts of cosmic radiation.

DNA damage sets out to determine the effect increased cosmic radiation on the ticking of our epigenetic clock to help us understand how the clock works and what causes some people to age quicker than others.

Thomas will take saliva samples to obtain DNA from the crew and preserve them over time. With these, we hope to unravel the secrets to why we age and how we can safely travel in space. This investigation promises to help us develop ways to keep us ticking longer and healthier – on Earth and in space.

Brain cells and neuroscience

The Dreams experiment will put astronauts' sleep under the magnifying glass. The experiment uses a novel sleep headband to study how sleep is influenced by living in weightlessness and isolation. Using small ECG sensors, this biomedical device will collect neuroscientific data that will help prepare for long missions to the Moon and Mars.

In the cellular domain, the Cerebral Ageing experiment will investigate how brains age on a molecular level. Researchers are using the rapid ageing that occurs when human cells travel in space to study brain cell development and ageing. The cell structures are prepared on Earth and cultivated in space before returning to Earth for analysis. The goal is to better understand genetic diseases such as Progeria as well as better understand how weightlessness and radiation can affect astronauts' brain cells.

Continuing French neuroscience experiments started on the Russian space station Mir, the Pilote experiment will evaluate a new way of providing tactile and visual feedback to astronauts when operating robots. A virtual reality headset and a haptic device can recreate the feeling of pressure and touch when tele-operating a robotic arm. The results from Pilote will improve control interfaces on the International Space Station and future spacecraft for lunar and martian missions, where astronauts in orbit could operate rovers on the surface.

Pilote experiment training (CNES–T. De Prada, 2020)

Immersive Exercise: virtual reality sport

Astronauts exercise two hours a day to compensate for the loss of bone and muscle mass from living in weightlessness. The daily workout can quickly become repetitive in the closed and unchanging environment, leading to lack of motivation. The Immersive Exercise experiment aims to break the monotony with virtual reality. Coupled with the Space Station's exercise bike, an astronaut can pedal in space while riding through Earth landscapes. Videos filmed in 360° on Earth are played back on the headset, with the speed changing depending on how fast the astronaut pedals. A number of scenes have been captured, including one trip around Paris and its monuments at Thomas's request. Already in use in some terrestrial fitness centres, the Immersive Exercise equipment could evolve to include gradient difficulties to recreate mountain roads. The Immersive Exercise technology should keep astronauts motivated on the International Space Station and improve their performance – an important aspect to consider on longer missions to the Moon and Mars.

Thomas Pesquet during Immersive Exercise training at the European Astronaut Centre (ESA)

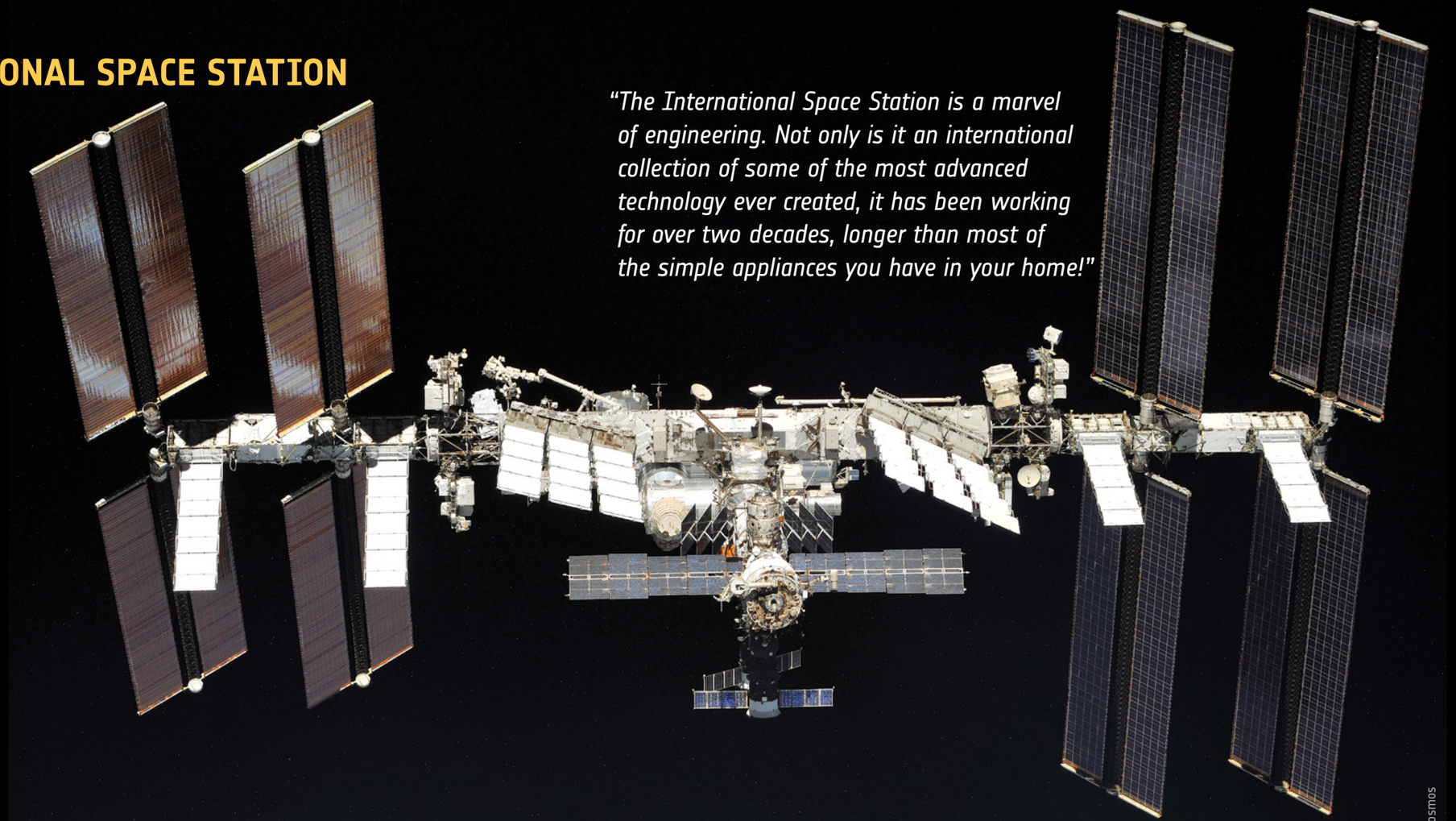
DESTINATION: INTERNATIONAL SPACE STATION

The International Space Station is a shining example of broad cooperation, uniting Europe, USA, Russia, Japan and Canada in one of the largest partnerships in the history of science.

The Station is one of the greatest engineering works ever achieved by humankind, and proof that it is possible to sustain life away from Earth. Results relating to the effects of long stays in orbit teach us how to manage the risks of future human missions farther out in space.

The endeavour has brought humankind together to live and work in space uninterrupted for two decades.

"The International Space Station is a marvel of engineering. Not only is it an international collection of some of the most advanced technology ever created, it has been working for over two decades, longer than most of the simple appliances you have in your home!"



Roscosmos

DID YOU KNOW?

The International Space Station

- flies about 400 km above Earth
- orbits the planet once every 90 minutes, 30 times faster than the speed of a Jumbo jet
- can be seen as a bright moving star with the naked eye from most places on Earth
- is larger than a six-bedroom house with two toilets and fitness facilities
- required 200 space missions to build and maintain
- has been inhabited since 2000

THE HUMAN FACTOR

A day in the life

FIRST TWO WEEKS: adapt to microgravity and Space Station working routine

Luca Parmitano dedicates some of his free time to taking pictures from the Station's Cupola, an observation module made in Europe (ESA/NASA)

FITNESS: exercise for two hours per day, six days a week

Andreas Mogensen exercises in the space gym to prevent muscle and bone loss during long-duration spaceflight (ESA/NASA)

SLEEP: eight hours per day

Samantha Cristoforetti rests in her free-floating sleeping bag (ESA/NASA)

SOCIAL: enjoy daily phone calls with family and friends

Thomas Pesquet contacts amateur radio stations on Earth (ESA/NASA)

FACTS AND FIGURES

- Over 560 people have been to space, of which around 250 have stayed on the International Space Station
- Astronauts have performed over 210 spacewalks to build and maintain the Station
- Cosmonaut Gennady Padalka has spent a record 879 days in space over five missions
- Cosmonaut Valeri Polyakov holds the record for the longest single stay in space, 437 days on Mir in 1994/5
- 6 months: typical astronaut stay on the Station

HEALTH CHECK: participate in weekly conferences with doctors

Tim Peake has his blood drawn for health and science research in space (ESA/NASA)

WEEKENDS: carry out housekeeping, public relations and voluntary tasks, plus spare time

Alexander Gerst carries out cleaning duties on Station (ESA/NASA)

A NEW FLIGHT TO SPACE

Voyage in a Dragon

Thomas will be the first European to fly as part of NASA's commercial crew programme to the International Space Station. Designated as Crew-2, his launch will be the second in the new, more frequent rides to space.

Launching from NASA's Kennedy Space Center in Florida, USA, on a Falcon 9 rocket standing 70 m tall, the crew of four will be boosted to orbital height and speeds in 8 minutes 48 seconds. Docking with the International Space Station is planned a day after launch.

Meanwhile, the first stage booster returns to Earth to be used again after refurbishment. The booster that launches Thomas and crew into space has already proved itself by launching the first commercial crew.

KEY DATA

Launch site	Kennedy Space Center, Florida, USA
Launch	April 2021
Landing	October 2021
Spacecraft	Crew Dragon
Launcher	Falcon 9

SpaceX Crew-1 launch (NASA)

SpaceX Crew Dragon arriving at the International Space Station (NASA)

"As a pilot I am eager to fly in this new spacecraft. But I am extra privileged to have flown in the trusty Russian Soyuz too. I get to try both these remarkable machines."

DRAGON

The Crew Dragon spacecraft is based on the uncrewed cargo version that SpaceX has been using to ferry supplies and equipment to the International Space Station since 2010.

The Crew version can transport up to seven astronauts. The automated spacecraft is monitored and controlled if necessary using touch screens, a first for spaceflight.

The nose cone of the Crew Dragon opens to reveal the docking port. Once docked with the Harmony module, the Crew Dragon will remain there for the duration of the Alpha mission. The spacecraft acts as lifeboat if ever the crew need to return to Earth in an emergency.

Return to Earth

After living and working on the International Space Station for around six months, Thomas will return to Earth for the second time with his three crewmates.

The Crew Dragon will return to Earth with a splashdown in the Atlantic Ocean. The capsule has a heat shield which protects it against the 7000°C temperatures – hotter than the surface of the Sun – encountered when reentering Earth's atmosphere at a speed of around 27 000 km/h. The nose cone, which protects the docking adaptor during ascent and reentry, is jettisoned before splashdown.

Four parachutes deploy at the final stages to ensure a calm splashdown, and boats are nearby to welcome the four out-of-this-world travellers. The astronauts then go for debriefing and recovery.

The Crew Dragon is reusable, and SpaceX aims to fly it up to five times more.

"A big difference between my two missions is that we had a touchdown of the Soyuz in the steppes of Kazakhstan for Proxima, while for Alpha we get to splashdown in the Atlantic Ocean, off the coast of the USA."

Space Crew Dragon splashdown (NASA)

THE SPACE GENERATION

Thomas will bring a universe of educational activities down to Earth. The astronaut will encourage the study of science, technology, engineering and mathematics among the next generation of explorers and also promote a healthy lifestyle through sports.

European Astro Pi Challenge

Astro Pi uses two credit card-sized computers equipped with a host of sensors and cameras on the Space Station. Students all over Europe, up to 19 years old, have the opportunity to run their own computer programmes in orbit during the school year by joining two challenges. While 'Mission Zero' teams will work to display a greeting message and the Station's temperature humidity on the Astro Pi computers, 'Mission Space Lab' teams will design a scientific experiment to investigate life in space or on Earth.

Mission-X: walk to the Moon

Space training goes back to school. Future space explorers are on their marks to train like astronauts for the Mission-X challenge, an international campaign focused on health, fitness and nutrition. CNES and ESA have supported the initiative since its launch in 2011. Thomas has encouraged and congratulated schoolchildren for the 2021 edition. Students aged between 8 and 12 years old will practice scientific reasoning and teamwork while participating in hands-on training targeting strength, endurance, coordination, spatial awareness and more.

Astro Pi gives students the opportunity to run their own computer programmes in space (Alasdir Allan/Bailim Light Industries)

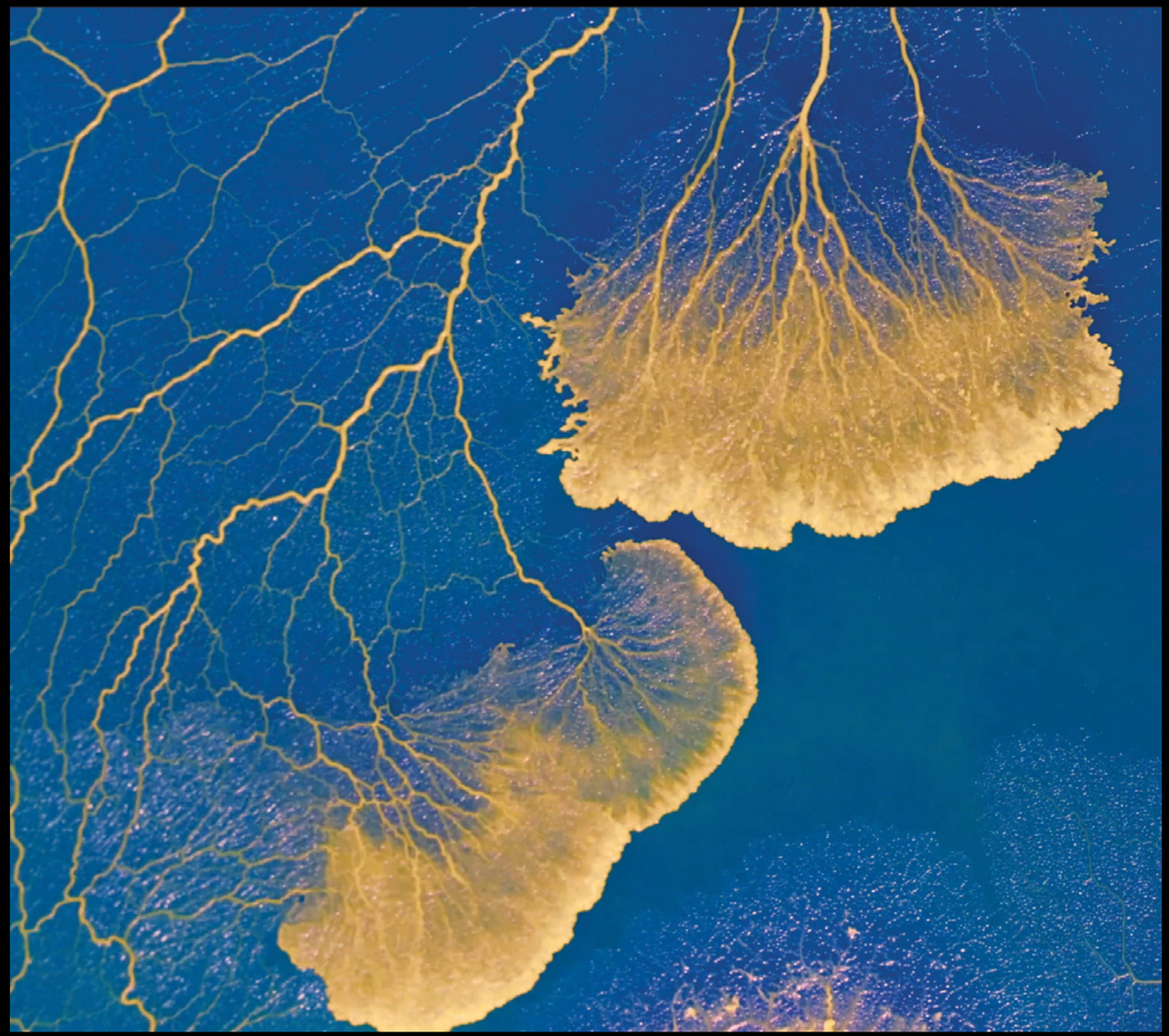
Generation ISS: TetrISS and Eklosion

TetrISS is a technology demonstrator that will show the work of Ernst Chladni in space. Chladni figures visually display acoustic waves on vibration plates with fine particles. In space, the sound waves will move to create three-dimensional structures.

Mixing botany and poetry, Eklosion will send French marigold seeds to space to provide a personal companion for Thomas and symbolise the link between Earth and the International Space Station. The Eklosion capsule includes scented cards with personal messages for Thomas from his loved ones. The Eklosion project invites the public to also grow French marigold flowers and share their progress on social media.

Blob

Space research can be conducted in a school laboratory. Students aged between 10 and 18 years prepare to investigate the Blob, a naturally occurring slime mould, or *Physarum polycephalum*, that is capable of basic forms of learning and adaptation. Blob is neither plant, nor animal, nor mushroom. Composed of just one cell and without a brain, it is still able to move, feed, organise itself and even transmit knowledge to like-minded slime moulds. Thomas will conduct an experiment on the Space Station to see how the Blob's behaviour is affected by microgravity. Students will replicate the experiment in their classrooms, comparing their results to a timelapse video from space, to see differences in the Blob's speed, shape and growth.



Slime mould (CNRS–A. Dussutour)

Moon Camp Challenge

Astronauts living on the Moon will need to rely on new infrastructure to protect them from radiation and meteorites as well as produce energy, extract or recycle water, produce food and overcome other challenges. ESA's Moon Camp Challenge dares students to design their idea for a lunar base in a 3D modelling tool (Tinkercad or Fusion 360).

ARISS: Talk to astronauts in space

Not everything in space is high-tech. Radio enthusiasts can make contact with the International Space Station over old-fashioned radio waves. As he flies over Europe, Thomas will talk to children equipped with radios supplied by the organisation Amateur Radio on the International Space Station (ARISS). A conversation via ARISS usually lasts 12 minutes, during which children from selected schools can ask the astronaut questions about life and work in space.

To the Moon

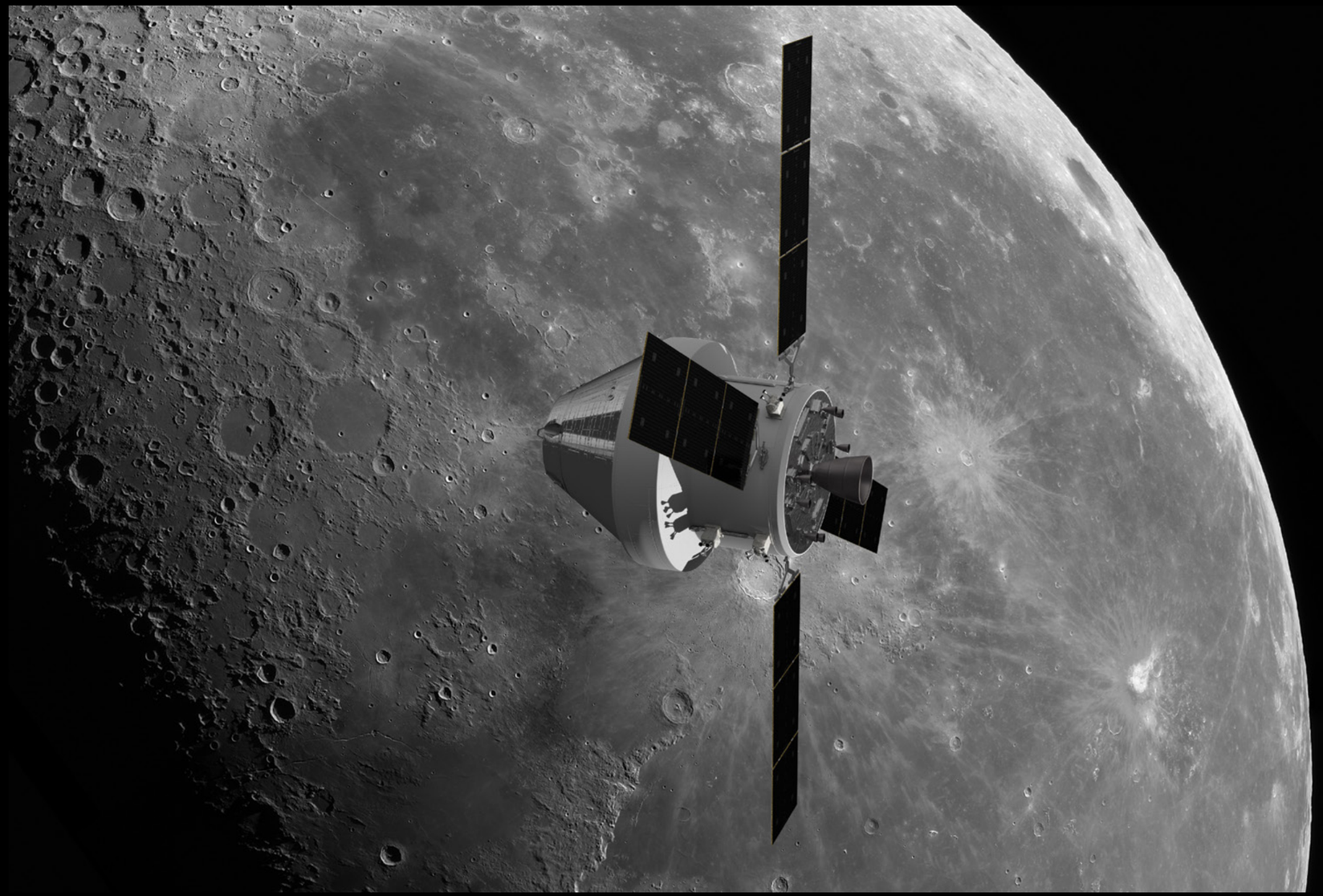
Space is a harsh, inhospitable frontier. European astronauts, engineers and scientists are working together to open the door to future explorers living off the land, away from Earth.

While continuing to exploit operations on the International Space Station, ESA is setting its sights on the Moon. NASA's Orion spacecraft, with the European Service Module at its core, will build bridges to Moon and Mars. Orion will also help to build the Gateway in lunar orbit, a distant human outpost where we can learn to live and work thousand of kilometres farther out in space than on the International Space Station.

Modules for the Gateway are already in development; the habitation module I-Hab and communications and refuelling module Esprit are being built in Cannes, France, where Thomas was an intern during his studies.

Moving away from one-shot orbital missions, bold ambitions foresee humans exploring the polar regions of the Moon hand-in-hand with robots, in international cooperation and with commercial partners.

These steps are bringing us closer to our ambition: sending the first Europeans to the Moon and beyond, with Europe as a leading force in humankind's greatest adventure.



Artist's impression of Orion over the Moon (NASA/ESA/ATG Medialab)

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