minerva

2022

“This is my second mission to the International Space Station, but it’s like returning home. I can’t wait to settle into a full schedule of science, maintenance and operations 400 km over Earth.”

Samantha Cristoforetti

SAMANTHA CRISTOFORETTI

Cristofoready for space

Italian ESA astronaut Samantha Cristoforetti was first launched to the International Space Station in 2014 for her 200-day Italian Space Agency ASI mission, Futura. In 2022 she returns to Earth's orbital outpost ready for a new ESA mission: Minerva.

Samantha holds a master's degree in mechanical engineering with specialisations in aerospace propulsion and lightweight structures. She also earned her fighter pilot wings in 2006 as part of the Italian Air Force before being assigned to fly the AM-X ground attack fighter at the 51st Bomber Wing based in Istrana, Italy.

In 2009 Samantha was selected as an ESA astronaut and in 2012 she was assigned her first space mission to the International Space Station as a flight engineer on Russian spacecraft Soyuz TMA-15M for Expedition 42/43.

In 2022 Samantha will be launched to the Station once again – this time alongside NASA astronauts Kjell Lindgren, Bob Hines and Jessica Watkins in a SpaceX Crew Dragon as a member of Crew-4. On Station, she will serve as a member of Expedition 67.

During her ESA mission known as Minerva, Samantha will carry out a full programme of scientific research and Station maintenance in microgravity and is scheduled to support the commissioning of the European Robotic Arm (ERA). She will also share her experiences of living and working in microgravity 400 km above Earth.

Minerva

The name of Samantha's second mission is inspired by Roman mythology. For the ancient Romans, Minerva was goddess of wisdom but also a warrior and protector of the handicrafts and the arts. Samantha chose this name as a homage to the competence and sophisticated craftmanship of people all over the world who make human spaceflight possible.

Minerva is often depicted with her sacred owl, a key feature of Samantha's mission patch. The eye of the owl is a yellow Moon casting a white glow onto Earth. Its beak hints at the shape of the International Space Station, with its characteristic solar panels, while waves of ever-darker blue make up the owl's body – encouraging us all to rise to the challenge as we move further into deep space.

ESA–A.Conigli

"Minerva was also a warrior goddess, so she embodies the fortitude, the toughness and the discipline that is required of us, as well as the wisdom that we aspire to demonstrate, as we consolidate and expand human presence in space."

NAME
Samantha Cristoforetti

BORN
26 April 1977
Milan, Italy

OCCUPATION
Astronaut
Former Italian Air Force Pilot

EDUCATION
Master's in mechanical engineering from the Technical University of Munich, Germany

MISSIONS
Futura (2014-15)
Minerva (2022)

TIME IN SPACE
199 days 16 hours 42 minutes (and counting)

HOBBIES
Reading, learning languages, hiking, scuba diving and yoga

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 are one of these citizens, then your support plays a vital role as we explore farther in space.

ESA's mission is the peaceful exploration and use of space for the benefit of everyone. Our family of scientists, engineers and business professionals from all over Europe 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.

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

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

Knowledge developed through our work on the Space Station makes it possible to send humans farther into space than ever before and improve the quality of life here on Earth.

Artist's impression of the ESA patch floating in the International Space Station's European-built Cupola window (ESA)

Headquarters of Italian Space Agency ASI in Rome Italy. (ASI)

ITALIAN SPACE AGENCY – ASI

Established in 1988, the Italian space agency, Agenzia Spaziale Italiana (ASI), prepares and implements the Italian space policy. ASI is a major player in all space sectors from space science, Earth observation, human and robotic exploration, space transportation, telecommunications and navigation.

Today, ASI plays a key role at the European level where Italy is in the top three contributing countries to ESA and at global level with many space agencies worldwide. ASI has a close working relationship with NASA which has led to its participation in many of the most interesting scientific missions of recent years, including the International Space Station.

Samantha's Futura mission was the result of a special agreement between NASA and the Italian Space Agency ASI. Minerva will see ASI sponsor and support a great number of the scientific experiments that Samantha will carry out in space.

GROUND CONTROL

User support and operations centres

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

The Columbus Control Centre (Col-CC) distributes data to the USOCs and receives information from them. This information is used to generate mission plans and timelines for the flight controllers and astronauts.

Columbus Control Centre

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

Col-CC is the direct link to Columbus in orbit. Its main functions are to command and control the European space laboratory's systems, coordinate operations of European payloads on the Space Station and to operate the European ground communications network.

Col-CC's operational teams focus on aspects of Columbus from the flight director to safety, equipment, ground systems and configuration and provide assistance 24 hours a day, seven days a week.

The voice of Earth

The European Communicator and Medical Operations (EUROCOMs) console is based at ESA's European Astronaut Centre (EAC) in Cologne, Germany, and is the interface between astronauts, the Columbus Flight Control Team, User Support and Operation Centres and space medicine experts.

EUROCOMs are selected from EAC's Crew Support, Crew Instructors and Biomedical Engineers to perform and manage communication between ESA's Columbus Control Centre, User Support and Operation Centres (USOCs) all over Europe and astronauts from all countries working on ESA activities in orbit.

Columbus Control Centre (ESA/DLR)

EUROCOM (European Spacecraft Communicator) preparing the Daily Planning Conference between the Columbus Flight Control Team and the crew of the International Space Station. (ESA)

Samantha collects samples in a lava tube. (ESA-R.Shone)

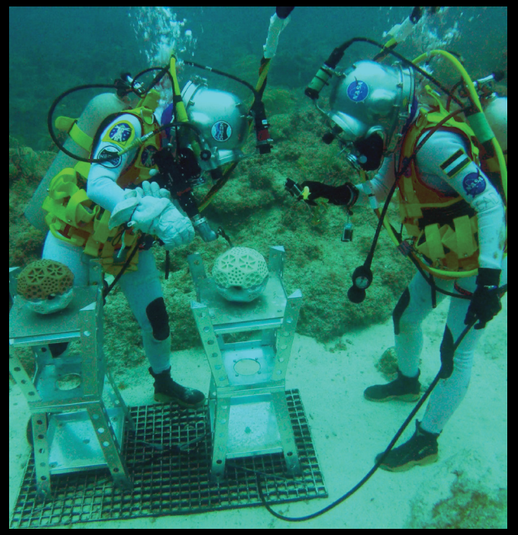
TRAINING FOR FLIGHT

Land, sea and space

Between her Futura and Minerva missions, Samantha undertook technical and management duties at ESA's European Astronaut Centre. She led the student-centered Spaceship EAC initiative, under which young professionals and researchers test early concepts to advance the future of human and robotic space exploration, before serving as ESA crew representative in the Gateway project to establish a staging post around the Moon.

In 2017 she participated in ESA's Pangaea training course designed to provide astronauts with the fundamental knowledge and practical skills to be effective field scientists during future planetary exploration missions to the Moon and Mars. Then, in 2019, she served as commander for NASA's 23rd Extreme Environment Mission Operations (NEEMO23). This was a nine-day mission to the Aquarius Reef Base undersea research habitat, 19 m below the surface of the Atlantic Ocean, off the coast of Key Largo, Florida, USA.

The full NEEMO-23 crew. (NASA- K.Shreeves)



Testing repair techniques for future habitats. (NASA/NEEMO23)

Crew-4 astronauts Jessica Watkins, Robert "Bob" Hines and Kjell Lindgren of NASA and Samantha Cristoforetti of ESA during a training session at NASA's Kennedy Space Center in Florida, USA. (NASA/SpaceX)

During NEEMO23, Samantha and NASA astronaut Jessica Watkins evaluated the second version of ESA's Lunar Evacuation System Assembly prototype during a simulated Moon walk on the ocean floor. This device is designed to be rapidly deployed by an astronaut in lunar gravity to rescue a crewmate in need. Samantha and Jessica will work together again, this time in microgravity, as Crew-4 and International Space Station crew mates.

ESA announced Samantha's assignment to a second space mission in March 2021. Since then, she has been training with international partners for her flight to the Station and her tasks in orbit.

"On my first mission to the ISS I was part of Expedition 42. Forty-two, of course, is the answer to the ultimate question of life, the universe and everything. This time I will be part of Expedition 67. And what is 6x7? The answer is... 42!"

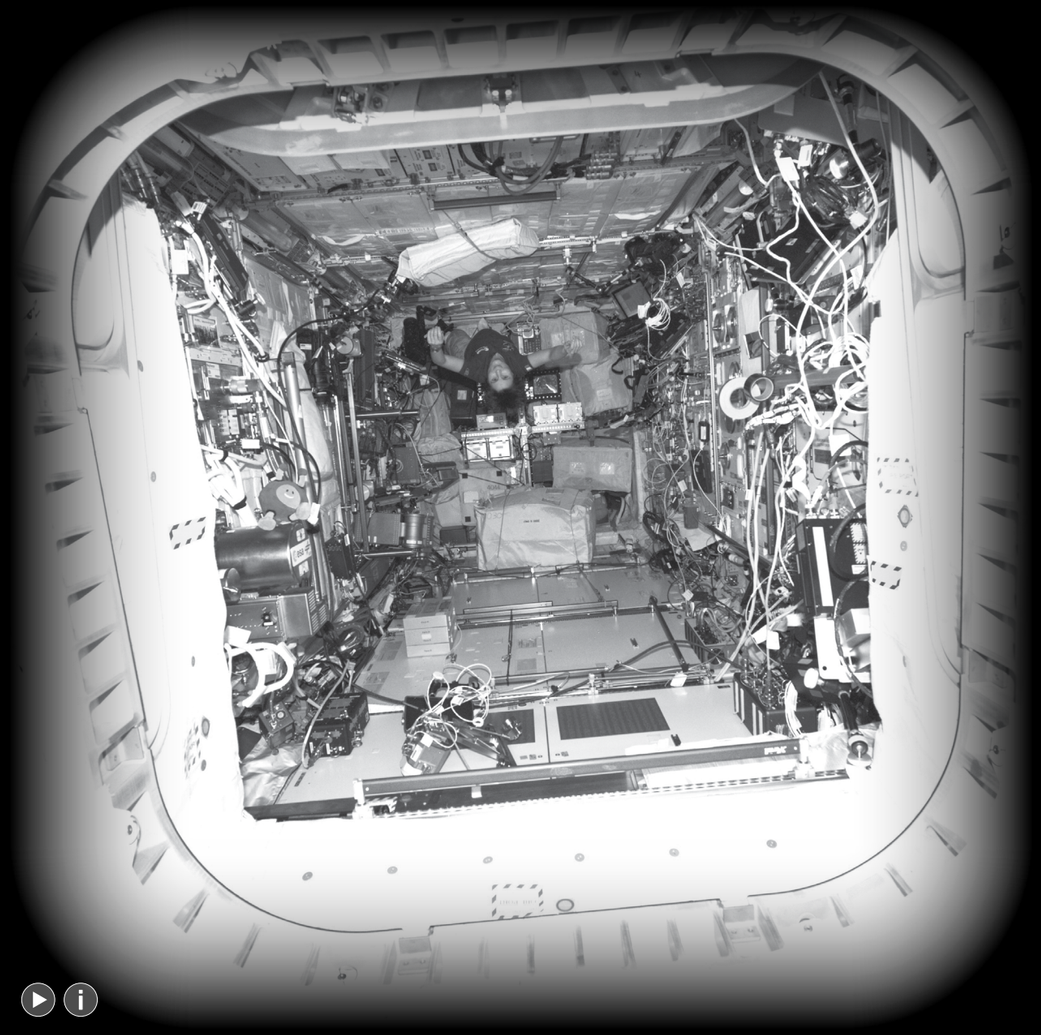
Samantha Cristoforetti

RESEARCH FOR THE BENEFIT OF HUMANKIND

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 – making it a fantastic resource for enhancing scientific knowledge.

In constant freefall around the planet, astronauts on the Space Station live and work in microgravity. This weightless laboratory allows them to perform experiments that are not possible on Earth. Up there, crews run pioneering research, test new technologies and push the boundaries of knowledge. Samantha will devote much of her 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.

ESA astronaut Hans Schlegel works on Columbus exterior (ESA/NASA)



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

"Every little thing that you do on orbit, even if it's just a 20-minute activity to install an experiment and switch it on, is incredibly gratifying. As astronauts, we get to put the cherry on the cake of many years of hard work that it takes to develop an experiment and get it into space."

Samantha Cristoforetti

THE COLUMBUS LABORATORY

Home of European science in orbit

Columbus is Europe's laboratory on board the International Space Station. This lab accommodates a wide range of scientific research in space, from astrobiology and solar science to metallurgy and psychology. Inside and out, it provides the microgravity environment and capabilities needed for researchers to test technology and observe phenomena that cannot be observed on Earth.

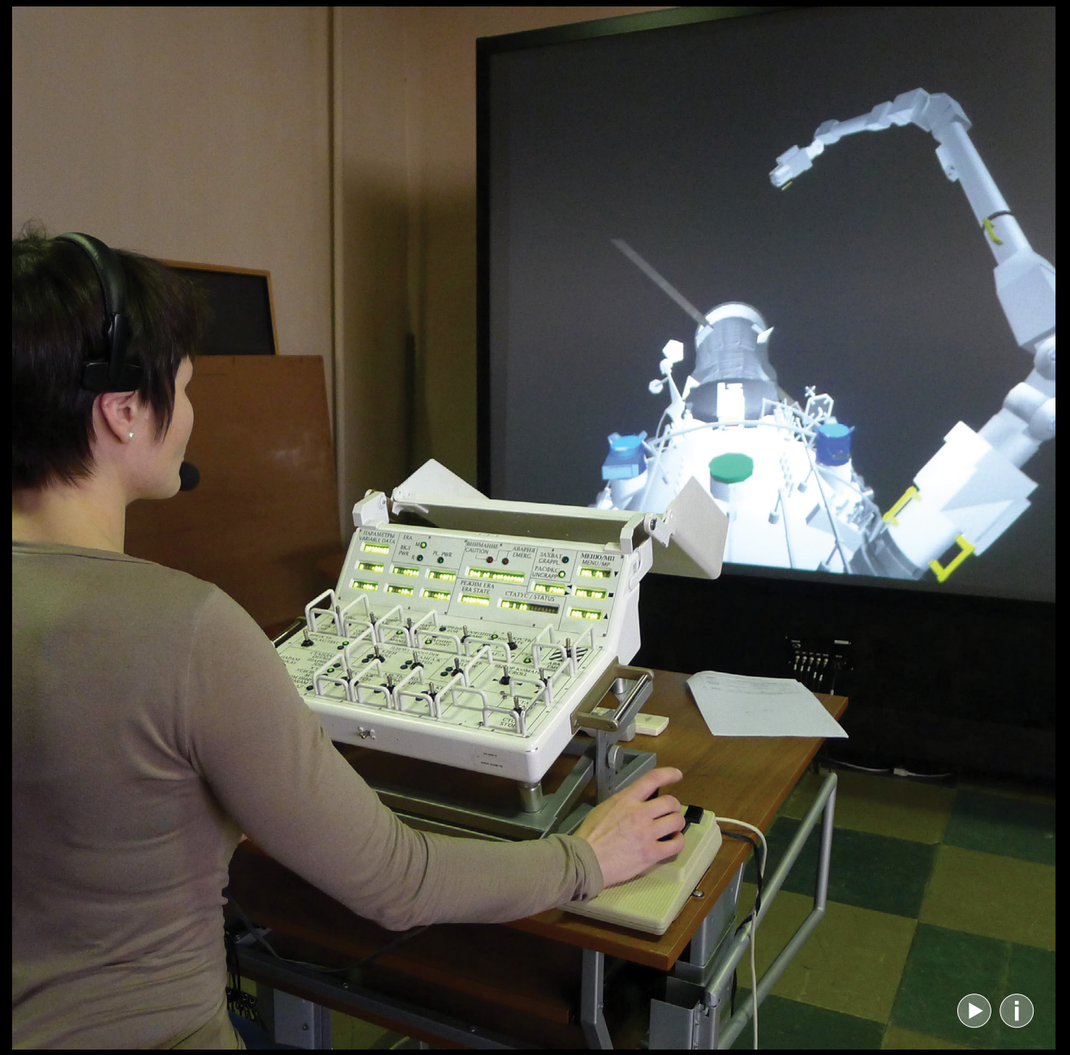
This lab will be Samantha's main workstation throughout Minerva and includes 16 experiment facilities that operate 24/7. Each unit functions independently, with its own power and cooling systems and communications links to scientists on Earth. After more than a decade in orbit, circling our planet at 28 800 km/h, Columbus is a versatile laboratory that is constantly breaking new scientific ground. More than 250 experiments have been carried out in this remarkable facility, with many more to come.

In this section you will find a snapshot of some of the science activities and technology demonstrations taking place throughout Samantha's Minerva mission. Stay tuned to Samantha's Twitter account, the ESA website and ESA's Exploration blog for regular updates on science in orbit.

European Robotic Arm

Launched to the Station on 21 July 2021, the European Robotic Arm (ERA) is the first robot capable of 'walking' around the Russian segment of the orbital outpost. It can handle components up to 8000 kg with 5 mm precision, be operated from inside and outside the Space Station and will transport spacewalking astronauts from one working site to another.

Five spacewalks are planned to set ERA up and enable its first space operations, some of which will occur during Samantha's mission.



Samantha Cristoforetti trains in operation of the European Robotic Arm. (Roscosmos)

NASA astronaut Mike Hopkins installs the Columbus KA-band antenna (ColKa) outside ESA's Columbus laboratory (ESA/NASA)

"The Columbus laboratory is a slice of Europe in space, and it's been undergoing a mid-life upgrade. I'm looking forward to the possibilities brought about by new facilities such as ColKa and contributing to the upgrades and maintenance on board."

Samantha Cristoforetti

Enhanced communication

An upgrade to the communications system on the Space Station is delivering broadband internet speeds, similar to those enjoyed by people on Earth. This means that experiments on the Station can now be monitored from Europe in close to real time. Previously, data from investigations such as those focusing on the effects of radiation on seeds and biomining research had to be stored on hard drives and returned to Earth many months later.

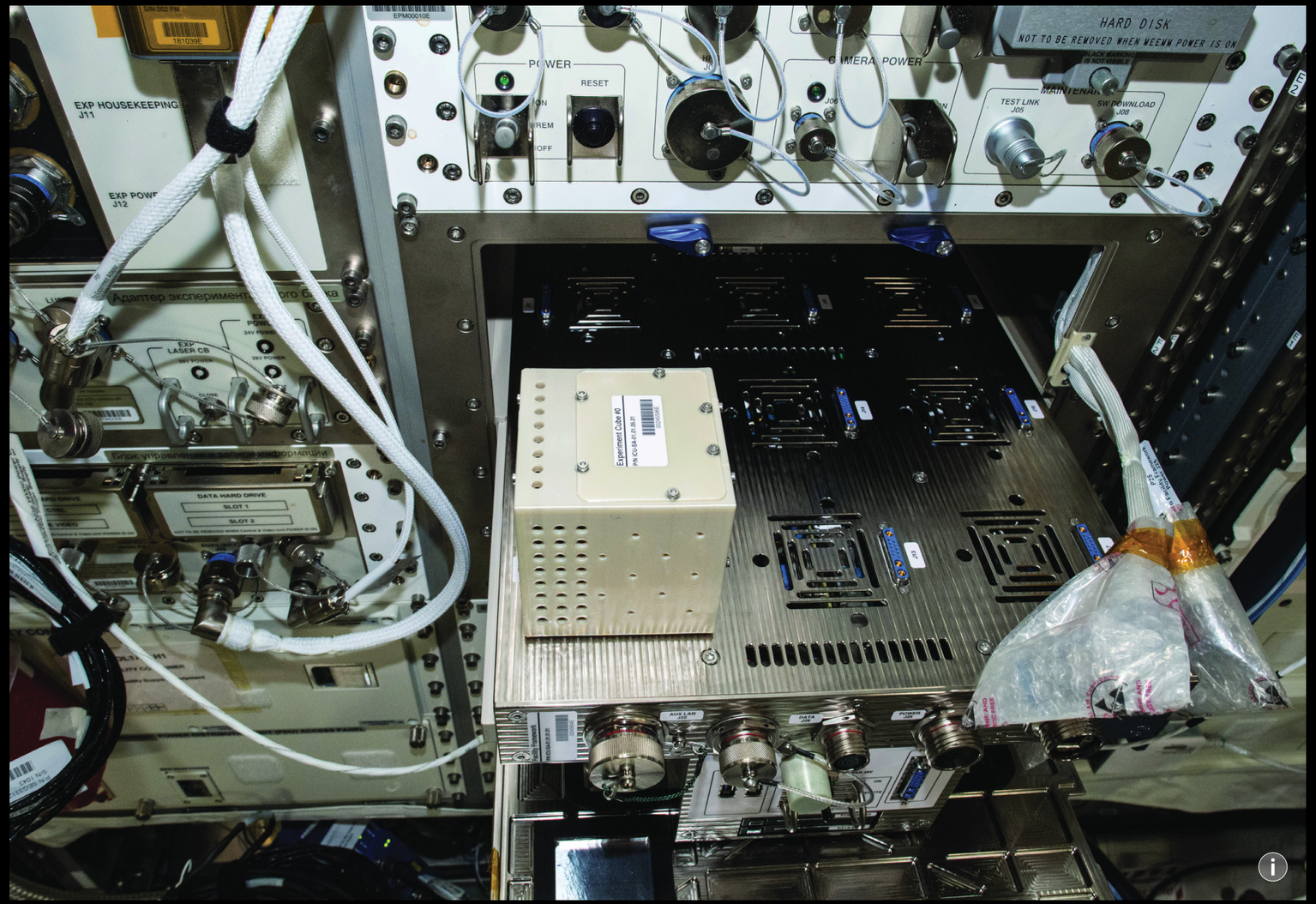
The communications device that enables this, known as 'ColKa' for 'Columbus laboratory Ka-band terminal', was installed during a spacewalk in January 2021. ColKa uses the European Data Relay System communications satellite, which was developed as an ESA Partnership Project with Airbus. ColKa will be active throughout Samantha's mission – providing speeds of up to 50 Mbit/s for downlink and up to 2 Mbit/s for uplink to the Space Station.

Commercial access to space

The Bartolomeo platform, mounted to the exterior of the Columbus laboratory, offers a high-speed data link and unique view of Earth and deep space. Built by Airbus in Bremen, Germany and operated jointly with the Columbus Control Centre in Oberpfaffenhofen, it provides easy and competitively priced access to space for companies, organisations and research institutes.

Inside ESA's orbital laboratory, a facility known as Ice Cubes also enables commercial research in weightlessness. During Samantha's mission, crew time will be used to install and attend to small modular experiment cubes.

In 2019, ESA also established a partnership with Kayser Italia to offer the Kubik incubator facility on the International Space Station to commercial customers for biological, biotechnological and biochemistry experiments through a service called Bioreactor Express.



Ice Cubes facility in Columbus. (ESA/NASA)

The Analyzing Interferometer for Ambient Air-2 (ANITA-2). (OHB System AG)

Air quality in orbit

In the closed atmosphere of the International Space Station, irritating, poisonous and carcinogenic gas compounds emanate from materials, equipment and the crew itself. But with no possibility of opening a window to freshen the room, astronauts must rely on their 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 gaseous 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 designed to constantly monitor air quality. Considerably smaller than its predecessor that flew in Space Shuttle Endeavour to the International Space Station in 2007, and with improved software, the spectroscopy-based facility flew to the Station on SpaceX-24 in December 2021 and will run automatically in the background while astronauts get on with their work. ANITA-2 technology can be applied in environmental monitoring, and in the monitoring of air quality in other closed environments such as in submarines.

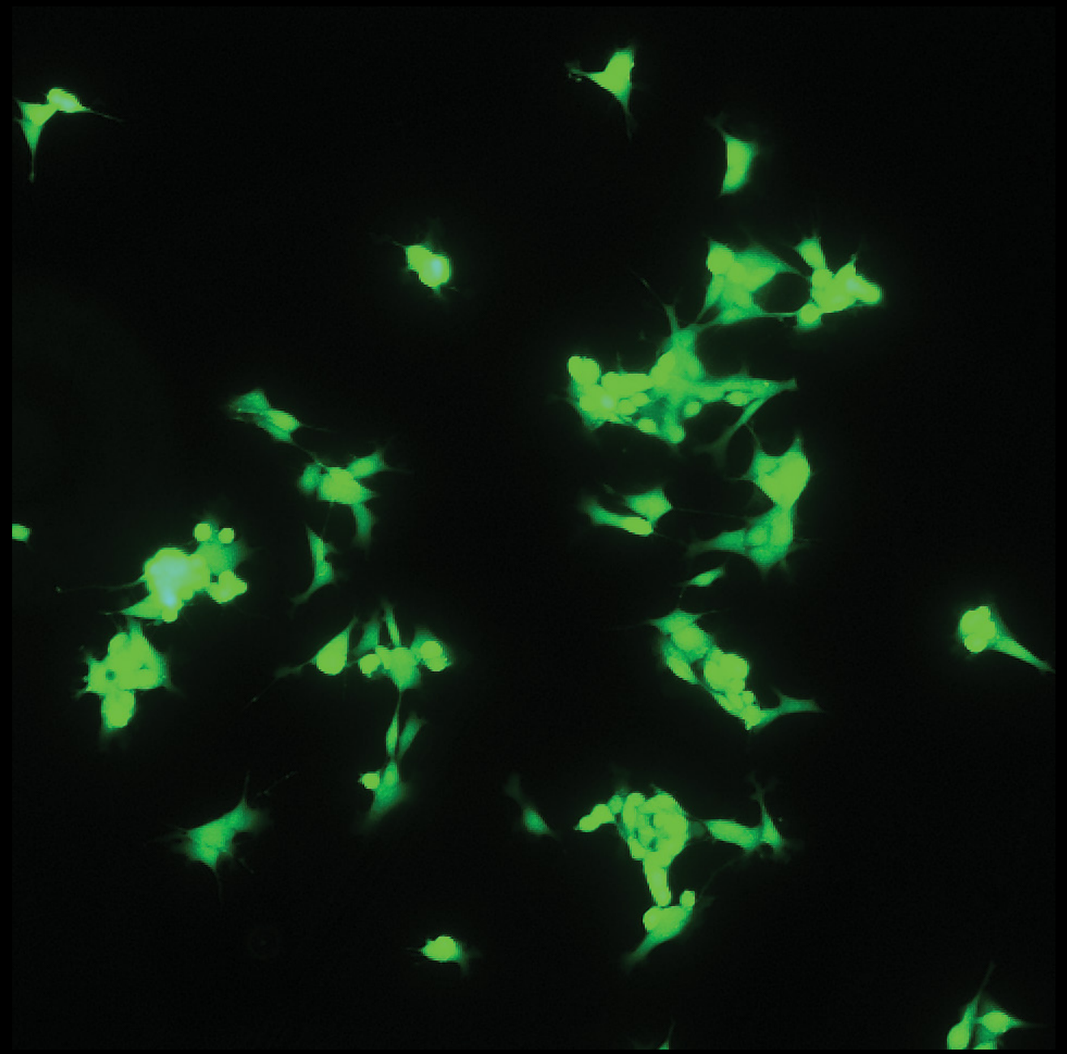
Space biology

Oxidative stress underlies many of the harmful effects of spaceflight. It also contributes to the genesis of several pathological conditions on Earth such as Chron's and Parkinson's disease.

As the central nervous system is the most critical target of oxidative stress, a new experiment from Italian Space Agency ASI, PROMETO (aka Antioxidant Protection), seeks to investigate how antioxidant protection could reduce this stress.

Under the scientific guidance of the Smart Bio-Interfaces research line of the Istituto Italiano di Tecnologia, Antioxidant Protection aspires to enable longer human missions in space, while bringing useful support to patients on Earth.

Another ASI experiment, Ovospace, seeks to determine microgravity's impact on the female reproductive system. Ovospace uses bovine ovarian cell cultures that will be incubated at 37°C for 72 hours in orbit before they are frozen and returned to Earth for analysis.



Antioxidant Protection investigates oxidative stress. (ASI)

ESA astronaut Luca Parmitano performs Acoustic Diagnostics. (ESA/NASA)

"The experiments we support in orbit enhance understanding across all scientific disciplines for better lives on Earth and more sustainable exploration beyond our planet."

Samantha Cristoforetti

Astronauts as test subjects

Many of the studies conducted in orbit involve astronauts as test subjects. Samantha will participate in a number of familiar experiments during her mission such as the Italian Space Agency ASI's Acoustic Diagnostics.

Scheduled for the first-time during ESA astronaut Luca Parmitano's Beyond mission in 2018, this experiment uses special headphones containing a small device that records the response of the inner ear to study the effect of microgravity and background noise on astronaut hearing. Detecting hearing loss in space will both help take care of astronauts' health during long missions and improve a device for testing hearing more accurately in any noisy environment on Earth.

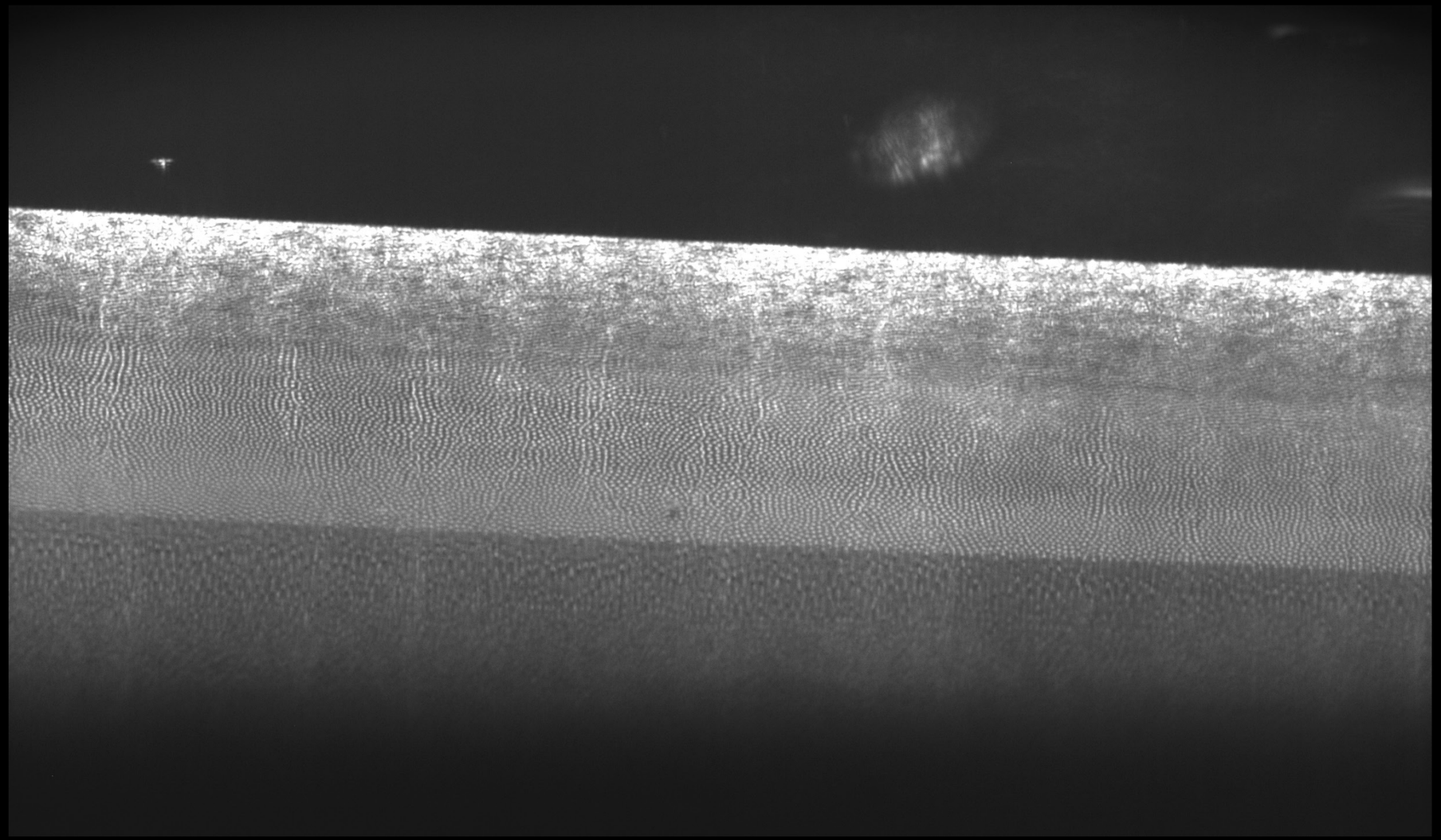
Samantha will also track her energy intake for ASI experiment NutrISS. Just as it is on Earth, maintaining a good energy balance in orbit is crucial to an astronaut's health, wellness and quality of life in orbit. It can also limit microgravity-induced bone and muscle loss and insulin resistance. Bone health is key area of interest for Samantha, who will work with the International Osteoporosis Foundation throughout her mission to highlight the importance of building and maintaining healthy bones at a young age to mitigate the impact of bone loss later in life.

Further human physiology payloads that Samantha will support include DNAmAge, an investigation by Oslo University Hospital, UCLA Fielding School of Public Health and Public Health England into the ageing process, and Brain-DTI, an experiment developed by researchers at the University of Antwerpen, Liege and Leuven in Belgium study to learn more about how astronauts' brains adapt to spaceflight.

Melding metals

Studying the way materials behave in weightlessness helps researchers isolate and better understand fundamental heat and mass transfer processes that are frequently masked by gravity on the ground. This enhanced understanding helps in the development of lightweight, high-performance materials that can be used on Earth and in the future of space exploration.

Most metals used today are mixtures of different metals, known as alloys. These alloys combine properties to make new materials and are found everywhere from your smartphone to aircraft. The Transparent Alloys (CETSOL) experiments are set to continue during Minerva – using Europe's space furnace to heat metals under temperatures as high as 880° C and study microstructures during the solidification of metallic alloys.



How a metal alloy could look as it solidifies. (E-USOC)

Extending the shelf life

An experiment known as EVOO in Space will investigate the impact of microgravity and radiation conditions on extra virgin olive oil's physicochemical, sensorial, nutritional and microbiological characteristics. Researchers will observe how the composition of olive oil secondary metabolites, such as phenols and tocopherols (vitamin E) is affected by microgravity and gather new information about olive oil's composition and shelf-life.

In the context of their 'Bonus Food' allowance, ESA astronauts can request additional dishes to supplement the standard space diet. The same carefully selected extra virgin olive oils, distinct in intensity and sensory profile, that will be available for Samantha and her crewmates on Station have also been used to prepare some of her Bonus Food dishes. As well as the psychological benefits of consuming tasty food, olive oil has been shown to be rich in antioxidants and have anti-inflammatory properties. The EVOO in Space experiment could help produce oil that maintains its nutritional benefits for astronauts during long-duration spaceflight.

Olive oil for space. (CREA/UNAPROL/ASI)

Virtual Reality for training in space

Virtual Reality technology is increasingly used as a training tool for astronauts on ground but poses unique challenges for use in space. The VR-OBT technology demonstration aims to address the logistical and technical challenges of using virtual reality on the Space Station.

During her mission Samantha will use a virtual reality headset to receive additional training on a tricky maintenance task for the European Life Support Rack (LSR). The LSR's Deionisation Unit needs to be removed and replaced and there are many instances where a mistake could damage the rack or hinder its operations. VR-OBT will focus on the complicated parts of the maintenance task and allow Samantha to spend time getting familiar with the most challenging aspects of LSR's maintenance, before tackling the real thing.

VR-OBT tested during parabolic flight. (ESA/DLR)

DESTINATION: INTERNATIONAL SPACE STATION

The International Space Station is a shining example of cooperation beyond borders, uniting Europe, USA, Russia, Japan and Canada in one of the largest partnerships in the history of science. As one of the greatest engineering works ever achieved by humankind, the orbital outpost is 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 more than two decades.

ESA/NASA–T.Pesquet

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 three 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 approximately two hours per day, six days per 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 regular phone calls and weekly video calls with family and friends

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

FACTS AND FIGURES

- Over 600 people have travelled to space
- Astronauts have performed over 246 spacewalks to build and maintain the Station
- Cosmonaut Gennady Padalka 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: participate in weekly medical conference with flight surgeon

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

WEEKENDS: housekeeping, public relations and voluntary tasks, enjoy spare time, watch the world from the Cupola

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

SpaceX Crew-4 (SpaceX)

JOURNEY TO SPACE

Samantha will be the third ESA astronaut to travel to the International Space Station under NASA's commercial crew programme. As such, she will be launched as part of Crew-4 in a SpaceX Crew Dragon spacecraft from Kennedy Space Center in Florida, USA.

Samantha's Crew-4 crew mates are NASA astronauts Kjell Lindgren, Robert Hines and Jessica Watkins. The crew of four will be boosted to orbital height and speeds in 8 minutes and 48 seconds, beginning their journey to the International Space Station. Meanwhile, the booster's first stage will return to Earth to be refurbished and reused.

"After sharing the adventure on NEEMO23, I'm grateful to have Jessica as a crewmate again. With Kjell and 'Farmer' in Crew-4 and our crew mates on orbit, this mission will be fun."

Samantha Cristoforetti

Dragon: up close

The Crew Dragon spacecraft is based on the uncrewed cargo version that SpaceX has been using to ferry supplies and equipment to the Space Station since 2010. The automated spacecraft is monitored and can be controlled from the inside if necessary, using touch screens.

The nose cone of the Crew Dragon opens to reveal a docking port. Once docked with the Space Station, the spacecraft will remain in place for the duration of the Minerva mission and act as lifeboat for the crew in case of an emergency.

KEY DATA

Launch site	Kennedy Space Center, Florida, USA
Launch date	April 2022
Duration	Approx. 6 months
Spacecraft	Crew Dragon
Launcher	Falcon 9

SpaceX Crew-3 launch (SpaceX)

Crew-2 Return (SpaceX)

Samantha during US Commercial Vehicle water survival training. (NASA-R.Markowitz)

SpaceX Crew Dragon splashdown. (NASA)

Return to Earth

At the end of her mission, Samantha and her Crew-4 colleagues will return to Earth in the same Dragon capsule that brought them to the Space Station.

The capsule has a heat shield which protects it against the 7000° C (hotter than the surface of the Sun) temperatures encountered when re-entering Earth's atmosphere at a speed of around 27 000 km/h. Its nose cone is re-closed after undocking to protect the docking adaptor during ascent and re-entry.

Four parachutes deploy at the final stages to ensure a safe landing in the Atlantic Ocean. Nearby boats will be ready to welcome the crew before taking them for debriefing and recovery. The Crew Dragon is reusable and will fly again.

INSPIRATION STATION

European Astro Pi Challenge

Two brand new Astro Pi computers equipped with a host of sensors and high-quality cameras have just arrived at the Space Station. Students across Europe up to 19 years old have the chance 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 message and the Station's temperature or humidity on the Astro Pi computers, 'Mission Space Lab' teams will design a scientific experiment to investigate life in space or on Earth.

Space Slime

Students will conduct space research in their own school laboratories as part of the ASI Space Slime programme. Space Slime is a naturally occurring slime mould that is capable of basic forms of learning and adaptation. Composed of just one cell and without a brain, it can move, feed, organise itself and even transmit knowledge to like-minded slime moulds. Students will learn how to conduct both ground preparatory and ground reference experiments and they will compare their results with those in space, understanding how the slime's behaviour is affected by the microgravity environment. Results will be released at a special event following Samantha's mission.

Artificial intelligence for exploration

Artificial intelligence (AI) is becoming part of our daily life, thanks to algorithms implemented in everyday devices. Students aged 13-15 will be challenged to build an interactive voice assistant, design its shape and learn about how AI devices may be used to support space exploration missions.

Space-ready Astro Pi hardware. (Astro Pi Foundation)

Mission-X: train like an astronaut

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. Samantha will act as the challenge ambassador and encourage school children to prepare for the 2023 edition. Students aged between 8 and 12 years old will practice scientific reasoning and teamwork while participating in hands-on classroom investigations and completing exercise missions targeting strength, endurance, coordination, spatial awareness and more.

Space for excellence in teaching

An ASI initiative during Samantha's mission will celebrate the work of teachers and schools that choose to use space as a context for teaching STEM. Individual or groups of teachers will submit recounts of space-related projects they have created, such as, space weeks, space careers events, hackathons, and more. Top projects selected by an expert jury will be awarded special prizes.

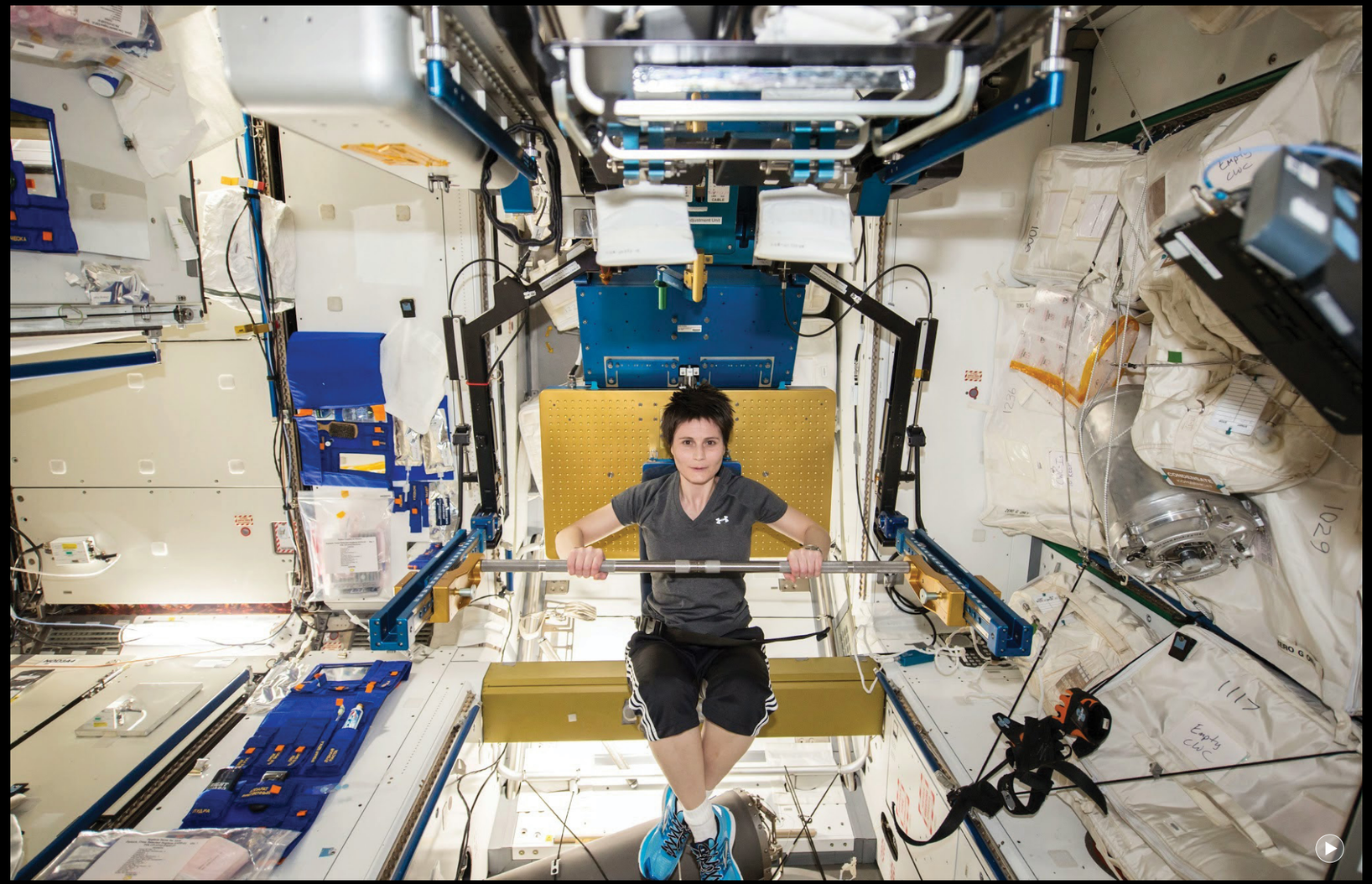
Yoga in space

When she gets a moment on Earth, Samantha likes to practice yoga. It is a good way to restore focus and calm, while moving her body and improving flexibility and balance. But with gravity playing a major role in yoga movements, could yoga be practiced in space?

In partnership with YouTube channel Cosmic Kids Yoga, Samantha will try a yoga sequence in orbit to see how the weightless environment impacts her poses as she encourages children from all over the world to move their bodies, practice mindfulness and let their imaginations take (space)flight.

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).



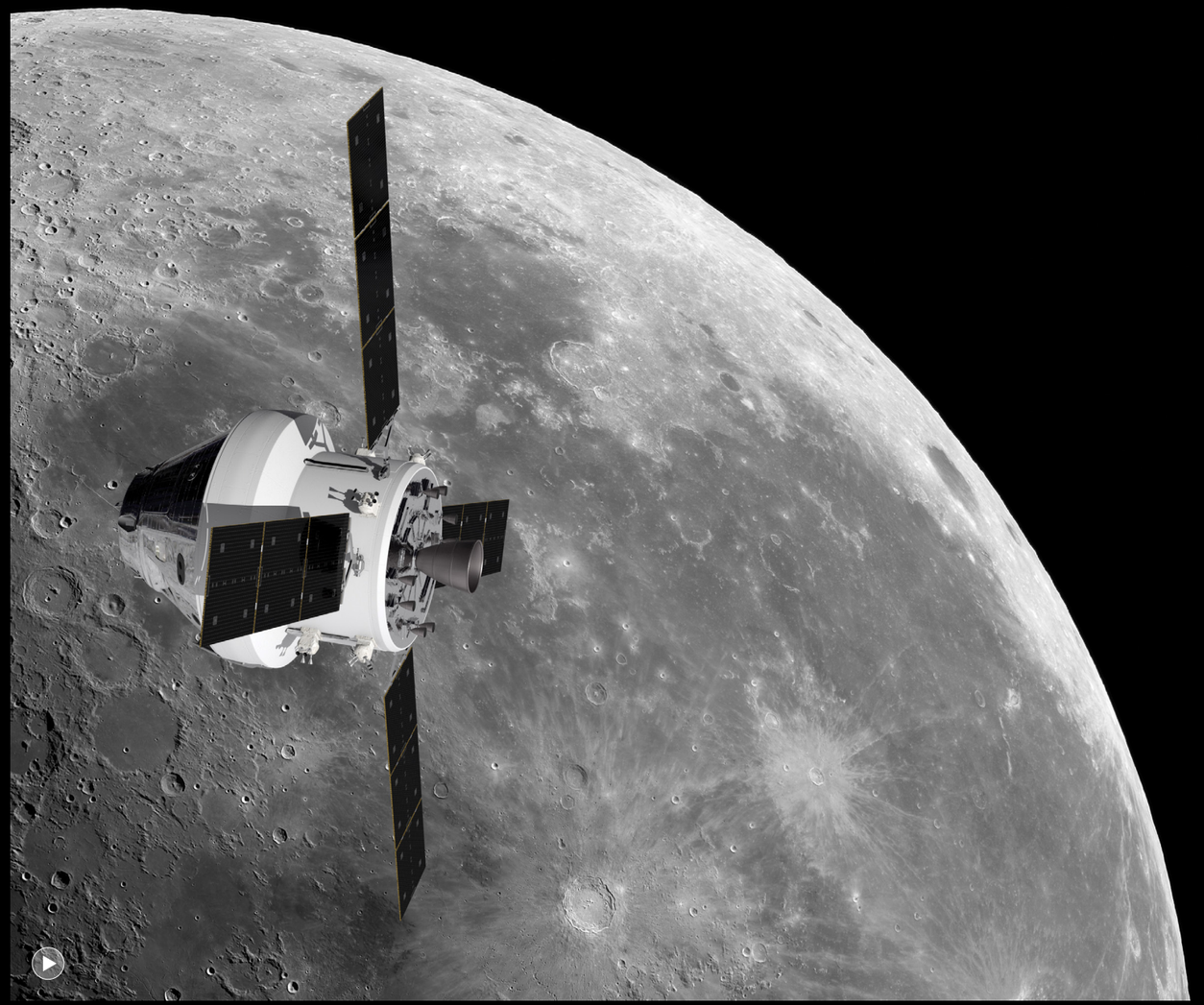
Samantha works out on the Station's Advanced Resistive Exercise Device ARED. (ESA/NASA)

Next stop: Moon

The Space Station is a steppingstone for future exploration. Lessons learnt from our time on board have fed into technology that will take European explorers to the Moon and potentially even farther in the not-too-distant future.

Under Artemis I the inaugural flight of NASA's Space Launch System (SLS) rocket and Orion spacecraft, powered by the European Service Module (ESM), will set the stage for development of a Space Station in lunar orbit and crewed flights to the Moon. With parts made in 10 countries in Europe and assembled in Bremen, Germany, the complete ESM was flown to Kennedy Space Center at the end of 2018. As the powerhouse for the Orion spacecraft, it provides the propulsion system and the consumables that astronauts need to stay alive.

Modules for an outpost in lunar orbit known as the Gateway are also already in development. The habitation module I-Hab and communications and refuelling module Esprit are being built in France, as we move away from one-shot orbital missions towards a sustainable presence – exploring together with robots, in international cooperation and with commercial partners.



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

Follow Samantha's journey

www.esa.int/Minerva

www.youtube.com/europeanspaceagency

www.twitter.com/astrosamantha

An ESA Production

www.esa.int