beyond

2019

European Space Agency

"What we do on the International Space Station is for Earth, for humankind. Working on the orbital outpost is our only way to learn what science and technology we need to go beyond."

Luca Parmitano

#BeyondMission

LUCA PARMITANO

A leader with nerves of steel

Luca Parmitano's colleagues describe him as a very focused and straightforward person, always able to give prompt feedback and show strong leadership. He embraces difficulties and constantly looks for new challenges.

Luca was the first European astronaut to reach the International Space Station in less than six hours. Though it is now the standard flight duration of a Soyuz spacecraft, back in 2013, this same-day rendezvous was eight times faster than usual.

During his first stay in orbit Luca carried out over 40 science experiments, many of which are still running today. He also showed nerves of steel when faced with a life-threatening emergency during his second **spacewalk**. As water began to accumulate inside his helmet, he was forced to return to the airlock as quickly as possible, but remained calm throughout.

Beyond

Luca's second mission is called '**Beyond**', to signify the exploration of our Universe, looking far beyond our planet and broadening our knowledge.

He will share the ride in the Soyuz capsule with Russian cosmonaut Alexander Skvortsov and NASA astronaut Andrew Morgan.

During the second part of his Beyond mission, Luca will become **commander** of the International Space Station, and become the first Italian to do so. This is the third time a European astronaut will take up this role on a Space Station Expedition.

NAME
Luca Parmitano

BORN
27 September 1976,
Paternò, Italy

OCCUPATION
Astronaut,
Italian air force test pilot

STUDIES
Political sciences,
flight test engineering

MISSIONS
Volare (2013),
Beyond (2019)

TIME IN SPACE
166 days

SPACEWALKS
2 > 7 hours 39 minutes

HOBBIES
Triathlons, skydiving,
science-fiction literature

"The beauty of being in command of the Space Station is that I will not be a babysitter. When you are the commander of the most qualified people on Earth and off Earth, your job is to be a facilitator."

ESA–A. Conigli

TRAINING FOR SUCCESS

On the road to space

On his return from his first space mission, Luca continued **training** to keep his skills at a high level and to support other astronauts.

As part of this ongoing development, he trained to become 'Capcom' – a communicator for astronauts in orbit. This role helped ensure he is up to date with the activities and changes taking place on the Space Station.

The astronaut's refresher courses included scientific, engineering and medical skills, as well as orbital mechanics and Russian language, plus **survival training** in prolonged isolation and under psychological stress.

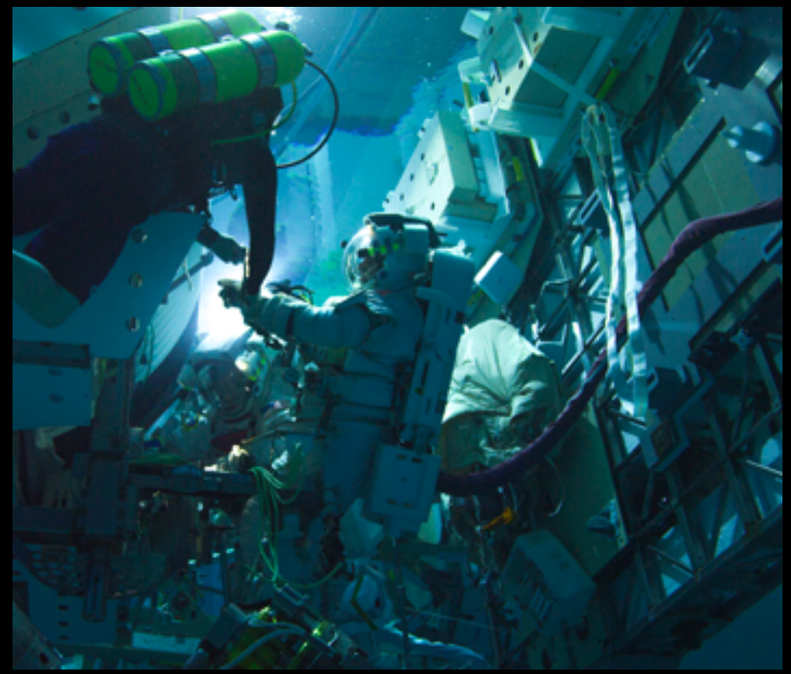
For critical tasks, such as flying a Soyuz, the astronauts train over and over in simulators. Continuous training helps astronauts be mentally prepared to handle emergencies, such as spacecraft depressurisation, fire or toxic spills.

The road to space also requires going under water. Luca was immersed in 12-m deep pools in the United States and Russia to practise spacewalking on submerged mockups of the orbital outpost. He also developed new procedures for operations outside the Space Station. During the NASA Extreme Environment Mission Operations, or **NEEMO**, he simulated living on a spacecraft 20 m below the sea surface and tested spacewalking techniques.

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

Luca works as Capcom at NASA's Johnson Space Center in Houston, Texas (NASA)

"I think I am more experienced now, but space is still a dangerous place. A real emergency is something you have not been trained for before."



Spacewalk training starts underwater (NASA)

Suited for outer space (NASA)

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, Luca 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.

An astronaut’s working space (ESA/NASA)

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

"Working on the orbital outpost is our only way to learn what science and technology we need to go beyond, and to explore the limits of human capabilities."

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 the microgravity needed to unmask phenomena that cannot be observed on Earth.

Luca's work station is a place of science where 16 experiment facilities run 24/7. Each unit functions as an independent laboratory with its own power, 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.

EXPLORE FARTHER

Astronaut drives robot

From the International Space Station, Luca will operate a rover to scout terrain, collect interesting rocks and bring them back to a simulated lander on Earth. He will use an intuitive interface to control the robotic explorer through the Moon-like landscapes of Lanzarote, Spain.

The Analog-1 experiment enacts future scenarios in which astronauts orbiting distant planets and moons can instruct robots to do difficult tasks and set up base before landing. ESA teams will monitor the interaction between ground teams and the astronaut on the Space Station, and also how the robot copes with the hazardous terrain.

In a new approach to real-time telerobotics, the experiment will expose Luca to a combination of video, audio and force feedback to test his performance in microgravity.

There is also potential for applications on Earth. Teleoperated rovers can carry out surveillance missions in disaster or remote areas too dangerous for humans to access.

"We are getting ready, in the future, to go to the surface of the Moon or Mars with a rover. We want to do exploration, but instead of putting ourselves in danger, we will do it through telerobotic operations from deep-space habitats."

Intelligent co-worker – the rover will be controlled by Luca from the Space Station (ESA)

Alexander Gerst installs the Life Support Rack facility (ESA/NASA)

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. A new system that promises to recycle half of the carbon dioxide into oxygen reduces the amount of water that must be shipped into space by about 400 litres per year.

Luca will operate and test the performance of ESA's Life Support Rack, a facility designed to be able to produce oxygen for 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 supplies from Earth.

These operations 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.

WORK SMARTER

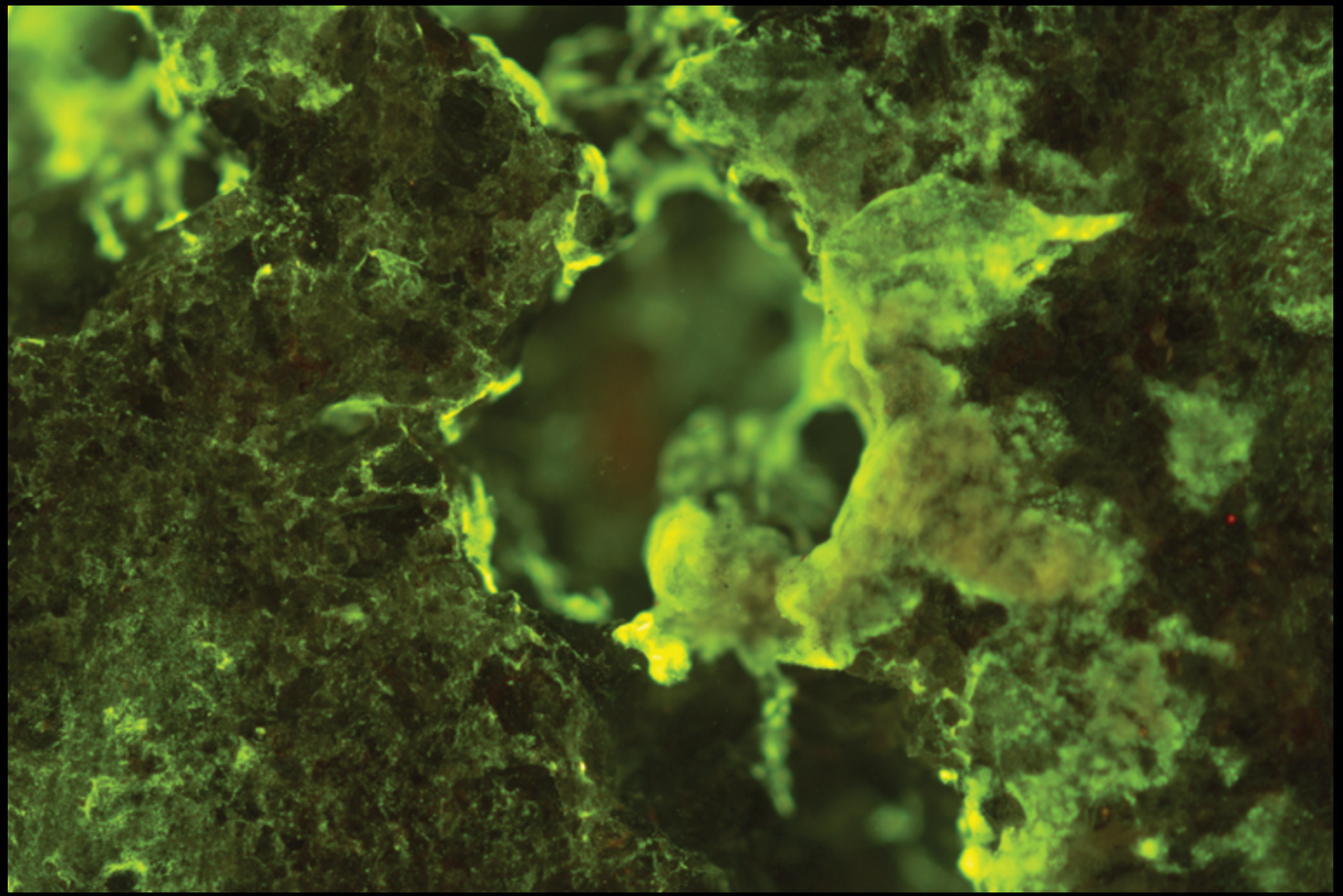
Space mining with microbes

Some microbes are able to extract minerals, such as iron, calcium or magnesium from the surface of rocks – they can be considered microscopic miners. Microbes can also generate food and oxygen, and recycle waste. These resistant multitaskers can be very useful for space exploration.

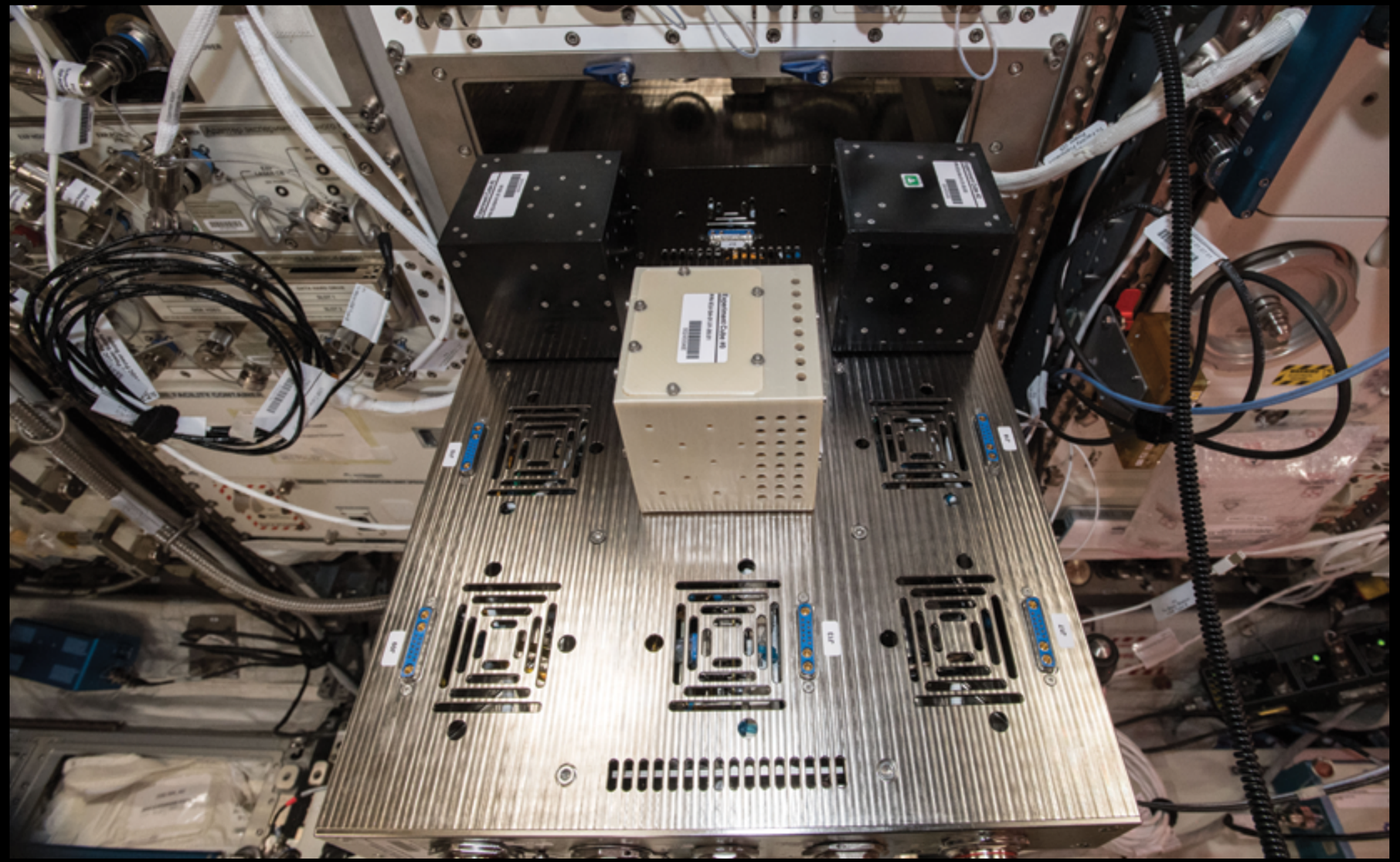
The Biorock experiment will help scientists learn how microbial miners can colonise a rock, whether they can be used in 'biomining' on other planetary bodies, as well as yielding new insights into how communities of microorganisms grow on the rocks in space conditions with applications to life support systems.

Researchers suspect that altered gravity changes the way terrestrial bacteria gather nutrients and oxygen from minerals. The experiment will use ESA's Kubik units, a set of mini labs that will spin three types of microorganisms and expose them to different gravity levels, from Mars to Earth gravity.

This experiment will allow, for the first time, researchers to examine how partial gravity affects the way microbes can interact with rocks. Would martian gravity hinder the growth and mining performance of our microbes?



A colony of microbes growing on a basaltic rock as seen by a fluorescence microscope (University of Edinburgh–R. Santomartino)



Easy access to space research for cube-sized experiments (ESA/NASA)

Going commercial

From idea to reality in less than a year, anyone's experiment can be launched to the Space Station. Europe's commercial research facility on the International Space Station, called ICE Cubes Service, allows fast, simple and affordable access for research and technology experiments in microgravity.

A first for European commercial research, the facility offers plug-and-play installation for cube-sized experiments that relay experiment data back to Earth. From anywhere in the world, at any time, a customer can log in and send commands to their experiment through an internet connection.

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. A previous ICE Cubes experiment looked into methane-producing microorganisms and how they survive in space conditions.

The fourth ICE Cubes experiment will test the ground for a new ESA exobiology facility that will be attached to the outside of the Space Station. During Luca's mission, the SPECTRODemo experiment will investigate the performance of an advanced spectrometer for analysing the chemical elements and molecular composition of life in outer space.

LIVE BETTER

Understanding the force

Gravity is constantly exerting its force on objects. In the weightless environment of the International Space Station, astronauts are like infants learning to adjust to a new world with no up or down. How their brains learn to manipulate an object in space is at the core of the Grip and Grasp experiments.

Luca will get a handle on how microgravity affects his ability to grab an object. He will perform a series of movements while gripping a purpose-built sensor that measures grip-forces, moisture and acceleration to assess how the body adapts to every situation.

The Grip experiment is helpful to engineers designing prosthetic limbs on Earth and interfaces for astronauts to command robots on other planets with different gravity levels.

Grasp investigates the physiology behind eye–hand coordination. When reaching for a cup of coffee, the brain calculates how far your hand is moving by using visual clues as well as how shoulder muscles counteract the downward force of gravity to keep your arm straight.

Luca will wear a virtual reality headset that simulates a series of tasks. A 3D motion tracker will update the display in real time in response to his hand, body and arm movements.

This research could shed light on how to treat disorders relating to vertigo, balance and spatial orientation. For astronauts, the research will be useful during spacewalks, where coordination in weightlessness with few visual clues is vital.

A dexterous laboratory in space (ESA/NASA)

Thomas Pesquet uses EveryWear to monitor his health in orbit (ESA/NASA)

Energy balance

An optimal diet, paired with constant exercise, is essential to counteract the effects of spaceflight on the human body. Bone loss, muscle atrophy and depleted nutrient stores such as protein, fat and vitamin D are among the negatives of space travel.

Research shows that energy intake in orbit is usually lower than on Earth. Throughout his mission Luca will monitor changes in his body mass and log his meals on a tablet as part of the NutrISS experiment.

EveryWear is an iPad-based application that collects physiology and medical data and connects the astronaut with nutrition experts on Earth, who can suggest the best combination of meals for a healthy stay in orbit.

The results will help improve the physical performance and quality of life of astronauts during and after spaceflight, but also help patients suffering from nutritional diseases.

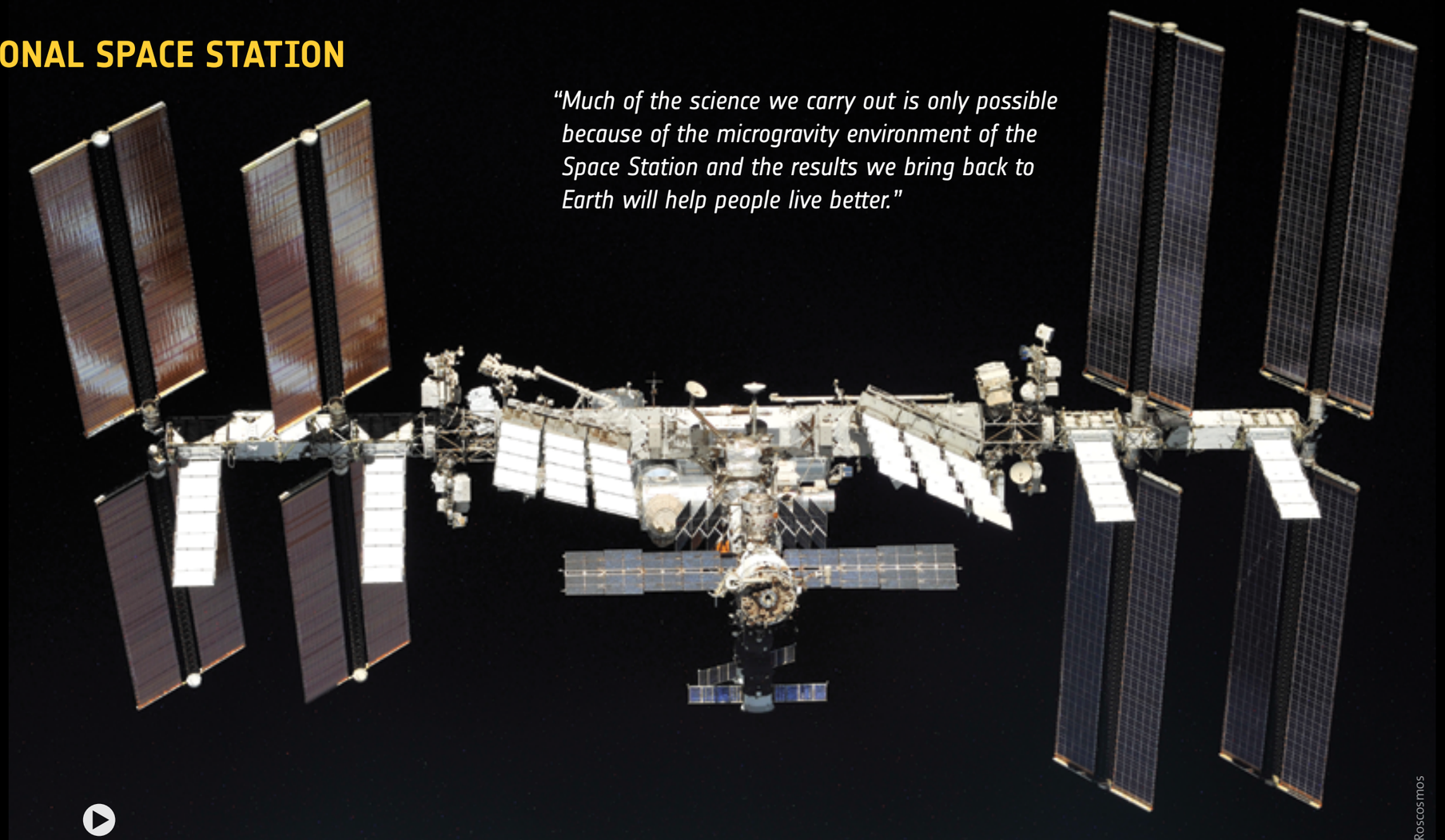
DESTINATION: INTERNATIONAL SPACE STATION

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 humanity together to live and work in space uninterrupted for two decades.

"Much of the science we carry out is only possible because of the microgravity environment of the Space Station and the results we bring back to Earth will help people live better."



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 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

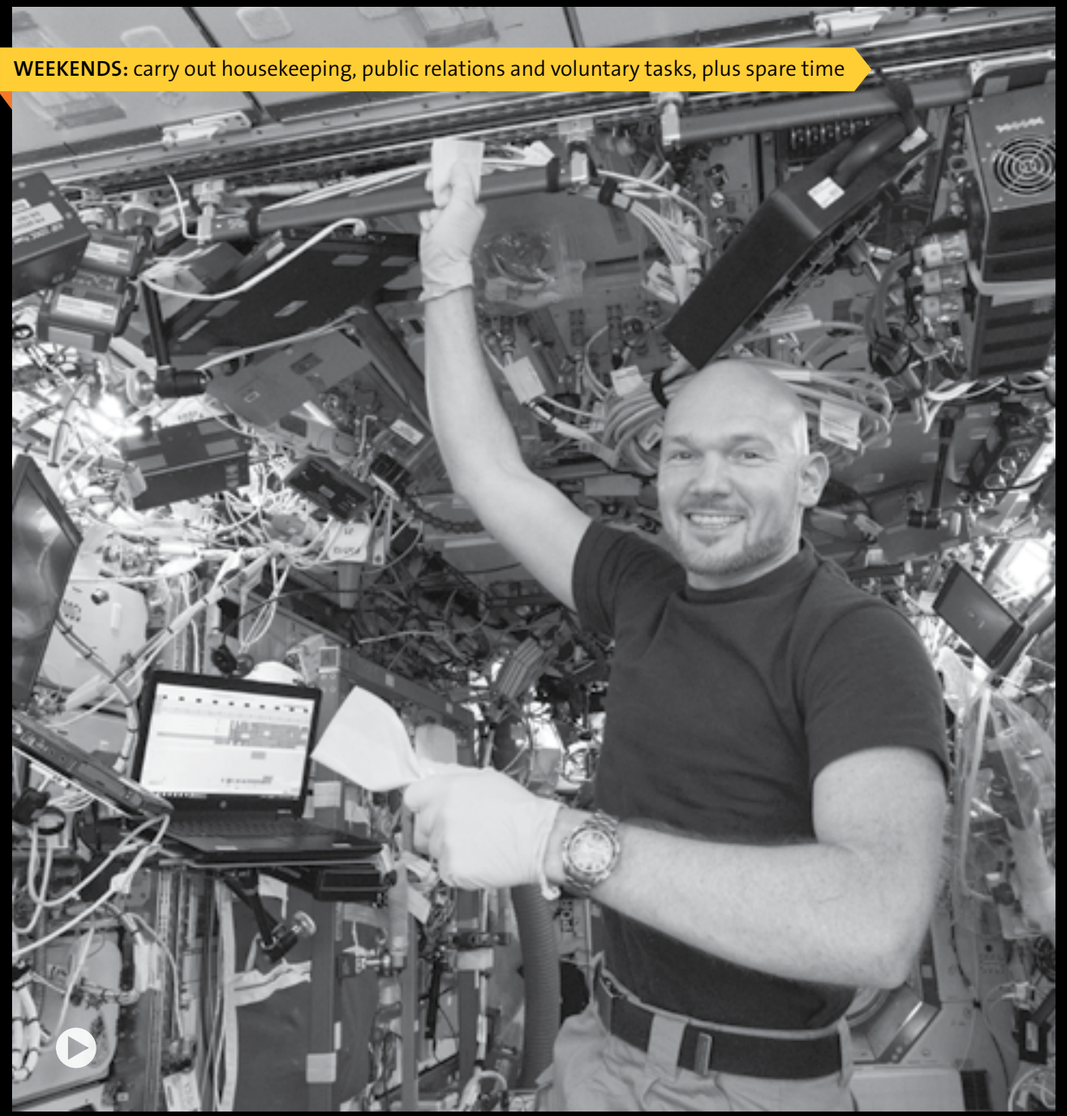
Thomas Pesquet contacts amateur radio stations on Earth (ESA/NASA)

FACTS AND FIGURES

- Over **560 people** have been to space, of which around **230** 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

Blood draw 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)

RETURN TICKET TO SPACE

A voyage with Soyuz

Four boosters, each about 20 m in length loaded with 225 tonnes of fuel and liquid oxygen, will propel Luca Parmitano into space from the steppes of Kazakhstan. Less than 10 minutes into the flight and at speeds of about 25 000 km/h, he will enter Earth's orbit and float in 'weightless'.

Soyuz rockets have launched crewed spacecraft and satellites into orbit for over half a century – they are the most-used launch vehicles in the world. The Soyuz spacecraft shares the same name as its launcher – Soyuz means 'union' – and it is currently the only transport system for astronauts to reach and leave the International Space Station.

KEY DATA

Launch site	Baikonur, Kazakhstan
Launch	July 2019
Landing	December 2019
Spacecraft	Soyuz MS-13
Launcher	Soyuz FG

A Soyuz rocket launches from the Baikonur Cosmodrome, Kazakhstan (NASA–B. Ingalls)

The Soyuz spacecraft can transport up to three people to and from the International Space Station (ESA–A. Gerst)

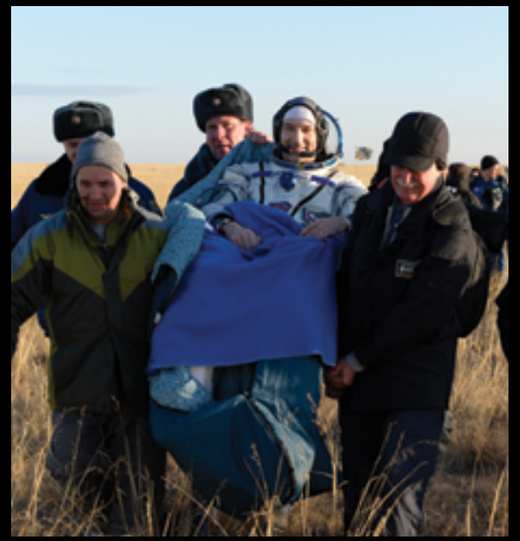
The Soyuz spacecraft can manoeuvre, rendezvous and dock in orbit in an automated or manual control mode. Luca will support the Soyuz commander as copilot during launch and return to Earth.

Russian search and rescue teams arrive at the landing site shortly after touchdown (NASA–B. Ingalls)

After living and working on the Space Station for over six months, Luca will return to Earth in the Soyuz capsule with his two crewmates. Only one of the three modules of the Soyuz survives the reentry into Earth's atmosphere – the descent module.

Reentry begins at an altitude of about 100 km, when the speed at which the capsule travels is reduced dramatically and the crew is pushed back into their seats with a deceleration of up to 5 g, feeling the equivalent of 5 times their body weight.

Less than four hours after leaving the Station, the Soyuz touchdown will signal the end of his 'Beyond' mission. Luca will fly directly to Cologne, Germany, where all medical checks, rehabilitation activities and post-flight science will take place.



Luca back on Earth in 2013 (ESA–S. Corvaja)

THE SPACE GENERATION

Smart and fit

Luca Parmitano 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.

European Astro Pi Challenge

Astro Pi uses two credit card-sized computers equipped with a host of sensors and cameras on board 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 on the Astro Pi computers, 'Mission Space Lab' teams will design a scientific experiment to investigate life in space or on Earth.

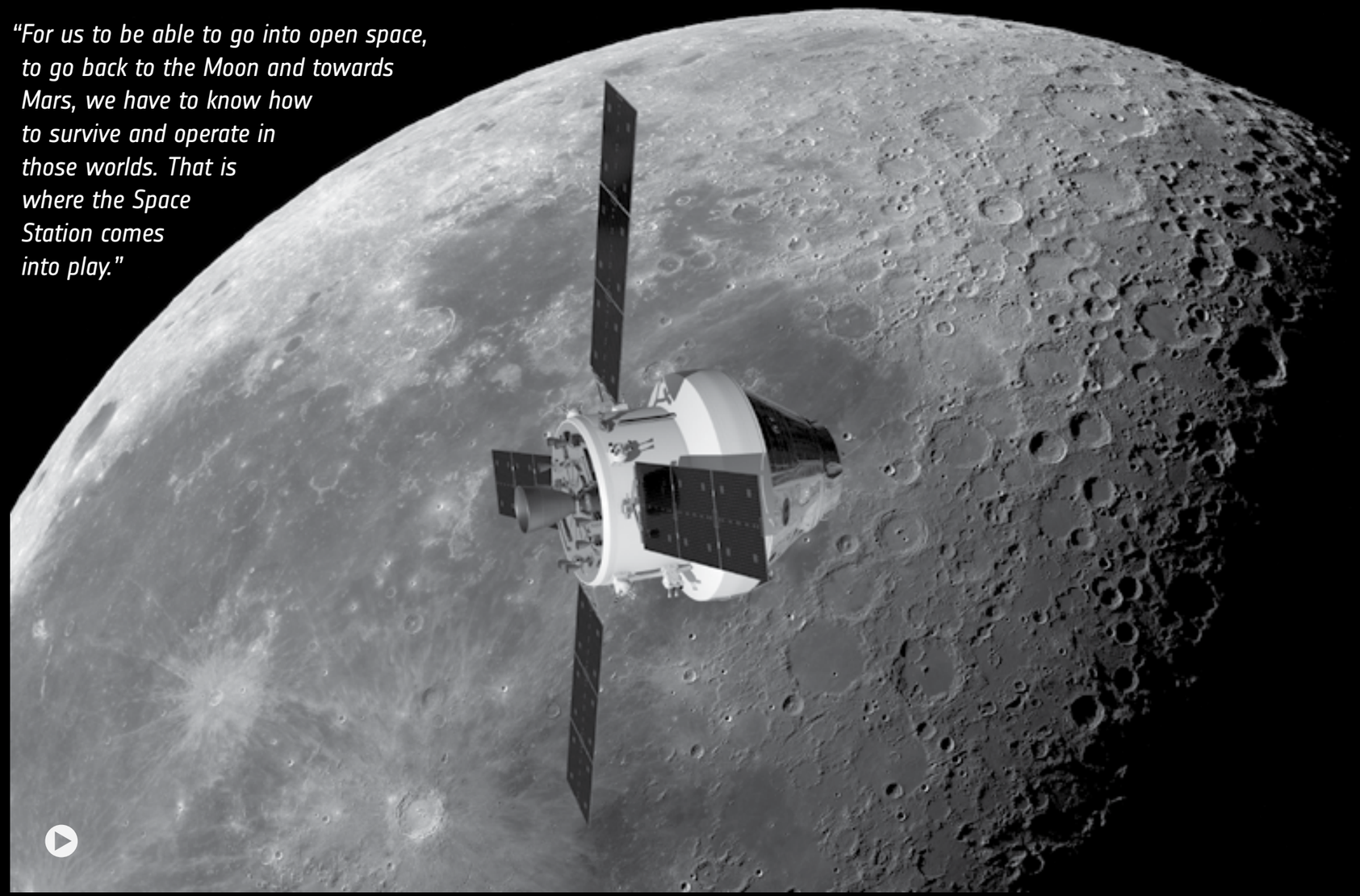
Mission-X

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. Luca will give school children tips on maintaining a fit and healthy lifestyle for mission success. Students aged between 8 and 12 years old will practice scientific reasoning and teamwork while participating in hands-on training missions targeting strength, endurance, coordination, spatial awareness and more.

"What we are learning in low Earth orbit will eventually enable the next generation to go farther and keep exploring."

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

"For us to be able to go into open space, to go back to the Moon and towards Mars, we have to know how to survive and operate in those worlds. That is where the Space Station comes into play."



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

BEYOND

The future in our hands

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 a thousand times farther out in space than on the International Space Station.

ESA is preparing for a **robotic Moon landing** in partnership with Russia as early as 2023, looking for water ice that scientists believe may be found in the dark polar regions.

Moving away from one-shot orbital missions, bold ambitions foresee humans exploring the polar regions 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.

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