cosmic kiss

2021

“I'm looking forward to my first spaceflight because it will be an incredible experience, not only for me as a human being far from home but also for the opportunity to support scientific research on behalf of the researchers on Earth.”

Matthias Maurer

MATTHIAS MAURER

Next stop: space

Originally from Sankt Wendel, Saarland, Germany, Matthias Maurer joined ESA's astronaut corps in 2015. Cosmic Kiss will be his first space mission, and he is well prepared.

With a doctorate in materials science engineering, Matthias is the inventor on over 10 patents. As a student, he gained extensive cross-cultural experience in France, Spain, the United Kingdom, Argentina and South Korea, and his passion for travel and intercultural collaboration continues to this day. He looks forward to sharing his experiences and learning from his crew mates on the International Space Station.

Matthias's passion for exploration is not limited to low-Earth orbit. He is also a strong advocate for ESA's journey forward to the Moon and Mars.

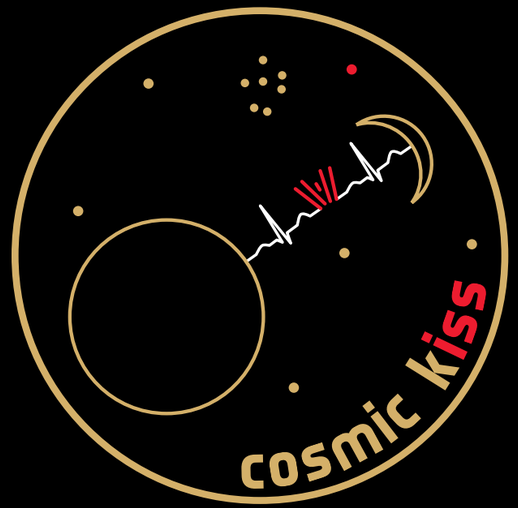
Prior to his mission assignment, Matthias project-managed the development of ESA's soon-to-be-built Luna facility. This facility at ESA's European Astronaut Centre (EAC) in Cologne, Germany, will combine an area of simulated Moon dust or regolith, with a lunar habitat powered by an innovative energy system, representative of what could be used for a lunar base.

Cosmic Kiss

Matthias will be launched to the Space Station from Florida, USA, in a SpaceX Crew Dragon spacecraft alongside NASA astronauts and fellow Crew-3 members Kayla Barron, Thomas Marshburn and Raja Chari.

The name of Matthias's mission, Cosmic Kiss, is a declaration of love for space. It communicates the special connection the Station provides between Earth's inhabitants and the cosmos. It also conveys the value of partnership in exploring farther to the Moon and Mars, alongside the need to respect, protect and preserve the nature of our home planet as we seek a sustainable future on Earth.

His patch takes inspiration from the Nebra sky disc ('Himmelsscheibe von Nebra') – the oldest known realistic illustration of the night sky.



"Cosmic Kiss communicates the special connection the Station provides between Earth's inhabitants and the cosmos. Partnership is so important in exploring farther to the Moon and Mars, as is the need to respect, protect and preserve the nature of our home planet as we seek a sustainable future on Earth and beyond."

NAME
Matthias Maurer

BORN
18 March 1970
Sankt Wendel, Germany

OCCUPATION
Astronaut
Materials scientist

EDUCATION
PhD in materials science engineering
Institute of Materials Sciences
Technical University of Aachen, Germany

MISSIONS
Cosmic Kiss (2021-22)

HOBBIES
Travel, photography, reading, politics and learning foreign languages

SPORTS
Cycling and hiking

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.

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

German Space Agency at DLR foyer (DLR-F.Walker)

THE GERMAN SPACE AGENCY AT DLR

The German Space Agency at DLR is Germany's national space agency. On behalf of the German Federal Government, the Agency works to advance German science and expertise in space. It promotes the commercialisation of space technologies, the innovation potential of German SMEs, and the transfer of technology to benefit people on Earth – improving the quality of life in Germany, Europe and the rest of the world. To achieve this goal more than 300 employees based in Bonn coordinate all of the German space activities at national and European levels. The tasks of German Space Agency at DLR include the planning and implementation of the national space programme and the management of Germany's contributions to ESA, to the European Commission as well as to the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).

In coordination with ESA and space agencies around the world, the German Space Agency conducts medical, biological, physical, and technological research in microgravity. It will contribute German experiments to Matthias Maurer's Cosmic Kiss mission and provide opportunities for members of the public to experience the wonder of 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 ground and the Space Station.

The Columbus Control Centre distributes data to the User Support and Operations Centres 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 operations teams, consisting of the console teams: Columbus Flight Director, STRATOS, COMET, GSOC-GC and Syscon, as well as various support teams, provide assistance 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. Col-CC, EAC (and MUSC, CADMOS, B.USOC, BIOTESC as support centres) are the only European facilities with extensive experience in human spaceflight. DLR wants to make further substantial contributions in human spaceflight together with ESA in the coming decades, such as the operation of human habitats on the lunar Gateway or lunar surface.

Microgravity User Support Centre

DLR's Microgravity User Support Center (MUSC) in Cologne, Germany is a facility directed by the cooperating institutes of: Aerospace Medicine, Materials Science and Space Operations, and Astronaut Training. MUSC operates major equipment for the scientific use of space across materials science, biological and extraterrestrial sciences and technology. The Center qualifies space experiments for their flight readiness certification, supports operation with the necessary infrastructure during their flight and makes archived data accessible for users throughout Europe after each successful mission.

MUSC operates the Biolab, Expose, DOSIS, Materials Science Lab, FASTER (Facility for Absorption and Surface Tension), European Drawer Rack (EDR) and Electromagnetic Levitator facilities on the Space Station on behalf of ESA.

Columbus Control Centre (ESA/DLR)

DLR's Microgravity User Support Center (DLR)

Matthias Maurer participates in 2018 Pangaea-X test campaign in Lanzarote, Spain (ESA–A. Romeo)

TRAINING FOR FLIGHT

Cosmic Kiss is Matthias's first mission to the International Space Station, but he is ready for the challenge. In September 2014, prior to officially joining the European Astronaut Corps, Matthias was a member of the ESA CAVES expedition crew, contributing his Eurocom skills and extensive research and development experience to the programme, while assessing its suitability for participation by international partners.

Between 2017 and 2019, he continued to participate in geological field training related to future Moon exploration and has been a strong advocate for the Luna facility at ESA's EAC.

In 2016 Matthias participated in the NASA NEEMO 21 analogue mission, spending a total of 16 days underwater as part of a crew testing exploration strategies and tools for future Mars missions.

In preparation for spacewalks from the Space Station, he has also trained in NASA's Neutral Buoyancy Laboratory and the Roscosmos underwater training facility in Star City, Moscow. He is currently the only astronaut certified to perform spacewalks in both the US Extravehicular Mobility Unit (EMU) and Russian Orlan spacesuits.

NASA Extreme Environment Mission Operations (NEEMO) 21 crew descends to the underwater Aquarius base reef off the coast of Florida, USA (NASA NEEMO)

"The fact that I am the only astronaut worldwide currently certified in both the Russian and the NASA spacesuit right now puts me in a unique position. I hope to be the starting point for closer cooperation and that even more astronauts will train for both in years to come."

Matthias Maurer trains in the Russian Orlan spacesuit (GCTC)

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 Space Station is a place where the rules governing sedimentation, buoyancy and convection do not apply – offering unique opportunities for science.

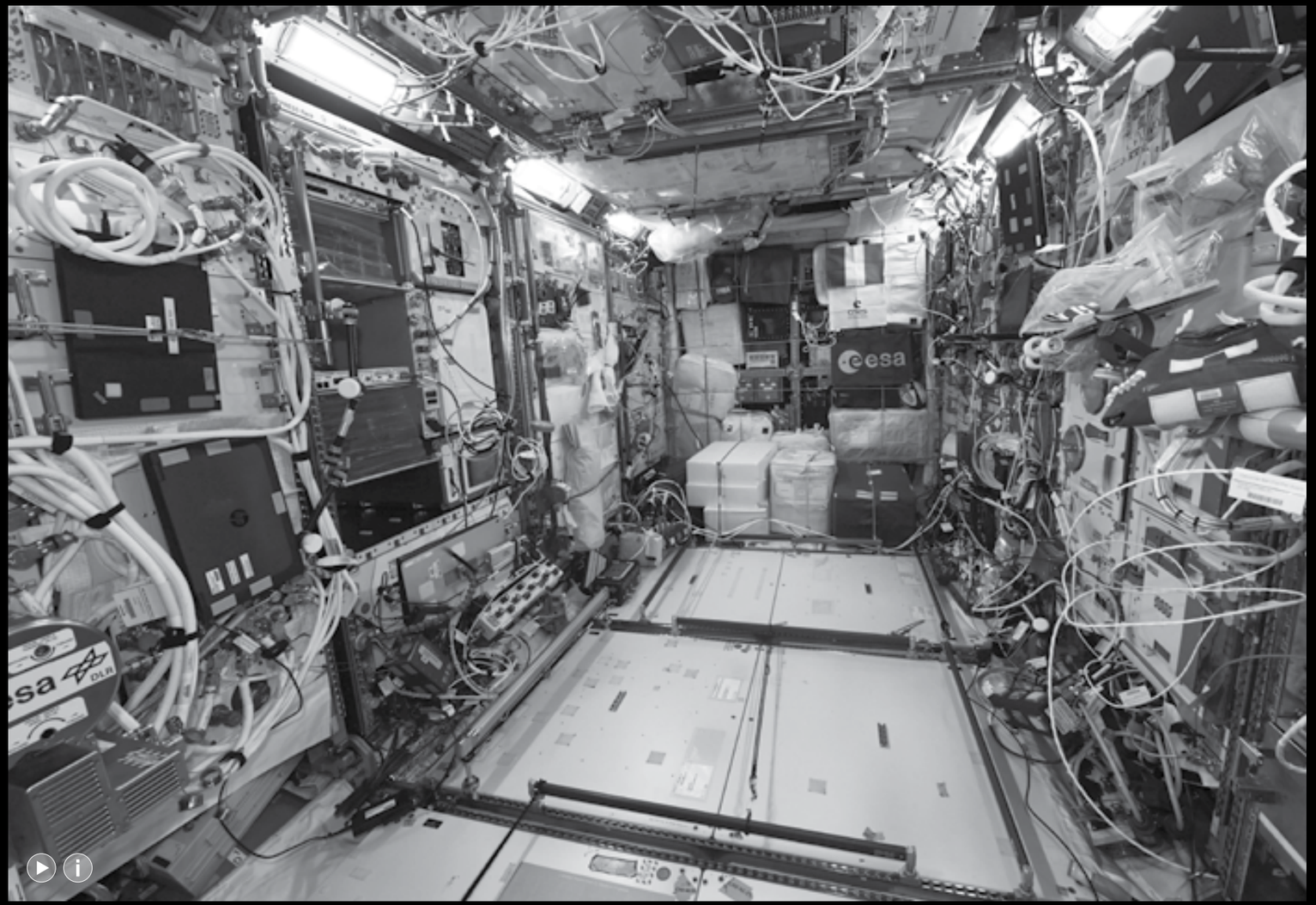
In constant 'freefall' around the planet, astronauts on the Space Station live and work in microgravity. This 'weightless' laboratory allows them to perform experiments that are not possible on Earth. Up there, crews carry out pioneering research, test new technologies and push the boundaries of knowledge.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

Explore farther, work smarter, live better

Matthias will support many European and international experiments during his time in orbit. Of these, 36 have been contributed by the German Space Agency at DLR – a strong partner in this mission.

"The International Space Station is a unique laboratory where we can conduct science like nowhere on Earth. My goal is to support this science as best as I can so we can explore farther and achieve more on Earth and in space."

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



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

"I am proud to be able to carry out and support many European and international experiments in orbit across topics from human biology to materials science and proving new technologies for spaceflight."

THE COLUMBUS LABORATORY

Where science happens

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 Matthias's main workstation throughout Cosmic Kiss 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.

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

Boosting connectivity

A high-speed satellite link nicknamed 'ColKa,' for 'Columbus Ka-band terminal,' is improving connections with Europe.

Installed outside Columbus during a spacewalk in early 2021, this small fridge-sized antenna allows astronauts and researchers to benefit from a direct link with Europe at home broadband speeds, independent from the NASA system.

Like any new addition, ColKa required some in-space testing once installed. This testing was carried out by teams at Col-CC in Oberpfaffenhoffen, who manage all Columbus's systems and software from the ground. Matthias is scheduled to be part of ColKa's first on Station operations.

Knowhow gained from designing, building and running ColKa will be instrumental in developing the Esprit communications and refuelling module for the new lunar Gateway – an outpost in lunar orbit, over 1000 times farther from Earth than the Space Station.

Commercial access to outside space

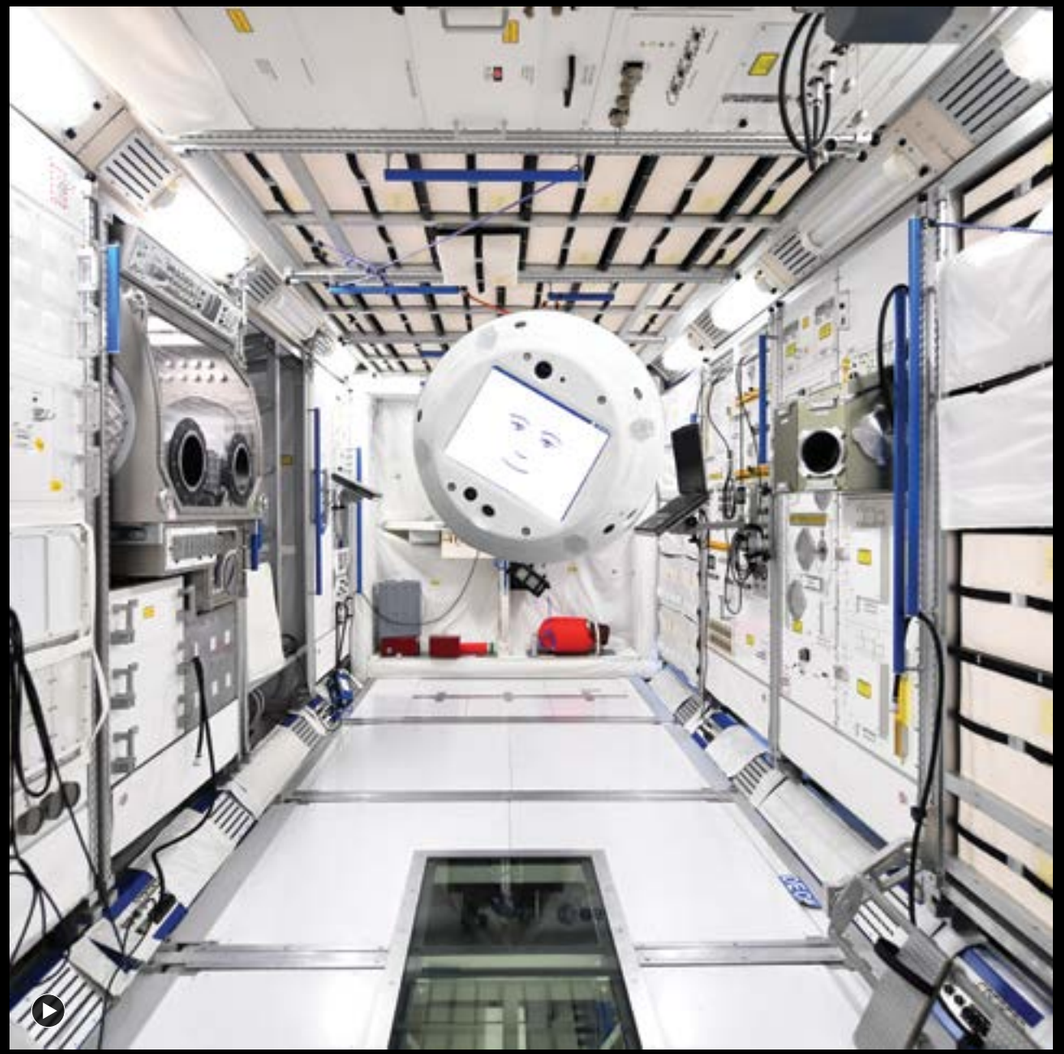
From idea to reality in less than a year, anyone's experiment can be launched to the International Space Station. Europe has a new commercial research facility outside the Space Station called Bartolomeo, after the explorer Columbus's younger brother.

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 lifeforms can. ESA plans to use Bartolomeo to expose tiny lifeforms, such as bacteria, seeds, and lichens, to the harsh conditions of space for extended periods of time.

The platform was built by Airbus in Bremen, Germany, and will be operated jointly with the Columbus Control Center at DLR's site in Oberpfaffenhofen.

Bartolomeo and Canadarm2 outside the International Space Station (ESA/NASA)



CIMON (Crew Interactive MObile CompanioN) (DLR)

Assisting astronauts with artificial intelligence

On Earth, virtual assistants support people in a variety of ways as they go about their daily work. A similar system will also help Matthias complete his daily tasks and run experiments on the Space Station. However, this 'extraterrestrial companion' is capable of much more than its Earthly counterparts.

CIMON (Crew Interactive MObile CompanioN), developed, constructed and funded in Germany, is a part of the crew and acts as an intelligent floating assistant to the astronauts. Equipped with artificial intelligence (AI), it is intended to support the astronauts in their daily work and improve the efficiency of activities on the Space Station via human/machine interaction. Following the successful demonstration of CIMON's technology by ESA astronauts Alexander Gerst and Luca Parmitano, the focus is now on potential research applications. The mobile crew assistant will communicate with Matthias to guide and support him as he carries out complex scientific work. In addition to the support it provides on the Space Station, CIMON will also drive innovation on Earth regarding robotic applications in the fields of industrial production, education, medicine, and care.

A floating companion and a mobile retinal scanner

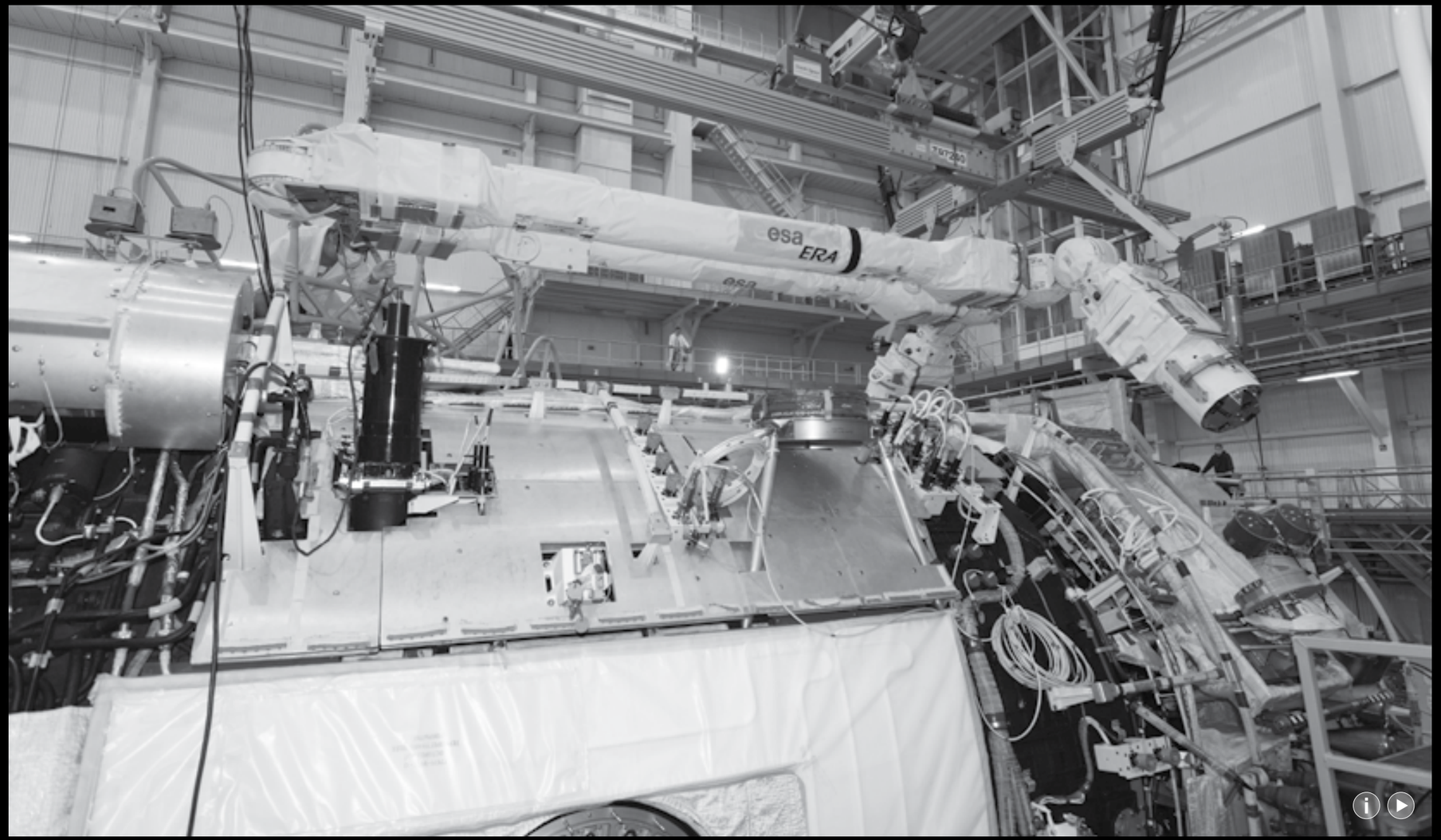
In the field of medicine, for example, CIMON could soon assist the Retinal Diagnostics project of the Institute of Aerospace Medicine at DLR in Cologne. Here, an ocular lens used for routine clinical diagnostic operations will be used as an adapter for mobile devices such as a smartphone or tablet. On the Space Station, the system will be used to take images of Matthias's retinas to detect Spaceflight Associated Neuro-ocular Syndrome (SANS). The ways in which Matthias's eyes change will be recorded, examined, and evaluated. These videos will be transferred to mobile devices to test and train AI models that will then be used to automatically detect any retinal changes in astronauts in the future. CIMON is ideally suited to help here. Combining the AI crew assistant and AI retinal diagnostics system is advantageous in terms of cost, payload size, weight, and diagnostic capabilities. It would also be suitable for use on long-duration space exploration flights such as those of the Artemis programme. On Earth, the AI-based Retinal Diagnostics project is revolutionising the ability to detect diseases via retinal changes using a mobile system.

European Robotic Arm

The European Robotic Arm (ERA) is the first robot that can 'walk' around the Russian segment of the Space Station. Matthias is trained to assist with ERA's setup and initial operations on Station.

Launched from Baikonur Cosmodrome in Kazakhstan on 21 July 2021, this 11-m-long European-built robot will attach to the Russian Multipurpose Laboratory Module, also known as 'Nauka'.

One unique feature of ERA is the capability for astronauts to control it from inside and outside the Station. It can handle components up to 8000 kg with 5 mm precision and will transport spacewalking astronauts from one worksite to another.



The European Robotic Arm during installation on top of the Russian Multipurpose Laboratory Module at the Baikonur Cosmodrome, in Kazakhstan (RSC Energia)




Matthias Maurer wears a special muscle-stimulating suit for EMS training in space (ESA/NASA/DLR)

A new suit for training

The muscles in the limbs and trunk provide the body with stability and motion for human performance. On Earth, our muscles must work against gravity, which allows them to grow stronger naturally. To prevent muscle atrophy and the resulting bone loss in microgravity, astronauts on the Space Station exercise for around two and a half hours every day.

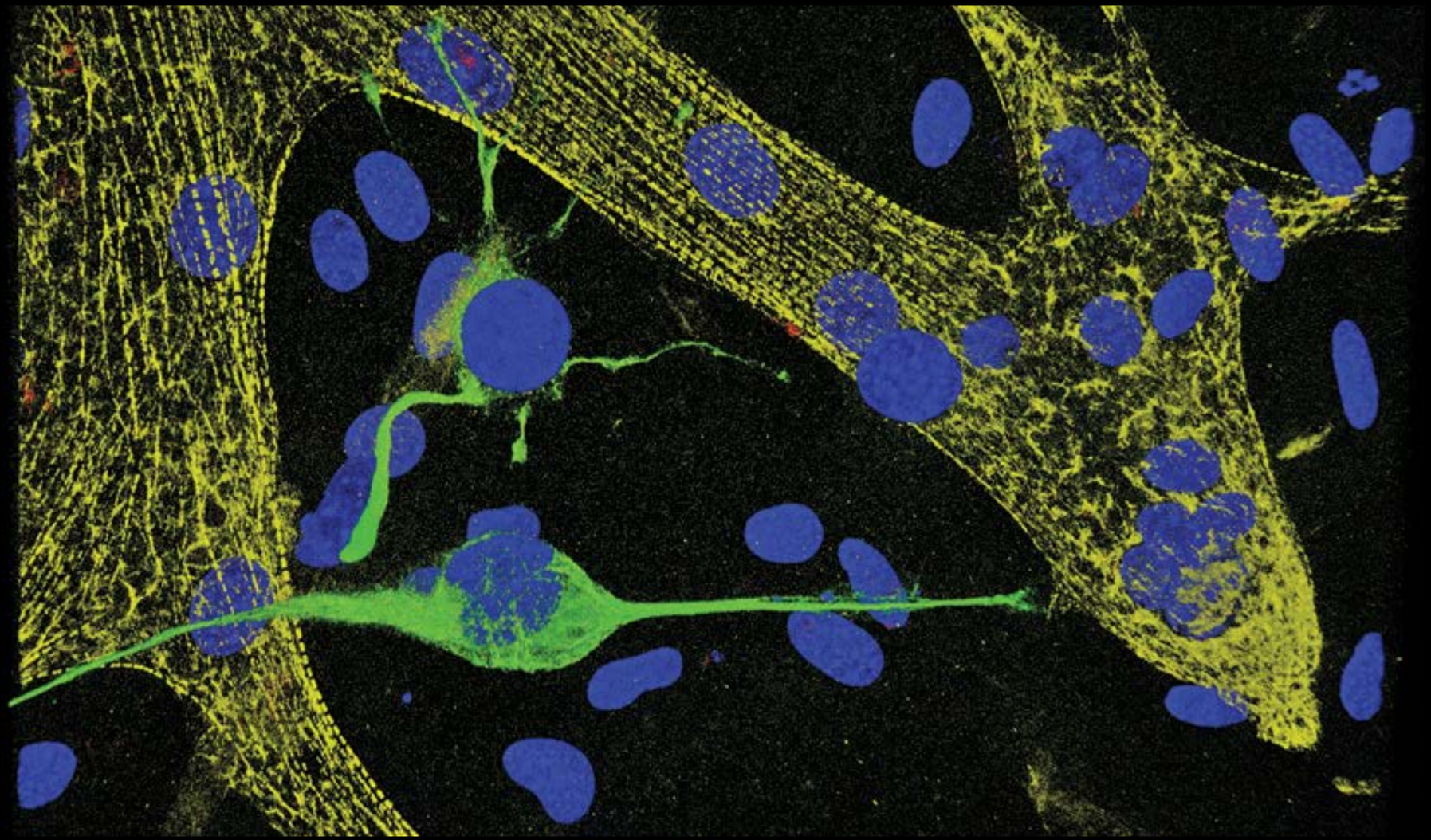
Electrical muscle stimulation (EMS) is a modern strengthening technique in which muscles are stimulated by applying electrical impulses. Combining targeted exercises with the underlying muscle tension achieved using EMS can significantly increase the efficiency of exercise. On the Space Station, Matthias will use a specialised EMS suit to complement his exercise programme, which consists of running, cycling and strength training. The EMS project is scientifically led by the Charité in Berlin.

Rapid wound treatment with bio-ink

On longer space exploration missions, skin injuries, muscle injuries and bone fractures need to be treated quickly and effectively. In the Bioprint First Aid experiment, under the scientific lead of Technical University Dresden, Matthias will test innovative 3D bioprinting on the Space Station for the first time.

Initially, the ink will consist of fluorescent microparticles. In the near future, a bio-ink consisting of the body's own skin cells will be directly applied to treat superficial wounds. The material produced by the bioprinter will cover the affected area like a plaster and accelerate wound healing by facilitating the formation of new skin tissue. In the future, this technology will be used during space exploration missions as well as on Earth.

Matthias in training with the bioprinter device (ESA-C.Diener)



Nerve-Muscle Co-culture (NEMUCO) for the Cellbox-3 experiments (Charité Berlin)

Studying cells

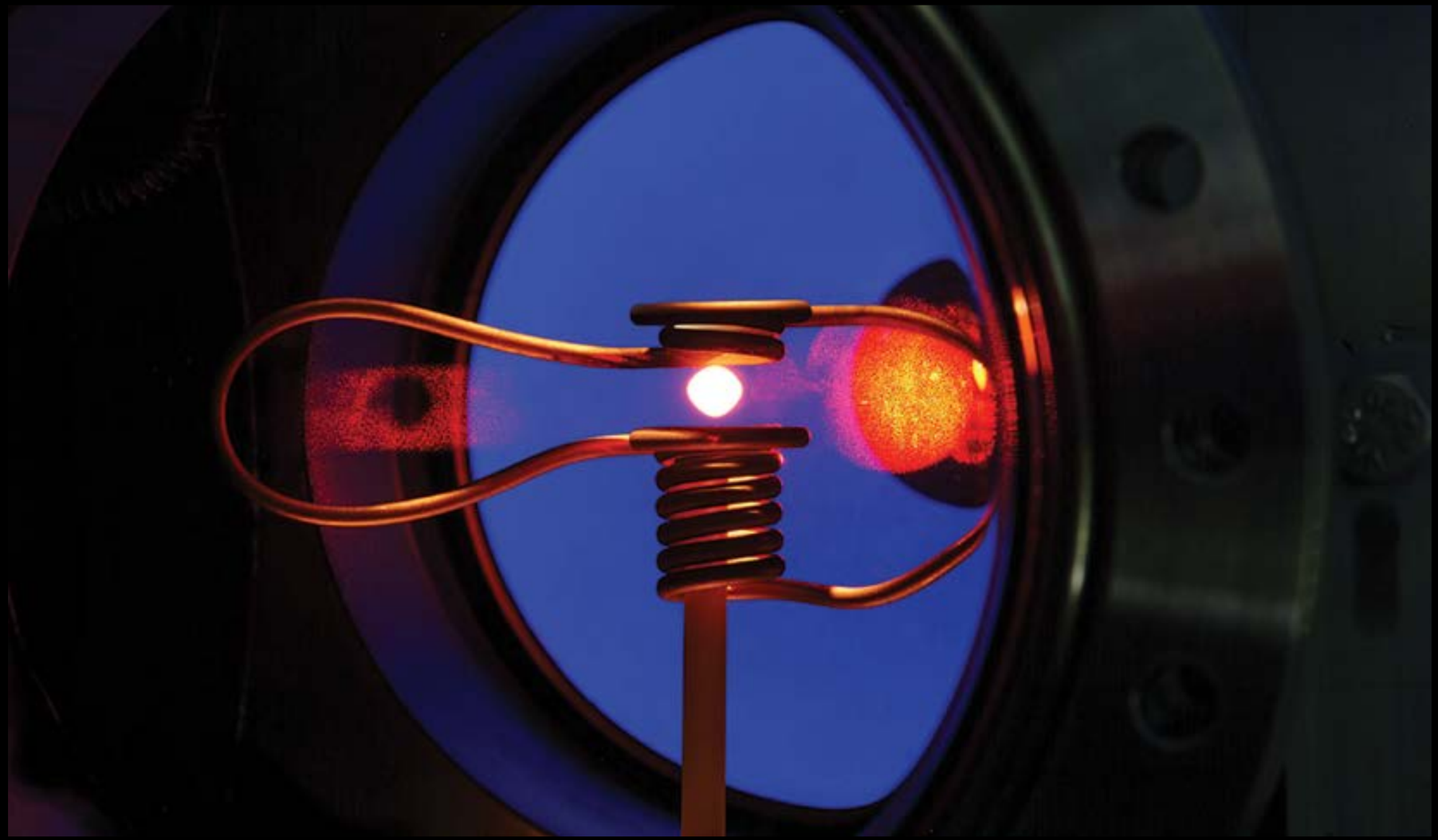
Cells and the processes that take place within them are affected by gravity. How do these processes differ under microgravity conditions in space, and what can we learn about cell processes on Earth by studying these changes?

To answer these and other questions, three-dimensional multicellular models of bone marrow and co-cultures of skeletal muscle cells and nerve cells will be studied in microgravity in the Cellbox-3 experiment under the scientific lead of Goethe University Frankfurt and Charité in Berlin. This research will improve our understanding of blood formation in bone marrow and the molecular processes involved in supplying muscles with nerve cells. The results should advance the development of effective therapies against immune diseases and muscle weakness.

Spotlight on ‘space fever’

A longer stay in space leads to a prolonged increase in the body's core temperature. This 'space fever' poses a potential risk to astronaut health – especially during exercise and spacewalks. The Thermo-Mini experiment under the scientific lead of Charité in Berlin will record Matthias's core body temperature and circadian rhythm using a miniaturised thermal sensor strapped to his forehead in a non-invasive manner. The data obtained will help improve our understanding of this phenomenon and prove that this small thermal sensor is suitable for long-term use in space. A future version could be used in hospitals, by people working in extreme environments on Earth such as miners or firefighters and included in standard astronaut health monitoring.

Thermo-Mini technology demonstration during a parabolic flight campaign (Novespace-N.Courtioux)



A free-floating molten metal suspended by electromagnetic force. The electromagetic levitator on the International Space Station in ESA's Columbus laboratory is a furnace that can heat metals up to 2100°C and then cool them rapidly (DLR)

Modern materials made to measure

Melting experiments on the Space Station help improve technology used in the industrial casting processes of high-tech materials on Earth. Producing new, lighter versions of complex machine parts, such as aircraft turbine blades and engine casings, leads to lighter aircraft and cars with lower fuel consumptions.

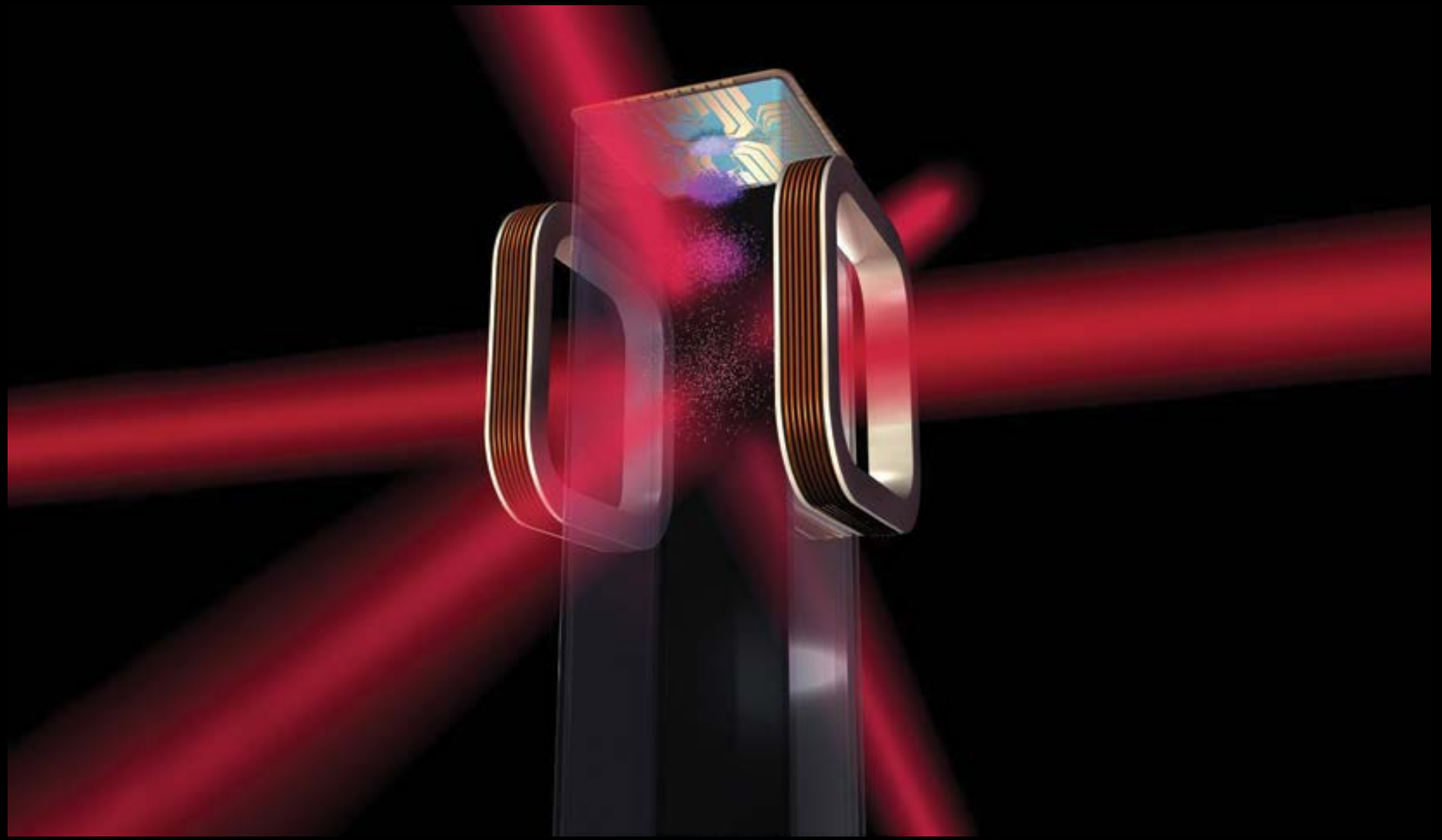
In this research, samples are melted and re-solidified in various Space Station melting furnaces such as the Electromagnetic Levitator, the TRANSPARENT-1 facility, and the Materials Science Laboratory. These processes can be carried out more precisely in space as microgravity conditions reduce the complex flows in the material that occur in laboratories on Earth. The resulting data on the properties of metal and alloy melts, such as their viscosity, surface tension and crystal growth under microgravity, are in high demand as they are used in the optimisation of the computer models that simulate and improve industrial casting processes.

Concrete mixes for space exploration

Cement is one of humankind's oldest building materials. Combined with water and an aggregate, it is used to produce concrete – an important modern building material. In its viscous state, concrete is a multi-layered mixture. As the water chemically binds to the cement, the 'paste' hardens. On Earth, this solidification is strongly influenced by gravity, which ensures that the high-density components fall to the bottom and are deposited on the ground. Previous investigations on board the International Space Station have been limited to the solidification of pure cement.

In the Concrete-Hardening project, organised by DLR institute of Material Physics in Space as well as the Ruhr University Bochum, Matthias will investigate for the first time how different concrete mixtures – containing cement, sand or 'Moon dust' regolith, combined with water and various admixtures such as air-entraining agents, harden in microgravity. This research will facilitate the development of new, improved concrete mixtures that could be used as building material for astronaut habitats during lunar and Mars missions and for sustainable housing construction on Earth.

Artist's impression of a 3D printed lunar base made from layered regolith (ESA/Foster + Partners)



Artist's impression of the Cold Atoms Lab (CAL). The lab is a compact, atom chip-based facility for examining ultra-cold quantum gases such as Bose-Einstein condensates (BEC) (NASA)

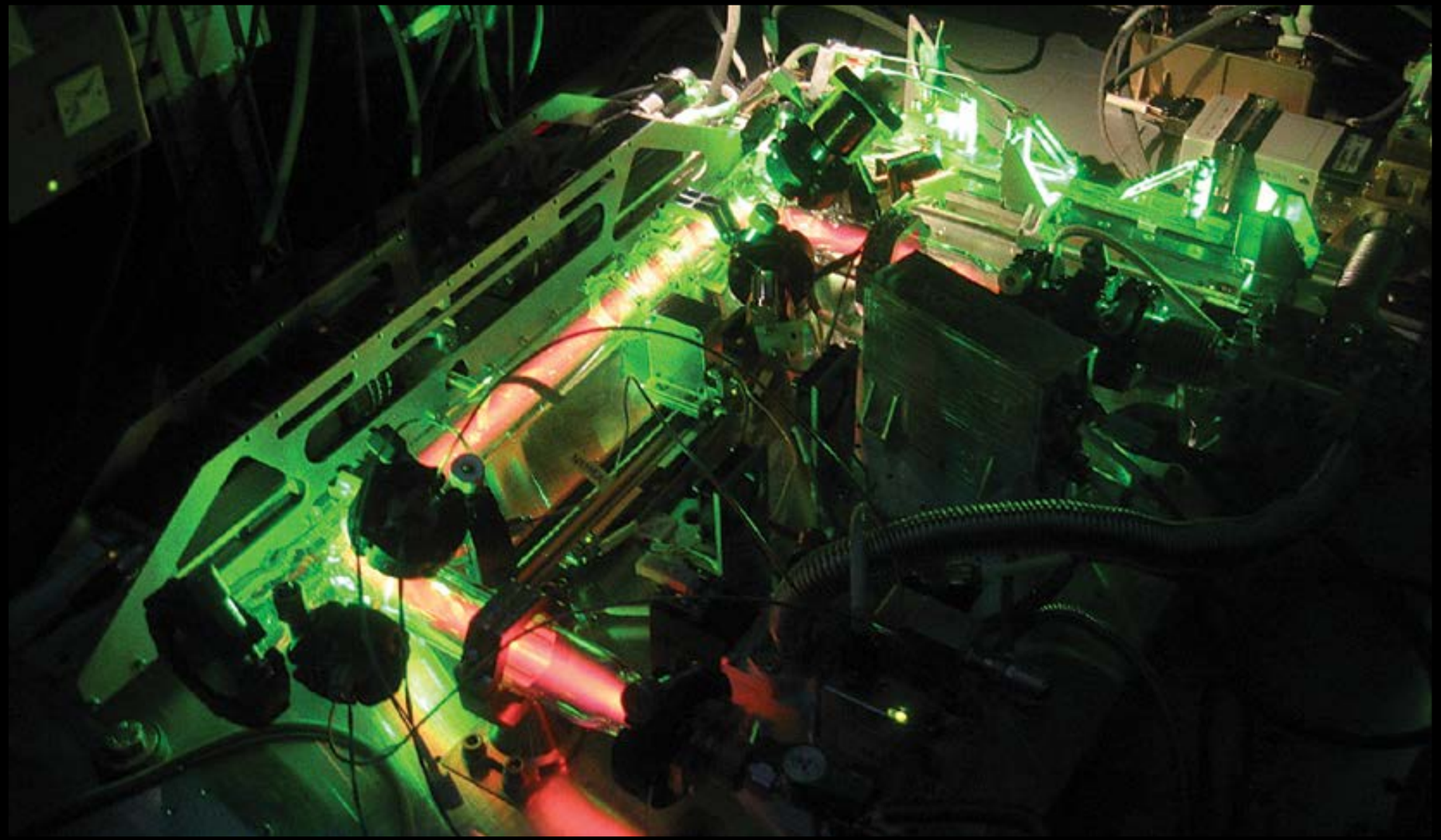
Ultra-cold atoms

The Cold Atoms Lab (CAL) – a cooperation of German Space Agency at DLR and NASA – will make it possible to study ultracold atoms and Bose-Einstein condensates (BEC) under microgravity conditions over an extended period for the first time.

In this unique orbital laboratory, clouds of rubidium and potassium atoms will be cooled down to temperatures extremely close to absolute zero using a laser and confined with a magnetic field to create a Bose-Einstein condensate. These BECs behave like a single 'giant atom' on which quantum phenomena can be observed at the macroscopic level. Experiments performed using these ultracold atoms will test important predictions of quantum physics and other fundamental theories such as Einstein's general theory of relativity. These long-term experiments, with the participation of the universities in Hanover and Ulm, will also advance the development of state-of-the-art integrated circuit technology, miniaturised laser modules and high-precision clocks and sensors. Among other benefits, these developments could help make satellite navigation even more precise in future.

Exploring plasmas in weightlessness

Through the PK-4 plasma crystal experiment, with the participation of the DLR institute of Material Physics in Space, the Russian Academy of Science (RAS) and Giessen University, processes that take place at the atomic level can be made visible to the human eye. Plasma is ionised gas and therefore electrically conductive. If the plasma also contains dust particles or other microparticles, these too become charged, and a 'complex plasma' is created. In microgravity, these particles are free to spread out and form ordered, three-dimensional crystal structures. Researchers study the formation of these structures to gain insight into fundamental physical processes that could lead to future applications in space physics, plasma physics and technology, fusion research, and industrial fluid design. This research facilitates advances in semiconductor and integrated circuit technology, in the development of modern propulsion systems, valves and shock absorbers, and most recently in the medical field in the killing of multidrug-resistant pathogens during wound treatment and disinfection.



ESA–Roscosmos Plasma Kristall-4 experiment (M.Kretschmer)

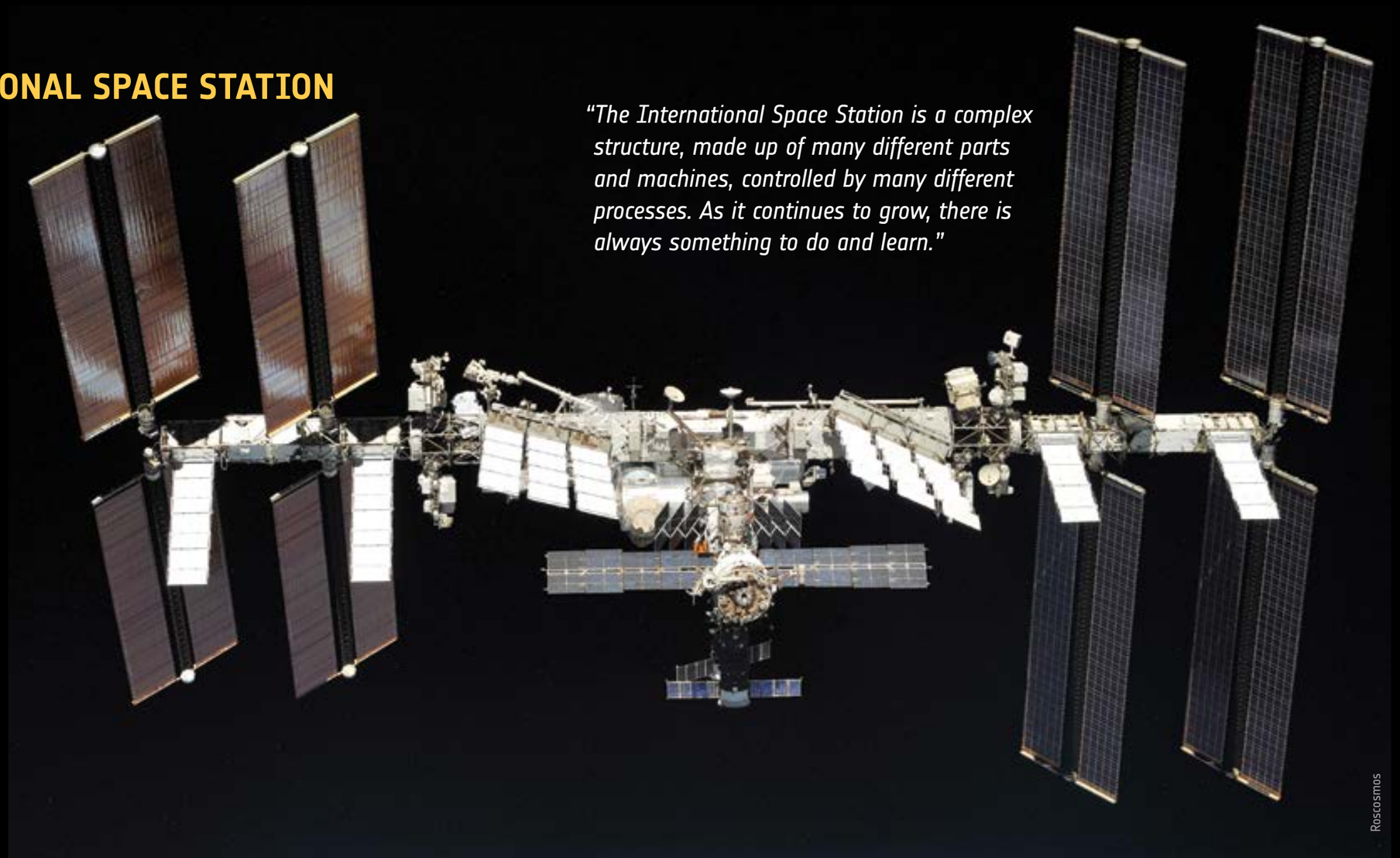
DESTINATION: INTERNATIONAL SPACE STATION

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.

"The International Space Station is a complex structure, made up of many different parts and machines, controlled by many different processes. As it continues to grow, there is always something to do and learn."



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 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 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

FACTS AND FIGURES

- Over 570 people have been to space, of which around 250 have stayed on the International Space Station
- Astronauts have performed over 242 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

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

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)

DRAGON

Matthias will be the second European to fly to the International Space Station under NASA's commercial crew programme.

As a member of Crew-3, he will be launched from NASA's Kennedy Space Center in Florida, USA, in a SpaceX Crew Dragon spacecraft on a Falcon 9 rocket. The crew of four will be boosted to orbital height and speeds in 8 minutes 48 seconds, beginning their journey to the Space Station. Meanwhile, the booster's first stage will return to Earth to be refurbished and reused.

KEY DATA

Launch site	Kennedy Space Center, Florida, USA
Launch	No earlier than 31 October 2021
Landing	April 2021
Spacecraft	Crew Dragon
Launcher	Falcon 9

SpaceX Crew-2 launch (SpaceX)

SpaceX Crew Dragon Endeavour arriving at the International Space Station (JAXA/NASA–S. Noguchi)

"I am excited to fly on the SpaceX Crew Dragon capsule. The fact that I have no comparison with previous vehicles allows me to approach this task with a fresh perspective on my way to space."

DRAGON

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.

This Crew version can transport up to seven astronauts, but only four seats are fitted for NASA missions. 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 Cosmic Kiss mission and act as lifeboat for the crew in case of an emergency.

SpaceX Crew Dragon training (SpaceX/NASA/ESA)

Matthias Maurer during water survival refresher training at NASA's Johnson Space Center (NASA-N.Moran)

Space Crew Dragon splashdown (NASA)

Return to Earth

After living and working on the Space Station for around six months, Matthias and his Crew-3 colleagues will return to Earth.

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.

The nose cone, which protects the docking adaptor during ascent and re-entry, is jettisoned before splashdown. Four parachutes deploy at the final stages to ensure a calm 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

Though we cannot all experience the thrill of flying to and living in space, Matthias will do his best to bring this wonder back to Earth. Education and outreach are major components of any astronaut's mission to the Space Station. During Cosmic Kiss, Matthias will encourage the next generation of researchers and change-makers to explore farther, reach higher and take action for our Earth.

Hand-in-Hand Around the World

More than 1000 students between the ages of 8 and 12 have already taken part in DLR's hands-on campaign Hand-in-Hand Around the World. In doing so, they drew 'class selfies' depicting themselves holding hands with one another in a long row. Put together, the 30 winning motifs form a human chain on a 10 m long textile strip that will accompany Matthias into space. The remaining drawings have been stored on a USB stick that will also be flown to the Station. Once Matthias returns to Earth, the winning classes will receive their pictures and certificates back for exhibition – a 'feat of space' for permanent inspiration in the classroom.

Earth Guardian

Through school competition Earth Guardian – Space for Change, the German Space Agency at DLR is going in search of young climate and environmental heroes for the third time. Students aged 12 to 14 will develop their sustainable ideas for the protection of our climate and environment and view the world with different eyes as young researchers. During his mission, Matthias will act as an ambassador from space, where he will send video messages to the young climate and environmental heroes and provide important information about the different climate zones.

Matthias Maurer with Hand-in-Hand Around the World 'class selfies' and Earth Guardian (DLR)

CallipEO

CallipEO is also a call for students up to the age of 13, focused on environmental impact. Participants in this DLR activity will program a Space Station minicomputer equipped with sensors to conduct their own environmental experiments.

A touch of science

Where humans go, microbes follow. After many years of human presence, the Space Station has its own microflora with various types of microorganisms. This 'space biotope' not only impacts the health of astronauts, it can also lead to material damage. In Touching Surfaces, nanostructures are applied to novel surfaces, made of copper and brass, with a laser and then examined for their antimicrobial effect. The scientific experiment also has an education component: several schools will receive identical material samples. These samples will remain on Earth and are an important part of the experiment because they will be compared to those in space. All samples will be evaluated together with the students and researchers at DLR.

European Astro Pi Challenge

Two brand new Astro Pi computers equipped with a host of sensors and high-quality cameras are set to launch to the Space Station. Students all over 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.

Matthias Maurer talks with children during Asteroid Day weekend in Luxembourg in 2018 (Max Alexander/Asteroid Day)

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. Matthias will act as the challenge ambassador and encourage school children to prepare for the 2022 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.

Moon Camp Challenge

Astronauts living on the Moon will need to rely on new infrastructures 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 using 3D-modelling tools.

ARISS: Earthlings in direct radio contact with Space Station

As he flies around Earth, Matthias will personally answer questions from students using radio systems provided by the ARISS organisation (Amateur Radio on the International Space Station). In each of these 12-minute contacts, Matthias will talk to students in his former home region, Lebach, Germany, and answer any questions students may have about his impressions of work and life in space.

Forward to the 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.

Currently scheduled during Matthias's mission is the launch of Artemis I. The inaugural flight of NASA's Space Launch System (SLS) rocket and Orion spacecraft, powered by the European Service Module (ESM), as an integrated system 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 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 hand-in-hand with robots, in international cooperation and with commercial partners.

"ESA and NASA are strong partners in the Artemis programme, so we know that Europeans will be on the spacecraft that will fly towards the Moon. I am pretty sure that we will see the very first European walking on the surface of the Moon by the end of this decade. It's an exciting time ahead."

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

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