Alexander Gerst
horizons – a journey of discovery for science and society

DLR

horizons – devising solutions for the challenges of the future

Alexander Gerst's launch to the International Space Station (ISS) on 6 June 2018 for his mission 'horizons – Knowledge for Tomorrow' will mark the start of his second mission to work on the largest international technology project in the history of humankind. In this scientific laboratory, the major spacefaring nations are joining forces to develop solutions for the global challenges of our society: 'Health, Environment and Climate Change', as well as 'Digitalisation, Industry 4.0, Energy Supply and Mobility of Tomorrow'. Germany is, amongst the European member states, the most important partner for the other nations involved in the ISS – the United States, Russia, Japan and Canada. All German contributions to the Space Station are coordinated and managed by the German Aerospace Center (DLR) Space Administration in Bonn on behalf of the German federal government, in coordination with the international ISS partners. In addition to science, the Space Station also provides opportunities for commercialisation. Germany's participation in the ISS has a direct effect on its economy. A cost-benefit analysis by the accounting firm Price Waterhouse Coopers confirms: every euro invested provides a return of one euro. In addition, the ISS is a driver of innovation for new branches of industry and technologies, such as laser communications, robotics and sensor technology. For Germany as an exporting nation and a hub of high technology and science, research on the ISS represents an investment in the future, and, at the same time, is a source of inspiration for the next generations in science and industry. German ESA astronaut Alexander Gerst's horizons mission strengthens Germany's position as a hub of science and innovation, and makes the Federal Republic one of the most intensive users and beneficiaries of the scientific equipment on board the International Space Station, turning 'science fiction' into 'science facts'.

DLR.de/en/horizons

'Reaching new horizons and conquering them is what drives us humans. The ISS gives us the opportunity to leave our 'spaceship Earth'. The Space Station is not just a one-of-a-kind laboratory, but also the first spacecraft that shows us how to live together in a multicultural community beyond our planet Earth. For me, horizons is also the perfect continuation of my Blue Dot mission, for which the focus was on our blue planet. With horizons, I am looking forward to broadening my horizons even further.'

Alexander Gerst,
first German commander of the ISS

Key facts

Mission:	horizons – Knowledge for Tomorrow
Number of German experiments:	approximately 50
Astronaut:	Alexander Gerst (born 3 May 1976 in Künzelsau)
Launch to ISS:	6 June 2018 from Baikonur Cosmodrome in Kazakhstan
Mission duration:	expected to be 187 days
Docking:	8 June 2018
Hatch opening:	8 June 2018

Crew Expedition 56

Andrew Jay Feustel, Commander
Oleg Germanovich Artemyev
Richard R. Arnold

Alexander Gerst — Commander
Serena Maria Auñón-Chancellor
Sergei Prokopiev

Alexey Ovchinin
Nikolai Tikhonov
Tyler N. Hague

Crew Expedition 57

Return to Earth:	scheduled for 10 December 2018

horizons – first German commander for humankind's outpost in space

Since its inception, the International Space Station has been a symbol of international understanding and peaceful coexistence. Six astronauts from different nations live and work together on humanity's outpost in space approximately 400 kilometres above Earth, united by a major goal – to improve life on our planet. From early June 2018, Alexander Gerst will be one of these six astronauts. The German ESA astronaut will remain on the ISS for 187 days, and during the second half of his mission, he will lead this international space community as commander – similar to the captain of a ship. In this role, for the first time taken up by a German, he will be responsible for the safety of the crew, help to resolve conflicts, and work intensively with the flight director on the ground. In the event of an emergency, he will decide on the rescue measures to be taken – up to and including aborting the mission and returning to Earth prematurely. In order to successfully master this high responsibility job, he has undergone intense training at the Yuri Gagarin Training Centre near Moscow and in the US space agency NASA's Johnson Space Center in Houston. But during his mission, Gerst will be more than a commander – he will also be a researcher, craftsman, 'port master' and teacher. Before he departs to the Space Station, his tasks will be defined and he will undergo the respective training; this will prepare him for knowing what to do in every experiment, how to check and, if necessary, change water circuits and valves, and how to dock cargo spacecraft. In addition, he has learned to provide inspiration to children and young people about space.

DLR.de/en/horizons

Ready for the mission: the crew of Expedition 56/57 with Serena Maria Auñón-Chancellor, Sergei Prokopyev and Alexander Gerst (from left to right) posing in their Sokol spacesuits during a visit to the Russian Star City.

Volker Schmid/DLR

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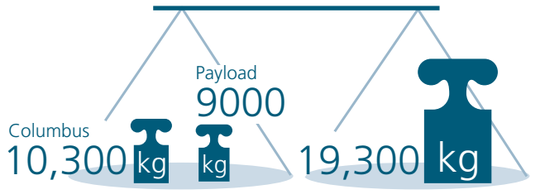
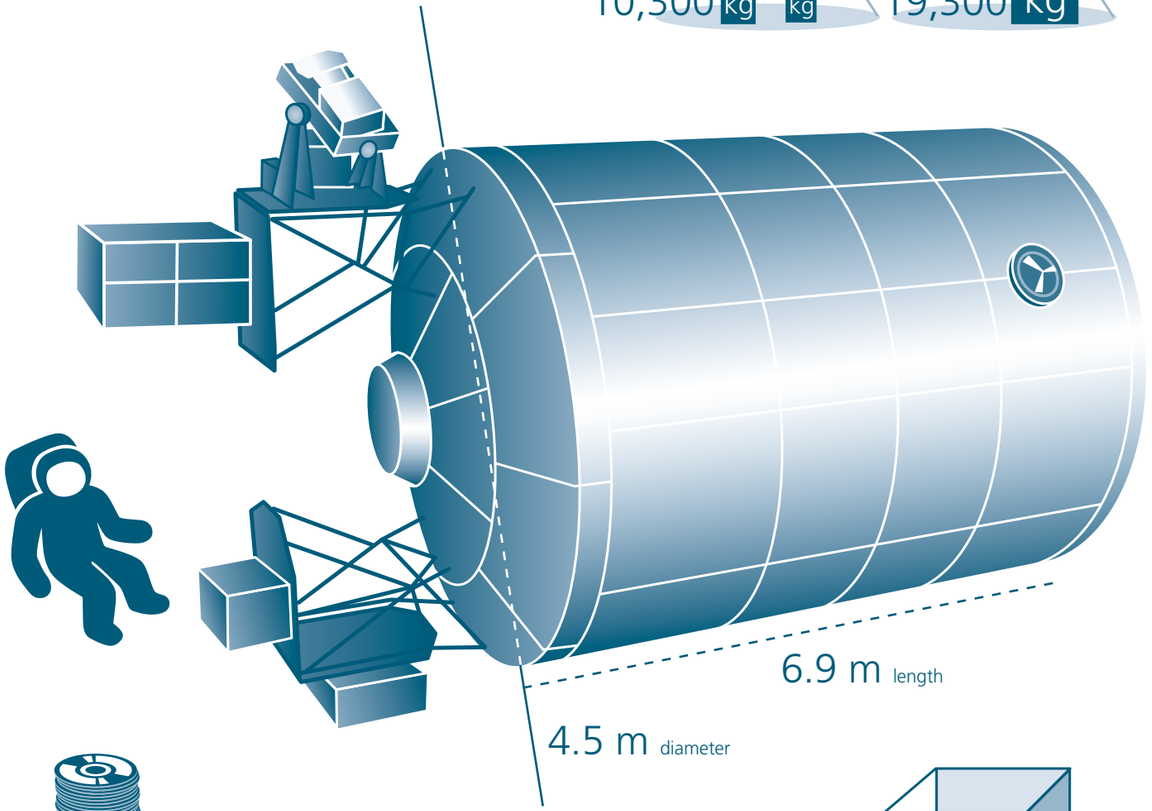
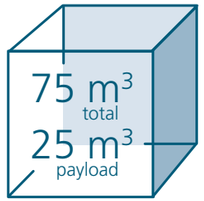
Return to Earth:	scheduled for 10 December 2018

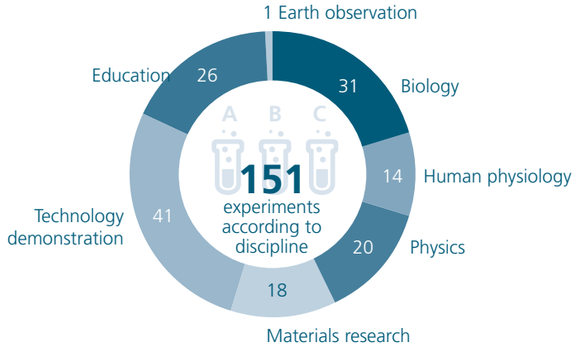
58,464
orbits of Earth in 10 years

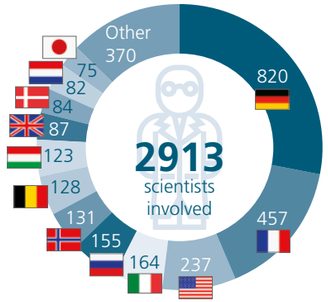




800 terabytes
of scientific data, transmitted using
the Data Management System
(equivalent to a 30-metre-high tower of DVDs)







The diagrams shown here refer to the period from February 2008 to February 2018.

The Columbus laboratory – the heart of European space research

The Columbus laboratory was launched to space on 7 February 2008 and has been the scientific heart of European research on the International Space Station for more than 10 years. In microgravity, researchers can gain unique insights to find solutions to the global challenges of our society: ‘Health, Environment and Climate Change’, ‘Digitalisation, Industry 4.0, Energy and Mobility of Tomorrow’. DLR has overseen the development and production of the ISS module on behalf of the European Space Agency (ESA), is actively involved with experiments at the research level and manages operations from the Columbus Control Centre in Oberpfaffenhofen. The final assembly of the European module was carried out at Airbus in Bremen.

DLR.de/en/columbus

horizons – Where will the highlights from German industry and research take place?

CIMON:
CIMON is a type of 'flying brain' – an autonomously acting astronaut assistant. Equipped with Artificial Intelligence (AI), this globally unique technology demonstration supports the work of the astronauts on the ISS.

DLR.de/en/horizons/cimon

METERON SUPVIS Justin:
In METERON SUPVIS Justin, astronauts on the ISS assign complex exploration tasks to a robot via a tablet PC, which their humanoid 'colleague' can then, largely independently, carry out on Earth – an important experiment for future industrial production.

DLR.de/en/horizons/supvis-justin

Time capsule:
A time capsule will be a special guest on board the ISS. It stores important information of our time and photographs of the everyday lives of many people, as well as numerous wishes of schoolchildren from across Germany.

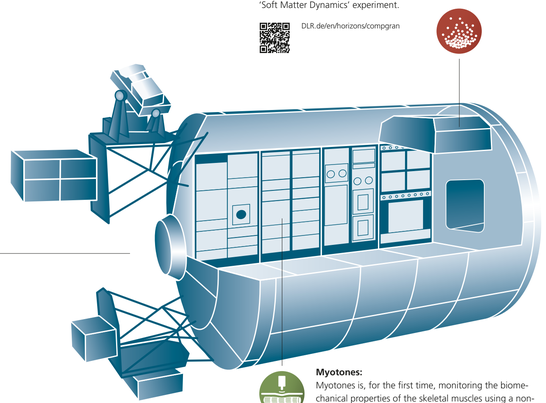
DLR.de/en/horizons/zeitkapsel

Earth Guardians:
A student competition will look for the 'Earth Guardians'. Alexander Gerst will address the students in short video messages from the Columbus module, and as such spark their commitment to protecting the environment and preserving biodiversity on Earth.

DLR.de/en/horizons/beschuetzer-der-erde

ARISS:
Schoolchildren from 13 different schools and three DLR laboratories for school pupils – the DLR_School_Labs – will connect with the ISS to ask Alexander Gerst questions in real time, which he will answer from the Columbus module.

DLR.de/en/horizons/ariss



Soft Matter Dynamics/CompGran:
To better process bulk goods such as sand or grain, the behaviour of such moving granular media (CompGran) is examined under microgravity conditions in the Fluid Science Laboratory (FSL) as part of the 'Soft Matter Dynamics' experiment.

DLR.de/en/horizons/compgran

Myotones:
Myotones is, for the first time, monitoring the biomechanical properties of the skeletal muscles using a non-invasive, portable device on board the ISS, in order to examine changes to the muscular system caused by a lack of gravity. The additionally required ultrasound is stored in the European Physiology Module (EPM).

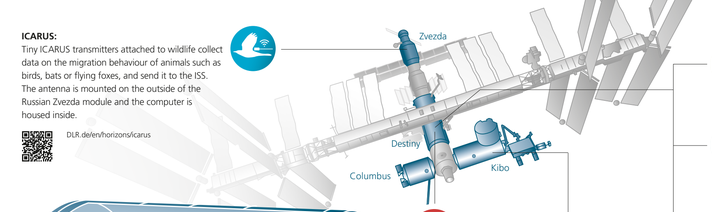
DLR.de/en/horizons/myotones

PK-4:
The plasma crystal experiment PK-4 allows processes that occur at the atomic level to be made visible to the human eye in the European Physiology Module (EPM).

DLR.de/en/horizons/pk4

ICARUS:
Tiny ICARUS transmitters attached to wildlife collect data on the migration behaviour of animals such as birds, bats or flying foxes, and send it to the ISS. The antenna is mounted on the outside of the Russian Zvezda module and the computer is housed inside.

DLR.de/en/horizons/icarus



EML/TRANSPARENT:
Using the EML installation in the European Drawer Rack (EDR) of the Columbus module and TRANSPARENT-1 in the Destiny module, the properties of molten metals and alloys – such as viscosity, surface tension and crystal growth – can be examined under microgravity conditions.

DLR.de/en/horizons/eml-msl-transparent

MagVector/MFX:
The MagVector/MFX-2 installation will examine the interactions of Earth's magnetic field using a variable electrical conductor at high speed in the European Drawer Rack (EDR) – this can only be done on the ISS.

DLR.de/en/horizons/magvector-mfx

FLUMIAS:
The FLUMIAS 3D fluorescence microscope will make it possible – for the first time – to observe processes in living cells under microgravity conditions in real time and outline their changes.

DLR.de/en/horizons/flumias

Immuno-2:
Immuno-2 examines the weakening of the immune system caused by stress in astronauts and people on Earth in order to develop effective countermeasures.

DLR.de/en/horizons/immuno2

Gene Control Prime:
The Gene Control Prime experimental series is investigating the epigenetic causes of immunodeficiency in microgravity.

DLR.de/en/horizons/gene-control-prime

Cold Atoms Lab:
Thanks to the Cold Atoms Lab (CAL), long-term basic experiments can be carried out for the first time on ultra-cold atoms and Bose-Einstein condensates (BEC) in microgravity in the US Destiny laboratory module.

DLR.de/en/horizons/cal

PBR photobioreactor:
The PBR photobioreactor is for the first time preparing for the use of a hybrid life-support system on the ISS, further closing the resource cycle by connecting a biological and a physical-chemical system.

DLR.de/en/horizons/pbr

High flyers:
Students from universities in Stuttgart, Frankfurt on the Main and Duisburg-Essen have devised experiments themselves. These will be supervised by Alexander Gerst on board the ISS.

DLR.de/en/horizons/ueberflieger

The experiments and activities featured here are just some of the many that will be carried out during the horizons mission.

CIMON

METERON SUPVIS Justin

ICARUS

MagVector/MFX

Photobioreactor

FLUMIAS

Myotones

Immuno-2

Gene Control Prime

CompGran

EML/TRANSPARENT

PK-4

Cold Atoms Lab

Time capsule

Spaceflight show

High flyers

ARISS

Earth Guardians

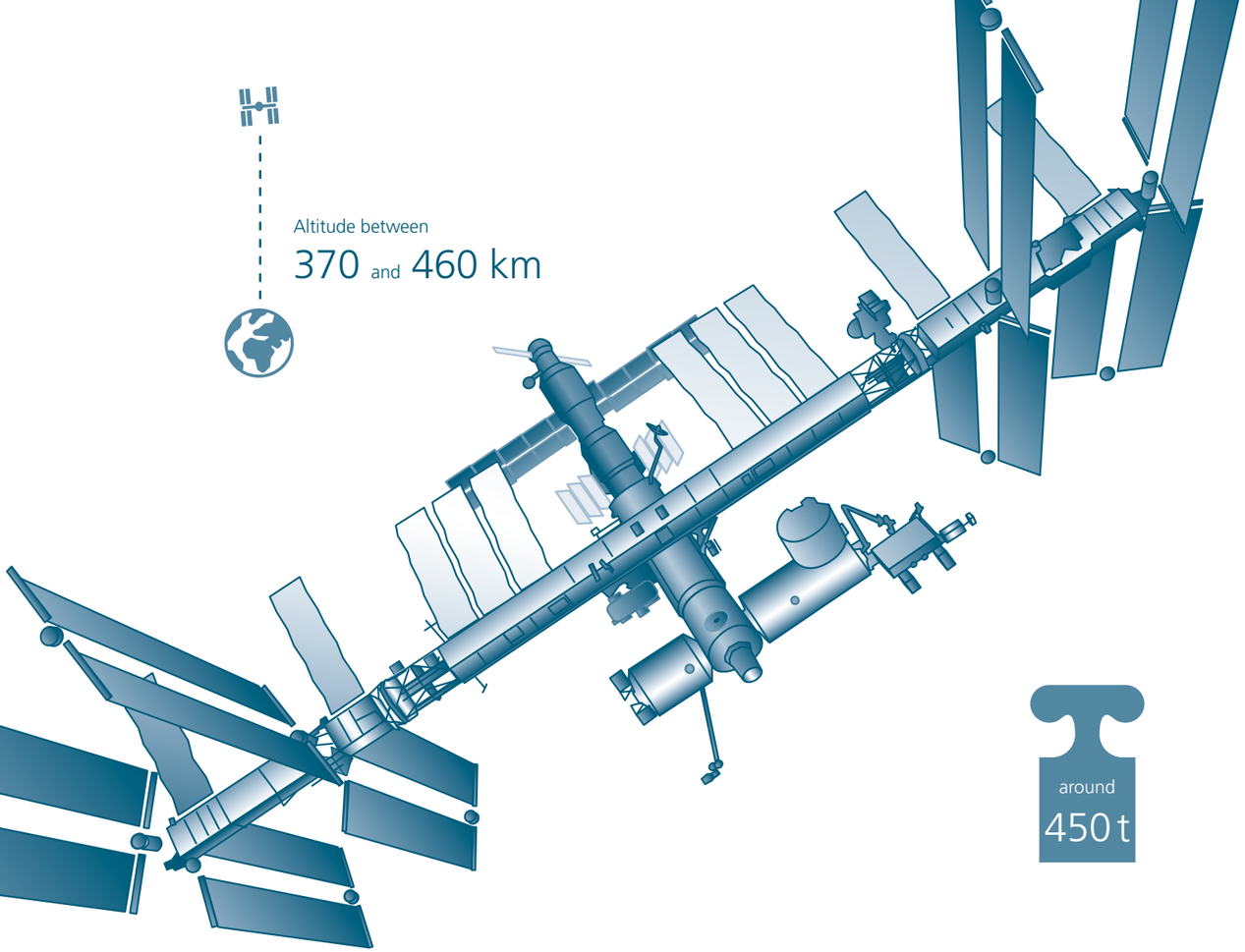
DLR site

Control centre

horizons – Cutting-edge space research in Germany

Although Alexander Gerst will carry out experiments on the International Space Station during his horizons mission, the research is not limited to space. The experiments were devised on Earth, and the hardware and software were developed and built there. The samples come from Earth laboratories and return upon completion of the experiments on the ISS for analysis. The data from the experiments is sent via the Payload Operations Integration Center at NASA's Marshall Space Flight Center in Huntsville, Alabama (USA) to all the other control centres that look after the payload. The Columbus Control Centre (Col-CC) in the German Space Operations Center (GSOC) at the DLR site in Oberpfaffenhofen is responsible for the European Columbus laboratory. From here, data is transmitted to the national user control centres, such as the Microgravity User Support Center (MUSC) at the DLR site in Cologne, and from there, to the scientists. The results of this research in turn drive innovations on Earth. The horizons mission involves the work of 1000 scientists, engineers and programme managers across Germany, who are working on approximately 50 German experiments. The mission will also be addressed in numerous schools. DLR has developed a comprehensive education programme about the horizons mission. This includes, amongst other things, competitions for pupils and teaching materials – but, for example, also a space show, designed to inspire an interest in research and technology in children and young people in many places. In addition, DLR has initiated an ideas competition inviting students to submit an idea, and the best proposed experiments will be carried out during Alexander Gerst's mission. The German highlights of the mission and the participating DLR sites are shown on the map.

DLR.de/en/horizons



Altitude between
370 and 460 km

around
450 t

Orbital period approx. 94 min.

51.6° inclination of orbit

Orbital velocity approx. 28,000 km/h

horizons – International Space Station ISS Facts and figures

The ISS is humanity's largest technology project.

The astronauts have as much space on the ISS as in a jumbo jet:
1200 m³

Germany finances 41 per cent of the European contribution to utilisation of the ISS.

262,400 solar cells extend over 2500 m² and provide the astronauts on the ISS with as much electrical power as is required by 40 homes.
110 kW

110 m

88 m

1998 2010

The ISS was assembled in 32 stages over a period of 12 years. The components were flown into space via 36 Space Shuttle and five Russian launches.

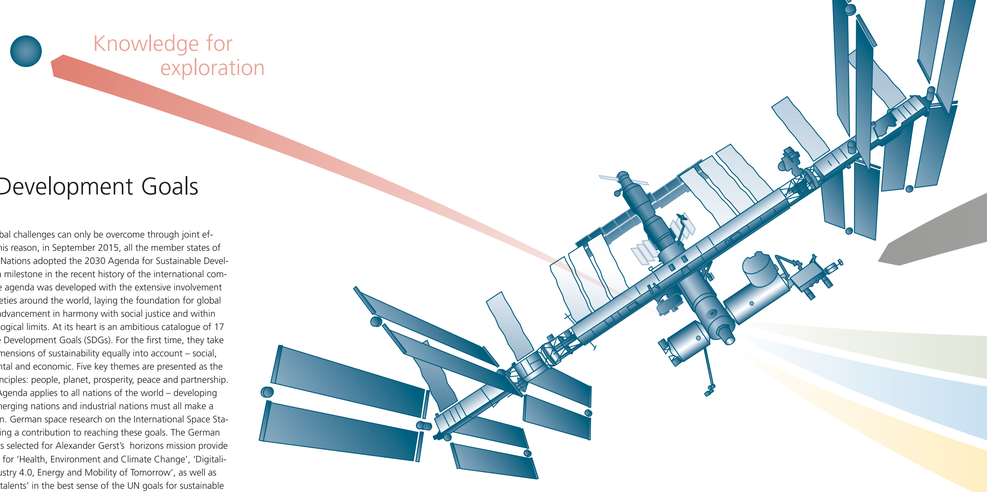
ISS partner countries:

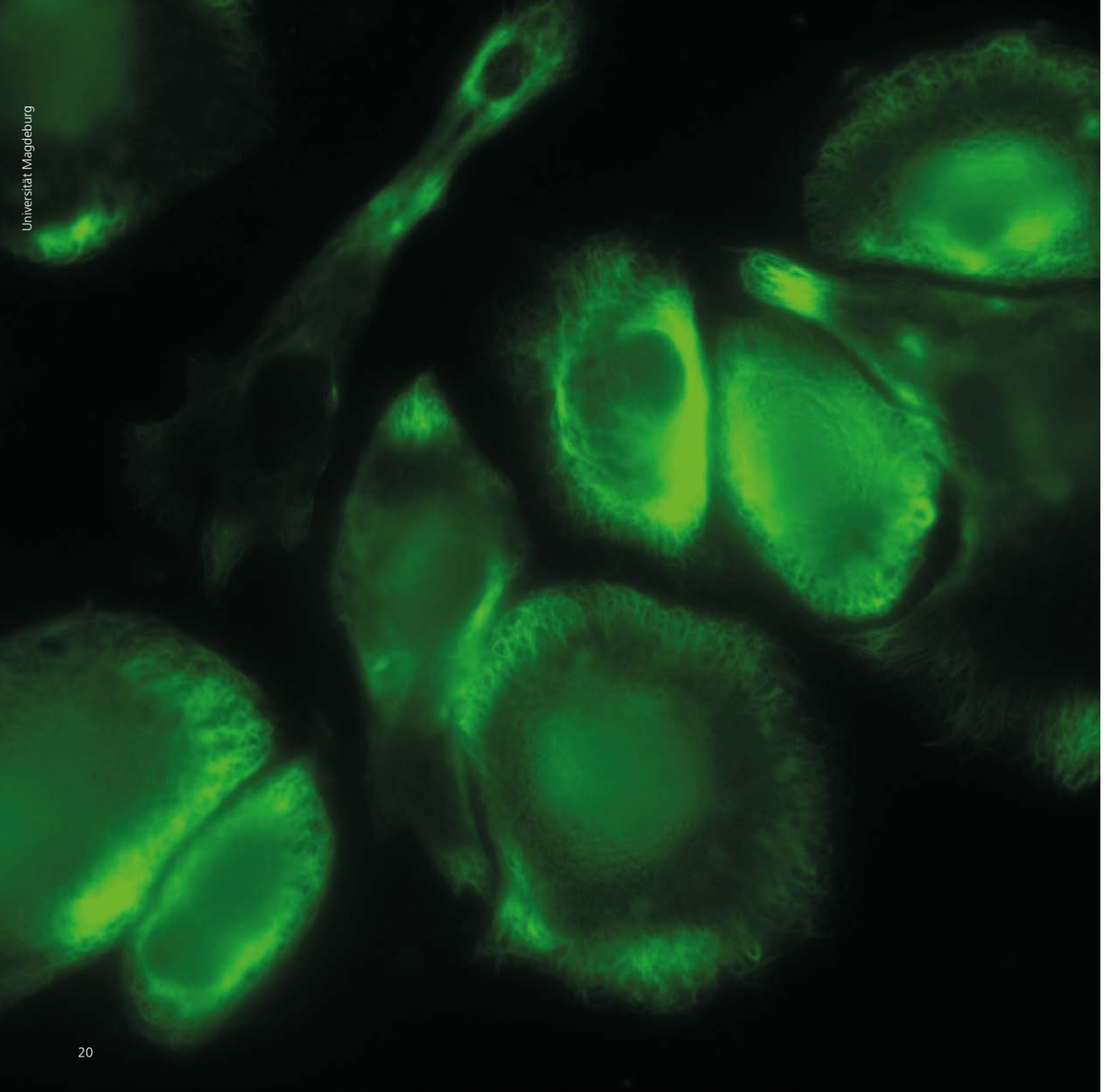
horizons –
Achieving Sustainable Development Goals

Today's global challenges can only be overcome through joint efforts. For this reason, in September 2015, all the member states of the United Nations adopted the 2030 Agenda for Sustainable Development – a milestone in the recent history of the international community. The agenda was developed with the extensive involvement of civil societies around the world, laying the foundation for global economic advancement in harmony with social justice and within Earth's ecological limits. At its heart is an ambitious catalogue of 17 Sustainable Development Goals (SDGs). For the first time, they take all three dimensions of sustainability equally into account – social, environmental and economic. Five key themes are presented as the guiding principles: people, planet, prosperity, peace and partnership. The 2030 Agenda applies to all nations of the world – developing nations, emerging nations and industrial nations must all make a contribution. German space research on the International Space Station is making a contribution to reaching these goals. The German experiments selected for Alexander Gerst's horizons mission provide knowledge for 'Health, Environment and Climate Change', 'Digitalisation, Industry 4.0, Energy and Mobility of Tomorrow', as well as for 'young talents' in the best sense of the UN goals for sustainable development and improved spaceflight.

DLR.de/en/horizons

www.un.org/sustainabledevelopment/





Universität Magdeburg

horizons – Knowledge for health, the environment and climate change

A one-of-a-kind laboratory, the International Space Station (ISS) provides excellent opportunities to research our bodies, as well as the cells of humans, animals and plants under space conditions. In this way, for example, we are gaining insights into illnesses such as cancer, immunodeficiency and bone and muscle atrophy. Innovative medications and therapeutic approaches can be derived directly from this knowledge, which will improve our life on Earth. For example, thanks to FLUMIAS, a new microscope that magnifies and shows cells in 3D in microgravity, we are gaining a completely new insight into human tissue, cell cultures, microorganisms and plants. This will help us to improve global health through new medical opportunities.

Myotones, a new mobile and non-invasive device, will for the first time monitor the fundamental biomechanical properties of the skeletal muscles in order to examine changes due to the lack of gravity. On Earth, the knowledge obtained will lead, for example, to improved rehabilitation and training programmes as countermeasures to muscle and bone atrophy. Astronauts' bodies will be examined to investigate the stress-related weakening of the immune system of both people in space and on Earth and to develop effective countermeasures. This knowledge is a prerequisite for the development of new, preventive and therapeutic measures for astronauts as well as for seriously ill patients in intensive care.

FLUMIAS, a new microscope on the ISS, will for the first time directly image cells in microgravity (here vimentin, an element of the cytoskeleton of vertebrates and a general marker for soft-tissue tumours).

Bourry/DLR

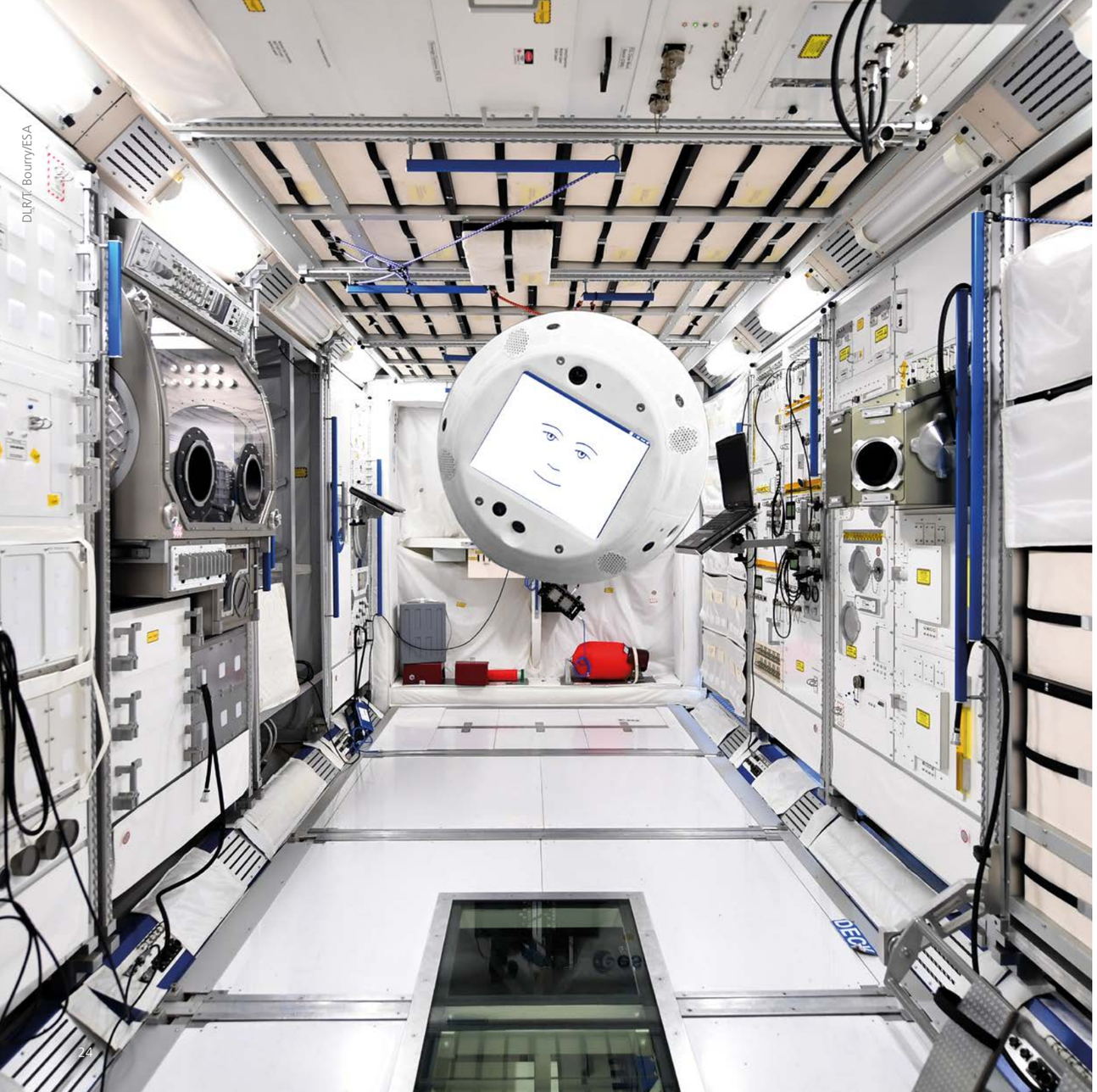
The migratory behaviour of animals can tell us a great deal about environmental and climate changes. Tiny transmitters attached to small animals such as birds send data to the ISS in the ICARUS project, allowing us to track their routes globally for the first time.

The treatment of multidrug resistant bacteria is a major health problem across the globe. According to a study, several thousand people die each year from these pathogens because they are resistant to antibiotics. Thanks to research on the ISS, a remedy has been developed – cold plasma. It can be applied to wounds and, according to clinical studies, it has a 70 per cent success rate in killing pathogens. Cold plasma is already being used for disinfecting medical equipment.

Environmental and climate conditions can also be researched from the ISS. For example, animals have a very strong intuition for sensing climate change and have a ‘sixth sense’ for impending natural disasters such as volcanic eruptions and earthquakes. Within ICARUS, tiny transmitters attached to small animals such as birds or bats send data on their migratory behaviour to the ISS. Researchers can analyse this valuable information and draw conclusions about climatic changes on Earth. More information about these experiments can be found on page 29.

DLR.de/en/horizons

www.un.org/sustainabledevelopment/



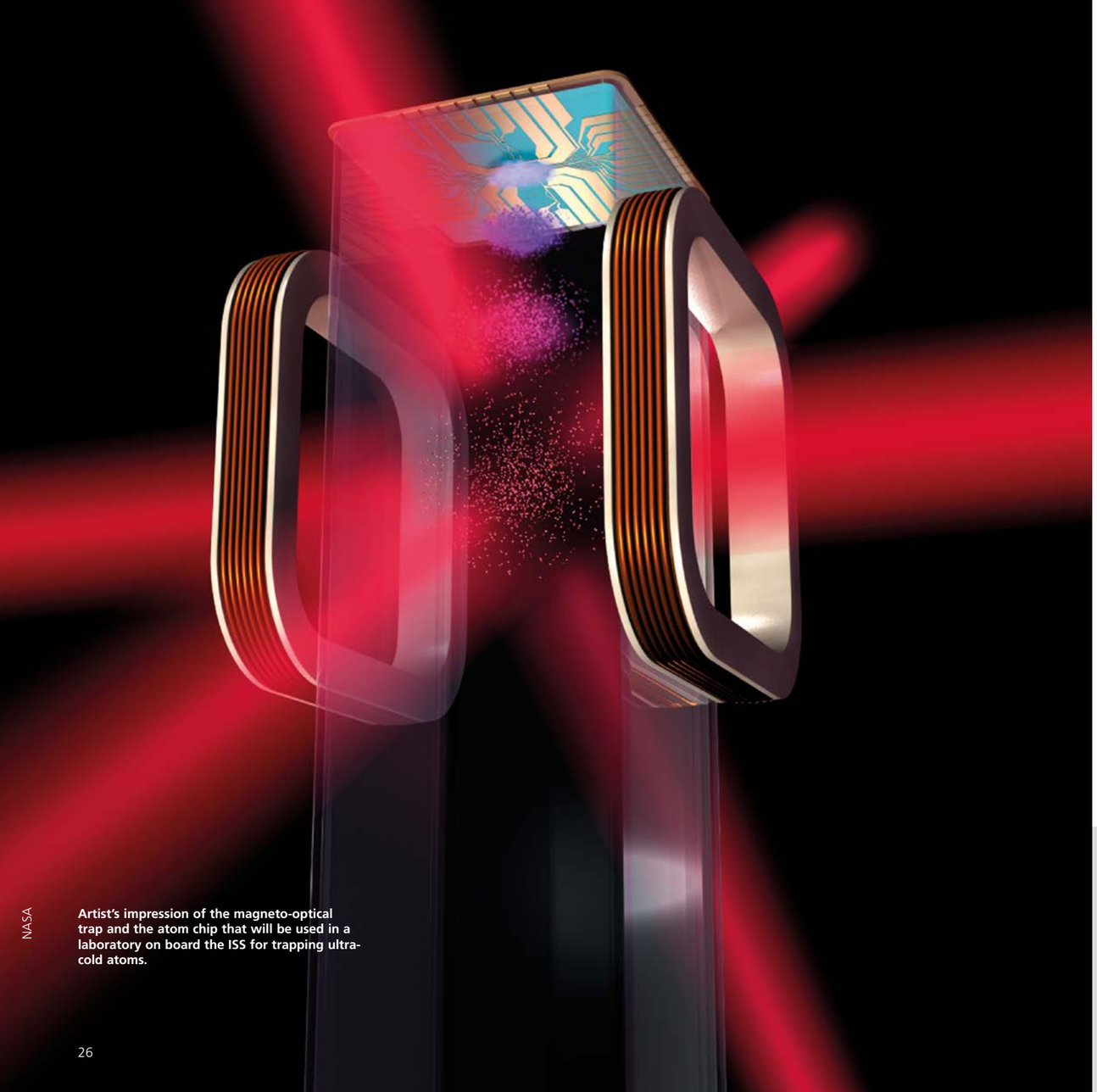
DLR/T. Bourry/ESA

In this photomontage, CIMON floats as the seventh ISS crew member in the Columbus module at the European Astronaut Center in Cologne. CIMON is able to 'fly' and is equipped with Artificial Intelligence – a globally unique technology demonstration.

horizons – Knowledge for digitalisation, Industry 4.0, energy and mobility

Digitalisation means change. This change presents a structural challenge to our modern information society, making it necessary for us to further technological progress in both hardware and software. In our everyday lives, we notice this in continuous follow-up developments – smartphones are becoming more intelligent and they link via the Internet of Things to domestic appliances such as refrigerators and washing machines. Speech assistants support people in their daily work. One such digital assistant will be used on the International Space Station (ISS). CIMON, however, is an extraterrestrial companion and more than a mere speech assistant. The seventh crewmember is a 'brain on the ISS'. Equipped with Artificial Intelligence – an important future building block in the digitalisation age – it will, in the classic sense of human-machine interaction, support the astronauts in their daily work and increase their efficiency. But robots are not only used on the ISS. During his mission, within the METERON project, Alexander Gerst will give commands to a humanoid robot on Earth, so that it can solve tasks largely autonomously. A key objective of CIMON and METERON SUPVIS Justin is also to drive innovation for terrestrial applications in the fields of robotic industrial production, medicine and care, as well as education.

The CompGran experiment in the fields of physics and materials research should bring further industrial advancements. On the ISS, Alexander Gerst will investigate the behaviour of granules in order to



NASA

Artist's impression of the magneto-optical trap and the atom chip that will be used in a laboratory on board the ISS for trapping ultra-cold atoms.

improve industrial processes and facilities on Earth. This research will have a great effect on the economy, because granules such as sand or grain are the most processed goods after liquids. Gerst will also investigate the behaviour of plasmas, in order to expand our understanding of this state of matter. This knowledge should result in technological advances in the production of semiconductors – including microchips – modern propulsion systems, valves and shock absorbers. Melting experiments in the Electromagnetic Levitator (EML) on the ISS should generate technological advances in the industrial casting processes of high-tech materials on Earth – such as new types of lighter aircraft turbine blades and engine casings. Amongst other things, this research will make aircraft and cars lighter, thus helping to save fuel and energy – for cleaner mobility in the future. Long-term experiments on ultra-cold atoms in a new, unique laboratory can further advance the development of cutting-edge chip technology, miniaturised laser modules and high-precision clocks and sensors. With these developments, satellite navigation, for example, will be even more precise in the future. More information about these experiments can be found on page 29.

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www.un.org/sustainabledevelopment/

DLR

An aluminium sphere full of surprises – the DLR time capsule includes a durable data carrier holding the wishes of school children as well as photographs from everyday life. In addition, a toy car, a paper plane, the most enigmatic stone in the world and other terrestrial and extraterrestrial materials are included, and will wait to see light again in 2068.

horizons – knowledge for young talents

Young enthusiastic people are key for our future. The challenge of economies around the world is summarised in this simple statement. The space industry also depends on young people. The horizons mission provides the ideal opportunity to inspire the youth about spaceflight, and thus the natural sciences and high-tech professions as a whole. To this end, DLR has tied an entire education package to Alexander Gerst's flight. For example, a time capsule has been sent to the ISS, which, in addition to important data of our time and photographs of the everyday lives of many people, also contains numerous wishes for the future of pupils across Germany. Upon his return to Earth, Alexander Gerst will hand over the time capsule to the German National Museum of Contemporary History (Haus der Geschichte) in Bonn, where the aluminium sphere will be kept until it will be opened on the 50th anniversary of the launch of the horizons mission.

Furthermore, DLR – together with renowned partners such as the Deutsche Physikalische Gesellschaft (German Physical Society), the Klett MINT publishing house and Jugend forscht – has produced educational materials, which have met with an enthusiastic response already before Gerst's launch to space. And while 'Astro_Alex' is ultimately orbiting Earth, the DLR space show will simultaneously be on tour to inspire many thousands of pupils, in the style of a science-on-stage presentation. 'Earth Guardians' will also be sought in a large competition. What can we do to protect habitats and maintain biodiversity? Pupils will address this question. In this, they will deal with the ICARUS project, which observes the movement of animals from the ISS. Thus they will find out how animal migration behaviour is linked to environmental changes and natural disasters.

In addition, children and young people from 14 different schools and three DLR pupil laboratories – the DLR_School_Labs – will call the ISS to ask Alexander Gerst questions in real time. And, finally, the DLR_School_Labs will be holding teacher workshops that will also carry the subject of research in microgravity to schools. However, during the horizons mission, there will be more than just campaigns for schoolchildren – 'High flyers' will be selected in a competition for students. With the support of space experts, students of German universities have devised, set up and built their own experiments. Here, pump technologies for future spaceflight will be developed and the formation of planets studied.

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DLR.de/next/

www.un.org/sustainabledevelopment/

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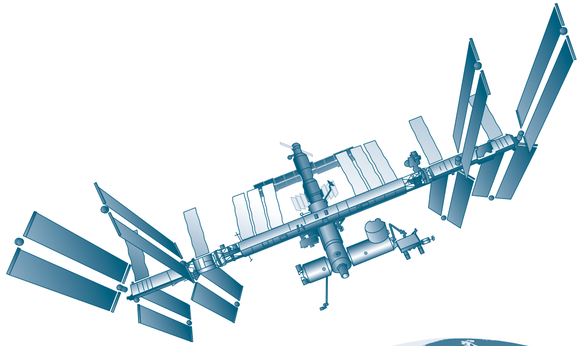
horizons information cards – 13 experiments at a glance

When Alexander Gerst conducts research on the International Space Station (ISS), he will carry out approximately 65 European experiments – Germany contributes to approximately 50. We have selected 13 German experiments of the horizons mission, which exemplify the mission motto of 'Knowledge for Tomorrow' and will provide us with knowledge related to the United Nations' 17 Sustainable Development Goals (SDGs).

horizons – Knowledge for Tomorrow



When Alexander Gerst returns to Earth in December 2018, the horizons mission will come to an end – but the story of the International Space Station (ISS) will continue. Thanks to generous support from the German government, Europe has been able to keep its promise to extend ISS operations until 2024. With this planning security, many new test facilities and experiments are being worked on by the DLR Space Administration with funds from the German Federal Ministry for Economic Affairs and Energy (BMWi). In this way, German scientists and engineers at DLR institutes, universities and space companies, together with colleagues in other countries, can continue to develop solutions to society's global challenges: 'Health, Environment and Climate Change', as well as 'Digitalisation, Industry 4.0, Energy and Mobility of Tomorrow'.

DLR.de/en/horizons

DLR at a glance

The German Aerospace Center (DLR) is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, digitalisation and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

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