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DLR Institute of Space Systems

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Exterior view of the DLR Institute of Space Systems

Institute of Space Systems

The Institute of Space Systems in Bremen designs and analyses possible future spacecraft and space missions (launchers, orbital and exploration systems, satellites) and assesses them in terms of their technical performance and cost. The Institute relies on modern methods of multidisciplinary engineering for its systems design and analysis that include, among other things, a computerised system for concurrent design.

In addition, the Institute of Space Systems develops, builds and operates its own spacecraft and missions for scientific research and technology demonstration in the fields of small satellites and planetary landing craft in cooperation with other DLR institutes and research institutions. As a competence centre for system engineering and being specialised in system design, system integration and system testing, the Institute has a coordinating and integrating role in the development process.

To make future space missions possible or to improve existing technologies in terms of performance, the Institute of Space Systems conducts research into relevant system technologies with a focus on the behaviour and influence of cryogenic fuels in tanks, landing technologies, attitude and orbit control systems, avionics systems and high-precision optical measurement systems.

To learn more, please visit **DLR.de/IRS/en/**

Entrance to the
Institute of Space Systems

Systems analysis

The Concurrent Engineering Facility (CEF) at DLR Bremen

SpaceLiner 7 during staging operations

The design and analysis of future space systems such as launchers, reusable transport systems, satellites, planetary landing probes, space stations, or bases on the Moon or Mars, requires multidisciplinary engineering capabilities, such as:

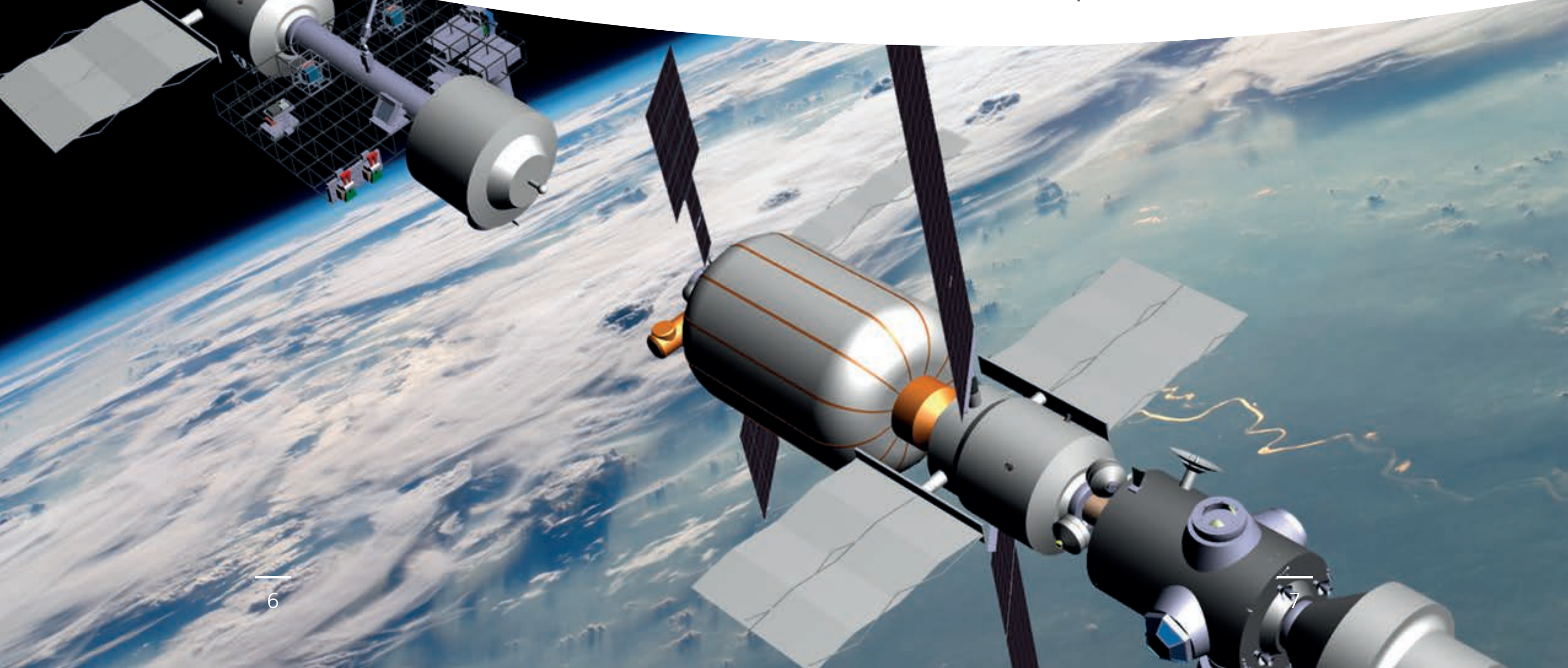
- mission analysis
- structural engineering
- thermal control
- aerodynamic design
- propulsion technology
- flight control
- avionics

Engineers from various disciplines apply modern computer-aided design methods and work simultaneously with the aid of a 'Concurrent Engineering Facility' (CEF) to create their designs. In this way, development times are reduced and subsequent costly product changes avoided.

The concepts under development are examined for their technical feasibility and performance (i.e. mass, energy consumption), and also evaluated with regard to their costs. Critical technologies are identified, leading to the creation of the necessary technology development programmes.

Systems analysis serves both for the design of the Institute's own projects and for the provision of consultancy and advice to government, industry and society.

DLR conceptual design for a near-Earth orbital observation and research platform



Development and construction of space systems

The Institute of Space Systems develops, builds and tests spacecraft, with a focus on small satellites and planetary landing probes.

The development and implementation of complex space missions are based on a combination of key core competences in project management and system engineering (system design, system integration, system verification and system qualification) offered by the Institute of Space Systems. This allows effective and efficient project management and project implementation.

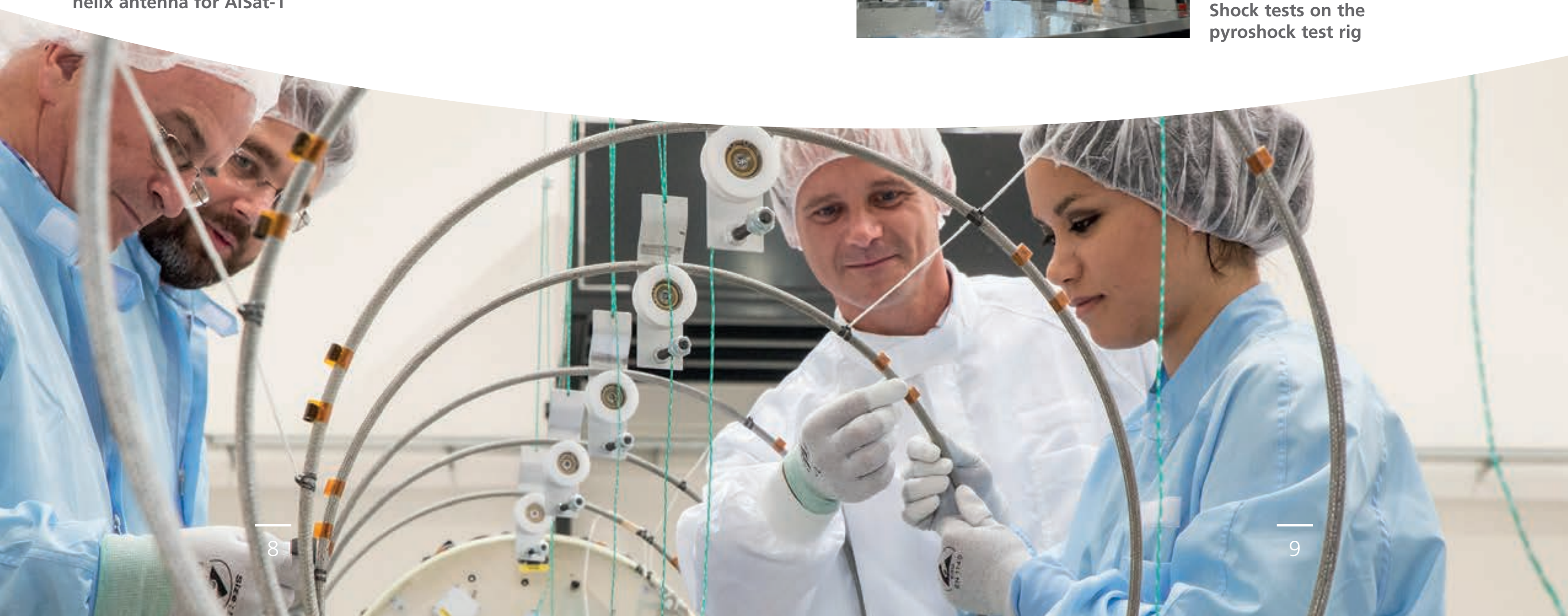
The spacecraft are constructed in a central integration laboratory, supported by different test stands, equipment and laboratories. Modern product and quality assurance processes are applied during development and qualification.

Integration of the DLR compact satellite for the Eu:CROPIS mission

Integration of the electronics box for the MASCOT asteroid lander

Vibration test rig in the dynamic mechanical testing laboratory

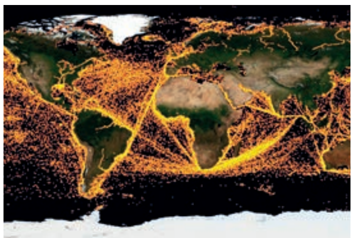
Shock tests on the pyroshock test rig



Integration of deployable helix antenna for AISat-1

AISat-1 – nanosatellite for receiving signals from ships

Electromagnetic compatibility (EMC) is checked for each system, and the tests are conducted in accordance with the usual EMC standards for everyday devices



One year in space – global shipping traffic received by AISat-1

Satellite-based air traffic control with ADS-B – two years in orbit

There are facilities to study spacecraft components and space systems under space conditions, where they can be tested both mechanically and under thermal vacuum conditions. Test chambers for electromagnetic compatibility, for space radiation simulation and for studying the emission characteristics of materials complement the simulation options. Optical laboratories allow high-precision distance measurements based on laser interferometry.

Examples of the Institute's work include the construction of the compact satellite Eu:CROPIS, the national satellite AISat-1 – used for monitoring shipping – and the construction of the asteroid lander MASCOT. All the above-mentioned projects were supervised by the Institute of Space Systems from systems analysis up to integration.

Final integration of the MASCOT asteroid lander developed by DLR for the Hayabusa-2 mission

Research and development of relevant system technologies

Landing and mobility test facility (LAMA) with subject (Philae lander)

The Institute of Space Systems develops relevant and innovative system technologies in terms of their space capability. These developments include, among others, flight control systems, avionics systems, landing technologies, fuel handling systems in tanks with cryogenic fuel and high-precision optical measurement systems.

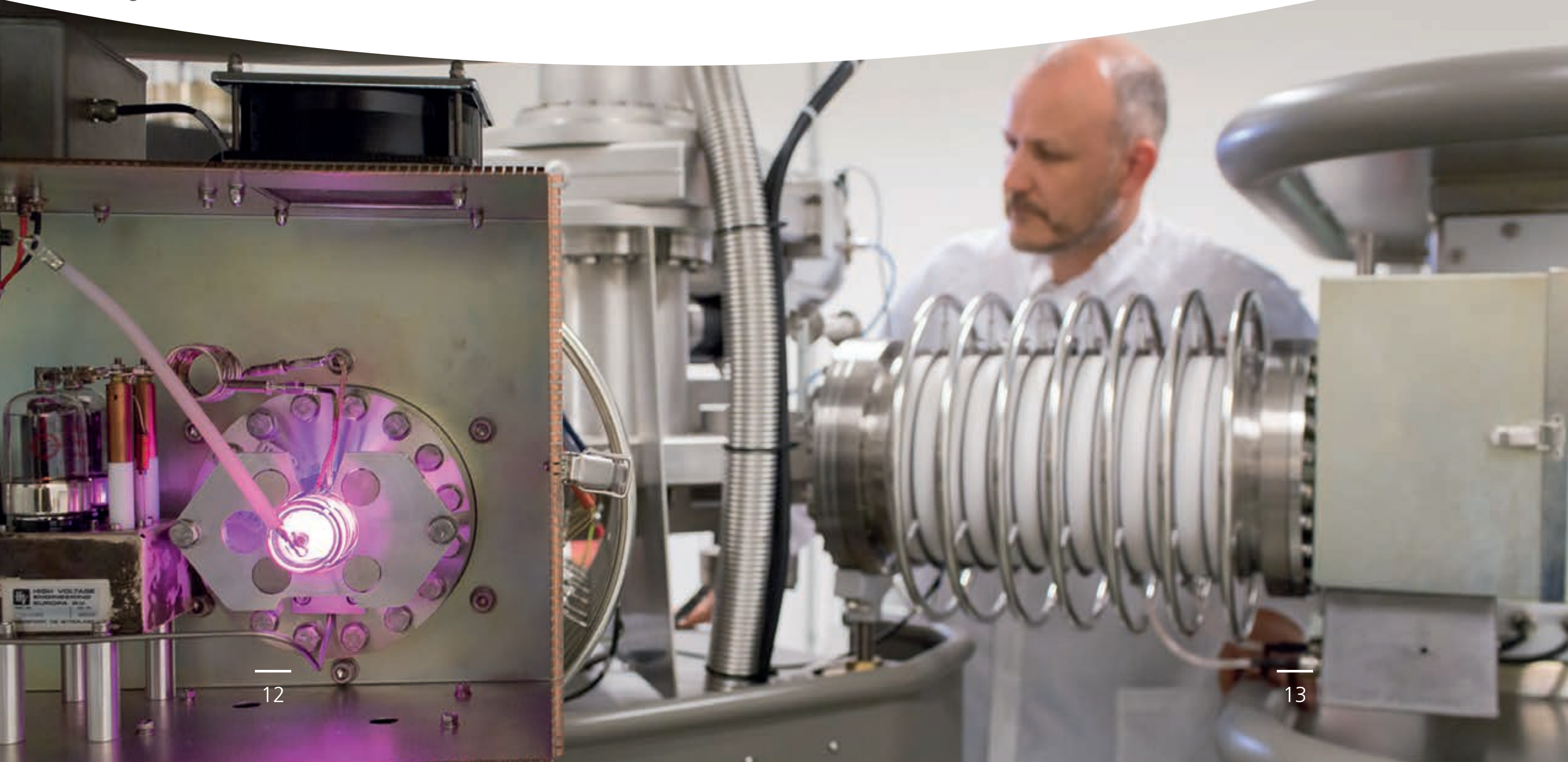
Examples of the Institute's work are its contributions to the comet lander Philae, to the realisation of the asteroid lander MASCOT and the construction of the HP^3 instrument for the US InSight mission to Mars.

As part of the Gravity Recovery and Climate Experiment (GRACE) follow-up mission, scheduled for launch in 2017, Optical Ground Support Equipment (OGSE) was developed for the Laser Ranging Instrument carried by the two satellites, and the necessary measurements were subsequently carried out.

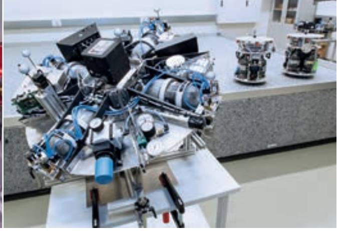
The successful execution of fuel handling for cryogenic upper stage systems is a key technology to achieve the development goals for future launchers. This includes, for example, the realisation of missions with long ballistic-free flight phases and multiple engine re-ignitions.

The Institute of Space Systems has the required capacity for these research and development activities, with its unique, distinguishing feature being a cryogenic laboratory equipped with special test equipment. The cryogenic laboratory offers the possibility to conduct experiments with cryogenic liquefied gases, which are

Complex irradiation facility for degradation investigation of material surfaces



High precision optical measurement system



Simulating the movement of a satellite with five degrees of freedom to test control systems in the TEAMS laboratory

commonly used as spacecraft propellants, including liquid hydrogen at minus 253 degrees Celsius. In this way, findings in the cryogenic laboratory make a significant contribution to strengthening the upstream national competence in this field.

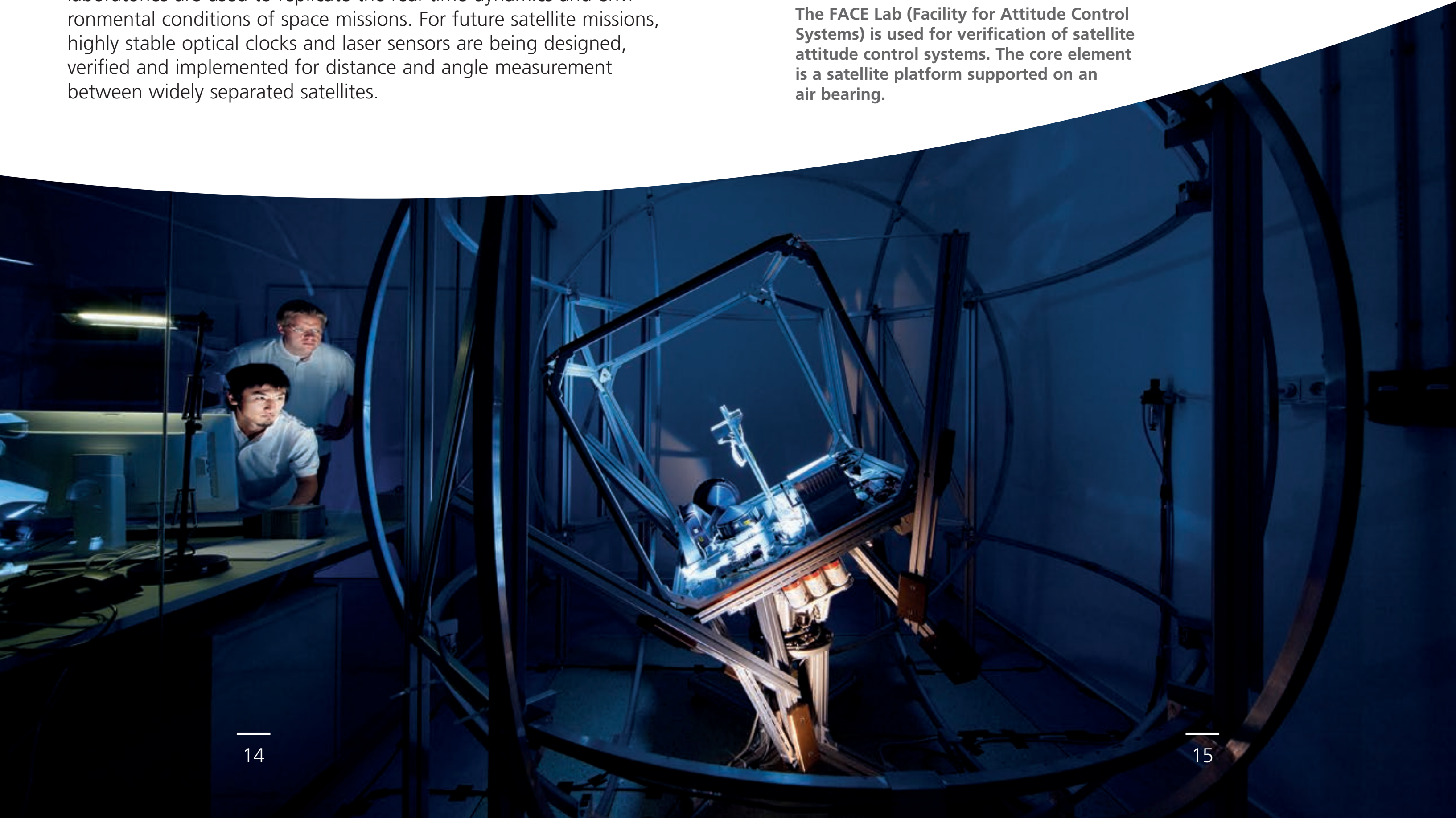
Analysis, design, simulation, development, implementation, testing and verification of attitude and orbit control systems (AOCS) and guidance, navigation and control systems (GNC) for use in space are further research priorities. To this end, tools for modelling and simulation of the above-mentioned systems are developed and test laboratories are used to replicate the real-time dynamics and environmental conditions of space missions. For future satellite missions, highly stable optical clocks and laser sensors are being designed, verified and implemented for distance and angle measurement between widely separated satellites.

Cryogenic laboratory – investigations on tank models for launch systems

Space simulation facility for tests under vacuum and thermal boundary conditions

The expertise in the research and development of technologies for landing and return devices is shown in the design of mechatronic components, mechanisms and energy-absorbing elements, in the experimental and numerical methods used for landing and touchdown dynamics, as well as in the analytical methods used for landing safety and reliability. For these tasks, the landing and mobility testing facility LAMA and its associated test rigs are operated in the exploration laboratory.

The FACE Lab (Facility for Attitude Control Systems) is used for verification of satellite attitude control systems. The core element is a satellite platform supported on an air bearing.



Test of control systems spacecraft docking in the Test Environment for Applications of Multiple Spacecraft (TEAMS) laboratory

Sail fabrication for large deployable membranes

On-board computers and on-board software constitute research priorities in the avionics field. Innovative computer architectures and advanced design methodology are the subjects of the latest developments. An example of this is the development of a scalable on-board computer, which adapts itself – in terms of essential parameters – to the differing requirements of each space vehicle.

In addition to the design, construction and qualification of structures, mechanisms and thermal control systems, main research priorities include large deployable structures and degradation studies

The EDEN laboratory for the study of bio-regenerative life support systems

Verification and calibration of inertial sensors for spacecraft navigation in the GPS/INS laboratory

for materials under space conditions. For the qualification of deployment systems, a test rig that enables realistic deployment tests with partial compensation of gravity is used.

Thus, valuable contributions can be made to DLR research missions in particular, as well as to the development of space systems technologies in general.

An autonomous Moon landing is simulated in a laboratory with the help of a robotic arm that moves a camera over an illuminated terrain model

Out of school – into the lab

The DLR_School_Lab in Bremen focuses on spaceflight – how are people and technology transported into space, and what conditions do they encounter there? How is Earth observed from space, and how are other planets, moons and asteroids explored?

The Bremen-based DLR Institute of Space Systems primarily focuses on a comprehensive systematic approach as a key element of research. In line with this approach, young visitors at the DLR_School_Lab can perform a complete mission to Mars as part of a team – from the rocket launch to landing on the Red Planet, and from controlling a robot on the planet to sample analysis. They also experience, first hand, the importance of good teamwork for the success of a mission.

Overall, hands-on experiments are offered in three areas:

- extreme conditions and dangers in space
- satellite technology and remote sensing
- Mission to Mars

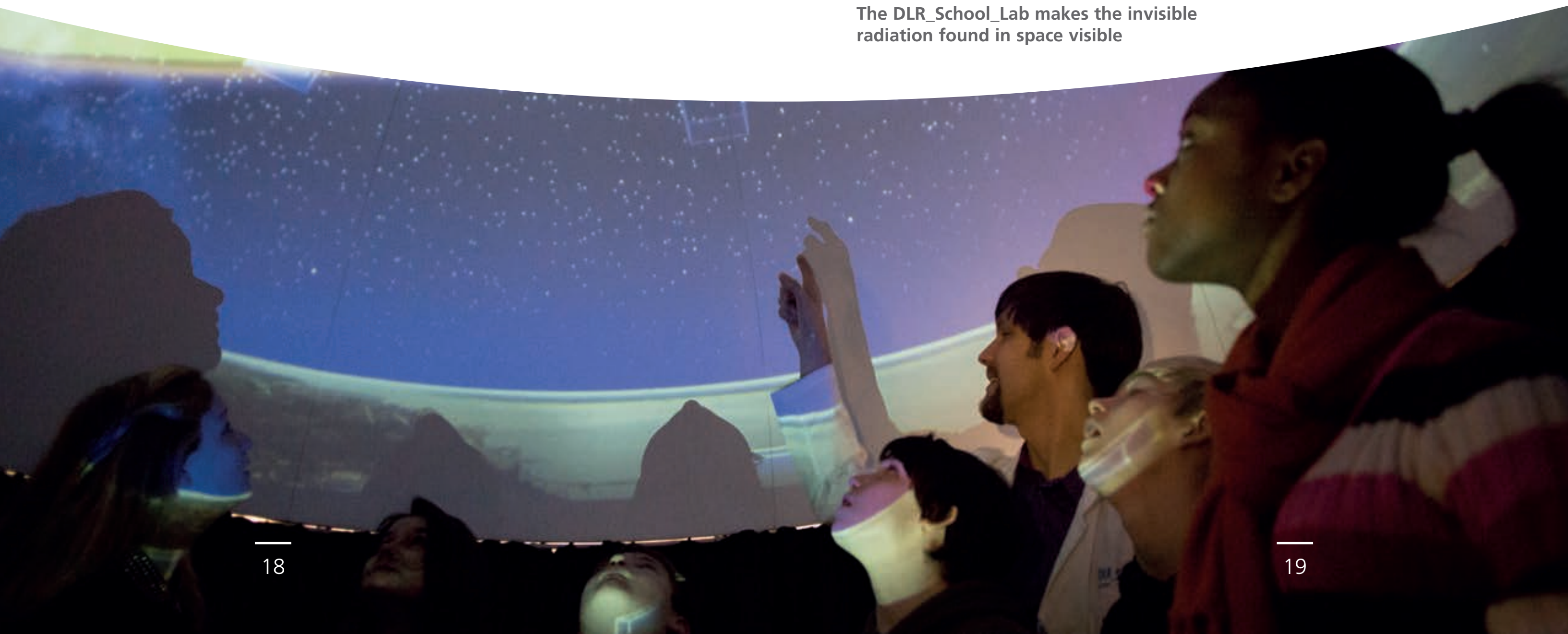
A student explores a martian landscape using a robot

Lab manager Dirk Stiefs explains the operation of a water rocket

The students explore phenomena such as vacuum, microgravity and space weather. They deal with infrared, radar and attitude control systems, and carry out experiments on the topics of propulsion technology, landing navigation, robotics and sensors. These tests can also be performed independently of one another.

Based on these exciting hands-on experiments, students can learn about current DLR research projects and gain fascinating insights into the world of science and technology.

The DLR_School_Lab makes the invisible radiation found in space visible



Opportunities for advancement at the DLR Institute of Space Systems

Employment opportunities for students

Successful career paths do not just begin after graduation – with an internship or curriculum-related activity at the DLR Institute of Space Systems, students are offered the opportunity to use and expand their knowledge in any of the many fascinating projects managed here. From the very start, students take responsibility for particular areas and receive feedback on their technical performance.

The Institute offers internships of varying lengths, including pre-study internships so that students can get a taste of the exciting everyday activities at DLR before they commence their studies. The Institute of Space Systems works closely with the University of Bremen. Within the study framework – supported by a team of four professors and several teaching assistants – members of the Institute hold lectures with aerospace-specific content at the University of Bremen.

The Director of the Institute, Andreas Rittweger, leads the Space Technology Department at the University of Bremen.

Hansjörg Dittus, a Member of the DLR Executive Board, leads the Space Systems Department at the University of Bremen.

Görschwin Fey, Head of the Avionic Systems Department, leads the working group 'Reliable Embedded Systems' in Faculty Division 3 (Mathematics and Computer Science) at the University of Bremen.

Claus Braxmaier, Head of the System Enabling Technologies Department, holds the Chair of Aerospace Technology at the University of Bremen and is the Director of ZARM.

Qualified engineer Silvio Schröder gives an explanation to a mechanical engineering student at the LAMA testing facility

Education and training at the Institute of Space Systems

The German Aerospace Center (DLR) offers various programmes for students, and several vocational training courses.

The DLR Institute of Space Systems in Bremen trains electronics technicians for devices and systems, as well as administration specialists.

Electronics technicians for devices and systems

The standard training time is 3.5 years, and is accompanied by vocational school classes. A big advantage of training at the Bremen site is the direct relation to practical applications. Circuits, systems and other components built during training will find direct use in aerospace applications.

Administration specialists

Administration specialists carry out organisational and commercial activities. The focus of the training is to teach business and operational relationships, together with the use of administration tools. The training period is usually three years, a period during which the trainees are introduced to various secretariats, project teams and parts of the administration (Personnel, Accounting and Procurement) at the Bremen site and at the DLR offices in Braunschweig.

Students are not just equipped with the necessary practical skills, they are also supported with additional lessons and helped to prepare for examinations. They are gradually introduced to tasks requiring more and more responsibility. Everything possible is done to prepare the students for the professional world following their training at DLR.

Data acquisition in the electronics laboratory with a modern radio measurement receiver

DLR at a glance

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 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.

DLR has approximately 8000 employees at 16 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Jülich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim.
DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

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