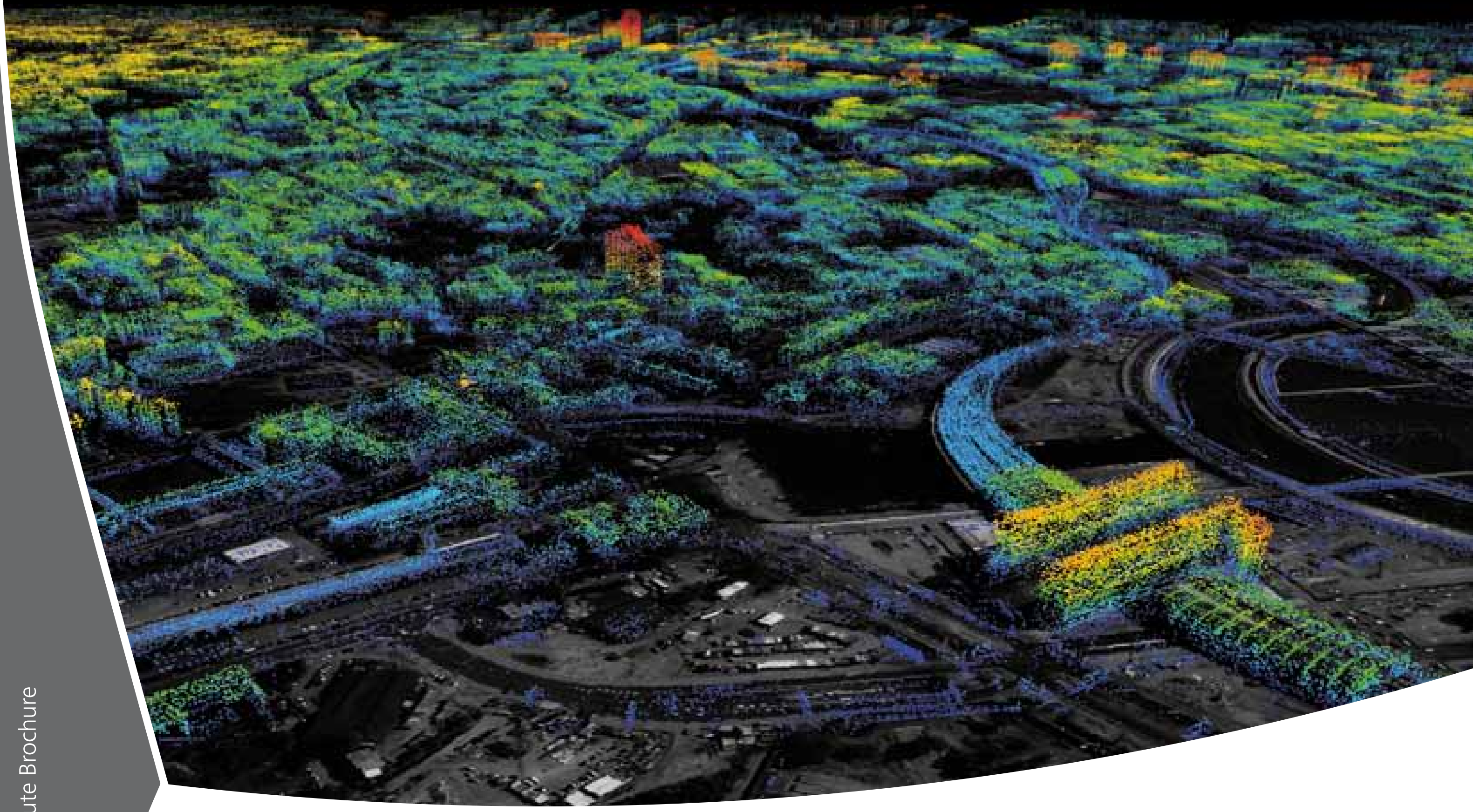


Institute Brochure

Earth Observation Center (EOC)

Remote Sensing
Technology Institute

DLR

EOC's Remote Sensing Technology Institute

The Remote Sensing Technology Institute (IMF) of the German Aerospace Center (DLR) and the German Remote Sensing Data Center (DFD) together comprise DLR's Earth Observation Center (EOC), which is a center of competence for earth observation in Germany. The institute is located at DLR facilities in Oberpfaffenhofen near Munich, in Berlin-Adlershof, and in Neustrelitz, Mecklenburg - Western Pomerania.

IMF is engaged in research and development in the field of remote sensing technologies. Algorithms, methodologies and data processing systems are developed to obtain geoinformation from remote sensing data. IMF thereby contributes to the best possible use of modern remote sensing sensors for dealing with current scientific and social challenges.

The Earth Observation Center - EOC - in Oberpfaffenhofen near Munich

The institute has three primary technological emphases:

- Remote sensing with synthetic aperture radar (SAR)
- Imaging optical remote sensing
- Atmospheric spectrometry

Scientific and experimental methodologies as well as processors for operational use are developed. The processors are integrated into the data reception and processing chains of DFD or industrial partners for national, European and international missions.

IMF operates the airborne optical sensor suite of EOC. Its calibration and spectrometry laboratories furnish the basis for optimal utilization of remote sensing data. And lastly, the institute contributes its remote sensing expertise to the designing of new sensor systems and earth observation missions.

A particular concern is training the next generation of scientists. Secondary school students are introduced to earth observation topics in the DLR_School_Lab; thesis work toward bachelor's and master's degrees can be carried out "hands-on" as part of current projects, and stimulating scientific questions can be addressed in doctoral dissertations. IMF scientists teach at universities; the director of the institute holds a chair at Munich Technical University (TUM).

The Remote Sensing Technology Institute is certified in accordance with ISO9001:2008.

Remote Sensing Technologies and Methodologies

Remote sensing is a technology relevant for many fields and it plays a role in resolving a multitude of geo-relevant questions, be they global, regional or local.

As an example, the complexities of the Earth system and the changes it is undergoing are being measured long term and globally by means of remote sensing from space. Only an overall view of the closely interacting realms of the atmosphere, the land surface, the oceans and the polar ice sheets enables the relevant interrelationships to be understood and modeled. Based on this information predictions can be made about the future development of our habitat, how it is threatened, and the consequences of our interventions in System Earth. At the same time, a global view from space complements highly precise but isolated local measurements on Earth.

Remote sensing from space or aircraft using high resolution sensors also supports resource and hazard management as well as civil planning. Coastal management, disaster response, urban planning and traffic management are examples.

However, remote sensing involves more than recording images which are as detailed as possible. The focus is much rather on obtaining geoinformation, in other words, on quantitatively determining such values as terrain or building heights, deformations of the earth's surface, the concentration of ozone and other trace gases in the atmosphere, wind speeds, wave heights, phytoplankton concentrations in water bodies, and traffic density. Such quantities can be measured from space only indirectly, for example, by analyzing the spectral distribution of light recorded by a spectrometer mounted on a satellite. Deriving the desired quantitative information from this measurement data is a basic function of remote sensing and accordingly also a crucial scientific topic investigated at the Remote Sensing Technology Institute.

TanDEM-X

IMF develops information extraction methodologies for the following remote sensing measurement approaches:

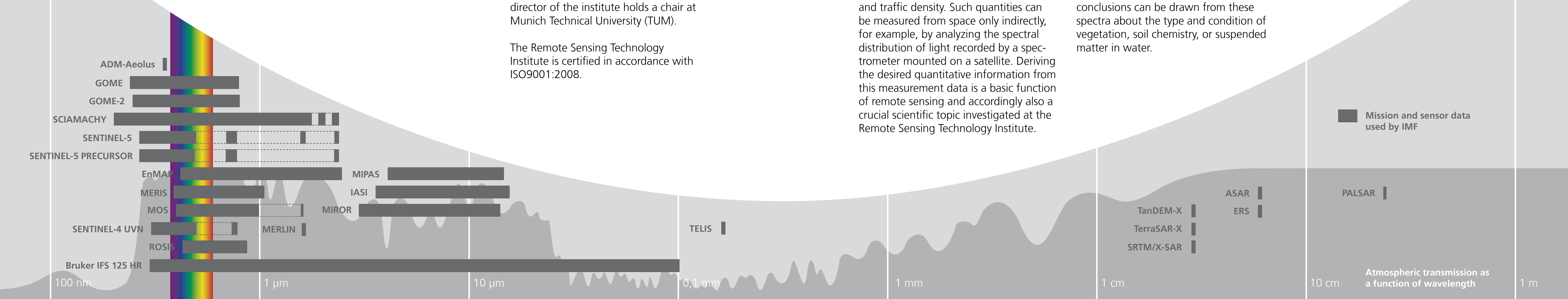
Synthetic Aperture Radar (SAR)
uses microwave radiation to create images of the earth's surface and accomplishes this independently of the position of the sun or cloud cover. SAR image data provide information about ground moisture and vegetation, ocean wave heights and wind speeds. Interferometric SAR systems supply data which can be used to produce digital elevation models of the earth and to record geotectonic movement, ground subsidence and deformations in civil infrastructure.

Imaging optical spectrometers
provide images in which each pixel represents a spectrum of anywhere from a few to over a hundred spectral values ("colors"). Depending on the application, conclusions can be drawn from these spectra about the type and condition of vegetation, soil chemistry, or suspended matter in water.

High resolution optical imaging systems make it possible to generate maps, model terrain and cities, and record traffic flow.

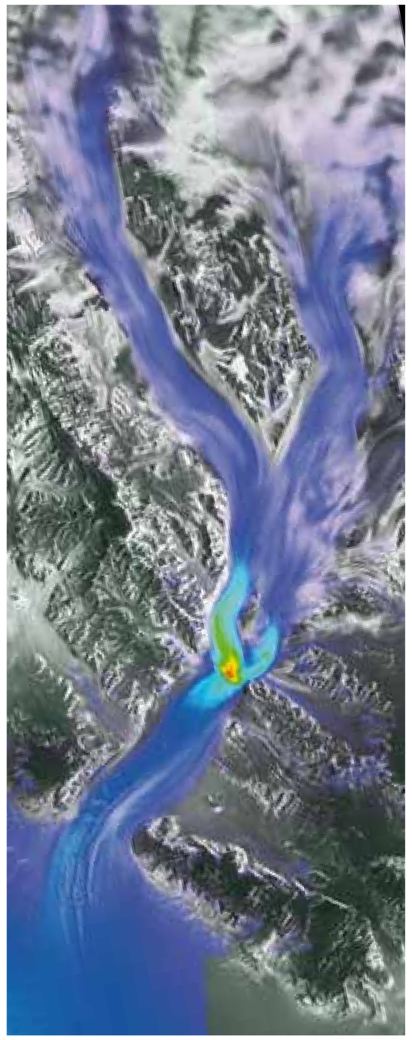
Atmospheric spectrometer
often with several thousand spectral channels, provide ultraviolet, visible and infrared spectra from which temperature, pressure and trace gas concentrations in the atmosphere can be derived. In addition to methodologies for passive spectrometers, IMF is also developing approaches for active lidar systems. The results which have been obtained are yielding important information on air quality, global climate change and the state of stratospheric ozone.

Data from different sensors are frequently complementary as to information content, which means that for many applications they need to be combined. With the increasing availability of remote sensing satellites carrying a variety of sensors, so-called data fusion will become ever more important. IMF is developing fusion methodologies, for example for optical and SAR data, based on its competence in the above-mentioned remote sensing technologies.



Synthetic Aperture Radar

Synthetic aperture radar (SAR) scans the earth's surface from an aircraft or satellite using microwave pulses. Because it operates regardless of the level of solar illumination or cloud cover it can reliably provide precise maps of geophysical parameters like ground moisture, biomass, or ocean wave heights. SAR is therefore put to use for continuous monitoring of the oceans, polar regions, earthquake risk zones and volcanoes, as well as for disaster management.



TerraSAR-X velocity analysis of Antarctica's Nimrod Glacier

Because of their high resolution, modern SAR systems such as TerraSAR-X can even monitor individual buildings.

IMF develops powerful algorithms for processing SAR raw data, right up to the generation of value-added thematic products. The emphasis is on digital signal processing and incorporating radar measurements in geophysical models.

SAR Processing

A SAR instrument does not provide images, but rather hologram-like data sets which must be processed before use. This involves focusing, radiometric calibration and geometric rectification. The SAR processor line developed at IMF accommodates all modern sensor operating modes, such as Stripmap, ScanSAR, TOPS and Spotlight, with a standardized algorithm. Based on this processor, operational systems are designed and employed at DLR for the national radar missions TerraSAR-X and TanDEM-X. These processing systems are providing high-quality image products for science and industry year after year.

SAR Interferometry

SAR interferometry methodologies use the phase information contained in every pixel for millimeter-precise distance measurements. Digital elevation models can thus be created with this technology from the vantage point of space. IMF developed processing systems for the first SRTM (2000) global measurement of the earth as well as for the current TanDEM-X mission (2010), which will significantly improve the precision of the SRTM elevation models.

Besides topography, surface movements can also be measured with SAR interferometry, for example those caused by earthquakes, unstable slopes, groundwater extraction or volcanism. In order to measure movements in the millimeter range IMF has developed and operates a persistent-scatterer interferometry system for long-term interferometric analyses.

High resolution SAR methodologies are also useful for traffic research. With the help of along-track interferometry, velocity profiles of vehicles on highway sections can be determined at IMF from TerraSAR-X data and used to detect traffic jams or to calibrate conventional induction loops.

SAR Oceanography

Because microwave reflection is strongly dependent on surface structure, SAR is especially suitable for imaging waves and is accordingly used in oceanography for sea weather reports and wave statistics. Toward this end IMF derives important parameters from SAR images of the ocean surface, such as wave height and the speed and direction of wind. SAR can also be used to detect ships and their routes, an application with increasing relevance for the fishing industry and coastal monitoring.

Imaging Optical Remote Sensing

High-precision Geometry and 3D

Remotely sensed image data are now primarily analyzed automatically. Data from different sensors and with different imaging geometries are combined with cartographic information from other sources with the help of geographic information systems (GIS). To achieve this step the data must be related with high precision to a terrestrial coordinate systems in a process known as georeferencing. The increasing geometric resolution of modern satellite cameras is accompanied by demands for greater georeferencing accuracy.

IMF develops operational georeferencing methodologies for most satellite and aerial optical camera systems. These processors also meet time-critical demands, such as providing timely geoinformation during catastrophes or extracting information about the traffic situation from airborne camera image sequences with real-time data transfer.

Another emphasis is generating digital elevation models from stereo satellite data. The exact form of the earth's surface, including buildings and vegetation height (biomass), is still only inaccurately known for many areas on earth.

The stereo procedures developed at IMF can already be used to generate city models from space using the highest resolution data available today. Recording three-dimensional changes is of particular interest, for example when monitoring urban growth or the progress of large and safety-relevant civil infrastructure construction projects, or for mapping damage after catastrophes caused, for example, by earthquakes.

Computer generated view of a very high resolution terrain model of K2 mountain in the Himalayas

Water Quality

Oceans and coastal areas are critical ecosystems affecting the climate and human security. IMF is developing methodologies to identify relevant organic and inorganic water constituents using high spectral resolution optical remote sensing data (currently ENVISAT/MERIS, later EnMAP). Indicators of water quality are being derived, such as chlorophyll concentration or the presence of toxic algal blooms. These measurements are provided on a daily basis to environmental authorities as part of an operational GMES (Global Monitoring for Environment and Security) service.

EnMAP

EnMAP (Environmental Mapping and Analysis Program) is a future German hyperspectral satellite mission designed to obtain ecosystem parameters relating to agriculture, forestry, geology, coastal areas and inland water bodies. IMF is responsible for developing an operational EnMAP processor system.

OpAiRS

In the context of the user service OpAiRS (Optical Airborne Remote Sensing and Calibration Facility), IMF operates a number of airborne optical sensors (hyperspectral systems, spectrometers, cameras) as well as diverse field spectrometers.

Together with DFD and the DLR Flight Experiments Department, international measurement campaigns are carried out for internal and external partners with these instruments. An IMF laboratory which is unique in Europe is specifically designed to characterize and calibrate imaging and nonimaging spectrometers

Atmospheric Spectrometry

Calibration

Deriving geophysical parameters from remote sensing instrument signals requires the conversion of signals into physical quantities, in other words, the calibration of the sensor. This task is especially complex in remote sensing of the atmosphere because of the large number of spectral channels and the demand for high precision. It requires comprehensive knowledge of the measuring system and careful monitoring of instrument characteristics throughout the entire mission. IMF carries out this work for the European sensors GOME on ERS and SCIAMACHY on ENVISAT.

Forward Models, Scattering Theory and Inversion

Typical products of atmospheric remote sensing are maps showing atmospheric state variables like pressure, temperature, and concentrations of trace gases and aerosols. In order to derive these quantities from measured spectra, radiative transfer and scattering processes in the atmosphere must first be mathematically modeled, in other words, the expected spectrum must be calculated based on specified atmospheric characteristics. By inverting this model, conclusions can then be drawn from the measured spectrum about the actual condition of the atmosphere.

IMF is developing radiative transport and scattering models as well as inversion procedures for remote sensing of the atmosphere. Besides precision, the emphasis is on optimized throughput and numerical robustness, which are essential for operational processors.

In addition to methodologies for routine applications, experimental methods are also developed to investigate new potentials of sensors or to improve the measuring precision of established procedures.

Processors

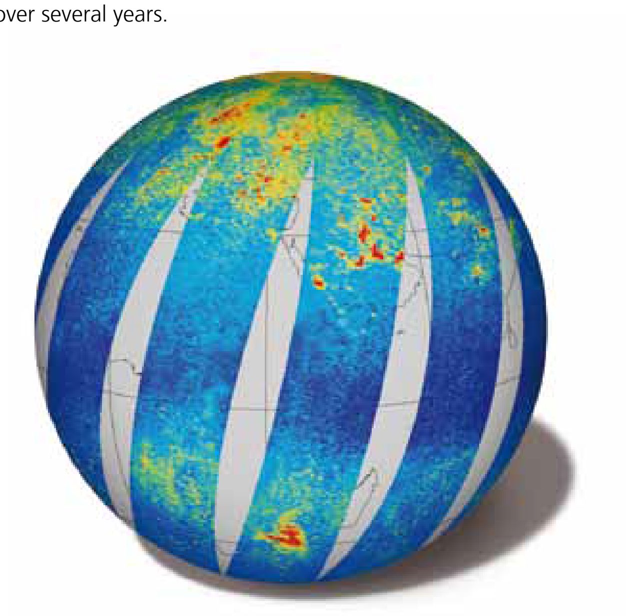
Operational processors used in the ground segment of an earth observation mission generate precisely defined products continuously and within the shortest possible time from the measurement data. They operate in a configuration-controlled IT environment and must function without interactive intervention as far as possible.

In the context of ESA and EUMETSAT missions, IMF is responsible for developing processors for the ERS/GOME, ENVISAT/SCIAMACHY and MetOp/GOME-2 spectrometers. This includes continuously improving the algorithms as well as reprocessing all past data sets for missions extending over several years.

IMF methodologies will have to meet new requirements for the future ADM-Aeolus lidar mission to derive global wind parameters.

Experimental Spectrometry

IMF develops and operates experimental Fourier transform and heterodyne spectrometers. New remote measurement procedures are being tested and validated for sensors operating in the thermal infrared and far infrared spectral ranges (MIROR and TELIS). Work at IMF's spectrometric reference laboratory is based on a high resolution spectrometer (Bruker IFS125HR) as well as on laboratory measurement technology and experience acquired over many years. The laboratory is making a significant contribution to improving the quality and size of spectrometric databases for atmospheric trace gases. Their reliability is essential for interpreting remote sensing measurements.



Global distribution of nitrogen dioxide

IMF Structure

Institute Director
Prof. Dr. Richard Bamler

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Oberpfaffenhofen und Neustrelitz
Head: Prof. Dr. Thomas Trautmann

Photogrammetry and Image Analysis
Oberpfaffenhofen
Head: Prof. Dr. Peter Reinartz

Experimental Methods
Oberpfaffenhofen
Head: Dr. Peter Haschberger

SAR Signal Processing
Oberpfaffenhofen
Head: Prof. Dr. Michael Eineder

Endowed Chair in Remote Sensing Methodologies
Munich Technical University (TUM)
Director: Prof. Dr. Richard Bamler
Deputy: Dr. Matthias Butenuth

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Cover: Permanent Scatterer Data of Berlin, derived from TerraSAR-X

DLR at a Glance

DLR is Germany´s national research centre for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Energy, Transport and Security is integrated into national and international cooperative ventures. As Germany´s space agency, DLR has been given responsibility for the forward planning and the implementation of the German space programme by the German federal government as well as for the international representation of German interests. Furthermore, Germany's largest project-management agency is also part of DLR.

Approximately 6,900 people are employed at fifteen locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim. DLR also operates offices in Brussels, Paris, and Washington D.C.

DLR's mission comprises the exploration of the Earth and the Solar System, research for protecting the environment, for environmentally-compatible technologies, and for promoting mobility, communication, and security. DLR's research portfolio ranges from basic research to innovative applications and products of tomorrow. In that way DLR contributes the scientific and technical know-how that it has gained to enhancing Germany's industrial and technological reputation. DLR operates large-scale research facilities for DLR's own projects and as a service provider for its clients and partners. It also promotes the next generation of scientists, provides competent advisory services to government, and is a driving force in the local regions of its field centers.

DLR

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