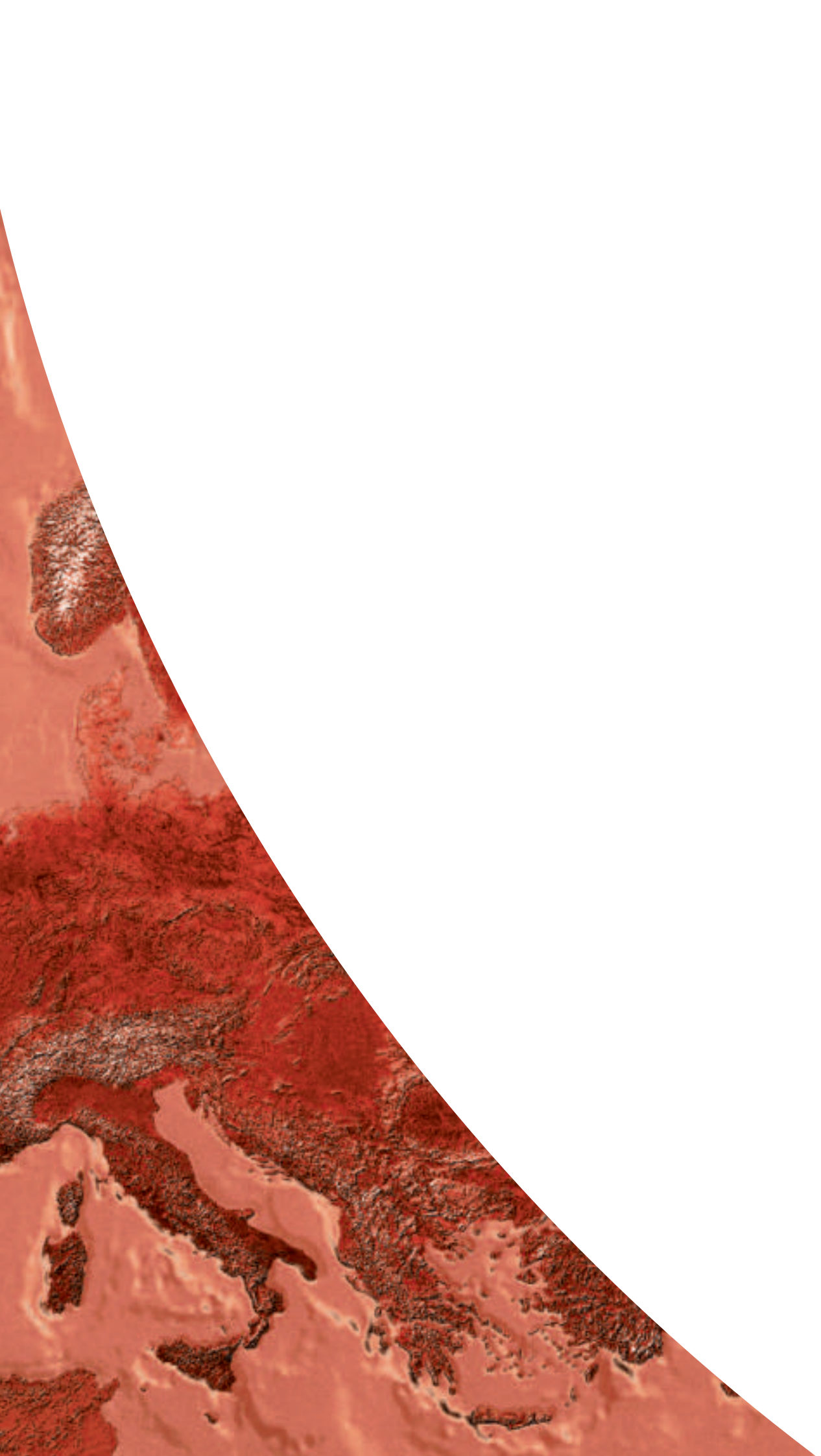
Annual Report

# Research and Corporate Results

2004-2005

DLR



# Research and Corporate Results 2004-2005

German Aerospace Center (DLR)

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## Corporate Results

# Data & Facts



# Preface

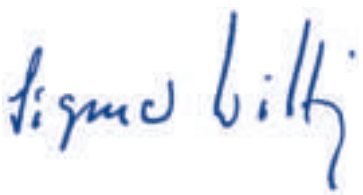
Our society and our economy thrive on innovation and growth. The German Aerospace Center DLR has not only accepted these challenges, but considers itself a pacesetter in achieving these goals. Like no other research establishment, its activities are focused on strategic fields of action: On the knowledge society by expanding basic knowledge about the earth and the universe, on the information society by leaps in the development of telecommunications, on the mobility society through new paths of satellite navigation and transportation research, on securing the future of our nation in terms of energy research, atmospheric research and catastrophe management and on the development of innovative processes for industrial growth through the introduction of new methods and materials, and by increasing reliability and miniaturization. The dynamic nature of this enumeration underscores the demands of our mission in opening up diverse new opportunities.

In our Research and Corporate Results 2004-2005, DLR will present the latest results of its research activities for securing the scientific and economic future of our society. Each of our four core areas was marked by exemplary achievement. Activities in our core area of aeronautics were highlighted by DLR's cooperation in the design and development of the largest transport aircraft in the world, the Airbus A380. Four hundred DLR researchers and engineers in almost all disciplines related to aircraft construction were involved in an essential way in the first successful flight in April 2005. In the core area of space, DLR's German Remote Sensing Data Center made a crucial contribution to master the tsunami catastrophe. Directly after the tragedy, it made satellite data available for on-site crisis management. We were also able to look back on continued expansion in the core area of transportation during the reporting period. Among other things, a unique large-scale facility for driving simulation was commissioned. In our core area of energy, pioneering work was done in the field of hydrogen generation where hydrogen was produced in a solar thermochemical cyclic process for the first time. This process has the potential of providing solar hydrogen on a large technical scale in the future at very favorable costs.

As Germany's space agency – a unique feature of DLR in the landscape of research – we provided diverse new impetus for further development of a European space strategy. In this case, DLR is providing momentum for a space policy that is being coordinated between the European Union and the European Space Agency ESA. It also supported the German presidency in the ESA Council of Ministers during this period by preparing new program decisions.

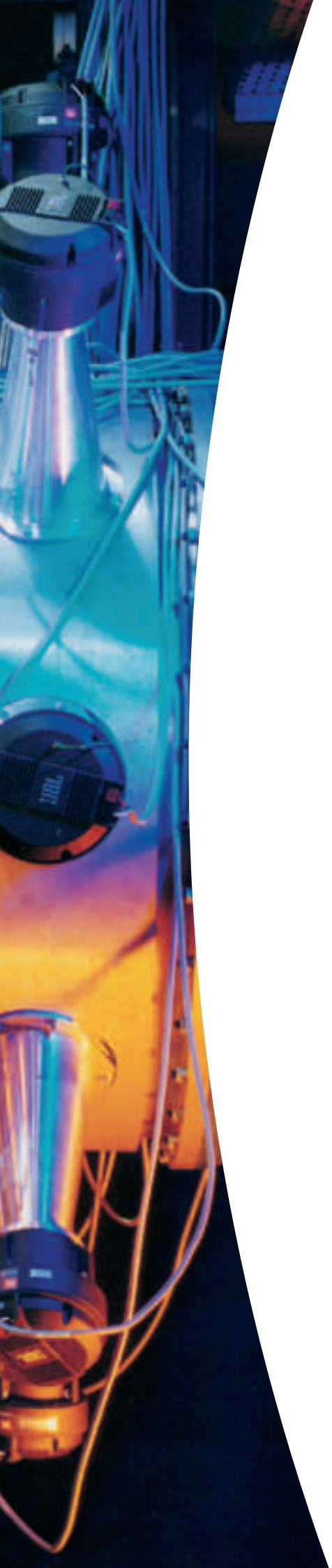
The second part of this annual report, the corporate results, provides insight into DLR's operations and function as a modern research enterprise. Its high rate of third-party funding (more than 40 %) does not shy away from comparison with national and European benchmark partners. The dynamic of successfully obtaining funding from EU's research framework programs remained uninterrupted. DLR's special characteristics as a research enterprise, such as a consistent program orientation, an internationally recognized and independently evaluated process orientation of the administrative and technical infrastructures as well as the substantial Europeanization strategy and a coherent strategy for international involvement will be discussed. The same applies to the highly advanced realization of DLR's role as a bridge between academia and industry.

Approximately 5,100 employees at eight sites in Germany are committed to realizing DLR's mission. They all have accepted the challenges facing DLR of promoting innovation and growth in order to secure our society's future.



**Prof. Dr.-Ing. Dr.-Ing. E.h. Dr. h.c. mult. Sigmar Wittig**

**Chairman of the Executive Board**



# RESEARCH RESULTS

# Aeronautics

**Three notable economic, political and strategic events influenced the current, positive image of aeronautics. The comeback of aeronautics after a clear decline due to the events of September 11, 2001 and the emergence of SARS continues a long-term trend of increasing demand (passengers, freight), coupled with an increase in flight operations.**

**The maiden flight of the Airbus A380 on April 27, 2005, which incorporated many innovative technologies, DLR's research results among them, also sends a positive signal for the future. And the publication of the Strategic Research Agenda (SRA2) was important in political terms. Published by the Advisory Council for Aeronautics Research in Europe (ACARE), it outlines four scenarios for developing the European air transport system and derived essential fields of technology whose work will become urgent over the next few years.**

These fields of technology form the basis for the orientation of future national and European research programs and also represent a challenge to both DLR and its network of industrial and scientific partners. DLR is well equipped for these responsibilities, because its multi-disciplinary, cooperative efforts enable it to embrace and work on complex topics, and it can also make use of the expertise of partner institutions within the framework of existing cooperative agreements.

One of DLR's important partners is the French research establishment ONERA, with whom DLR has expanded its successful cooperation from the fields of helicopters on to fixed-wing aircraft. The first joint projects were concluded successfully. These included the comprehensive ground vibration test that was crucial for the approval of the Airbus A380 just before its maiden flight, and standardized development of computational fluid dynamics (CFD) methods at both research institutions in the MIRACLE project. And DLR's cooperative agreement with the Dutch National Research Center NLR that has been in preparation for several years was formally concluded. This focuses on concentrating, expanding and jointly marketing mutual knowledge of modern methods of flight guidance. Both institutions have trend-setting simulation facilities at their disposal such as flight and tower simulators.

The following short reports are intended to provide information about DLR's activities in this area and about other important subjects in its five core program topics related to aeronautics: fixed-wing aircraft, helicopter and propulsion technologies, air traffic management and control as well as environmental issues.

# AWiTech

**Adaptive Wing Technologies**

There is a distinct interaction between aerodynamic forces and resulting structural mechanical deformations in the high aspect ratio of modern commercial aircraft during flight. When cruising as well as during take-off and landing, the aeroelastic states of equilibrium (which are a function of marginal conditions such as flight altitude or the aircraft mass) shift.

If for instance the aircraft mass decreases due to fuel consumption, the wings assume a different state of equilibrium than with a full tank. As a result, the effective wing shape deviates from its aerodynamic optimum over the course of the flight thereby reducing flight performance. DLR's AWiTech (Adaptive Wing Technologies) project has developed designs for adaptable structures that make the best flight performance possible for a wide spectrum of marginal conditions without diminishing the overall performance of the system by increasing mass in the process.

Based on the F11 model designed during Airbus A380 development, it was possible to develop a rigidity design that reduces in particular the link between bending and torsion. This is one of the dominant effects having a negative influence on the flight performance of strongly backswept wings. The center point of the concept is the advanced application of fiber reinforced materials utilizing directional properties (so-called aeroelastic tailoring).

In a high-lift configuration, the slot between the wing and the extended landing flap is of central importance. At AWiTech the elasticity of the flap was optimized such that very favorable slot geometries in the aeroelastic equilibrium were present with different flap positions. In addition, integrating multi-functional materials permits active adaptation of the shape, which increases high-lift performance or reduces mass by substituting reinforcements (so-called adaptronics or adaptive systems).

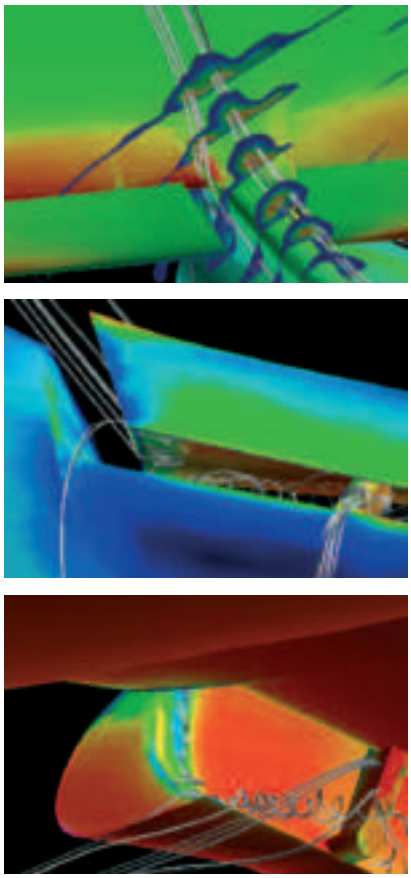
An important basis for the work is linking expert systems for computing the aerodynamics and structural mechanics in order to provide the necessary precision to assertions in both disciplines. In addition to the structural concepts, the numerical methods and tools developed represent valuable results from AWiTech, which will come into play in further-reaching projects.

**Curvature and torsion on the aeroelastically deformed wing**

# MIRACLE project

**Standardized development of CFD methods at ONERA and DLR: German-French MIRACLE project**

The goal of the MIRACLE project, which was begun in 2004, is standardizing the development of computational fluid dynamics (CFD) at ONERA and DLR. This allows available resources to be used most effectively as well as to better meet requirements of the European aeronautics industry. The focus of development on the French side is the structured flow solver elsA and on the German side the unstructured solver TAU, with the expertise of each side being incorporated into development.



**TAU computations of a high-lift configuration. Top: streamlines over the engine nacelle; center and bottom: vortex generation on the lateral edge and on the mount of a leading-edge flap**

Thus, the implicit treatment of turbulence equations was transmitted from the structured DLR CFD method FLOWer to the French elsA code. An important result in the further development of DLR TAU code was the introduction of an implicit time step method, considerably reducing required computing time. An essential property of an unstructured method is the possibility of automatically locally locally grid refinement so that important flow phenomena can be precisely computed without having to refine the entire grid, something that would lead to unacceptably high total computing expenses. The method for local grid refinement was completely harmonized and can now be used effectively on inexpensive PC parallel computers.

The advantage of an unstructured method is evidenced particularly with high-lift configurations with their many geometric details. Thus, these types of flow phenomena can be studied and utilized purposefully for a design, which in the past could only be evaluated in the best case through the use of very expensive experimental testing.

# Optical measuring technology

**non-invasive detection of pressure**

Pressure sensitive paint (PSP) is excellently suited for two-dimensional detection of flow phenomena on models in wind tunnels. This does not just include qualitative visualization, but also quantitative pressure measurement with a precision of up to ± 1 mbar on the model being tested.

The advantage of the PSP method as compared with conventional "pressure tap technology" is that it is not just possible to measure along a pressure bore series tap sections that is specified during model fabrication, but over the entire coated model area.

If the pressure distribution from all sides on the model surface is recorded by PSP (360° PSP), forces and moments acting on the entire model or even on individual components such as rudders or horizontal tail units can be determined. Using 360° PSP makes it possible to avoid linearization or extrapolation when determining the aerodynamic forces as well as to minimize grid generation and CFD computing time. Therefore, the results are of great value for further development and validation of numeric processes.

EADS and Airbus confirm that the pressure sensitive paint that was developed by the Institute of Aerodynamics and Flow Technology in their cooperation with the University of Hohenheim has great potential since it makes it possible to lower model fabrication costs and reduce required wind tunnel use.

Currently, further development of pressure sensitive paint is focused on the detection of unsteady flow phenomena.

**Pressure distribution over the entire model surface is detected using pressure sensitive paint on an EADS-MAKO model in the DNW high-speed tunnel**

# Ground vibration tests on the Airbus A380

**DLR and ONERA test series**

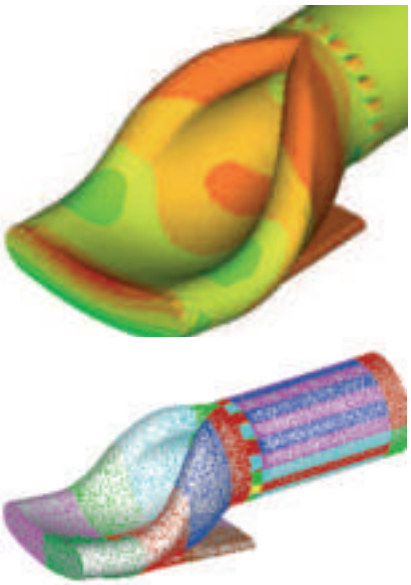
The central measuring campaign was successfully concluded in early 2005 with the so-called ground vibration test on the Airbus A380 before its maiden flight in Toulouse. Specialists from DLR's Institute of Aeroelasticity in Göttingen conducted the test in cooperation with engineers and technicians from the French Aeronautics and Space Research Center (ONERA). The measurements gathered form the basis for the aeroelastic certification process and thus for the approval of the largest and most modern civilian aircraft in the world.

Aircraft like the A380 are lightweight constructions that deform elastically in operation. Because of the interaction of inertial, elastic and aerodynamic forces, self-excited vibrations can occur, which must be taken into account early on when designing the aircraft and specifying its operating limits. During the ground vibration test, the natural vibrations of the aircraft structure are determined on the ground in order to provide evidence of flutter safety, which is required for the type certification. The flutter behavior of entire aircraft is simulated on the basis of these measurements, and the operational range of cruising speeds is thereby specified. Additional tests will be conducted during the maiden flight and during the complete flight test campaign.

While the first A380 was being ceremoniously unveiled, engineers and technicians from DLR and French ONERA worked under great pressure on the second completely assembled A380 in Toulouse. The measuring equipment used in the test simultaneously registered more than 800 sensors distributed over the entire aircraft. Approx. 25 kilometers of cable were required to reach each of the highly specialized and sensitive sensors. Approx. 20 electro-dynamic exciters made the aircraft vibrate. Actual test execution was guided by a strategy that was developed by DLR and ONERA over the last few years and refined during ground vibration tests on the predecessors of the A380. During testing, the data were completely analyzed on site at the same time that measurement was taking place. As a result, the measurement itself is more efficient to begin with, and secondly it was possible to gain a realistic picture of vibration behavior even during testing and this allowed Airbus to get an early start on additional calculations required for aeroelastic certification. Approximately 100 natural vibration forms were identified in the frequency range being tested, by far the most that had ever been detected in a ground vibration test on Airbus large-capacity aircraft. This can be attributed essentially to the new type of construction. Thus, for example, the ailerons on the airfoils are designed separately and not, as is customary, as a single component.

The joint venture between top German and French researchers, i.e., the concentration of specialized expertise on an international test team, functioned excellently here in an industrial context. DLR and ONERA have once again underscored their top position in the field of ground vibration technology. In the future, they will continue to conduct joint, large-scale testing and thus continue to play a crucial role with respect to future high-capacity aircraft.

**The Airbus A380-800 during the ground vibration test conducted by DLR and ONERA in Toulouse, France**
**(Copyright Airbus S.A.S.)**



Grid network and computational result (static pressure) of an engine intake

# TRACE

**Engine flow simulation**

The Institute for Propulsion Technology is developing a simulation system named TRACE for the calculation of threedimensional stationary and unsteady flows via one or more blade rows of an engine component. The program is being used successfully DLR-wide and at universities for scientific questions related to turbomachinery flows. In addition, TRACE is also being used to design aircraft engine components and stationary gas turbine components and has already been integrated into the design process at MTU Aero Engines, a long-term alliance partner.

The illustration of complex geometries is currently one of the focal points in the development of numerical modeling. Most of the present gaps between measurements and computing methods (non-periodicities, gap dimensions, surface roughness andcavities) will be closed by maximizing the number of illustrated geometric details in the numerical model. A first step in this direction is expanding TRACE for hybrid grid networks. When illustrating a complex geometry with a numerical computational network, using triangles (unstructured networks) offers an enormous simplification in grid generation in contrast to conventional, structured rectangular elements. In the first place, this enables the computational grid to be generated extremely flexible and efficiently as the basis for numerical simulation. The latest realistic example of such an application is the intake for the TP400 engine, the drive unit for the propeller of the European military transporter A400M. In this case, the branched intake produces strong non-homogeneities in flow, which are distributed over the entire circumference. As a result, the entire influx must be known in order to design the subsequent compressor. Thus, the three-dimensional intake (unstructured) and the first stator rows (structured) were networked over the complete circumference.

# Advanced aircraft structures

**Advanced fabrication methods**

Because of continually increasing costs for developing and building fighter aircraft, it is necessary to develop more cost-effective manufacturing methods as well as increase the efficiency of the aircraft in order to hold fast in international competition.

With this as a goal, new preform and resin infusion techniques were developed and tested within in the course of the DLR-EADS key project Advanced Aircraft Structures II. Manufacturing and handling processes were developed in order to increase the proportion of preforms in manufacturing. The infiltration of preforms was tested using typical components so as to develop and qualify a harmonized manufacturing technology for internal structures. The resin infusion processes (VARI, Vacum Assisted Resin Infusion, and SLI, Single Line Injection) were further developed in order to facilitate the manufacturing of complex, high-quality, three-dimensional components. To underscore the potential of the processes in terms of cost savings, identical components were fabricated using different processes. Then the quality of the component and the expense of manufacturing it were evaluated in the process. A reduction in the use of energy during manufacturing is thereby intended to reduce manufacturing costs overall.

Another goal is improving flight properties by increasing maneuverability. This goal is supposed to be achieved using actively elastically deformable structures that allow more efficient control of the aerodynamic forces by continuously adapting the wing contour. With this in mind, a concept was developed for a form-variable outer wing, which completely assumes the responsibilities of the conventional outer flap of a combat aircraft in all flight maneuvers (rolling control, maneuver load reduction, landing).

The high cost of materials currently limits using stealth structures to just a few areas on the aircraft. In order to continue to reduce the signature and thereby improve camouflaging, correspondingly cost-effective stealth construction styles were developed, which connect the improved camouflaging properties (e.g., broad-bandedness) with required structural properties.

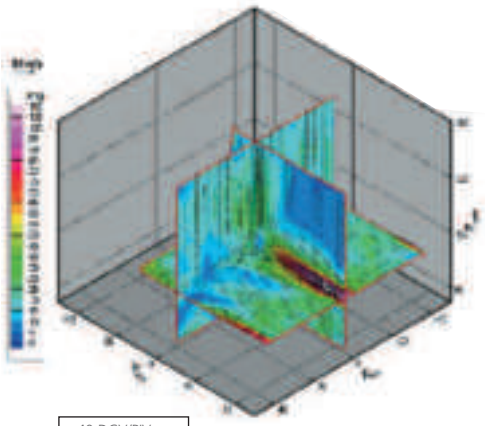
In the future, antennae will have to be integrated into the primary structure in order to do justice to increasing number of antennae in combat aircraft and the associated great requirement for space and adjustable directivity. For this reason manufacturing processes developed over the course of the project were adapted to the high requirements relating to radiator properties without impairing the structural characteristics of the affected areas. The function of the integrated antenna was verified experimentally using a test component.

# Measurement of wake vortices from the air

**LIDAR equipped to characterize wake vortices**

The DLR wake vortex project and the EU AWIATOR project showed that it is possible to detect and characterize the wake vortex behind an aircraft from the air from another vehicle with a lidar. During the test, the DLR test aircraft ATTAS generated wake vortices at an altitude of 2000 m and DLR's Falcon research aircraft that flew approx. 900 m overhead measured them. The lidar from the Institute of Atmospheric Physics was equipped with a scanner for this purpose and installed in the Falcon through the floor window. A smoke generator attached to the left wing tip of the ATTAS was used to intensify the backscatter signal since the ATTAS is a relatively small aircraft with a correspondingly weak wake vortex. Until now it has only been possible to detect and characterize near-ground wake vortices. The airborne measuring method now makes it possible to measure wake vortices that are located above the atmospheric boundary layer. Based on these very promising results, a new measuring strategy will be used in a second measuring phase in January/ February 2006.

**The vortex of the ATTAS, shown here during take-off of the VFW 614, was measured for the first time using a LIDAR from another aircraft (Falcon)**



• 40 DGV/PIV
Planes
2 mm interval

**Speed in the mixture zone at 2 bar**

# ADTurB II

**Advanced Design of Turbines and Blades**

Detailed aerodynamic and aeroelastic tests were conducted on HD turbine stages with differently coordinated stators and rotors during the European research project ADTurB II (Advanced Design of Turbines and Blades). The objective was determining the effect of low-frequency unsteadiness (low engine order) of the stator wake on the subsequent rotor. By simultaneously determining the unsteady excitation of the rotor blades and the unsteady blade reaction it was possible to determine the connection between certain vibrational shapes of the rotor blades and time-dependent flow forces, which are caused by (periodically variable) stator wakes. The low-frequency excitation of the rotor blades that resulted from small geometric deviations of the stator geometry from the target valve was particularly examined. For this purpose, the narrowest cross section of the stator passages and the blow-off quantity (blocking of individual blades) was periodically varied in an experiment. It was shown that there were only slight deviations in the unsteady flow quantities between the design configuration with a constant narrowest cross section and constant blow-off rate as well as "mistuned" stator geometries; the greatest effect on the excitation of the rotor blades was the blockade of the blow-off air. A sinusoid variation of the narrowest cross section resulted in a more or less dominant first harmonic of this low engine order excitation, while a periodic blockade of individual blow-off rates produces broad-band aerodynamic excitation with higher harmonics. In the flow-off field of the stator, the illustration shows amplitudes of the flow-off Mach number and angle determined in a Fourier analysis with a variation of the narrowest cross section and the blow-off quantity corresponding to a 5th engine order. The differently excited higher harmonics below the blade frequency (43 blades on the circumference) are interesting.

# Large Eddy Simulation

**Validation data generated for combustion chamber simulation**

A data record was developed to verify combustion chamber calculation methods based on the Large Eddy Simulation (LES).

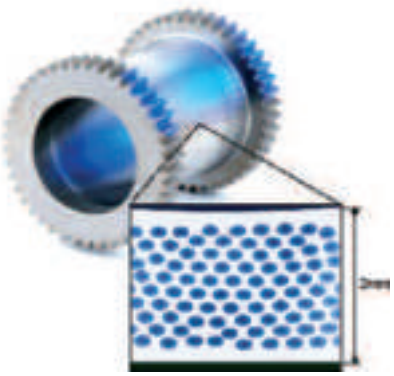
For aircraft engine combustion chambers,it is of crucial importance to master the mixing process of fuel and air as well as the mixing of primary and secondary air. It is currently not possible to calculate them in advance with the tools that are available to industry at present. Great hopes are being pinned on the introduction of unsteady calculation programs. In order to test the possibilities for application, a comparative case is required that covers the bandwidth of the essential phenomena of flow and reaction.

For his purpose DLR constructed a generic engine combustion chamber with wide optical access and developed a burner that allows the measuring method to be used in its direct near field. The speed fields of the primary and mixture zones were measured with planar methods and illustrate the unsteady characteristics of the burner flow and stream mixture. The temperature and species distribution in the primary zone were determined simultaneously. As a result, the turbulent speed field and distribution of the turbulent mixture fracture are available for the first time in an engine-like combustion chamber with realistic pressure and inlet temperatures.

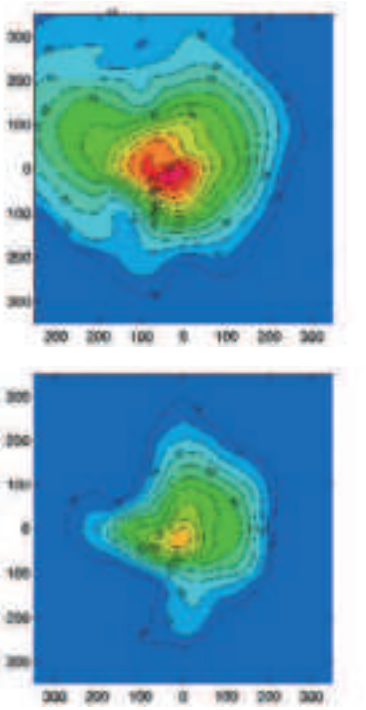
# Titanium matrix composites

**Use in aircraft engine drive shafts**

Titanium matrix composites (TMC or SiC fiber reinforced titanium alloys) are being manufactured at the Institute of Materials Research using a patented method that was developed in-house. TMCs are very attractive for applications in aircraft engines due to their excellent properties. The low specific weight of 4g/cm³ (with a fiber volume percentage of 40%) makes the material especially interesting for rotating components in which operating temperature is limited to 550° C as a result of oxidation of the titanium matrix. In the past, the use of TCMs in a compressor, in a bling (bladed ring) and in blades was studied in cooperation with the MTU and other DLR institutes. In morrecent projects (e.g., in a trilateral defense technology project and an EU projec with all prominent European engine manufacturers) TMCs' potential as drive shafts for aircraft engines was examined. The TMCs could transmit greater torque with the same shaft diameter due to their high rigidity and strength. In addition, the fiber composite allows the optimization of the maximum torque by adjusting the fiber orientation. The smallscale shaft in the illustration has a fiber orientation of 45° to the axis of the shaft (see section perpendicular to the axis of the shaft), which produces maximum torsional strength and rigidity with respect to driving torque.



**Maximum torsional strength and rigidity with respect to driving torque based on a fiber orientation of 45° to the axis of the shaft**



**Landing approach of the FHS helicopter, noise level on the ground (flight speed 120 km/h, flight altitude 100 m). Top: Normal approach 6 degrees; bottom: Steep approach 15 degrees.**

# Noise-reduced helicopter approaches

**Flight testing at the Cochstedt Airport**

Due to aerodynamic and flight mechanical characteristics, helicopters generate distinctly different kinds of noise during various flight conditions (flight path, speed, flight maneuver) and this noise can be perceived by an observer on the ground. Extensive flight testing was conducted at the Cochstedt airport in order to utilize this situation for reducing community noise generated by helicopters.

It was possible to achieve considerable improvements as compared with earlier tests. Two DLR research helicopters were used, the BO105 and EC135-FHS, which are among the best equipped helicopters in the world. A new noise measuring system, comprised of 43 microphones with a wireless connection to a central station, were distributed over a ground area with a diameter of 800 m. The systematic test matrix included approx. 400 flyovers by helicopters with steady flights and maneuvering flights in the helicopter's entire flight envelope.

The unique database is currently being analyzed with the goal of specifying low-noise approach paths for helicopters. Initial results indicate that a substantial reduction in noise on the ground is possible, specifically more than 6 dB(A). However, the computed low-noise flight paths are more complex than standard paths and more difficult for the pilot to fly, requiring him to be supported by appropriate guidance and control systems (pilot assistants). Within the PAVE project (Pilot Assistant in the Vicinity of Helipads) relevant pilot assistant systems are being developed.

# Tracking vibration and noise

**Initials results of the European HeliNoVi project**

The objective of the European HeliNoVi project (Helicopter Noise and Vibrations) is reducing noise and vibration of helicopters. This project focuses especially on examining the effect of interference between the main rotor, tail rotor and fuselage.

DLR's BO105 wind tunnel model (scale 1:2.5) was modified so that essential parameters could be changed during the test. Two tail rotor configurations were each varied in terms of their position

**Aerodynamic and acoustic measuring systems in the wind tunnel (DNW-LLF)**

vis-à-vis the main rotor, in terms of rotational direction and speed, and the fuselage contour was modified. It was possible to isolate and quantify interfering effects by measuring individual components (main rotor, tail rotor, fuselage), combinations thereof as well as the entire helicopter.

The comprehensively instrument-laden model and the dynamic balance as well as the aerodynamic and acoustic measuring systems in the wind tunnel (DNW-LLF) supplied consistent and complete data, which make it possible to analyze the individual phenomena, correlate with flight tests and validate still inadequate calculation methods. Proposals for measures to reduce vibrations and noise in helicopters are expected as a further result of the EU's ongoing HeliNoVi project.

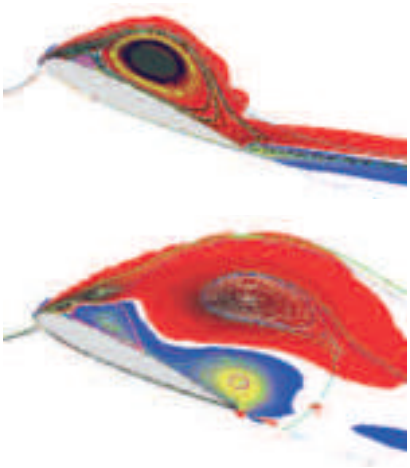
# Dynamic stall at helicopter rotors

**Simulation and validation of the flow behavior**

Flow behavior, which is referred to as dynamic separation of the flow or dynamic stall, affects retreating rotor blades in helicopters in rapid forward flight and in maneuvering flight with high lift. This three-dimensional phenomenon on the oscillating rotor blade is determined by the effects of unsteady flow, compressibility, transition and turbulence, among others. Although numerous studies in the past few years have dealt with this complex area, the processes during dynamic stall could not yet be explained completely. Since the useful flying range of helicopters (flight speed, load coefficient, stick forces) is clearly limited by these effects, there is a great need for better understanding, reliable calculation methods and possibilities for influencing the flow processes.

Taking the special competence and facilities at DLR and ONERA into account, the CFD methods for simulating these types of flows were further developed in a joint project and validated by careful experiments in various wind tunnels. A focal point of the work at DLR was examining an active leading-edge flap to influence the dynamic separation of the flow. CFD calculations and comprehensive wind tunnel experiments (DNW-TWG) were able to show that with appropriate control of the leading-edge flap the maximum values of profile moment and drag could be reduced considerably without a corresponding loss in lift.

The extent to which passive elements can be used to influence flow separation on the rotor blade is now being studied on the basis of the results achieved and the know-how the phenomenon. These types of devices can be used even with existing rotor blades to improve the so-called dynamic stall behavior and thereby substantially expand the flight envelope of the helicopter.



**Dynamic stall on an oscillating rotor blade**

**Rush hour on the tarmac**

# Total airport management

**Optimal airport utilization with CLOU**

Since 2000 DLR has been at work on total airport management – integral management of an airport. Until now the various stakeholders in an airport (airlines, air traffic control, airport and handling agents) have honed their processes more or less independently of one another. Using the first stages of collaborative decision making (CDM), an attempt was made to harmonize the stakeholders' information base so that each of the parties involved has up-to-date and reliable information at all times so that correct decisions can be made for each area. Total airport management should now also include planning and implementation of the plan in a cooperative, coordinated manner. To do this, a new element for managing an airport was developed – an airport control station. In this control station (which could be either physical or virtual) representatives of individual stakeholders will support airport operations via a TOP (Total Operations Planner) involving preplanning and mutual coordination with a practical time window of approx. three hours. Detailed implementation of these plans is then handled by existing control centers with the support of tactical planning systems (Arrival Manager, Turn-Around-Manager and Departure Manager).

DLR completed an operational and technical design of a first instance of the described TOP and prepared a prototype in close cooperation with Deutsche Flugsicherung GmbH, FRAPORT AG and Deutsche Lufthansa AG,. This prototype is called CLOU (Cooperative Local Ressource Planner). Evaluation tests of CLOU are scheduled for fall 2005 in an event simulation that was developed by the Technical University of Berlin. The research work was made possible by the Cooperative Air Traffic Management (K-ATM) project, which is sponsored by LUFO III, the aeronautics research program of the German government.

CLOU predicts and analyzes the traffic demand and compares it to prognosticated airport capacity. FRAPORT AG has now developed a system in the course of the K-ATM project that builds on experience with the traffic monitor developed by DLR, and is able to provide sufficiently precise predictions of capacity. Starting with this analysis of capacity and demand, CLOU selects an appropriate operating method (airport utilization strategy) and a working point for the airport (number of take-offs and landings within a time window). By allocating individual aircraft and controlling aircraft departure and arrival times using so-called target times it is possible to have an effect on the traffic demand. The boundary conditions of CFMU are being taken into account.

The optimization criteria for this new planning system are capacity-oriented resource utilization and the punctuality of air traffic. Controlling individual aircraft is supposed to take place in a subsequent implementation via a Central Flow Management Unit (CFMU), air traffic control and for the remote area via the airline operations center.

To begin with, the potential benefit will be examined using these first prototypes. The expanded stages of CLOU provide for dynamic optimization of the flows as well as what-if testing for operators in order to conduct real-time simulations using the prototypes. In addition, silent coordination is planned with local, tactical planning systems using the example of AMAN and DMAN.

# AT-One

**A strategic alliance in the area of air traffic management**

A strategic alliance was selected for close cooperation with the Dutch National Aerospace Laboratory (NLR) in the area of air traffic management. The preparations were so far along in 2004 that contracts, management structures and specialized cooperation could be implemented the following year. Joint products, services and research work will then be marketed in the future under the brand name AT-One.

The strategic alliance with the NLR in the area of air traffic management (ATM) under the AT-One name includes joint management of research work and completion of projects for industry, airports, air traffic control and public customers like the European Commission.

Both institutions are represented in many important projects in the European Commission's 6th research framework program. Cooperation within AT-One has already led to improved efficiency and better organizational possibilities.

A joint presence in the marketplace, coordinated planning of research work and investments along with the harmonization of the research facilities are a part of the alliance. Realization thereof was begun with the public signing of a declaration by the executive boards of DLR and NLR at the 2005 ATC Maastricht exhibition. The AT-One brand name was also introduced to technical circles there.

The AT-One implementation project (ATOI) includes both organizational tasks as well as technical cooperation between DLR's Institute of Flight Guidance and NLR's Air Transport Division within the course of the strategic research alliance. The project also establishes a joint AT-One management that overlays management of the DLR institute. In addition to the directors of AT-One, this will be comprised of managers of specialized units (areas of expertise) and so-called business managers. Still to be agreed upon are the required rules of cooperation, information exchange and responsibilities, and the technical infrastructure is yet to be established. Marketing and external and internal communication are among the responsibilities that must be resolved.

The technical cooperation, which includes joint strategic planning and development of common products, also extends to the large-scale facilities that are being used for validation and development in the area of air traffic management. Thus, during the first year of the ATOI project, air traffic control simulators in Amsterdam and Braunschweig will be harmonized so that they will be more productive and can be operated more cost effectively. Synergistic effects and complementary characteristics will be focal points of further harmonization of the large-scale facilities in subsequent years of the project.

# ADVISE-PRO

**Visual pilot support**

Enhanced vision systems allow pilots to continue to fly by "sight" even under poor visibility conditions. In this case, the normal outside view is replaced by a display of sensor images. Infrared sensors and millimeter radar sensors are suitable sensors for this. In this case, MMW sensors penetrate bad weather much better as compared with IR sensors, but radar images are considerably more difficult to interpret and as a rule do not allow direct derivation of vertical flight information in contrast to IR images. In the ADVISE-PRO project, the concept of visual guidance known from visual flight, was successfully transferred to the area of dwarf waves with the aid of PAPIs (precision approach path indicator) in order to support pilots with enhanced vision approaches under poor visibility conditions. Special radar reflectors (diplane reflectors) were developed and manufactured for the RADAR-PAPI concept, which behave (as related to the reflector perpendicular) in the horizontal direction like a retro reflector and in the vertical direction like a mirror. A suitable arrangement of several of these types of diplane reflectors with different angles of incidence in the vicinity of the touch-down point on the (auxiliary) landing strip creates a special pattern on the radar image from which the pilot can very simply make a determination of the position of the aircraft with respect to the target glide path. The feasibility of the concept was verified first in flight tests in Braunschweig on the "26-Gras" landing strip with the Enhanced Vision Experimental System on the Do-228 flight test vehicle. Secondly, studies in a cockpit simulator with numerous pilots showed that after just a short training period all pilots were able to land safely on a landing strip that was not equipped with additional navigation aids with only the assistance of RADAR PAPIs under CAT II (safety category) visibility conditions.

**Arrangement of the experimental RADAR PAPI system at the Braunschweig airport**

# Virtual tower

**Airports of the future**

"Virtual tower" represents the vision of a purely sensor-based control center for air traffic control in the airport area without a direct outside view. The goal within a time frame of 10–15 years is a "tower" without a physical tower structure, where the outside view is replaced by augmented vision wich is wide angle projection of a video panorama with integrated traffic and weather information. The main motivation here is the anticipated cost reduction of ground traffic monitoring, an increase in the air traffic controller's situational awareness as well as reduced dependence on weather.

The idea of a virtual tower was initially developed as a rough concept and was the winner of the Vision Competition as a conceptual study (2002–2004) in close contact with the Tower Division of Deutsche Flugsicherung (DFS). The first step towards a virtual tower experimental environment was the design of a high-resolution large projection in the new control station simulator at the Institute of Flight Guidance.

The ViTo conceptual study formed the basis for the new DLR project called Remote Tower Operation Research (RapTOr, 2005–2007). The partial goal of remote monitoring of small airports is handled in four work packages. A demand for this was revealed by cooperation with DFS on the Virtual Tower Study. Air traffic control and monitoring took place in this case via a specially designed remote tower (RTO) workstation in the tower of a remote larger airport. The basis for the design of the RTO workstation is a work and task analysis supported by the DFS at the Halle/Leipzig tower in combination with a cognitive resource and process model for simulating the novel work sequences. This contributes substantially to workstation and system design. The construction of the RTO experimental system began parallel to this, which, in addition to wide angle large projection, includes a high-resolution panorama camera system as a new component of the experimental ground traffic monitoring system at the Braunschweig research airport.

The Institute of Transport Research and Optical Information Systems facility in Berlin-Adlershof are contributing real-time image processing and object detection with advanced methods.

Tests with the entire system (monitoring rolling on the ground as well as take-offs and landings by an air traffic controller at the RTO workstation demonstrator) are planned for 2007.

The DLR remote tower experimental system will play a central role in the EU project ARTE (Augmented Reality Tower – Research & Technical Evaluation, consortium manager: SELEX Sistemi Integrati (previously ALENIA – Marconi)), where there are plans for it as a development and integration environment for an experiment virtual tower system at the Malpensa/Milan airport.

**Top: Augmented vision experiment at the Dresden tower with transparent holographic projection to overlay the weather data on the outside view; bottom: Control center with reconstructed outside view (right) using the example of the 300° tower simulator visual system as an augmented tower vision experimental environment (with integrated flight numbers)**

# Space Management and Space

**Despite a tense budgetary situation DLR can look back on a successful year in terms of both its function as a space agency and its space research program.**

**The scientific and technical successes range from spectacular images of the neighboring planet Mars and the successful landing of the Huygens probe on Saturn's moon Titan to the vital use of satellite images in relief efforts after the tsunami and the first movements of a robot arm in open outer space. In implementing space policy, DLR, in its function as an agency, assumed a prominent role in the pending negotiations concerning a European space policy in the Council of Ministers conference in December 2005 and therefore had an opportunity to make a substantial contribution towards shaping future space perspectives.**

**Space management:**

**European space policy (ESA/EU and Space Councils)**

The action plan submitted in the White Book dated November 11, 2003 describes an expanded need-oriented space policy. An attempt is being made to use space technologies to support the policies of the European Union. Space was incorporated into the draft of the European constitution as a shared competence, thereby strengthening the role of the EU in European space travel. A framework agreement on cooperation between the EU and the ESA entered into force in 2004.

In November 2004 and June 2005, the ESA and EU research ministers met at the first and second Space Councils. In the process, they agreed to begin with on a timetable for developing a common European space program. During the second meeting, an understanding was reached making the satellite navigation program Galileo and the satellite-based environmental and security system GMES the "flagships" of future EU space activities. Moreover, a division of responsibilities was agreed upon between the ESA and the EU and future priorities were set. The role of the EU is identifying and promoting meaningful space applications for environmental protection, security, information or even transport. The central role of the ESA lies in developing a basis for executing space activities and in the area of vehicles. Finally, the Space Council confirmed in its second meeting

that European space policy should encompass the following subjects:

- A European space strategy
- A European space program that takes this strategy into account and reflects the corresponding costs and sources of financing
- A commitment by the main players to their roles and responsibilities
- The most important implementation principles

There are plans to submit the first concept for the European space program on the occasion of the third European Space Council at the end of 2005. The guidelines for it are based on the framework agreement between the European Commission and the ESA, as well as the ESA convention.

**ESA return**

The return in the ESA programs to German industry declined in the years from 2002 to 2003. Even though the intervention limit had not yet been reached, counter measures were undertaken at a low of Euro 0.91 during the 4th quarter of 2002. Because of equalization agreements with France (Euro 104 million) and ESA (Euro 67.7 million) the German return coefficient improved considerably over the course of 2003. At the end of 2004 the German return was 1.03 and therefore posted a surplus of approx. Euro 57 million. The return coefficient was also 1.01 at mid-year 2005.

**New Chairman in the ESA executive bodies**

Following Prof. Wittig's unanimous election as chairman of the ESA Council by the delegates on June 22, 2005, Dr. Baumgarten assumed leadership of the German Council delegation. Mr. Hohage, manager of Launcher Systems Division in space management, became chairman of the Ariane program council.

**Preparations for the Council of Ministers conference**

In preparation for the 2005 Council of Ministers conference, which will be held on December 5 and 6 in Berlin, a DLR project group was established to make content-related preparations and a project team to handle organizational preparations and execution of the conference. A Conference Working Group (CWG) to make ESA-related preparations for the ESA Council of Ministers conference was established at the ESA Council on June 22, 2005.

# Ariane 5ECA

**Demonstration flight**

An extremely important milestone in the recovery plan was reached in the launcher sector with the first successful demonstration flight of the Ariane 5ECA on February 12, 2005. ESA put together this recovery plan following the abortive first flight of this carrier type at the end of 2002. The successful V-164 mission, in which the Ariane transported a Spanish-American telecommunication satellite into outer space, formed the vital basis for future marketing of the Ariane 5.

# Earth observation with EnMAP and TanDEM-X

**Call for a national earth sensing mission**

DLR space management selected the proposed missions EnMAP (Environmental Mapping and Analysis Programme) and TanDEM-X (TerraSAR Add-on for Digital Elevation Measurements) from the proposals submitted for the next earth observation mission. Phase A studies are currently being conducted for each of the two proposals. The study results will subsequently be used to prepare a proposal that will be realized as a mission in Phases B/C/D/E. Launch is planned for 2009.

The EnMAP proposal under the guidance of the GeoForschungszentrums Potsdam (GFZ) and supported by industrial partners, Kayser-Threde, EADS Astrium and the Gesellschaft für Angewandte Fernerkundung (GAF AG), intends to launch an earth sensing satellite with a spacial high-resolution hyperspectral instrument. Hyperspectral recordings illustrate the earth's surface spacially in over 180 color channels and above all thematically in high resolution. This makes it possible to sort out and solve current scientific and application-related questions on a global scale in the fields of the environment, agriculture, land utilization, water management and geology.

Mapping the earth from space with a precision that could not be achieved heretofore is the focus of TanDEM-X, submitted by the DLR Institute of Radio Frequency Technology and Radar Systems with the support of EADS Astrium. This is achieved via two satellite-supported high-resolution radar sensors, TanDEM-X for one, as well as a second, the TerraSAR-X currently under construction. Together they form a large radar interferometer. In a close, precisely controlled formation flight they generate stereo-image-like recordings with a relative altitude measuring precision of less than 2 m. The utilization potential of TanDEM-X with its five-year mission includes a wide field of applications in scientific, commercial and security-related areas.

Mission definition reviews with special attention being paid to documented user requirements were successfully concluded for both proposed missions. Incorporating the mission goals into the respective mission concept is the subject of the preliminary requirements reviews, which concluded the Phase A studies during the second half of 2005.

# A new generation of COMED

**Development and demonstration project for multimedia satellite networks**

The strategic objective of COMED NG is securing and expanding the presence of German companies in the global satellite telecommunications market. The emphasis is engaging key technologies, subsystems and products for geostationary satellites and for future applications and services. This includes the fields of solar generators, gyroscopes, traveling wave tubes, star sensors, avionics, antennae, propulsion systems, SatCom transmission amplifiers, ground segments, networks, communication services and optical communication. A further core topic is guaranteeing European autonomy in the component sector and satellite services. In addition, avenues for further expanding expertise for small geostationary satellites in Germany should be investigated.

# Data utilization

**Utilization of satellite data for marketable products**

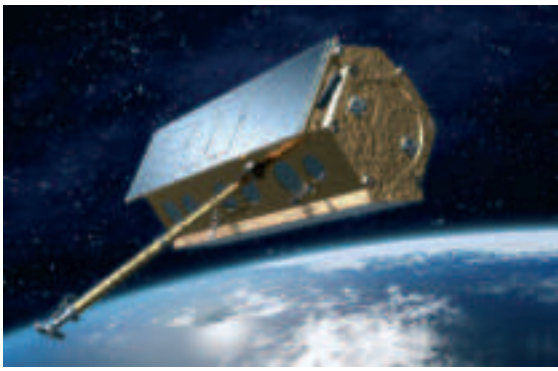
The orientation of the Earth Observation projects follows an integrated approach, which is aligned with the utilization emphasis of GMES (ESA/EU) and the information goals of the national missions and the TerraSAR-X, RapidEye and SCIAMACHY sensors. As a result, this should improve prospects for the success of German companies in competition for European funding (e.g., FP-6).

Increasing significance is being attributed to large project associations from research and industry in Germany, which are converting satellite data into marketable products (e.g., land usage maps). The competitiveness of the latter is being reinforced and its position in the European market stabilized.

Two large association projects on the subject of land usage and land coverage mapping are the DeCOVER and ENVILAND projects. The objective of DeCOVER is developing a national service for updating land coverage data based on remote sensing data. In preparation for subsequent technical implementation, three partial aspects should be examined to begin with by December 2005: requirements of public users, interoperability of existing national land coverage data and a cost-benefit analysis for DeCOVER.

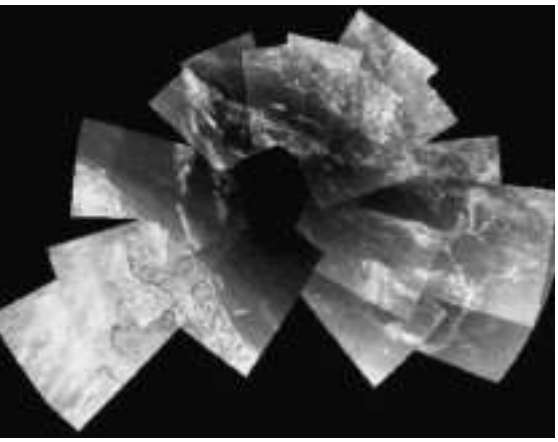
The ENVILAND project is aimed at the integrative use of SAR and optical data from the ENVISAT sensors ASAR and MERIS for use on land surfaces. Largely automated classification methods are supposed to be developed that can be realized free of scale, transferably as well as stably and economically. The development of integrated analysis methods from SAR and optical data also represents an important contribution to deployment preparations for the two German satellite missions TerraSAR-X and RapidEye.

In the area of atmospheric research, German responsibilities are concentrated on validating the two atmospheric instruments SCIAMACHY and MIPAS with data from ground-based, ship-borne, aircraft-borne and balloon-borne instruments. Most of these measurements have been completed in the meantime; reference measurements are still being carried out for the tropics.



**TerraSAR-X is Germany's first national remote sensing satellite, which was brought to fruition in a public-private partnership of the German Aerospace Center (DLR) and EADS Astrium GmbH with the considerable financial support of industry**

**On January 14, 2005 the ESA landing probe HUYGENS took the first ever picture of the Saturn moon Titan (ESA/NASA/JPL/University of Arizona)**



**The surface of the Saturn moon Titan, recorded by the ESA landing probe HUYGENS at an altitude of 10 kilometer (ESA/NASA/JPL/University of Arizona)**

**Results of integrated projects**

# CASSINI/HUYGENS

**Landing on Saturn's moon Titan**

The Cassini/Huygens NASA-ESA mission launched on October 15, 1997 reached Saturn on July 1, 2004 after a flyby of Saturn's most remote moon Phoebe at a distance of 2000 km. It then went into orbit around the destination planet. After two close flybys of Saturn's moon Titan (diameter 5,150 km; 16 days orbit time at a distance of 1.2 million km) on October 26 and December 13, 2004, the Huygens probe separated from the Cassini orbiter on December 25, 2004 and was guided on a ballistic trajectory to Titan.

On January 14, 2005 at 1:45 in the afternoon, a spectacular landing was initiated by a braking maneuver with the thermal shield. During the approximately three-hour long descent with parachutes through Titan's atmosphere, cameras on board Huygens took 350 pictures, which showed an "earth-like landscape" with meandering riverbeds and mountain ridges. The images from the ground showed debris fields on the surface made of ice. Temperatures of -190° C and an atmospheric pressure of approximately 1.6 bar prevail on Titan.

The atmosphere is comprised of 96 % nitrogen, 3 % methane and 1 % inert gases. During descent, Huygens was shaken by fierce winds of up to 400 km/h. The measuring instruments found evidence of the existence of a methane cycle, comprised of evaporation, condensation and precipitation, which is comparable to the water cycle on earth. A possible source of the methane supply in Titan's lower atmosphere could be a cryovulcanism.

In the meantime, the Cassini orbiter flew by at a secure distance from Titan and was used as a receiving station for the Huygens measuring data. It will continue to explore Saturn, its moons and the ring system. By mid 2008 Cassini will have completed 74 orbits of Saturn and in doing so "gain momentum" again and again from Titan in order to alter the orbit of the orbiter. The moon Titan will be explored in 45 close flybys. Thirty-seven flybys of the other moons are also planned. So far 34 Saturn moons are known. Three of them were discovered by Cassini.

German scientists are involved in eight of 12 Cassini instruments and in three of six Huygens instruments. Along with several universities and Max Planck institutes, the DLR Institute of Planetary Research in Berlin is contributing its considerable expertise with VIMS instruments (visual and infrared mapping spectrometer) and ISS (imaging science subsystem).

# Galileo

**Involvement of additional countries in the satellite-supported navigation system**

Galileo is currently in a development and validation phase, which, however, has been extended by approx. two years and whose costs have increased by approx. Euro 430 million. The reasons for this are altered framework conditions and requirements, which were not yet known at the start of the program and at the time the initial costs estimates were made. Formally, the participating countries must unanimously approve a modified program declaration for this and then assumption of the additional costs must be confirmed proportionally. Fifty percent of the costs will be borne by the European Commission. Approximately one third of all work packages are being put out for bid by the ESA; contracts for the main work packages have already been awarded to industry. Additional contracts and requests for bids are planned for the fall of 2005. In this case, attention is being paid to broad competition with preference being given to small and medium-sized enterprises (SME).

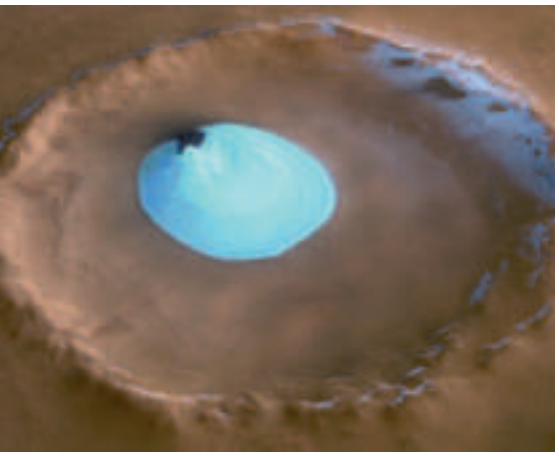
The Galileo Joint Undertaking (GJU), which is responsible for the selection and final negotiation of the concession contract among other things, is currently conducting discussions with the iNavSat and Eurely consortia, which have submitted a joint bid. The "consolidated" consortium with a working name of DION appears to be a more favorable alternative for the public sector as compared to individual bids since a higher return on investment and lower burden for the public sector are expected. The negotiations for third country participation in Galileo are continuing to develop. Along with China and South Korea, contractual details are also being discussed with Morocco, Argentina, Israel and an abundance of other countries. The goal of participation is standardizing Galileo world-wide as a satellite-supported navigation system for civilian applications.

# ConeXpress

**Orbital Life Extension Vehicle**

The CX-OLEV (ConeXpress Orbital Life Extension Vehicle) project harks back to a proposal by Orbital Recovery Ltd. (ORL) and has as its business model the goal of increasing the service lives of commercial telecommunication satellites. A "servicing satellite" is supposed to extend the time of existing commercial satellites in their operational orbits (e.g., by stabilizing the position), make necessary modifications to the orbit or transport a satellite that has been shut-down to a secure orbit. The project is being financed with both private and public funds (ESA and DLR among others). The satellite bus will be built by Dutch Space Co. (NL) and the docking payload by Kayser-Threde in Munich. From a technical standpoint the docking payload and its operation are the most demanding, but also the most crucial parts of the overall project.

The key to these types of service offerings is the ability to dock with non-cooperative satellites. The robotic capture tool for capturing a satellite that was developed by DLR's Institute of Robotics and Mechatronics is supposed to come into play here. Upon conclusion of the feasibility study, the system concept will be defined further including working out and selecting the technical configuration. This is currently underway in the course of Phase B.



**The European space probe MARS EXPRESS discovered a crater with water ice on the north pole of the neighboring planet Mars using the HRSC stereo camera developed at DLR**

**The 3D pictures from the German Mars HRSC camera excited both young and old. During the first half of 2005 approx. 250,000 visitors toured the DLR exhibit "Das neue Bild vom Nachbar Mars" (A new image of our neighbor Mars) in Bonn (DLR) and Munich (Deutsches Museum)**

# Passion for Mars

**First Mars Express Science Conference**

Pictures from the surface of Mars obtained with the assistance of the German high-resolution stereoscopic camera (HRSC) on the Mars Express continued with great success. In February 2005, the first Mars Express Science Conference was held at ESTEC in Noordwijk. The HRSC pictures showed very young, but currently inactive volcanoes and very young glacier erosions. Working jointly, DLR scientists in Berlin-Adlershof and other research facilities were able to discover a frozen body of water in the Elysium layer the size of the North Sea hidden under a layer of sand. The spectacular results have met with great resonance among the public.

The radar experiment MARSIS (Mars Advanced Radar for Subsurface and Ionospheric Sounding) was activated by deploying the antennae. Because of the very low temperatures, the first of the two 20-m booms initially got partially jammed in the process. The blockage was ultimately resolved by heating via targeted alignment with the sun.

Starting December 14, 2004 in the foyer of DLR Bonn-Oberkassel site, 3D pictures of the surface of Mars, models of the hardware and computer films were publicly displayed for the first time on a larger scale. More than 3,000 visitors, including groups of school children and company outings, have viewed the exhibit. Additional locations for the exhibit are currently the Deutsches Museum in Munich, Opel AG's main administration in Rüsselsheim and EADS in Berlin (Potsdamer Platz) for this year's Space Day. Text panels that were translated into Japanese will be shipped to Tokyo in October 2005 and will be on display there until December as part of the "Germany Year in Japan." Additional exhibits in leading facilities are planned for the coming year.

# OOV

**On-Orbit verification of new techniques and technologies**

The techniques and technologies promoted in the past in the Technology for Space Systems program were only seldom utilized in actual space projects since conclusive on-orbit verification was lacking. One reason for this was that potential customers felt that the risk of using technologies that had not been verified in space was too high. Current substantial funding that has been invested in development, proved ineffectual, because numerous, even commercially promising developments were either not used for space purposes or not marketed.

A determination of demand among industry, universities and DLR R&D yielded a consideration demand for verification, above all for new satellite bus technologies.

On the basis of an OOV concept study, new emphasis was placed on the program line On-Orbit Verification of New Techniques and Technologies (OOV) in

the Technology for Space Systems program. The kick-off meeting took place on January 31, 2005 with over 80 participants.

The OOV program is supposed to offer regular flight opportunities, in which the techniques and technologies developed in the national program and/or with R&D funds by industry and research facilities will be verified in orbit and their readiness for use in space demonstrated. As a result, their utilization in future space projects (especially in satellite missions since the great majority are satellite bus technologies) will increase and the competitiveness of the German space industry and research facilities will also rise.

A cost-effective satellite platform in the micro/mini satellite class that has already been verified in orbit will be used as a core element as a technology test carrier (TET). Because of the high demand for the period of 2006-2010, an attempt is being made to launch the first TET in mid 2008 (TET 108) and the second TET in 2010 (TET 210).

As a supplement to this, additional fly-along possibilities for on-orbit verification of payloads that cannot be accommodated on a TET should be used.

The OOV program plan and the TET project plan are currently in preparation. There are plans to conduct Phase A of the TET 108/210 project during the second half of 2005.

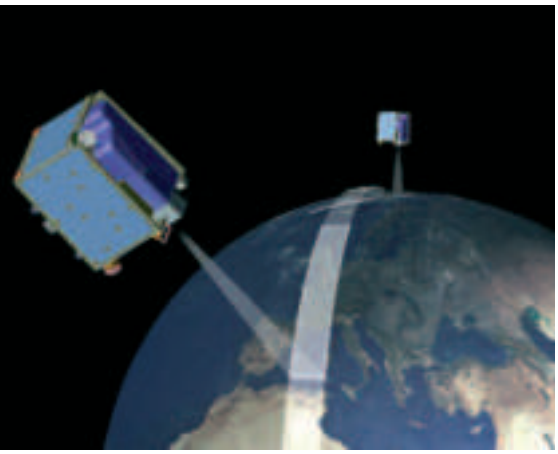
# DLR's parabolic flight campaign

**In 2004 for the first time in Cologne**

The 6th DLR parabolic flight campaign took place for the first time in Germany with the French Airbus A 300 ZERO-G, taking off from the Cologne-Bonn airport, which lent its infrastructure to the project. Biologists, physicians, physicists and materials researchers use parabolic flights both to conduct independent research in zero gravity as well as to prepare experiments for research rockets or for the ISS space station. On five flight days in mid-September 2004 over 100 scientists from German university institutes and companies conducted more than 20 experiments. Even students from three high schools in the region were involved, who studied the swim behavior of paramecia under the directorship of the DLR School Lab. Also invited were decision makers from the political sphere, economy and science, representatives of the media as well as persons in public life. They had an opportunity to look over the shoulders of researchers working in zero gravity and view convincing evidence of the high quality of the science. The parabolic flights were extraordinarily well received by the media and by the public and were one of the main attractions of the 2004 Space Day.

The 6th DLR parabolic flight in Cologne-Bonn showed that the scientists were well supported by closely related DLR institutes and that this kind of event promotes acceptance of space research among a broad segment of the public. As a result, plans are also being made for regular parabolic flights in Germany in the future.

**In 2004, the DLR parabolic flight took place for the first time in Germany, taking off from the Cologne-Bonn airport. Twenty-three experiments were conducted in zero gravity**



Two of the five RapidEye satellites in Earth's orbit (Source: RapidEye AG)

# RapidEye

**Scientific and commercial use of satellite data**

DLR's cooperative agreement with RapidEye AG in a public-private partnership and its investment of Euro 14.7 million in funds from the Federal Ministry of Education and Research has assured scientific utilization of the data. The RapidEye satellite system comprises five satellites with optical cameras, which for the first time will be able to take at least one picture daily of every point on earth in five spectral channels and thereby guarantee a high degree of up-to-dateness of the information product.

RapidEye is oriented to commercial usage by agriculture, the insurance industry, the food industry and organizations in the field of catastrophe aid. The planned products include thematic maps for determining crop damage, crop planning and crop prediction as well as digital elevation models and damage mapping. In addition, the information is supposed to be made available to government and international institutions. Along with commercial usage, DLR will also provide German scientists with routine usage of remote sensing data in numerous geoscientific application fields as well as fields related to environmental research.

Upon the successful conclusion of the Payload Critical Design Review in April 2005 and the Mission Critical Design Review in June 2005, the design of the RapidEye system is fixed except for a few small details.

As a result, Mission Phase C has ended and Phase D has begun, during which the actual construction of the satellite will begin. A Test Readiness Review of the first camera should follow at the end of 2005.

# Earth observation with TerraSAR-X

**High technology for Germany**

The TerraSAR-X project comprises the development, construction, testing and launch of an X-band SAR satellite with high geometric resolution and flexible modes of operation. The project is building on the results of the X-SAR and SRTM missions as well as long years of technology developments, DESA and TOPAS, and will include these in the operationalization.

TerraSAR-X is used to cover Germany's demand for scientific X-band radar data for the application fields of ecology, hydrology, geology, oceanography and interferometry and at the same time represents an introduction to the commercialization of earth observation.

The project is being conducted with the substantial participation of several DLR institutes in a public-private partnership with EADS Astrium GmbH. As a result, it conforms to the goal of the space concept of Germany's government which places a "high priority on the realization of a radar satellite concept," wherein national industries are supposed to participate in the form a public-private partnership. TerraSAR-X is making an essential contribution to expanding the corresponding institutional and industrial position of Germany as an economic site in this important high technology sector.

Integration of the satellite was begun at the end of 2004. The satellite bus structure has been completely constructed in the meantime, and the propulsion system and flight harness have been integrated into the structure. The first radar instrument tests are running successfully. The antenna performance model, a representative model of the radar antenna comprised of 12 units, was completed. Precise electrical measurement produced excellent results.

The construction of the ground segment is also on schedule, as well as the integration of the subunits, Mission Operations System (MOS), Instrument Operations and Calibration System (IOCS) and Payload Ground System (PGS). It can be assumed that work will be concluded on schedule in summer 2005.

# LCT

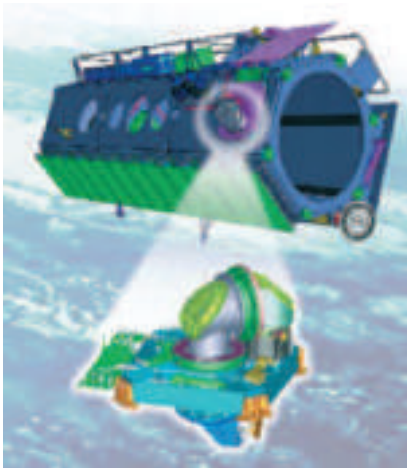
**Laser communications terminal**

The goal of the project is qualifying the laser communications terminal (LCT) technology developed in Germany for space applications and verifying functionality during a fly-along on the TerraSAR-X. The first verification of the LCT is supposed to take place with an experiment from ground to ground in September in a measuring campaign on the islands between two of the Canary Islands. Two LCTs with appropriate measuring and experimental equipment are being built for this. This will permit not only the functionality of the LCT to be verified, but will also allow an investigation of the coherent laser connection through the atmosphere. Work by the DLR Institute of Communication and Navigation is being conducted for this purpose.

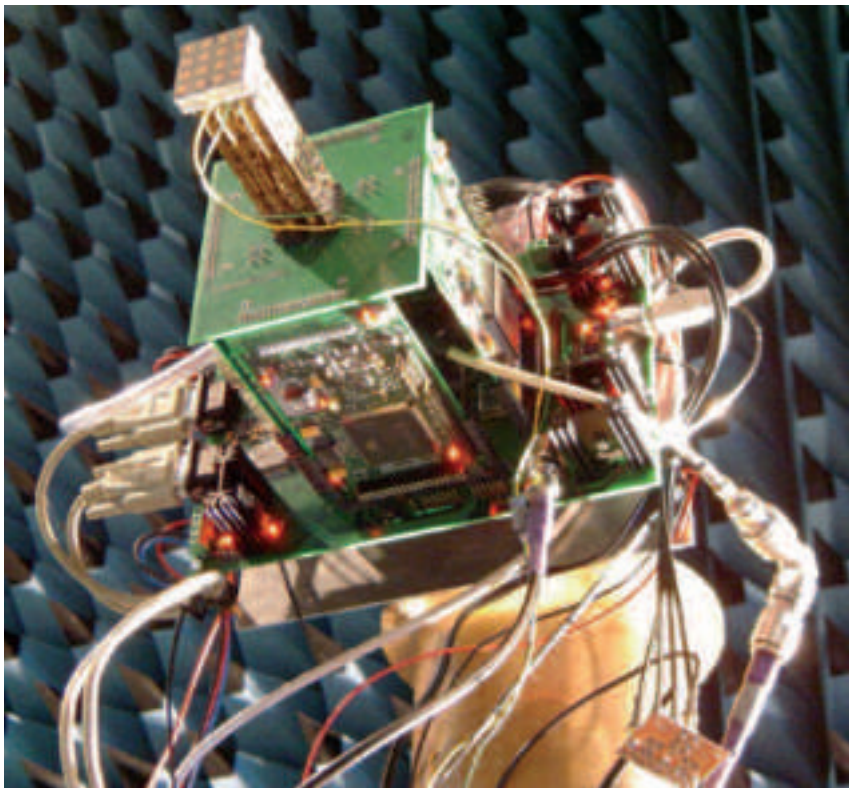
Verification of LCT in an intersatellite link experiment was proposed in 2003 as a joint political initiative of the US Department of Commerce and the German Federal Ministry of Economics and Labor to promote bilateral aerospace cooperation.

For this purpose a second laser communications terminal is supposed to be made available for fly-along on an American satellite. The goal is creating a data connection between TerraSAR-X and the US satellite. The first discussions with US representatives from the political realm and industry took place in March 2004 in Washington. In the process, the Americans expressed political support for this cooperative project and for renewing transatlantic cooperative possibilities. In a letter to the German chancellor's office from C. Rice in her position as security advisor to the US president, the American government expressly emphasized interest in its realization.

The industrial partner in the USA has proposed a second terminal fly-along on a NFIRE satellite with a launch date in the first half of 2006. An initial evaluation of technical and time-related feasibility in March 2005 was followed in May 2005 by more comprehensive discussions and a viewing of the LCT hardware in Backnang.



**Laser communication terminal**



**Technology demonstrator in the antenna measurement chamber**

# SANTANA

**A technology demonstrator from a forerunner project was further developed and optimized in the SANTANA II project.**

Included here among other things are an increased number of antennae elements (8x8) and an expansion in the range of the digital ray formation. The first experiments in spring 2006 are supposed to accelerate technology testing. An initial field test will test the connection between a stationary transmitter and a moving passenger vehicle. These tests will take place on the grounds of the DLR in Oberpfaffenhofen. Once successful reproducible test results are produced, an experiment will be conducted with a research aircraft from the DLR Institute of Flight Guidance in Braunschweig.

It is necessary to build a larger antenna with approx. 100 modules in a short period of time in order to test this antenna technology with a (geostationary) satellite and demonstrate it for potential users (e.g., aeronautics industry). But since this is not something that the current (SANTANA) consortium can afford to do, Lewicki microelectronic GmbH was selected to now manufacture the antennae using an industrial manufacturing process. A corresponding construction and connection technique must be developed first.

# CHAMP

**The German minisatellite CHAMP completes its fifth year in orbit**

CHAMP stands for CHAllenging Minisatellite Payload. The small satellite is used to measure the earth's magnetic and gravitational fields as well as provide associated atmospheric measurements. The satellite is still in the best technical condition and continues to supply valuable information on geodetic surveying, geophysics and oceanography as well as concerning the dynamics of the interior of the earth. Atmospheric and ionospheric observations are helping improve weather forecasting, navigation and monitoring global climate changes. The main user is the Geoforschungszentrum Potsdam (GFZ). With the joint efforts of DLR and GFZ and the support of BMBF, the successful mission was extended recently until the end of 2007.

**Selected results of DLR R&D projects**

# Assistance after the tsunami catastrophe

**DFD provides quick access to satellite maps**

DLR provided assistance after the tsunami catastrophe in southeast Asia at the end of 2004 with its Center for Satellite-supported Crisis Information, federal and state crisis reaction teams, and international workers in the devastated regions. The DLR's German Remote Sensing Data Center (DFD) prepared basic maps as well as up-to-date mapping of the regions that were affected by the tsunami tragedy.

The maps were used to aid in humanitarian measures on site. DFD's Center for Satellite-supported Crisis Information (ZKI) has specialized in providing rapid access to satellite maps in crises and has prepared map material many times in the past during natural catastrophes and for humanitarian relief measures. The special up-to-dateness of the satellite-based maps and their coverage of large areas are especially beneficial for comprehensive overviews of the current situation as well as for assessing damage and coordinating logistics on site. The satellite image maps are adapted specially to the needs of responding personnel.

# Greater precision and reliability

**Satellite-supported communication and navigation systems via ionospheric weather service**

Sun eruptions and the ion storms they trigger can deteriorate or even completely interfere with the signal quality of satellites. As a result, so-called ionospheric errors can produce a lack of precision of up to 60 meters in the global navigation system GPS.

DLR established an ionospheric weather service in July 2004 in Neustrelitz (Mecklenburg-Vorpommern), which is supposed to improve the commercial usefulness of GPS services, i.e., greater precision and greater reliability are the goals of this undertaking. Since it was established, the ionospheric weather service has been providing all communication and navigation systems as well as navigation services on a Europe-wide basis with current information, corrections and predictions about weather in space and its effects on the condition of the ionosphere. In particular, measuring methods and forecasting models for GPS users engaged in diverse fields of the economy are being further developed, above all with respect to the civilian European satellite-supported navigation system GALILEO that is under construction. This system places new challenges on the precision and reliability of satellite-supported navigation systems.

**Intelligent lightweight robotic articulation units of the ROKVISS experiment (EADS Space Transportation)**

# Premiere of ROKVISS

**Robotic arm moving in outer space**

The innovative robotic experiment ROKVISS (robotic component verification on the ISS) developed by DLR began its work on the ISS international space station on March 22, 2005. This represented a crucial step in the execution of the experiment. All systems are functioning normally and the planned year-long routine operation of the experiment under harsh outer space conditions was started. The approximately 50 cm long robotic arm with two joints, a metal finger and two integrated cameras were controled from the ground and then set into motion in so-called automatic mode. Concretely speaking, command sequences were transmitted to the ISS, which were then later executed by the robotic unit independently and automatically as programmed.

Since April 2005, the ROKVISS technology experiment can also be triggered directly from the ground and put into motion in open outer space. DLR conducted crucial tests from the Upper Bavarian ground station in Weilheim using the so-called telepresence mode with power feedback during an approximately six-minute flyover of the ISS international space station. For the first time a robot in space was operated from the ground without too great a time lag, something that was unheard of till now in space robotics.

# Saturn's moon Phoebe

**Fascinating observation**

There are much more varied chemical elements and molecules on Saturn's moon Phoebe, which is only 212 kilometers large, than was previously assumed. This is the result of an assessment of Phoebe spectrometer data collected by Cassini, the American space probe. A scientist from the Institute of Planetary Research in Berlin-Adlershof is involved in the study along with planetary geologist Dr. Ralf Jaumann. The composition of Phoebe supports the theory that the small Saturn moon did not originate along with the ringed planet, but had its origin further in outer space in the solar system, namely in the so-called Kuiper Belt between Neptune and Pluto. Not until later was it captured by Saturn's gravitational force.

The surface of Phoebe is comprised primarily of water ice, which is mixed with carbon dioxide, hydrated minerals, like those occurring on earth in loam and clay for instance, as well as with some as yet unidentified compounds. Even traces of primitive organic compounds, i.e., hydrocarbon molecules, are detectable. The composition of the surface shows little similarity with the asteroids found between Mars and Jupiter. On the contrary, the material of which Phoebe is composed originated far outside in the solar system. It is so cold there that these chemical compounds made of volatile elements are actually stable. This body is a part of the most primal material whatsoever in the solar system, the age of its surface is at least four billion years.

# New upper stage engine

**First long-time test under outer space conditions**

The most powerful European rocket, the Ariane 5, can transport a maximum of 9.6 tons into a geostationary transfer orbit. An upper stage engine is being developed for possible future applications, which can transport at least two more tons into orbit and can be re-ignited several times above the atmosphere in outer space. The so-called Vinci engine successfully concluded the first five-month test series at DLR in Lampoldshausen. As a result, an important requirement for a more efficient European rocket vehicle has been met.

The first long-time test with an engine burning period of 60 seconds took place in early summer 2005 on the P4.1 test bench under vacuum conditions, i.e., under conditions that are similar to those in outer space. This was a double premiere for the DLR in Lampoldshausen. First, full functionality of the brand new Vinci engine was verified after a total of only nine tests, and secondly the new P4.1 test bench, which was built especially for testing the new engine, was successfully qualified. As a result, two important milestones were reached for future support of the European rocket vehicle.

# Matroshka

**On the trail of cosmic radiation**

MATROSHKA was flown to the international space station in 2004, where it was mounted on the outer skin of the Russian part. MATROSHKA houses a life-size model simulating the upper part of the human body. As a result, it was possible for the first time to study the effects of cosmic radiation during extra-vehicular activities on organs such as the eyes, lungs, stomach, kidneys, intestines and other organ systems in the human body.

It is necessary to know the dose absorbed by the individual organs of the human body in order to estimate the risk of radiation-induced cancer. Since organ doses cannot be measured directly, realistic anatomical models have to be used for these types of measurements. This is the only possible way to determine the necessary relationship between the skin dose and the organ dose, which is required for a precise determination of the physical dose of the astronauts. This is particularly important in the case of extravehicular activities, because in contrast to staying inside the ISS in this case the skin dose is substantially greater than the dose to other organs. Thus, for the first time a concrete data record is available to detect the organ doses under EVA conditions.

As the main contractor, DLR's Institute of Aerospace Medicine successfully developed and constructed the MATROSHKA experiment on behalf of ESA. DLR's User Support Center (MUSC) in Cologne is handling operation of the experiment and they are involved for the first time as a user center for ISS activities on behalf of ESA.

# Transportation

**The positive development of the relatively DLR core research area of transportation has also continued during the reporting year. In addition to expanded internal networking, which is being documented by the three transportation institutes in Berlin, Braunschweig and Stuttgart as well as additional 18 DLR institutes involved in the core area of transportation, cooperation was also intensified with national and European transportation research. Targeted use in areas of competence already existent at DLR from the fields of space, aeronautics and energy makes unique synergistic effects possible in the research of transportation-related questions. This led to innovative problem-solving approaches for current and anticipated problems in the transportation sector.**

**The dynamic driving simulator makes near realistic testing of assistance systems possible**

## Driver Assistance Lab

**Another large DLR research facility is currently being constructed with the Driver Assistance Lab (FAS Lab)**

The goal in this case is developing and testing new ideas for driver assistance systems. Ideas for concepts come from own studies of the stress and strain of driving a car and from accident analysis. The key idea is offering the driver, via driver assistance, precisely the support that he really needs, which will help him in critical situations.

The first of three development stages in this lab is the Virtual Reality Lab (VR Lab). It is comprised of a so-called immersive projection system (CAVE) and the associated computer hardware. Stereo projection and head tracking makes realistic spatially perceptible simulations of an auto cockpit as well as the environment possible. A seat with a steering wheel and pedals are available to control the virtual vehicle. The rest of the vehicle's passenger compartment only exists virtually. Due to the fact that real cockpit equipment has been dispensed with almost completely, new driver assistance systems can be evaluated rapidly with regard to utility and acceptance (so-called rapid prototyping).

Systems that receive a positive evaluation are then realized as prototypes in hardware and integrated into stage two of the FAS Lab, the dynamic driving simulator. In this simulator, a complete passenger vehicle structure with fully functioning instrumentation as well as the movement of the simulator makes for an even more realistic effect. Only the surroundings are still simulated. Stage three of the FAS Lab will be comprised of a test vehicle that is supposed to be used to test the prototypes in reality. Its first use is planned for early 2006.

In order to be able to analyze and evaluate the stress and strain of the driver, additional comparable test drives are being conducted in the ViewCar measuring vehicle and in the VR Lab. In the case of the test drives in the VR Lab "hazardous" situations are also being provoked. The parallel tests are helping make it possible to also actually apply the results from the VR Lab to real driving situations.

# KOMPASS

**Mobility development in Germany**

The main objective of the KOMPASS project is preparing a report on the situation concerning mobility in Germany. Indicators are being prepared for this purpose and they will be used as the basis for evaluating mobility development. The DLR Institute of Transport Research in Berlin handled the preliminary content-related and coordination work. Later in a workshop held in May 2005, a joint course of action was worked out with leading partners from science, research and politics. The partners emphatically welcomed DLR's initiative in coordinating the development of such a set of indicators since this type of research and reporting activity has been considered necessary for some time now. Above all, KOMPASS is supposed to deal with the topics of economic efficiency, ecological stability and the social harmony of traffic and mobility in Germany. It is supposed to be used to monitor transportation development as well as identify current and emerging problem fields including any possible potential for improvement. Along with handling the overall coordination of the project, DLR will continue to advance content-related development and bolster it with their scientific contributions.

# Hylite

**DLR and automobile suppliers realize fuel cell hybrid vehicle**

The Hylite, a test vehicle developed by the DLR Institute of Vehicle Concepts, was unveiled to the public on June 14 in Stuttgart. The eponymous project was thereby successfully concluded. The primary objective of the project was building a mobile test platform for developing and characterizing components for fuel cell vehicles. The Hylite experimental vehicle was originally an electric vehicle, which DLR scientists converted to a fuel cell vehicle in cooperation with ten industrial partners from the automobile supplier industry. In addition, the vehicle was equipped with hybrid technology comprised of a combination of the polymer electrolyte fuel cell (PEFC) system and a traction battery. This allows the braking energy for instance to be reclaimed, which is supplied during vehicle acceleration to support the fuel cell and thereby increases the efficiency of the powertrain. The development of the energy management functions and of the operating strategy of the fuel cell system was also supported by DLR test benches.

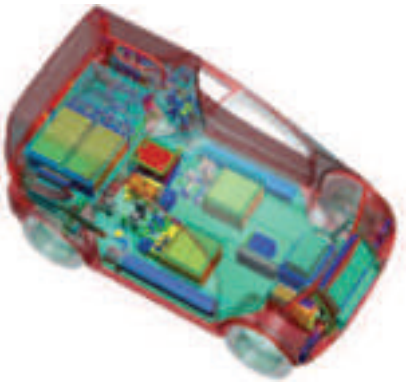


**Photo and cut-away view of the HyLite vehicle with the project partners' components**

**2D visualization in the RailSiTe driver's console**

# RailSiTe

**Railway simulation laboratory**

The RailSiTe® railway simulation lab represents an independent platform for researchers, manufacturers, operators and regulatory authorities, which can be used to perform comparative tests of systems and variants for the use of railway signaling and control systems with respect to operational behavior and productive capacity. In addition, it is also possible to test the conformity and interoperability of subsystems and components from a functional and operational or safety-related point of view. The modular structure of RailSiTe guarantees great flexibility and expandability of the lab. This is related for one to the possibility of supplementing RailSiTe with other technologies besides the currently implemented techniques of ERTMS (European Rail Transport Management System) and ETCS (European Train Control System). In addition, hardware-in-the-loop and cross-reference tests can also be conducted along with pure simulations.

RailSiTe depicts a complete chain from the signal box operator to the railway line and train dynamics to the driver of the tractive train driver. The latter is integrated into the process via a real driver's console with 2D visualization. In addition, the infrastructure available in the Institute of Traffic Management and Vehicle Control is supposed to be incorporated, i.e., the movement platform and the institute's own Virtual Reality Lab, which makes a stereoscopic 3D visualization of the driver's view possible.

The RailSiTe railway simulation lab is certified as specified in DIN EN 45004 and a recognized subcontractor of EBC (Eisenbahn Cert), the appointed office for interoperability of railway systems in Germany.

# GALILEO

**Applications for transportation**

Within the field of DLR transportation research, a working group comprised of the Institute of Transport Research, the Institute of Communication and Navigation and the Institute of Transportation Systems has been occupied intensively with the question of what added value the GALILEO satellite navigation system generates as compared to GPS/GLONASS and how this added value can be used for transport-related applications. The results of the work were summarized in the exposé entitled "GALILEO in Transportation." Included along with a description of the services of the GALILEO core system is a detailed delineation of the GPS and GLONASS systems already in existence.

It has been revealed that GALILEO also has integrated components for guaranteeing integrity and technical reliability in addition to improved accuracy and increased availability as compared with GPS/GLONASS.

This means that a time-defined warning message is modulated to the GALILEO navigation signal as soon as a violation of the specified performance level is detected. This is of vital importance above all with regard to applications that are critical for safety. In addition, as a civilian system GALILEO offers political reliability that is independent of sensitive political objectives. Based on the identified differences from GPS/GLONASS, specific research and development fields in the transportation sector are defined and described in the exposé, which can only be realized on the basis of the added value generated by GALILEO.

# Traffic Tower

**Construction of a virtual traffic management center in Berlin**

DLR's Traffic Tower at the Berlin-Adlershof site is a virtual traffic management center. Just like aviation simulators, this facility can generate traffic scenarios and simulate emergency conditions. The equipment in the Traffic Tower is based on real traffic centers thereby creating a fully functional traffic center in a virtual environment.

A closed loop link between a traffic control computer and a traffic simulation forms the core of the Traffic Tower. This creates a human integrated simulator for traffic centers, whose application fields will be research, testing and training.

Construction of the hardware, including renovating and equipping the premises, has already been completed along with integration of the first projects. Thus, e.g., traffic simulations of the Damschkeplatz in Magdeburg and the highway interchange in Munich-Nord were carried out. A section of the Berlin BAB 100 highway was also depicted as a prototypical realization of the closed loop and has been continually expanded since then. Completion of the traffic tower is planned for the end of 2005, and conclusion of the required validations for the summer of 2006.

**Traffic Tower – DLR's virtual traffic management center**

# Measuring and test route for traffic data

**Traffic research on the street**

Scientists at the DLR Institute of Transport Research have built a measuring and test route that is one and one-half kilometers long in a public street area. A flexibly useable test and trial field in the direct vicinity of the institute on the Ernst-Ruska-Ufer in Berlin-Adlershof, a heavily traveled highway feeder road, is available for traffic detection, data merging and preparation.

The measuring route is equipped with common traffic and surrounding field sensors, which are installed on two sign bridges and several streetlights. To begin with, the sensors are set up in such a way that they can continually detect a standardized basic load of the usual traffic data and surrounding field data. They can be configured individually as needed and be installed so that they are focused on the vehicle for example. In addition, new sensors can be installed without great expense on the sensor supports (sign bridges and streetlights) in order to test and reference these using existing sensors and video images. The data collected are transmitted from the route stations via optical wave fibre to the Traffic Tower, the institute's virtual traffic management center, where it archives, evaluates and combines them with other data (e.g., floating car data/FCD).

**Structure of a sign bridge on the Berlin measuring route**

# Energy

**DLR's work focuses on two central topics of energy research: increasing efficiency in conversion and utilization of energy, and developing new technologies for the provision of renewable energy.**

**The development of stationary gas turbines takes up a central position. Focusing on the fields of compressors, combustion chambers and turbines, DLR is making a contribution to generating electricity with the highest efficiency taking future fuels into consideration. Solar thermal power plants offer the option of providing electricity generated in an environmentally friendly manner on a large technical scale under most attractive conditions. Sensor technologies make it possible to operate future fuel cells systems automatically for most of the part. New research results allow the development of new, highly specialized functional layers for a variety of applications from fuel cells to heat transfer media. Interdisciplinary systems analysis serves as a basis for political consultation and supports the thematic orientation of energy research at DLR as well as at the Helmholtz Association.**

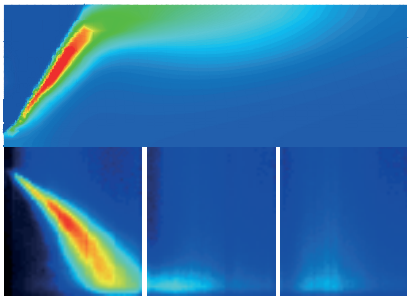
**Activities are concentrated on selected technologies and DLR is in a position to make crucial contributions because of its special expertise. DLR is also able to utilize synergistic effects from its other core research areas.**

## HEGSA

**Characterizing alternative fuels**

In collaboration with industrial partners, the use of lean syngases in modern gas turbines was studied in EU's "High Efficient Gas Turbine with Syngas Application" project (HEGSA). These fuels are characterized by a high proportion of hydrogen. In this case special attention was paid to combustion management and the design of the burner. Modern gas turbines are operated at high temperatures and high pressures. Because of their high reactivity the ignition behaviour of synthesis gases must be considered in order to exclude damage to the burner and combustion chamber due to possible self-ignition or flashbacks.

A detailed reaction model was validated for a wide range of parameters (pressure, temperature, fuel-air ratio) for syngas combustion with respect to heat emission. This reaction model was then reduced in two steps to a global reaction mechanism, which is comprised of only two reactions and five independent species. This reduced reaction model was implemented in a CFD combustion model developed at DLR. Combustion chamber flows with syngas combustion were numerically simulated. Combustion experiments for different syngas compositions (OH-PLIF, PIV) were successfully conducted at two pressures in a newly constructed test combustion chamber. The numeric simulations of these experiments with the aforementioned computational



**Simulation of combustion chamber flow. Top: CFD calculation; bottom: Measurement of OH molar fractions for synthesis gas**

models ultimately yielded very good conformity of calculation and measurement.

# Optimizing the gas turbine

**Local thermal protection via film-cooled turbine platforms**

Increasing the thermal efficiency of turbo machines is of great significance for the future energy supply. In the case of modern gas turbines, this leads to higher temperatures as well as flatter temperature profiles and thus to substantially greater thermal stress on the components. In the course of the AG-Turbo "Optimizing Film-cooled Turbine Platforms" project, several slot and hole arrangements were examined for efficient cooling of the highly thermally stressed first rim of the turbine guide vane; in this case, it was possible to define an improved cooling configuration and to reduce the demand for cooling air.

To cool the inlet area, cooling air is frequently blown out of a slot. The position of this slot plays a decisive role in the effectiveness of cooling and in the losses in the secondary flow field. Because of the vortex structures near the side wall (horseshoe and passage vortices) it is difficult to supply the pressure-side area of the passage with an adequate cooling film. One possibility is placing several rows of holes, which can be used to generate local thermal protection in a targeted manner.

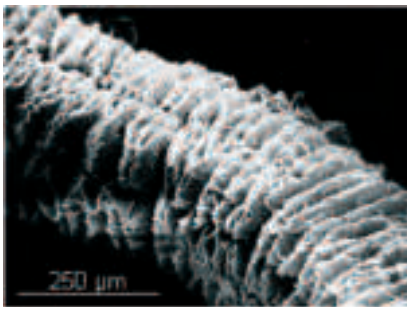
# Latent heat storage for power plant technology

**Thermal conductivity improved ten fold for new heat storage media**

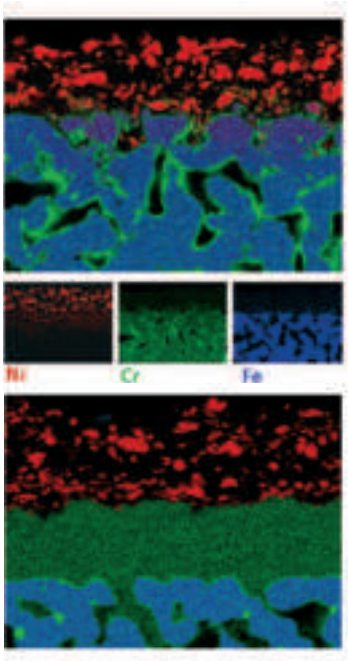
Latent heat storage is particularly well suited for efficiently storing heat or cold since. It utilizes a phase change, (e.g., solid/liquid melting) of a phase change material (PCM) and can thereby store large quantities of heat in a narrow temperature range around the phase transition. As a result, with small temperature changes of 10° C, a ten to 20-fold higher heat storage density can be achieved compared with conventional heat storage.

The crucial problem in technically converting the latent heat storage lies in inadequate heat transport between the store (PCM) and the heat transfer medium. The main reason for this is the generally low thermal conductivity of the organic or inorganic storage media.

DLR developed high-temperature heat storage for applications in power plants and industrial process heat. In this case, salts are choosen as the latent heat media. In a novel PCM materials concept salt and graphite composite materials were developed and manufactured for the first time on a technical scale together with the industrial partner SGL Technologies. The newly developed composite materials with a basis of 85 % salt and 15 % expanded graphite are distinguished by significantly improved thermal conductivity. Previous materials realized on the basis of potassium-sodium-nitrate mixtures and potassium-lithium-nitrate mixtures cover a temperature range of 150 to 300° C and are therefore predestined for storing and generating process steam.




**New composite material made of salt and graphite for high-temperature heat storage**




**Sectional images of a Ni-C/YSZ anode on an ITM14 alloy without a $LaCrO_3$ barrier (top) and with a $LaCrO_3$ barrier (bottom)**

# Long-term stability from plasma spraying

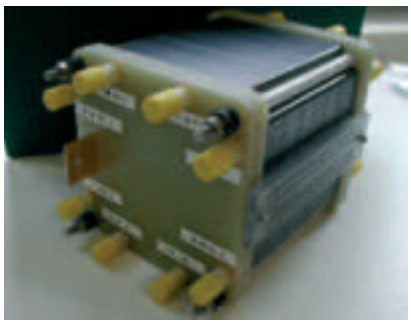
**New possibilities for fuel cells**

In developing oxide-ceramic high-temperature fuel cells (solid oxide fuel cell or SOFC), a focal point of work was the development of intermediate and insulating layers which are applied via vacuum plasma spraying and which are very important for the long-term stability and functioning of the SOFC. To prevent the damaging intermetallic diffusion of iron and nickel, $LaCrO_3$ diffusion barrier layers were developed, which represent an effective diffusion barrier and also possess high conductivity and an adapted coefficient of expansion. This is especially relevant for avoiding thermomechanical stress during heating processes up to 800° C and corresponding cooling times. These types of insulating layers were developed successfully in cooperation with an industrial partner and are required for all SOFC cell concepts currently under discussion.

# Direct methanol fuel cell

**Patented DLR method in use**

In the course of the EU project "DMFC (1 kW) Portable Power Generator" (PORTAPOWER), a direct methanol fuel cell stack with a maximum power of 1 kWel was built, which uses membrane electrode units (MEA) developed by DLR. These MEAs are manufactured with a patented DLR method using a dry coating. The project consortium selected the DLR MEAs, because they have a substantially greater power density than comparable products. The direct methanol fuel cell stack is currently being tested and integrated into a system for a grid-independent supply of electricity.



**Direct methanol fuel cell stack with 1 kW power**

# Solar thermal power plants for the Mediterranean region

**BMU-funded study documents economic efficiency with hybrid operation**

Population growth and economic development in North Africa and the Near East have produced a situation where the demand for electricity will approximately triple by 2050 and the demand for water will double. If the structure of the energy supply remains constant, $CO_2$ emissions will rise from 770 to 2,000 million t/a. The use of renewable energy, on the other hand, could diminish the emissions in the same time period to 475 million t/a. Electricity costs could be kept in the long term at approx. 4-5 c/kWh, instead of increasing to 8-10 c/kWh. A balanced mix of renewable and fossil energy is the most economical form of generating electricity for the Mediterranean region in the medium term. Solar thermal power plants will play a key role in this. The potentials in the region clearly exceed the demand and, thanks to thermal energy storage and hybrid operation, electric power is available at all times. In addition, in heat and power systems the heat can also be used to desalinate seawater and thereby make a substantial contribution to eliminating the shortage of drinking water. These are the results of the BMU-funded study "Solar Thermal Power Plants for the Mediterranean Region" (MED-CSP), which DLR prepared together with partners in the Mediterranean region. Imported electricity from solar thermal power plants could make a medium-term contribution to the supply of electricity in Europe.

# Decentralized solar power supply

**Performance records with Dish/Stirling systems**

Parabolic dishes with Stirling motors (Dish/Stirling systems) are being developed for decentralized solar electric power supply and are on the brink of being introduced into the market. Optimizing operational behavior and increasing reliability are presently the focus of development work. With a system located in the French Pyrenees a new power record of approximately 11 kWe was recently achieved. Among a number of things, this was due to switching the Stirling working medium from helium to hydrogen, resulting in higher efficiency. In addition, a new arrangement of the receiver insulation was developed, which considerably reduces heat losses. Furthermore, it was possible to raise availability to 95 % during the last few months at the facilities which are operated at Plataforma Solar de Almeria in Spain. Because of these excellent results, manufacturing a first small series of these systems is the current objective.

# Solar generation of hydrogen

**High efficiency in utilization of thermo-chemical cyclic processes**

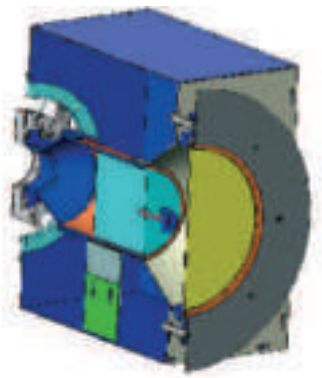
One of the new energy topics of the Helmholtz Association is the development of methods to generate hydrogen by using concentrated solar radiation. DLR works on this theme in several European projects.

In future, thermo-chemical cyclic processes can contribute to making hydrogen available from water in a renewable manner, highly efficient and without the discharge of greenhouse gases. In these processes, chemical reactions are used in which the base material applied to generate hydrogen must be thermally regenerated before it can be reused. This regeneration can be accomplished by using concentrated solar radiation. Thermo-chemical cyclic processes offer the opportunity of reducing the temperature of 2500-4000° C required for direct thermal water splitting to a manageable 1200° C or less. The more steps such a cyclic process has, the lower the required temperature can be, but the poorer the efficiency also becomes.

DLR has made crucial breakthroughs in two cyclic processes during the last few months. Solar hydrogen was generated for the first time using the two-stage cyclic process of water splitting on ferrites in solar furnaces in Cologne-Porz during the HYDROSOL project. In the meantime, it was possible to test a material, whose activity remained at an unchanged high level even after 15 regeneration cycles. This result suggests that a cycle number that is higher by several dimensions can be achieved, which is necessary for the process to be realized commercially.

In a second method, the three-stage so-called sulfur-iodine process or general atomics process, the crucial step is the thermal splitting of sulfuric acid. Recently, sulfuric acid was successfully split in the HYTHEC project in a new type of solar reactor with a very high conversion rate. This is a crucial breakthrough on the road to a technical conversion of the sulfur-iodine process on the basis of solar energy.

**Dish/Stirling prototypes during testing at the Plataforma Solar de Almería**



**HYTHEC reactor, sectional drawing**

# Project Management Agencies

## Project management agency for aeronautics research and technology

**National aeronautics programs remain the focus of the project management agency**

The project management agency for aeronautics research and technology (PT-LF) supports the German Federal Ministry of Economics and Labor (BMWA) in implementing the aeronautics research program of the German Federal Government (called "Lufo" for short) and the German states of Bavaria, Brandenburg, Hamburg and Rhineland-Palatinate, which supplement the federal program with their own funding. In 2004, PT-LF was fully involved in implementing the new federal research program for the period of 2003–2007. In the process, PT-LF handled 195 projects in 34 associations. At the same time, there were still 16 active projects to be processed from the aeronautics research program for 1999–2002 that had run times extending until 2005 in some cases.

Outlining the basis of the program in 2005 set the tone for the new 4th federal aeronautics research program. In continuity with the predecessor program, it continues to take aim at the challenges set for the time frame until 2020. A team of 11 employees handled these focal points of work together with other far-reaching activities listed here. A high degree of work capacity was involved due to the statements that had to be drafted in regard to the 2nd German Federal Court of Auditors report. In the part related to projects, 15 commentaries on individual projects had to be processed.

The support for the BMWA section extended as it did previously to processing loan contracts for the A380 as well as to preparing and manning the booth of the German aerospace coordinator at the ILA 2004 Berlin air show. The task of being a national contact point for EU aeronautics and security research has become more demanding and more comprehensive because of increased integration into the network of national contact points and requires increasing attention.

In October 2004 at the GARTEUR Council, Germany proposed forming an Aeronautics ERA-Net on the basis of the GARTEUR. On the one hand, this is intended to accommodate the EU Commission's push to form a network of Member States in the field of aeronautics research and, on the other hand, to avoid duplicating existing technological cooperative efforts. PT-LF has assumed a coordinator role in the ERA-Net "AirTN." Coordination within the consortium comprising 25 partners and contract negotiations will be concluded in 2005. The term is supposed to begin in January 2006.

The German states where aeronautics sites are located are making a contribution to aeronautics research in Germany with their own funding activities. Looking at the necessary coordination of activities by the German states with the German federal program and with EU aeronautics research, the responsible ministerial departments of Bavaria and Hamburg (where major sites are located) have also continued to have the project management agency for aeronautics handle their funding projects. The Ministry of Economics of the German state of Brandenburg also concluded a separate contractual agreement with the DLR in 2004 to have the project executing organization look after its aeronautics research funding projects.

In 2004, project management agency responsibilities for the German states of Bavaria, Brandenburg, Hamburg and Rhineland-Palatinate included handling a total of 59 projects.

# Project Management Agency in DLR

**2004 – a year of consolidation**

PT-DLR, the project management agency in DLR, performs scientific, organizational and administrative management tasks for the German Federal Ministry of Education and Research (BMBF), the German Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (BMFSFJ), the German Federal Ministry of Health and Social Security (BMGS) and the German Federal Ministry of Economics and Labor (BMWA) in connection with their funding programs. It also acts on behalf of state ministries and private companies.

The mergers during 2002 and 2003 were followed by a year of consolidation in 2004. There were no large changes affecting the overall project management agency. However, it was possible to take the first steps toward moving more closely together. Four former sites in Bonn became two in the meantime.

The PT-DLR employed 500 people as of the reporting date of December 31, 2004. The total research funding handled by PT-DLR for promoting research reached a level of over Euro 558 million in 2004 (see table), which financed a total of approx. 4,200 projects. The funds administered increased slightly if the UMTS special funds that were time-limited until the end of 2003 are omitted from the accounting.

The content of PT-DLR's main activities included the fields of health and environmental research, information technology, new media in the economy and education as well as research on shaping the work world. Other focal points of PT-DLR's work were funding activities in the fields of education research, the humanities and equal opportunity and gender research. PT-DLR operates both nationally and internationally and because of its many years of experience in the fields of research and educational promotion as well as project management, it has forged very good contacts with researchers and research institutions, specialized groups and proven experts in the national and international research world.

The PT-DLR shows great flexibility in adapting to the ever-changing requirements of its contractors. As a result, despite cutbacks in the federal budget, the PT-DLR was able to gain several new assignments. The most recent examples of this are the execution of the Einstein Year 2005 as well as coordination of the all-day school program, both assignments from the BMBF. Special emphasis should also be given to PT-DLR's participation, on behalf of the BMBF, in the 6th research framework program of the European Commission in several calls for proposals to expand to the so-called ERA networks (ERA = European Research Area). This funding instrument created, for the first time, the possibility of networking the national funding programs of the EU Member States with those of the European Commission. The goal is reciprocal access to funding programs as well as developing and implementing common measures. A total of 12 of the applications submitted by PT-DLR to the EU were successful, which is a great first step in the direction of Europe-wide business segments.

A detailed description of all work and programs can be found in the PT-DLR's annual report at: (www.pt-dlr.de/pt/service/publikationen).

**Use of budget resources**

| | 2003* | 2004 |
|---|---|---|
| Information technology | 192,615 | 168,027 |
| Health research/human genome research | 181,197 | 165,548 |
| Environmental research and technology | 53,497 | 59,898 |
| Education research | 32,200 | 40,157 |
| New media in education and technical information | 98,849 | 35,314 |
| New media in the economy | 38,735 | 29,921 |
| Development of work | 28,899 | 26,983 |
| Helmholtz Association Strategy Fund | 19,142 | 11,389 |
| International office | 9,467 | 10,330 |
| Equal opportunity/gender research | 5,975 | 6,595 |
| Humanities | 2,169 | 2,234 |
| Office for Einstein Year 2005 | — | 1,929 |
| European programs | — | 106 |
| **Total:** | **662,745** | **558,431** |

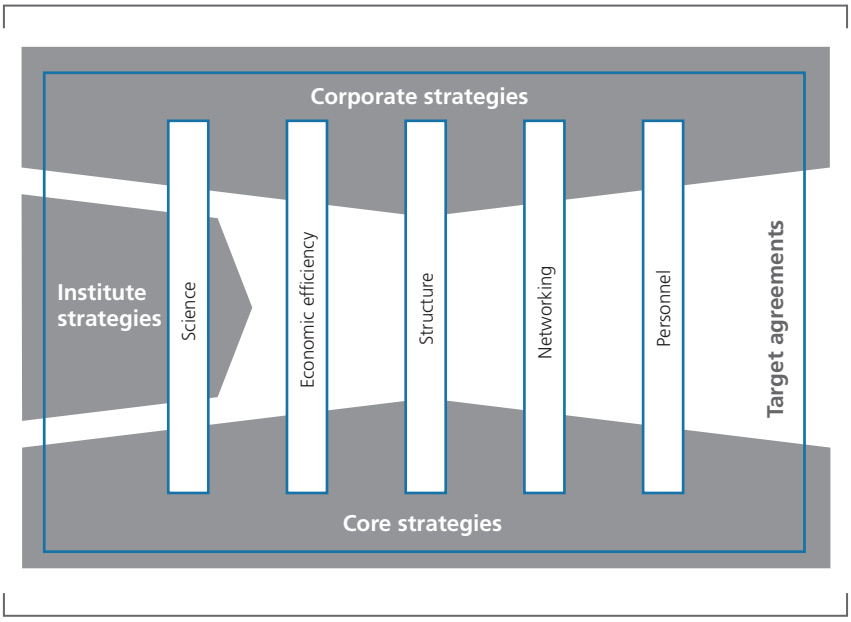
* This includes the considerable UMTS funding which was time-limited through 2003; if these funds are not taken into account there was a slight increase in funding from 2003 to 2004.
All data in thousands of Euro


DLR

# CORPORATE RESULTS

# Corporate Strategy

**The DLR considers itself a "research enterprise." This translates to combining first-class research at the highest level with an organization, which blends corporate dynamics, efficiency and flexibility. With this claim DLR has continually improved the professionalism of its approach to work over the last few years. This begins with a stringent corporate strategy, from which the specialized strategies of the core areas of aeronautics, space (with the integrated German Space Program), transportation and energy are derived, which in turn represent the basis for the business plans of the 31 institutes and facilities (see diagram). DLR has a consistent process orientation in the administrative technical infrastructure (ATI) in terms of providing various service functions such as third-party funding administration for example. It also includes a far-sighted Europeanization strategy and targeted international commitment. And it is manifested in modern human resources management, which places special emphasis on motivation, equal opportunity and family friendliness.**




This second part of the annual report, the corporate results, will describe the foregoing corporate areas and discuss the most important activities. This is substantiated by the presentation of selected key numbers, which underpin the "research enterprise" claim. These figures are not just intended as a verification of our achievements, but they also represent a benchmark for partners and competitors. DLR uses these results to get its bearings, which particularly underscore scientific excellence and economic success in the scientific and research system and serve as verification of the importance and demand for its research activities, also at an international level.

# Results

## Third-party funds

A third-party funding rose again in 2004 by Euro 2 million to Euro 242 million. What must be specially emphasized here, among other things, is the increase in income in the domestic economy by 18 % to Euro 39 million, which is based not just on the successful conclusion of a large project, but also on an increase in contracts in this field as a whole and higher individual revenues. This was contrasted by a drop in the percentage of income from foreign customers to 35 %. Even though the income from foreign commercial enterprises increased, it was not sufficient to compensate for the substantial drop in income from third-party projects with foreign government agencies. The cause of this was the ending of the VINCI P 4.1 project, which as in previous years contributed to 85 % of the income from foreign government agencies.

Income from EU projects as well as other projects remained at approximately the same level as 2003. The decrease in income brought about by the final conclusion of projects in the 5th EU research framework program in the EU area was almost completely balanced out by an increase in income from projects of the 6th EU research framework program. In the process, the success rate of EU proposals (averaged over three years) increased considerably from the previous year's figure of 33 % to 42 %. The ratio of coordinator/EU projects remained about constant overall at 13 %.

Income from national governmental sources (without project management agency) rose by 5.9 % to Euro 53 million. However, projects with national governmental institutions dropped by Euro 1.9 million. This is essentially due to a decline in project support from the German federal government of Euro 1.8 million. As a result, the previous year's trend, based on a modified funding policy, continued. What must be noted, however, is that results of funding from German states increased slightly (up Euro 0.6 million). This upswing is the result of support for the construction of the Institute of Vehicle Concepts (Stuttgart) and Institute of Transport Research (Berlin). Income from contracts with the German federal and state governments dropped by Euro 0.7 million. However, this is contrasted by an increase in other domestic governmental research and development in the amount of Euro 12.5 million. What is crucial in terms of this increase is above all the increase in income from Helmholtz Association subsidies, which was produced by the conclusion of new projects (virtual institutes). Income of Euro 47 million was produced in the field of project management agency activities.

**Third party-funding**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Total third-party funding | Euro 233 m | Euro 240 m | Euro 242 m |
| Third-party funding as a percentage of total income | 49 % | 49 % | 49 % |
| Growth in German operating income from R&D | +20 % | -11 % | +18 % |
| Percentage of income from foreign customers (income volume) | 35 % | 39 % | 35 % |
| Success rate of EU proposals over the past three years (accepted/submitted) | 38 % | 33 % | 42 % |
| Income from EU support | Euro 12.6 m | Euro 13.1 m | Euro 12.5 m |
| Ratio of coordinator/total (current EU projects) | 15 % | 14 % | 13 % |

Numerical data according to financial statements

# Research-related results

For an application-oriented research institution like DLR, third-party contracts are an important indication of the quality of its services and the demand for them. However, the scientific results of research work are just as important. Publications, lectures and teaching activities provide information on scientific quality and productivity, and are continuously recorded. Numbers may fluctuate for various reasons, including project work, changes in personnel levels, or contract activity.

In 2004, somewhat fewer (in absolute terms) articles were published in refereed technical journals (450) as during the previous year (524). However, if one adds refereed publications in proceedings, books, etc., to this, the result is a grand total of 950 publications, which were subject to some form of review by experts before publication.

Fortunately, all key figures in the table improved as compared with 2003. Especially noteworthy are the obvious increases in teaching contracts at universities as well as masters' theses. Doctoral dissertations also registered another notable increase.

**Research-related results**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Talks at scientific conferences, workshops and lectures* | 0.77 | 0.82 | 0.88 |
| Appointments to universities | 11 | 11 | 12 |
| Teaching contracts | 131 | 137 | 159 |
| Masters' theses | 150 | 199 | 235 |
| Doctoral dissertations | 63 | 77 | 86 |
| Postdoctoral lecture qualifications | 3 | 4 | 5 |

* per scientific employee in institutes and facilities

# Technology marketing

Technology changes markets, and markets influence technologies and products. DLR's technology marketing sees itself in this area of interaction as an agent for innovative technologies and as a partner to industry who provides technological solutions to problems. Technology marketing is a core process of DLR which extends from the needs of the market to marketing DLR's expertise to industry. The main objectives are modifying DLR technologies in accordance with demand so that products can be sold with partners from industry, as well as acquiring new customers, protecting business segments through intellectual property rights, and supporting the creation of new companies.

**Examples of successful technology marketing**

In 2005, the technology transfer (TT) project Tempering and Processing Composite Fiber Components with Microwaves was successfully concluded with the Institute of Composite Structures and Adaptive Systems.

The goal of the project was process development for hardening of CFK duroplastics using microwave radiation. This process makes it possible to process carbon fiber reinforced composite materials without an autoclave even for large components. Advantages of the method are a reduction in production times and reduced production costs based on lower requirements for the production environment (temperature, pressure) and energy savings. Development and cooperative partners were Composite Technology Center (CTC) from EADS Airbus (Stade, Germany) for the aeronautical qualification of a C-spar segment for Airbus that was manufactured with microwave technology, Maschinenbau Scholz, Co. (Coesfeld, Germany) for the market launch of autoclaves based on DLR's

microwave technology, Fricke & Mallah, Co. (Peine, Deutschland) for the development and marketing of microwave chamber furnaces based on DLR process expertise und Bolle & Cord, Co. (Horst, Germany), which put a system for heating resin with microwave technology on the market.

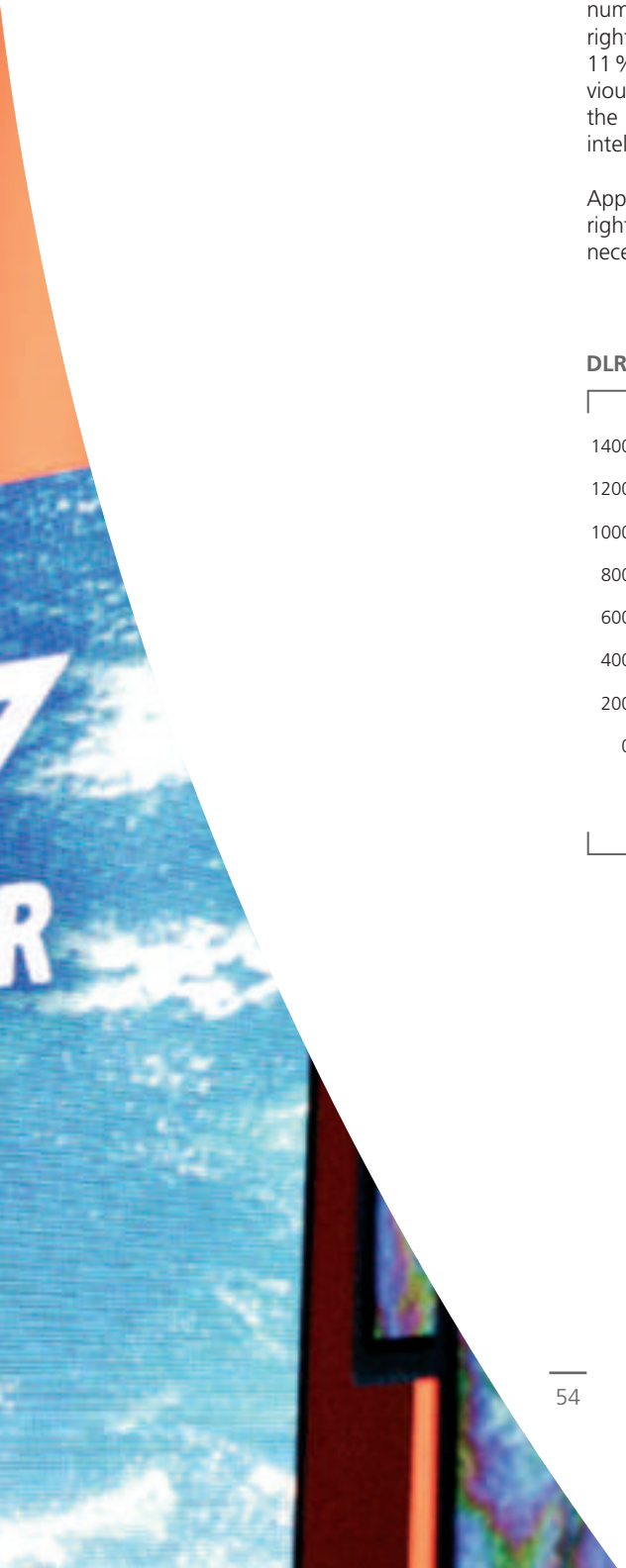
DLR has concluded a licensing agreement with Orbital Recovery Limited (ORL, England) for satellite servicing, i.e., service-life-enhancing measures for satellites already in orbit by coupling an auxiliary satellite with a propulsion/fuel unit. The subject of this licensing agreement is the capture tool, a mechanism for docking with the auxiliary satellite. In a contractually agreed upon cooperative arrangement with ORL, Dutch Space/DS (Leiden, Netherlands) and Kayser-Threde/KT (Munich, Germany), the Institute of Robotics and Mechatronics will adapt the existing capture tool to mission conditions on behalf of KT in the course of a technology transfer project. DLR will receive income from this both from development orders as well as from licensing income for successful missions.

One application area for aerogels is manufacturing fireproof lightweight walls. The manufacturing technology was adapted in cooperation with a partner in industry to the partner's requirements with regard to statics, construction regulations and ease of production. The lightweight walls can be utilized in the construction industry among others.

In 2005, it was possible to conclude the digital film scanner technology transfer project, which was carried out on the basis of digital optical sensor technology developed at the Berlin-Adlershof site along with Kinoton GmbH (the market leader in the movie theater and studio equipment sector), with a model that was ready for series production. The objective was developing a film scanner that was capable of digitizing analog film material rapidly, cost-effectively and with a high level of quality. The film scanner is able to digitize any 35 mm film (or even 16 mm) without a problem. With mature CCD line technology, the film scanner supplies brilliant digital 16-bit images of the highest quality, and does it in the shortest possible time. Its excellent optical properties achieve crisp image resolution of up to 6 µm. The product is currently in the process of being introduced to the market and is already being sold.

**Technology marketing**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Income from licenses | Euro 1.9 m | Euro 3.9 m | Euro 4.2 m |
| Spin-off companies | 0 | 1 | 1 |
| New own technology transfer projects | 12 | 10 | 12 |
| Investment in technology transfer projects | Euro 1.7 m | Euro 2.2 m | Euro 2.4 m |

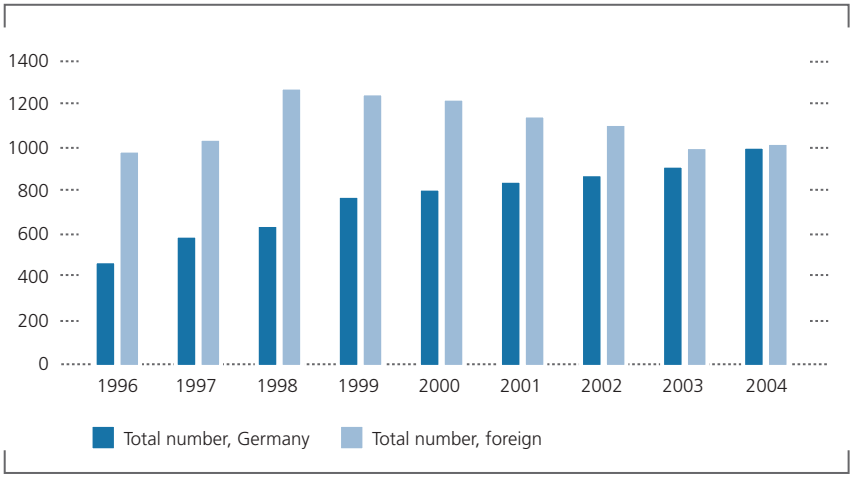


**Intellectual properties rights**

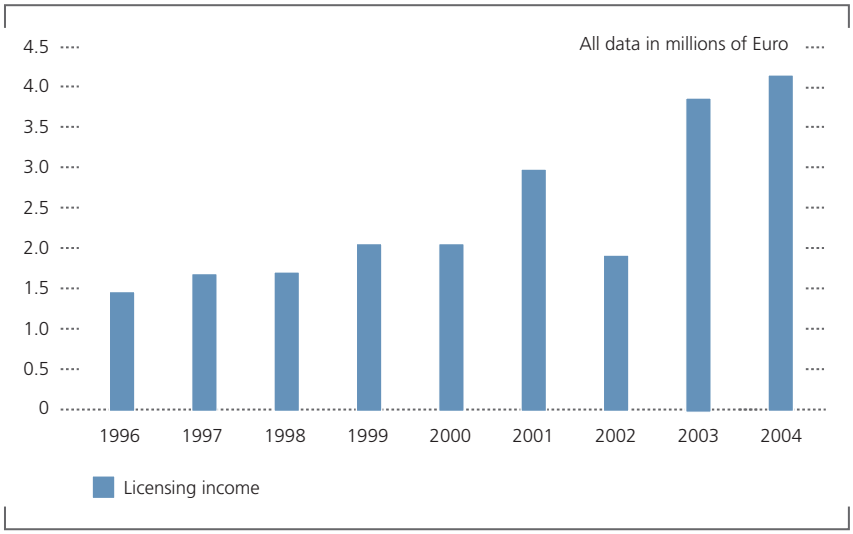
The number of applications for inventions increased in 2004 to 176 and as a result is almost double the number for the previous year (96 applications). The number of German intellectual property rights held by DLR increased by about 11 % in 2004 as compared with the previous year. At the end of 2004 DLR was the holder of just under 1,000 national intellectual property rights.

Applications for intellectual property rights in other countries are primarily necessary for industrial partners. DLR applies for intellectual property rights in other countries at its own expense only when this is necessary to protect core working areas in order to maintain DLR's freedom of action over the long term. Due to this restrictive application policy, the number of foreign intellectual property rights has declined by a good third in the period from 1998 to 2003. In 2004, the number of foreign intellectual property rights increased again slightly for the first time. The reason for this is also innovation projects initiated by technology marketing over the past few years, projects for which appropriate foreign protection is indispensable for safeguarding marketing opportunities.

**DLR intellectual property rights in Germany**



**Patent costs/licensing income**




## Licenses

Die DLR licensing income increased slightly over the previous year from Euro 3.9 million to approximately Euro 4.2 million. Compared with the average of the years 1996 through 2000, the annual licensing income for DLR has more than doubled. The reason for this is the success of technology transfer projects, which were initiated by DLR technology marketing between 1997 and 2000 and now have produced increased licensing income.

In terms of outside costs for patent applications, general cost increases, particularly expenses for outside patent attorneys, produced a slight increase in costs. DLR dedicates approximately 0.5 % of its budget to the application and preservation of intellectual property rights.

## Spin-off companies

The Anwendungszentrum (Application Center) GmbH Oberpfaffenhofen (AZO) was created during the reporting year. AZO is a strategic spin-off company, which DLR set up with the assistance of the Free State of Bavaria at the DLR site in Oberpfaffenhofen as an incubator especially to support the creation of new companies. AZO GmbH is a company that belongs to ESINET, the European Space Incubators Network, and is intended primarily to support applications in satellite navigation. DLR is a partner in the company with a minority interest of 25 %.

# Structure

## Corporate development

**Administrative Technical Infrastructure**

The organization development process "ATI in transition" begun in 2003 was continued during the reporting period. Numerous projects and activities were initiated and operated in connection with it, all of which pursue the same goal: consistent and sustained orientation of the organization to the processes and optimizing the processes with respect to value creation, costs and transparence for the customer. In this case, the parts of the process in institutes were also included in the consideration in order to achieve a better meshing of core processes with support processes.

An important milestone was the successful evaluation of the Technical Infrastructure (TI) in November 2004. The concept for reorganizing the TI that was presented to the experts and positively assessed by them is now being implemented in the Facility Management (FM) and the System House Technology (SHT) projects. In the course of the Facility Management project, uniform business processes are being introduced for all services connected with plant and facilities and cost allocation is being redesigned thereby producing far-reaching controllability of costs by the institutes. The focus of the organization of the System House Technology is a strategic orientation of the performance spectrum of the individual technical operations of TI to customer requirements, connected with a redesign of the process flows and a resulting new design of the organization.

**The publication of the "DLR Centers of Excellence 1998–2004" brochure in the Goals and Strategy series represents the conclusion of the first round of this DLR-internal excellence competition with notable results**

**DLR Centers of Excellence**

Upon successful conclusion of the previous "DLR Centers of Excellence" and the associated positive effects, both internally as well as externally, the executive board decided to use this designation on a regular basis and in June 2005 again invited tenders for a "2005 DLR Center of Excellence." The intention is to honor on recognized top research. The results of completed activities can be downloaded from the Internet at: http://www.dlr.de/dlr/ Organisation/ aussenbeziehungen.

With this DLR has consistently realized its corporate goal of focusing on research fields, which are strengths of the DLR and make it possible for the DLR to enter well-prepared into international competition with other research facilities for leadership opportunities, scientists and customers.

**Corporate communication**

During the reporting period, corporate communication of DLR intensified its positioning in the general public and in technical circles, with the dual goal of increasing DLR's degree of recognition and improving its image along with communicating technical information in an informative and generally understandable manner. In the process, DLR made greater inroads as the focus of TV reporting. Particularly ARD, Phoenix and broadcasters like N-TV and N24 broadcast considerably more subjects related to research and above all space topics. The goal of being represented in the media with statements by the executive board, institute heads and employees was also achieved just like the general positioning of technical subjects.

In terms of media communication, DLR is increasingly involved in cooperative media efforts such as with Lufthansa's magazine, among other things. A special highlight of corporate communication was DLR's emergence for the first time as the publisher of a popular scientific book, "Mountains From Space," with DFD handling scientific project management.

Highlights that had a special effect in the general public and among political decision makers were the Space Day with the 6th DLR parabolic flight campaign, which drew more than 100,000 visitors in Cologne alone as well as an event at the Löbe-Haus in the Reichstag complex in Berlin, where outstanding German contributions to Mars exploration were the focal point. The communication strategy of partnership co-profiling has been proven at these types of events, i.e., at the Space Day with the Air Force and the Cologne-Bonn Airport and at the Löbe-Haus in the Reichstag with representatives from Max Planck and various universities. The annual meeting can be cited as a highpoint of communication in specialized technical circles, which was covered by the Phönix TV network and broadcast several times.

Overall, one can say that the positioning of DLR as the competent facility for aeronautics and space in Germany is clearly moving along.

**German employees at ESA**

For several years DLR has intensified and focused its efforts related to increasing the German percentage of personnel at the ESA. For the third year in a row, the percentage of German applicants in all applications received by the ESA increased, and the success rate of German applicants among job offers also improved again. The percentage of German candidates among all new hires at the ESA is currently more than 23 % and as a result is in the vicinity of the German contribution percentage for the first time.

Work continued to progress in the area of exchange programs. Two employees assigned to ESA have begun their work.

Another new measure is being considered to establish a "network" of the "aeronautics and space universities" in Stuttgart, Munich, Aachen, Berlin, Karlsruhe in order to place beginners in the profession from these universities at ESA sites with the financial assistance of ESA.

In order to increase the attractiveness of an ESA job, in 2005 the executive board approved a furloughing regulation for DLR employees at ESA, which makes it possible for them to be rehired at DLR after certain time limits.

**Presentation of the activities related to space exploration at Löbe-Haus, Berlin**

# Quality management and environmental protection

**A fundamental factor for the efficiency of DLR is the quality of its research results, products and services. They should do justice to the customer, imposed requirements and be environmentally friendly. The satisfaction of shareholders, partners and customers as well as the commitment of our employees is the basis and measure for this. Continuous improvement is our stated objective at DLR.**

**For years safety and environmental protection have been crucial criteria for the work of DLR.**

**Quality management**

Back in 1999 DLR decided to organize quality assurance for its R&D services according to the ISO 9000 system. In subsequent years, a decentralized quality management (QM) system was created and successively implemented at the institutes. In the meantime, nearly all institutes and facilities have employees responsible for quality.

By mid 2005, quality management systems had been certified at a total of 13 institutes, facilities and organizational units; they are still in the process of being created at 12 other institutes and facilities. The emphasis for developing quality management over the past year was expanding the existing system by widening the scope of application both by including additional performance processes in the management system as well as by increasing the demand for the management system. A clear trend for integrating management systems has emerged, comprised of managing quality complemented by work safety and environmental protection.

In 2003, the management process of quality management at DLR was certified by Bureau Veritas Quality International (BVQI). Since then the management process has undergone annual monitoring audits twice, both successfully. Uniform quality management for the entire organization is one of DLR's unique features within the framework of the Helmholtz Association.

The Institute of Space Propulsion is now certified in accordance DIN EN ISO 9001, DIN EN ISO 14001 and SCC and has therefore established the first integrated management system at DLR.

**Quality management**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Certifications and accreditations | 9 | 13 | 13 |
| Number of DLR auditors | | | 9 |

Based on certification in accordance with DIN EN ISO 9001 and DIN EN ISO 13485, the Institute of Aerospace Medicine received a certificate in accordance with Directive 93/42/EEC to manufacture and market medical products. In addition, quality management of the core work area of aerospace psychology was also certified in accordance with DIN EN ISO 9001. The certificate covers the entire process of psychological suitability diagnostics and is the first of its kind internationally. The associated international visibility had the direct impact of bringing in third-party funding from Switzerland and Indonesia.

Quality management at DLR was a decisive argument for awarding the ESS Test Center of the BMBF to the DLR project management agency.

In September 2004, the new quality management official enthusiastically assumed responsibilities. During the same month, the DLR quality prize was awarded for the second time in the course of DLR's innovation market. DLR quality management again participated in the 2004 Ludwig-Erhard Prize as an assessor.

The presentation of quality management at DLR was shortened and improved by simplifying the explanation in the handbook. The establishment of a new intranet created a uniform communication platform that is available to all employees as well as a new forum especially for the quality officials' working group.

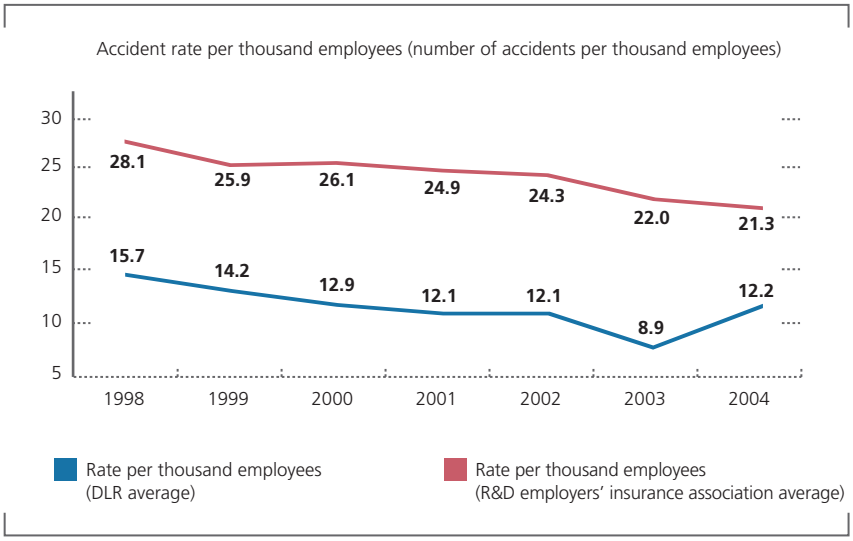
The training of auditors of management systems was standardized. Since September 2004, employees who could prove adequate technical knowledge and knowledge of DLR procedures were appointed DLR auditors. During the reporting period, system audits were conducted at 14 facilities at DLR.

A uniform procedure for handling malfunctions in processes and on products was introduced at DLR. A decentralized, but DLR-wide, uniform process for determining customer satisfaction at DLR is in the works.

Introducing a uniform instrument for assessing suppliers has been discussed with the Purchasing Dept. and will be introduced shortly.

The quality guidelines in effect since 1999 are currently under review. The new quality policy and new goals will be documented in the goals and strategies of DLR.

**Accident trends at DLR**




## Environmental protection and safety

Environmental protection and safety have been an important criterion for DLR's work for many years. Operational environmental protection according to international standards supplements DLR's diverse research activities on climate protection, conservation of resources and other objectives related to sustained development. For example, for some time the central goals of scientific work at DLR have included reducing noise, emissions and fuel consumption of aircraft or the development and utilization of satellites to collect environmental data.

In 2000, DLR's technical infrastructure at the Cologne-Porz site was the first facility in the Helmholtz Association to be certified in accordance with environmental management standard ISO 14001, and efforts to make constant improvements continue. In the process, safety and quality aspects have been tackled and included on a modular basis. Assigned product-oriented organization units like the central workshop in Cologne were then integrated according to the ISO 9001 quality standard. In 2004, an integrated management system was certified on a complete site. Quality and safety were combined with environmental and health protection into a single system at the Lampoldshausen site for the first time and successfully audited in accordance with ISO 9001 and ISO 14001. These integrated systems specify objectives and regulate the collection, documentation and publication of all relevant activities. In particular, they include the obligation that DLR has imposed on itself to constantly improve its product-related and system-related measures, minimize environmentally relevant effects and optimize safety equipment in order to protect personnel, the environment and the facilities. Independent experts again successfully verified this commitment.

One emphasis of the ongoing improvement process is the transfer of information both inside and outside the organization. The "environment server," an Internet and intranet platform (www.umwelt.dlr.de) for communication with various target groups, is being expanded continuously and is linked to the Internet platform of the Helmholtz Association. Training for managers is designed and provided for multiple regions. Information events for employees are being offered. The 2004 Health and Environmental Protection Day was held at the Cologne-Porz site using the slogan "DLR-GUT." Topics related to the disposal sector, health precautions, fire safety and energy management were selected, and were made more vivid for visitors with the support of external partners. Audience participation was a particular point of emphasis this time with, e.g., fire extinguishing exercises, measurements and fitness training being offered. Questions ranging from ergonomics at the workplace to energy savings at the office were addressed. DLR facilities were again involved and presented projects that were relevant to environmental protection.

In spite of intensive technical and organizational precautions, accidents cannot always be avoided. There were some 61 accidents subject to reporting requirements in 2004, almost 50 % of which occurred not at the workplace, but in public transportation with automobiles and bicycles. Despite this slight increase, DLR, which had an accident rate of 12 accidents per 1,000 people, continued to be well below the average for the Federal Republic of Germany (over 30) for 2004 and also below the level of the responsible employers' accident insurance association, which was 21 for 2004.

While products or substances at DLR are generally examined to determine their risk and whether they can be recycled, the research facilities are also reaching their limits. In preceding years, a great deal of effort was made to equip machinery with cooling lubricants made of rapeseed oil. However, the results of this project proved to be unsatisfactory. The anticipated advantages, such as longer service lives and conservation of resources did not materialize. On the contrary, increased expenses for cleaning and servicing were the result. The search for alternative products will now be intensified in general.

DLR is deliberately pursuing a continuous improvement process in environmental protection and safety. Service providers, suppliers and other partners will now be included increasingly in our activities and evaluated. Evaluating the safety and environmental protection system in the course of further development of the infrastructure in cooperation with competent partners will lead to optimizing safety management, the organizational structure and personnel resources in 2005. Performance figures concerning improvement of the basic data and for comparison with other facilities, regular audits and team developments will continue to shore up these processes.

# Networking

## Helmholtz Association of National Research Centers

### Development of programs

For the second year of program-oriented funding, DLR has achieved its stated objectives in the transportation and space research area, which is handled solely by DLR, despite difficult boundary conditions. The respective interim expert opinions for the space and transportation programs have verified the orientation of the work. In the integrated earth observation system, DLR is coordinating cooperation between four centers of the Helmholtz Association, which extend beyond the borders of the research field. Two new work areas of airport systems and space-supported applications for transportation were created in the transportation program. In the aeronautics program, cooperation with the NLR in the field of aeronautics management must be mentioned.

The first year of program-oriented funding for DLR involvement in the research field of energy was also successful. DLR along with three other centers of the Helmholtz Association concluded a cooperative agreement with Siemens Power Generation for continuous and intensified exchange of knowledge.

### Initiative and Networking Fund

Within the framework of the Initiative and Networking Fund of the Helmholtz Association, DLR obtained funding for a new junior staff group in cooperation with the Technical University of Berlin in the area of optical measuring technology for turbo-machine diagnostics. The evaluation of three new applications is pending in the still ongoing bidding process for funding additional new groups of junior staff in cooperation with an institution of higher learning.

## National and European Networking

### Networking in the Aeronautics Research Program

DLR was involved in over half of all approved projects in the third German aeronautics research program (Lufo III, see page 46). DLR is represented in six of the seven Lufo technical fields with the subjects of propulsion, helicopters, fixed-wing aircraft structure, fixed-wing aircraft cabin/onboard, fixed-wing aircraft flight physics and air traffic. The impressive success of this work is discussed in the Aeronautics section of the Research Results. In addition, DLR continues to be actively represented in designing the successor program, Lufo IV.

**DLR and the University of Cottbus signed a cooperative agreement for aeronautics research**

### Cooperation with universities

In April 2005, DLR and the Brandenburg Technical University of Cottbus concluded a cooperative agreement in the field of aeronautics. For DLR this represents a further step towards utilizing the capacities for aeronautics research available in the eastern part of Germany and makes new and intensive synergistic effects possible between large research facilities and institutions of higher learning. The cooperation includes aero-acoustics (particularly engine acoustics), propulsion technology, new engine designs, laser measuring technology and lightweight materials for propulsion. Of special interest in this case is the funding of scientific up-and-comers and expanding instructional offerings.

DLR and the Technical University of Hamburg-Harburg intend to cooperate with Airbus Deutschland in establishing a research group for air transport concepts and technology assessment (FLT) in Hamburg. The objectives of the new facility are research planning that is coordinated early in the process, and coordinated multidisciplinary work that includes the entire air transportation system.

Important management positions at DLR in the field of turbine aero-thermodynamics and external aerodynamics will be filled in the future via two joint appointments with the University of Hannover (Institute of Turbo-machines) and existing

cooperation with the university will be intensified. This cooperation will further advance DLR's involvement in the network of universities in Lower Saxony in the field of flow mechanics.

In order to study the diverse effects of weather and climate on the energy supply, DLR and the University of Oldenburg teamed up at the beginning of the year to establish the Virtual Institute of Energy Meteorology (VIEM). The objective of the association is incorporating solar and wind energy technologies more intensely into the energy supply. For this purpose, meteorological methods and data are intended to be made available for weather-dependent "fuels" from solar and wind energy. The Institute of Atmospheric Physics, the German Remote Sensing Data Center and the Institute of Technical Thermodynamics are involved on the DLR side.

The DLR Institute of Aerodynamics and Flow Technology and the Institute of Space Systems at the University of Stuttgart have initiated a long-term cooperative arrangement in the field of space transport. Joint work in the fields of magneto-hydrodynamics, surface catalysis and flight mission analysis were begun. One-of-a-kind test facilities for the development of reusable spacecraft and electric space propulsion are available for the partners' work in Göttingen and Stuttgart.

**Participation in programs of the German Research Foundation (DFG)**

Comprehensive networks of researchers, who are dedicated to interdisciplinary work on a major complex of issues, receive support in the so-called "coordinated programs" of the German Research Foundation. In special research areas, the emphasis is placed on excellent research; core area programs help establish technical capacities and courses of lectures for graduates assist in the training of outstanding junior scientists. During the reporting period, DLR institutes participated in special research areas eight times, in core area programs 21 times and in courses of lectures for graduates seven times. As a result, the number increased slightly as compared with the previous year.

**National and European networking**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Participation in DFG | 32 | 34 | 36 |
| Partnership arrangements | 32 | 37 | 43 |

**Trilateral Memorandum**

The Trilateral Memorandum is a memorandum between the DFG German Research Foundation/ universities, industry (BDLI) and DLR in the area of aeronautics and space. The goal of the memorandum is improving the harmonization of research objectives and programs among the partners and promoting training and advanced training of the junior scientific-technical staff, with the goal of concentrating the influence of aeronautics and space research and increasing its efficiency. The focus of work is currently satellite navigation and promoting a new generation of scientists in the area of innovative aircraft configurations.

**Partnerships**

Ensuring that a high-qualified new generation will be active in research and development is an essential concern for both science and industry. Partnerships combine the promotion of the new generation with the objective of achieving a rapid transfer of technology between people. In this arrangement, companies contribute half of the costs of training junior scientists, who are employed for a period of three to four years at DLR and work in areas that are of interest to both DLR and the companies. The young scientists also spend a portion of their time at the companies.

There were a total of 43 partnership arrangements in 2004; this is another increase as compared with the previous year and can be attributed primarily to the involvement of Airbus. The trend is continuing: there were a total of 47 partnership arrangements during the first half of 2005.

**Involvement in the Association of European Research Establishments in Aeronautics (EREA)**

In December of the year 2004, the EREA Board under the chairmanship of Prof. Szodruch invited representatives of the European Parliament, European Commission, national and regional ministries to the Hotel Europa in Brussels to commemorate the 10th anniversary of the Association of European Research Establishments in Aeronautics (EREA). Looking back, EREA's fundamental contributions to harmonizing research activities through common technical networks and projects under the auspices of EREA and in the EU research framework program were honored.

EREA was represented with a poster stand at the ACARE Aerodays in March of this year. The 2nd strategic research agenda was officially presented on the occasion of the Aerodays. Representatives of the EREA membership were involved in preparing this research agenda.

The EREA working groups are also actively involved in helping organizing the aeronautics portion of the future 7th EU framework program. EREA's board meeting with EU Commissioner of Research Potocnik that is planned for the fall of this year is also related to this.

**Partnership between DLR, Airbus and ONERA**

As DLR's most important partner within EREA, cooperation with ONERA is continuing to be intensified in existing coordination of research work on fixed-wing and helicopter technology. Joint dealings with industry are also becoming more and more important. Along with Eurocopter, Airbus is also increasingly playing an important role. A memorandum of understanding between DLR, ONERA and Airbus on establishing a trilateral strategic partnership was initiated in 2003. Now nothing else stands in the way of a cooperative framework agreement, which should be signed in August 2005. DLR and ONERA developed CFD computational code (CFD Computational Fluid Dynamics) based on their TAU and ELSA programs. The introduction of these CFD codes as a standard computation program at Airbus will play an important role as the first step in the cooperation.

**Cooperation with NLR**

The strategic alliance with the Dutch national aerospace laboratory NLR that was announced last year in the field of air traffic management (AT-One) was formally realized when the executive boards of both facilities publicly signed a declaration on the occasion of the 2005 ATC Maastricht exhibition. In the course of the AT-One implementation project, joint management that overlays DLR institute management should henceforth be established. Required rules of cooperation, exchange of information and responsibilities as well as questions about external marketing must still be agreed upon. It will be possible to take advantage of synergistic effects and complementary characteristics and these will be focal points of action and the further development of the infrastructure facilities. Both partners are considered expert research facilities in matters of air traffic management and hope to market joint products, services and research work under the AT-One brand name.

**Cooperation with CNES**

Discussions on bilateral research and development cooperation were intensified with the French space agency CNES. The focus was in the field of earth observation and future launch vehicles, in which there are various approaches relating to a common interest and benefit.

The second High Connection Committee met in May 2005. A joint working group was put into place in the field of vehicles to evaluate technologies for new generation launchers (NGL). This group is supposed to work on proposals for designing future launch vehicles for the ESA Council of Ministers conference.

Additional joint high visibility projects are supposed to be identified from the fields of AURORA, oceanography or formation flying.

In June 2005 an agreement on establishing a joint competence center in the field of information extraction was signed. This institute is installed at the ENST in Paris. Prof. Datcu of DLR heads the joint professorship at the center.

Signing of the agreement: The orientation of the 6th international conference for developing future launch vehicles will take place this year under the joint responsibility of CNES, DLR and ONERA. Approx. 400 experts from related international fields are expected at the conference that will be held in Munich.

**Network of technical centers**

After the topic in the ESA framework had been tabled since ESA Director General Dordain took office, discussions resumed in February. Precisely with regard to the European space program, the utilization of national expertise should be taken advantage of more intensively. In this case, ESA is attempting a case-by-case pragmatic course of action, which has the support of Germany.

Discussions concerning intensifying technical cooperation were held on the executive board level with the management of the ESA technology center (ESTEC). Concrete activities for expanding cooperation should be started by the end of 2005.

# International cooperation

2004 was characterized by far-reaching events in international aerospace: In Europe the European Commission and the European Space Agency ESA signed a framework agreement on future cooperation; in January 2004 President Bush announced a new NASA mission related to space exploration; and the year 2004/2005 in terms of aeronautics was marked by the successful maiden flight of the Airbus 380 in early 2005.

As a result, three topics were in the foreground of DLR's international space cooperation: The positioning of German space travel in view of the NASA's Space Exploration Mission, whereby the further delayed first shuttle launch since the tragic Columbia accident increasingly impacted the international space station ISS. Second, building on the EU ESA framework agreement, efforts were made to pave the way for a harmonious European space policy, which also takes the new Member States of the expanded European Union into account. Third, as a result, the European space initiatives, Galileo and GMES, and the application potential of space travel came closer to center stage. Their increasing significance was tragically documented by the tsunami disaster, which late last year destroyed wide coastal regions of the Southeast Asia and caused thousands of causalities. In this case, the Center for Crisis Information at the German Remote Sensing Data Center DFD provided up-to-date catastrophe aid by supplying timely and valuable mapping information to German and international aid organizations. DLR was also aptly involved in constructing a German tsunami early warning system in Southeast Asia.

**ESTEC Director Courtois' visit to DLR**

**Cooperation with the USA**

NASA presented the content of the American space exploration initiative at two conferences in November 2004 and March 2005. At the same time, however, problems intensified in the concrete projects of bilateral German-American cooperation. With the resumption of shuttle flights being further delayed, additional construction and possible use of the ISS became a critical point of discussion. Framework conditions for further cooperation also remained unclear on the industry level, while German space science and research continued to enjoy a good reputation in the USA and the capabilities of the German space industry could be utilized for instance in the development of the new American Crew Exploration Vehicle (CEV). Delays on the side of NASA also affected cooperation on the aircraft telescope SOFIA. Additional American financing must be guaranteed for its use in research.

**Cooperation with new EU Member States**

In view of the eastern expansion of the European Union, DLR also had a great desire to expand bilateral cooperation with new EU Member States and to create and utilize new forums for this. A first example of this was the European Commission's conference on international space cooperation in February 2005. With the support of the BMBF, DLR made its own mark however: The DLR executive board's strategy fund and the use of Helmholtz Association funding made possible the first joint proposals in the EU research program incorporating central and eastern European partners. In addition, a conference on the topic of applied earth observation is being planned, whose objective is to present German infrastructures and industry know-how and strengthen bilateral networking.

**Cooperation with Russia**

Cooperation with Russia was characterized completely by cooperation on the issue of space. In addition to the strategic ESA partnership with Russia (Soyuz in Kourou), bilateral visits served the purpose of eliciting possibilities for expanding German-Russian cooperation. In August 2004, a delegation from the Russian space agency ROSKOSMOS under the leadership of General Shylov retired visited DLR as well as EADS, IABG and ministries of the state of Bavaria. Likewise, the potential for bilateral cooperation with GALILEO was also in the foreground during a return visit of Prof. Bachem to NPO PM in Krasnoyarsk. A central event in the cooperation was assuredly near the end of 2004 with the launch of the German robotic experiment ROKVISS with Progress M 51 to the ISS. In mid-January ROKVISS was successfully mounted on the outside of the service module and began operation. As a result, ROKVISS was also the subject of the Russian trip made by Federal Minister Bulmahn, who was accompanied by Prof. Wittig, chairman of DLR's executive board, and discussions focused on the ISS and Soyuz in Kourou.

**Cooperation with China**

The first Chinese manned space mission was marked by visits from the State Secretary of the BMBF and the DLR executive board with the objective of making greater efforts to probe and promote the cooperative potential of German industry and German research. In addition to the traditionally very close cooperation in aeronautics research, particularly with the Chinese Aeronautics Establishment (CAE), initial cooperative efforts were realized in the still new core area of transportation, which include a welcome return of third-party funding to DLR. Thus, utilization of the DLR traffic tower concept for Peking was agreed upon. DLR will support the Chinese CAAC in their pilot selection process. In the field of aeronautics research, the starting shot was sounded for seven bilateral R&D projects financed by Airbus at the 21st Joint Committee Meeting DLR – CAE in Peking. In a countermove, a delegation from the Chinese Science and Technology Ministry under the leadership of Vice Minister Prof. Ma visited DLR in Oberpfaffenhofen in mid February in the course of the Galileo program. Negotiations concerning various test facilities and their use in China were begun.

**Cooperation with Japan**

German-Japanese strategic dialog took place for the first time in 2004 with the new, combined Japanese Air and Space Agency JAXA. It was supplemented in February 2005 in Toulouse with a trilateral workshop on aeronautics research together with the French aeronautics and space research agency ONERA.

**Cooperation with other partners**

Negotiations on the trilateral TRAINERS project on atmospheric and ionospheric research were successfully concluded between the DLR Institute of Communication and Navigation and Indian and Indonesian space agencies.

Various subjects of cooperation were agreed upon in the field of fiber-reinforced structures during a workshop of the DLR Institute of Composite Structures and Adaptive Systems with the Australian Cooperative Research Center for Advanced Composite Structures, CRC-ACS. Canada also remained an important partner in 2004/2005 for cooperative projects in robotics and earth observation.

In Asia, South Korea is developing into an increasingly important partner country, also in terms of industry. DLR is attempting to build a broad basis of cooperation with KARI (Korea Aerospace Research Institute), borne by interesting perspectives for DLR research and development especially in the field of space.

**International cooperation**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| International visiting scientists (staying longer than one month) as a percentage of scientific employees in institutes* | 6.1 % | 6.1 % | 5.8 % |

* The number of visiting scientists remained the same in 2004 while the number of scientific employees in institutes increased.

# Human resources

## Promoting the next generation and equal opportunity

In May 2005, DLR was awarded the Work and Family Audit certificate by the non-profit Hertie Foundation. This "audit" is a management instrument for family-friendly personnel policies, which supports employers in recording the spectrum of their family-oriented personnel measures in a detailed manner and in sustaining their implementation.

After the re-audit in November 2004, new objectives were passed as an executive board decision. Taking the needs of both male and female employees into account, the greatest possible variability of flexible work time should be offered, consideration for family obligations should already be in the process of being incorporated into the operational reorganization and acceptance for telecommuting should be improved as well as internal communication on ongoing measures in the project. The topic of the work-family balance is being integrated into the management instruments and seminars. DLR's family orientation is also being emphasized in terms of its outside image.

This had already been integrated as a separate action item into the concept of promoting young scientists and equal opportunity. The stated intention is successively increasing the percentage of women in the sciences and in management positions. In this regard, the concept contains a new approach for identifying possible candidates as well as specific personnel development measures for this group. The new measures included in the concept, which were evaluated after a run-time of one year, were successfully adopted. The fireside chats and the dialog with junior staff as forums for discussion for junior staff in training with the executive board were met with great resonance and will also be a future part of permanent offerings for junior staff in training. Currently, a tenure-track program is being worked out that provides for systematic promotion of those with high potential. The primary concern is preparing the junior scientific staff for management functions in a purposeful manner. What is crucial in this program, which does not prescribe specific measures from the very outset like a six-month foreign stay, mentoring etc., is that these instruments are tailored to the qualification needs of management positions that will be vacant in the future and individual employee preferences in terms of career planning.

**Personnel**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Number of employees | 5,012 | 5,069 | 5,055 |
| Scientific employees | 2,334 | 2,354 | 2,336 |
| Permanent contracts/ fixed term contracts | 2,942/2,070 | 2,935/2,134 | 2,913/2,142 |
| Percentage of women | | | |
| - Overall | 28 % | 28 % | 28 % |
| - In management positions | 12 % | 12 % | 12 % |
| - Scientific employees | 12 % | 12 % | 13 % |
| Young scientists | 135 | 135 | 128 |
| Doctoral candidates (internal/external) | 335 | 437 | 453 |
| Trainees | 242 | 242 | 251 |

**Introductory event for the mentoring program**

# Personnel development at DLR

Personnel development at DLR is part of the integral support process of personnel management and focuses on the strategic objectives of the institutes and facilities.

The aim is to recognize and develop existing qualifications, skills, development needs and performance potentials of employees and harmonize them with the requirements of individual jobs. Personnel development is intended to ensure top-quality personnel for the organization and improve its operating efficiency; from the employee's viewpoint, it should register interests and potential skills, thereby optimizing work satisfaction and motivation.

Personnel development at DLR is directly intertwined with organizational development. In particular, strategic and structural change processes in the institutes and facilities are supported via moderated team workshops.

**Instruments and services for personnel development**

In addition to general advisory services on matters related to continuing education, employee management and employee development, personnel development at DLR includes the following primary services:

- Local and company-wide training programs with a focus on language and electronic data processing instruction, social competences, management competences and promoting health
- Differentiated personnel developmental for management and the junior management staff
- Team workshops on organization development (e.g., change management, strategy development, leadership and cooperation, tailor-made training seminars for teams)
- Support in the recruiting, selection and orientation of new employees
- Coaching of management personnel and employees as well as small groups
- Mentoring, in particular to further the young scientific staff
- Management feedback for the purpose of optimizing management and cooperation
- Project leadership on the subjects of equal opportunity and work-family balance
- Central coordination of training (251 trainees)

A total of 49% of employees participated in training programs or personnel development activities for management or team workshops at least once during 2004. Each employee spends an average of 1.7 days per year on personnel development activities (continuing education events or team workshops); this amounted to 8,707 days in 2004 for the entire workforce.

Personnel development administered a total of 11 mentoring teams.

In the meantime a new, cross-company mentoring project (so-called cross mentoring) was begun within the Helmholtz Association, with DLR taking the lead.

A survey of doctoral candidates at DLR led to additional specific educational opportunities for the junior scientific staff, which are aimed at optimizing work techniques, scientific presentations and publications, and providing prospects for continued career development.

Intensive training sessions in project management were more professionally focused and oriented to the American PMI via a binding curriculum. E-learning programs supplement this qualification (all the way up to preparation for PMI certification) and the internal DLR project management portal.

**New developments/process orientation**

Since 2003 the new, integrated personnel development system has been implemented continuously. Forming the basis for the model are systematic needs analyses on the 2nd and 3rd management levels concerning essential questions of personnel management and, on the level of the individual, employee discussions of target agreements. On this basis, qualified personnel developers for the organizational units prepare tailor-made personnel and organizational development concepts. They advise on and accompany the implementation of diverse personnel development instruments (one face to the customer) and evaluate their efficiency. On this basis five local operational agreements on personnel development have already been concluded, negotiations are currently underway for the remaining sites.

As a whole, the needs analyses on the management level showed an express desire for locally available integral support and advice on personnel management.

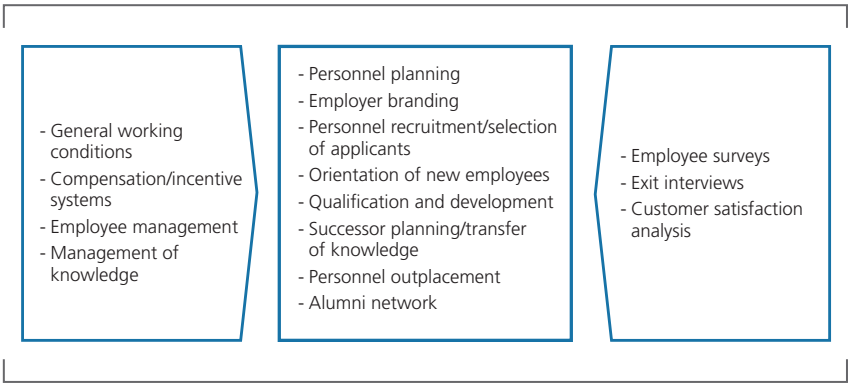
As a result, essential services of personnel development and personnel administration were geared to a standard personnel management process (see illustration).

The eight process steps depict a uniform personnel management system. They describe measures and instruments, which, taking operational as well as individual framework conditions into account, are supposed to influence the performance behavior and work satisfaction of employees in an optimal manner. In order to achieve this, management personnel should meet specific functions and personnel management should provide complementary services.

In addition, personnel management is responsible for arranging the most attractive possible work conditions and a greater orientation to performance when awarding bonuses. Management personnel are responsible for guiding employees in accordance with their potentials and needs, and assuring efficient management of knowledge with a dynamic fluctuation of employees. In addition, it must also be possible to measure the quality of personnel management more convincingly using empirical evaluation methods (exit interviews, employee surveys, customer satisfaction analysis).

A high-ranking group of experts recently rated this new personnel management process as effective and trend-setting.

**Integral personnel management process at DLR**




**Personnel development and mobility**

| | 2002 | 2003 | 2004 |
|---|---|---|---|
| Advanced training days per employee | 1.7 | 1.6 | 1.7 |
| Mentoring teams | 3 | 11 | 11 |
| Assignments abroad* (months) | 514 | 450 | 274 |

* The number of assignments remained constant in 2004. However, as of 2004 the DNW German-Dutch Wind Tunnel assignments are no longer included here

# Awards and prizes

## Internal awards

### DLR 2004 Science Prize

- Dr. rer. nat. Günter Schewe, Dipl.-Phys. Holger Mai and Dr.-Ing. Guido Dietz, Institute of Aeroelasticity
- Dr.-Ing. Stefan Hein and Werner Koch, Ph.D., Institute of Aerodynamics and Fluid Technology
- Dr. techn. Thorsten Hohage, University of Göttingen
- Dr.- Ing. Frank Holzäpfel and Dr.-Ing.Thomas Hofbauer, Institute of Atmospheric Physics
- Denis Darracq, Ph.D., and Henri Moet, Ph.D., CERFACS, Toulouse, France
- François Garnier, Ph.D., and Cécile Ferreira Gago, Ph.D., ONERA, Châtillon, France
- Dr.-Ing. Uwe Schulz, Institute of Materials Research
- Scott G. Terry, Ph.D., and Prof. Carlos G. Levi, Univ. of California, Santa Barbara, CA, USA

### DLR 2004 Senior Scientist

- Prof. Dr. sc. nat. Herbert Jahn, Optical Information Systems
- Dr. rer. nat. habil. Tom Rother, Institute of Methodology Remote Sensing

### DLR 2004 Research Semester

- Dr.-Ing. Richard Degenhardt, Institute of Composite Structures and Adaptive Systems (previously Institute of Structural Mechanics)
- Dr.-Ing. Ulrich Füllekrug, Institute of Aeroelasticity
- Dr. rer. nat. Karl-Heinz Funken, Institute of Technical Thermodynamics
- Dr.-Ing. Joachim Hausmann, Institute of Materials Research
- Dr. oec. troph. Martina Heer, Institute of Aerospace Medicine
- Prof. Dr.-Ing. Norbert Kroll, Institute of Aerodynamics and Fluid Technology
- Dr. rer. nat. Richard Meyer, Institute of Atmospherics Physics
- Dr. rer. nat. Andreas Neumann, Institute of Technical Thermodynamics
- Dr. rer. nat. Richard Woesler Institute of Transport Research

### Prizes from the Association of Friends of DLR

2004 Hugo Denkmeier Prize:

- Dr. Thomas Birner

2004 Fritz-Rudorf Prize to the Rosetta Lander team:

From DLR's Institute of Space Simulation in Cologne-Porz: Dr. rer. nat. Jens Biele, Dr. rer. nat. Johannes Bossler, Dipl-Ing. Cinzia Fantinati, Ursula Jacobs, Dipl.-Informatiker Sven Jansen, Dipl.-Ing. Michael Maibaum, Dipl.-Ing. Theo Neuhausen, Dipl.-Ing. Brigitte Pätz, Dipl.-Phys. Klaus Pelka, Peter Penkert, Dipl.-Ing. Ulrike Ragnit, Ing. grad. Volker Rehmann, Dipl.-Phys. Hartmut Scheuerle, Dipl.-Phys. Hans-Peter Schmidt, Klaus-Dieter Schmidt, Dr. rer. nat. Stephan Sous, Dr. rer. nat. Stephan Ulamec, Gert Warmbold, Dr. rer. nat. Rainer Willnecker

From DLR's Institute of Composite Structures and Adaptive Systems in Braunschweig:

Dr.-Ing. Joachim Block, Claudia Drescher, Cordelia Koch, Dr. Andreas Obst, Dr.-Ing. Rainer Schütze, Dipl.-Ing. Tom Spröwitz, Wolfgang Thal, Horst Wohl, Brigitte Zell-Walczok

**2004 Innovation Prize**

- Manfred Beversdorff
- Martin Müller
- Dr.-Ing. Ingo Röhle
- Dr.-Ing. Richard Schodl
- Dr. rer. nat. Guido Stockhausen
- Dr. phil. Christian Willert
- For the projected entitled "Doppler Global Velocimetry (DGV) for the Development of Modern Piston Engines" at the Institute of Propulsion Technology, Cologne-Porz

**DLR Quality Prize**

Dr. Nikolaus Hanowski, Space Operations, Günter Mansfeld, Institute of Flight Guidance, Manfred Senden, Finances and Corporate Controlling, Rainer Dröske, TESAT Spacecom and Manfred Engelhardt, Alpha- Mess-, Steuer- and Regelungstechnik GmbH are being honored for their excellent commitment in systematic quality assurance and quality management benefiting DLR as well as for their special services in introducing and consistently implementing quality management in their facility or their fields of responsibility in order to increase the quality of DLR products and services.

**2004 External prizes**

| Award | Recipient |
|---|---|
| 2004 Werner von Siemens Excellence Award | Dipl.-Ing. N. Bajcinca |
| IROS Finalist for the Best Conference (International Conference on Robotics and Systems) | Dipl.-Ing. N. Bajcinca<br>R. Cortesao<br>Prof. Dr. G. Hirzinger<br>Dipl.-Ing. M. Hauschild |
| 2004 EURON Technology Transfer Award (European Robotics Research Network) | Dr. J. Bals<br>Prof. Dr. M. Otter<br>Dipl. -Ing. M. Thümmel |
| 2004 IEEE Fellow (Institute of Electrical an Electronics Engineers) | Prof. Dr. R. Bamler |
| 2004 Reinhard-Furrer Prize from the Deutsche Gesellschaft für Luft- und Raumfahrt e.V. | Dr.-Ing. B. Dachwald |
| Prize from the Stiftung, Umwelt und Schadensvorsorge, Stuttgart (Environment and Loss Prevention Foundation) | Dipl.-Met. C. Gatzen |
| VDE Award | C. Geist |
| IUTAM Bureau Price (International Union of Theoretical and Applied Mechanics) | Dipl.-Ing. I. Kaiser |
| 2004 Science and Engineering Visualization Challenge of the National Science Foundation | Dr. rer. nat. R. Meisner<br>N. Sparwasser<br>T. Ruppert<br>C. Gredel |
| 2004 IEEE Student Paper Prize | T. Mette |
| 2004 IEEE Fellow of the Institute of Electrical and Electronics Engineers | Prof. Dr. A. Moreira |
| 2004 Innovation Prize from the City of Cologne | Dr. D. Neuhaus |
| 2004 Best Paper Award from the ASME (American Society of Mechanical Engineers) | Dr. rer. nat. K. Pottler<br>Dr.-Ing. E. Lüpfert |
| 2004 U.A. Helava Award - Best Paper of the ISPRS (International Society for Photogrammetry and Remote Sensing) | Dr. B. Rabus<br>Dr. M. Eineder<br>Prof. Dr. R. Bamler<br>Dr. A. Roth |
| 2004 Howard Hughes Awards 2004 from the American Helicopter Society (AHS International) | Dr.-Ing. habil. M. Raffel<br>Ing. H. Richard<br>Dr.-Ing. B. van der Wall et al. (Hart II Team) |
| 2004 Best Paper Award from the ISSSE (International Symposium on Signals, Systems and Electronics), Linz, Austria | R. Raulefs |

# Compilation of Performance Figures

| Third party-funding | 2002 | 2003 | 2004 |
|---|---|---|---|
| Total third-party funding | Euro 233 m | Euro 240 m | Euro 242 m |
| Third-party funding as a percentage of total income | 49 % | 49 % | 49 % |
| Growth in German operating income from R&D | +20 % | -11 % | +18 % |
| Percentage of income from foreign customers (income volume) | 35 % | 39 % | 35 % |
| Success rate of EU proposals over the past three years (accepted/submitted) | 38 % | 33 % | 42 % |
| Income from EU support | Euro 12.6 m | Euro 13.1 m | Euro 12.5 m |
| Ratio of coordinator/total (current EU projects) | 15 % | 14 % | 13 % |

Numerical data according to financial statements

| Research-related results | 2002 | 2003 | 2004 |
|---|---|---|---|
| Talks at scientific conferences, workshops and lectures* | 0.77 | 0.82 | 0.88 |
| Appointments to universities | 11 | 11 | 12 |
| Teaching contracts | 131 | 137 | 159 |
| Masters' theses | 150 | 199 | 235 |
| Doctoral dissertations | 63 | 77 | 86 |
| Postdoctoral lecture qualifications | 3 | 4 | 5 |

* per scientific employee in institutes and facilities

| Technology marketing | 2002 | 2003 | 2004 |
|---|---|---|---|
| Income from licenses | Euro 1.9 m | Euro 3.9 m | Euro 4.2 m |
| Spin-off companies | 0 | 1 | 1 |
| New own technology transfer projects | 12 | 10 | 12 |
| Investment in technology transfer projects | Euro 1.7 m | Euro 2.2 m | Euro 2.4 m |

| Management instruments | 2002 | 2003 | 2004 |
|---|---|---|---|
| Total project work | 62% | 64% | 65% |

| Quality management | 2002 | 2003 | 2004 |
|---|---|---|---|
| Certifications and accreditations | 9 | 13 | 13 |

| National and European networking | 2002 | 2003 | 2004 |
|---|---|---|---|
| Participation in DFG | 32 | 34 | 36 |
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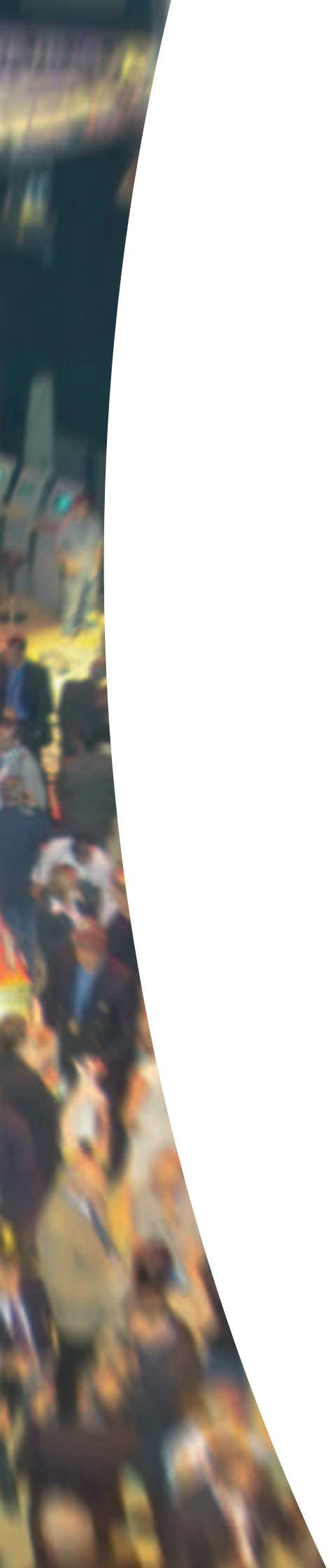

# DATA & FACTS

# Institutes and facilities

- Aerodynamics and Flow Technology
- Aeroelasticity
- Aerospace Medicine
- Air Transport and Airport Research
- Atmospheric Physics
- Combustion Technology
- Communication and Navigation
- Composite Structures and Adaptive Systems
- Flight Guidance
- Flight Operations
- Flight Systems
- German Remote Sensing Data Center
- German-Dutch Wind Tunnels Foundation
- Materials Research
- Optical Information Systems
- Planetary Research
- Propulsion Technology
- Quality Assurance and Product Safety
- Radio Frequency Technology and Radar Systems
- Remote Sensing Technology
- Robotics and Mechatronics
- Simulation and Software Technology
- Space Operations and Astronaut Training
- Space Propulsion
- Space Simulation
- Structures and Design
- Technical Physics
- Technical Thermodynamics
- Transport Research
- Transportation Systems
- Vehicle Concepts

# Members and executive bodies

**DLR had 49 sponsoring members in 2005 (as of June 30, 2005) along with honorary members, scientific members and ex officio members.**

## Honorary members

- The Honorable Daniel Saul Goldin, Washington
- Prof. Dr. rer. nat. Reimar Lüst, Hamburg
- Jean Sollier, Rueil-Malmaison
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- Robert Bosch GmbH, Berlin
- City of Braunschweig
- Bundesverband der Deutschen Luft und Raumfahrtindustrie e. V., Berlin
- CAE Elektronik GmbH, Stolberg - Carl-Cranz-Gesellschaft e. V., Weßling/Obb.
- Commerzbank AG, Großkundencenter West, Düsseldorf
- Computer Anwendung für Management GmbH, Gilching
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- Deutsche BP Holding AG, Hamburg
- Deutsche Gesellschaft für Luft- und Raumfahrt – Lilienthal Oberth e. V. (DGLR), Bonn
- Deutsche Gesellschaft für Ortung und Navigation e. V., Bonn
- Deutscher Luftpool, Munich
- DFS Deutsche Flugsicherung GmbH, Langen
- Diehl VA Systeme Stiftung & Co. KG, Überlingen
- Dornier GmbH, Friedrichshafen
- Dresdner Bank AG, Cologne
- EADS Deutschland GmbH, Munich
- ESG Elektroniksystem- und Logistik-Gesellschaft mbH, Munich
- Ford-Werke AG, Cologne
- Fraport AG, Frankfurt/Main
- GAF AG, Munich
- GERLING Vertrieb Firmen und Privat - AG/Gerling Vertrieb Industrie AG, Cologne
- GEW RheinEnergie AG, Cologne
- Industrieanlagen-Betriebsgesellschaft mbH (IABG), Ottobrunn
- Kayser-Threde GmbH, Munich
- KUKA Roboter GmbH, Augsburg
- LIEBHERR-AEROSPACE LINDENBERG GmbH, Lindenberg/Allgäu
- Lufthansa Technik AG, Hamburg
- MAN Technologie AG, Augsburg
- MST Aerospace GmbH, Cologne
- MTU Aero Engines GmbH, Munich
- Nord-Micro Elektronik AG & Co. OHG, Frankfurt/Main
- OHB-System AG, Raumfahrt- und Umwelt-Technik, Bremen
- Rheinmetall Defence Electronics GmbH, Bremen
- Röder Präzision GmbH, Egelsbach
- Rohde & Schwarz GmbH + Co. KG, Cologne
- Rolls-Royce, Deutschland Ltd & Co. KG, Dahlewitz
- RUAG Aerospace Deutschland GmbH, Weßling
- Siemens AG, Munich
- Snecma Moteurs, Vernon
- Tesat-Spacecom GmbH & Co. KG, Backnang
- Gemeinde Weßling, Weßling/Obb.
- ZF Luftfahrttechnik GmbH, Calden

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- Prof. Dr.-Ing. Maria Esslinger, Braunschweig
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- Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h. c. mult. Sigmar Wittig, Cologne
- Prof. Dr.-Ing. Johann-Dietrich Wörner, Darmstadt

# DLR Senate

**The following persons were members of the Senate on June 30, 2005:**

**From the sciences:**
- Prof. Dr.-Ing. Dr. h. c. mult. Hans-Jörg Bullinger ex officio
- Prof. Dr. rer. nat. Berndt Feuerbacher
- Prof. Dr. rer. nat. Ursula Gather
- Prof. Dr. rer. nat. Peter Gruss ex officio
- Prof. Dr.-Ing. Peter Horst
- Prof. Dr.-Ing. Wolfgang Kubbat (Vice Chairman)
- Dr.-Ing. Manfred Peters
- Prof. Dr.-Ing. Gottfried Sachs
- Uwe Teegen
- Prof. Dr. Ernst-Ludwig Winnacker ex officio
- Prof. Dr.-Ing. Johann-Dietrich Wörner

**From industry:**
- Dipl.-Ing. Frieder Hartmut Beyer
- Dipl.-Ing. Rainer Götting
- Dipl.-Betriebswirt Dieter Kaden
- Andreas Kleffel
- Dipl.-Ing. Reiner Klett
- Dr.-Ing. Norbert Rüdiger Ninz
- Dipl.-Kfm. Gerhard Puttfarcken
- Dipl.-Ing. Horst Rauck (Vice Chairman)
- Dipl.-Kfm. Burkhard Schuchmann
- Dr. rer. pol. Rainer Schwarz
- Dr.-Ing. Klaus Steffens

**From the public sector:**
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- Staatssekretär Dr. Hans-Gerhard Husung
- Ministerialrat Helge Kohler
- Ministerialdirigentin Dr. rer. pol. Waltraud Kreutz-Gers
- Staatssekretär Dr. Josef Lange
- Staatssekretär Prof. Dr. Frieder Meyer-Krahmer (Chairman)
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- Ministerialdirektor Dr. Andreas Schuseil
- Ministerialdirigent Dr. jur. Klaus-Dieter Stein
- Ministerialdirigent Dr. jur. Armin Tschermak von Seysenegg
- Staatsminister Dr. jur. Otto Wiesheu

# DLR Senate Committee

**On June 30, 2005 the Senate Committee included six members each from the sciences, the economy and industry, and the public sector.**

**From the sciences:**
- Prof. Dr.-Ing. Manfred Aigner
- Prof. Dr.-Ing. Klaus Drechsler
- Prof. Dr. rer. pol. Martin Grötschel
- Dr. rer. nat. Hans-Peter Kreplin
- Prof. Dr.-Ing. Reinhard Niehuis
- Prof. Dr. rer. nat. Sami K. Solanki (Vice Chairman)

**From trade and industry:**
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- Christa Fuchs
- Dipl.-Ing. Rainer Götting (Chairman)
- Betriebswirt Josef Kind
- Dipl.-Ing. Georg Rayczyk
- Dr.-Ing. Peter Tropschuh

**From the public sector (entitled to vote in 2005):**
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- Ministerialdirigent Helge Engelhard
- Ministerialdirigent Dr. jur. Wolf Günther
- Ministerialrat Dipl.-Ing. Helge Kohler
- Ministerialrat Dr. jur. Axel Kollatschny
- Vortragender Legationsrat 1. Klasse Dr. Karl-Ulrich Müller

**From the public sector (non-voting in 2005):**
- Ursel Anna Grunow
- Ministerialrat Dr. rer. pol. Gerd Gruppe
- Regierungsdirektor Dr.-Ing. Ulrich Stöcker

# Members of the Executive Board

**(as of June 30, 2005)**

- Prof. Dr. rer. pol. Achim Bachem
- Dr. rer. pol. Ludwig Baumgarten
- Prof. Dr. rer. pol. Bernd J. Höfer (Vice Chairman)
- Prof. Dr.-Ing. Joachim Szodruch
- Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h. c. mult. Sigmar Wittig (Chairman)

# Space Committee

**(as of June 30, 2005)**

- Ministerialdirektor Dr. C. Uhlhorn, Federal Ministry of Education and Research
- Vortragender Legationsrat 1. Klasse Dr. rer. nat. Karl-Ulrich Müller, Foreign Office
- Ministerialdirigent Joachim Schwarzer, Federal Ministry of Finances
- Ministerialdirigent Dr. jur. Wolf Günther, Federal Ministry of Economics and Labor
- Wolfgang Reimer, Federal Ministry of Consumer Protection, Food and Agriculture
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- Dr.-Ing. Ulrich Stöcker, Federal Ministry of Transport, Construction and Housing
- Rainer Hinrichs-Rahlwes, Federal Ministry of Environment, Nature Conservation and Reactor Safety
- Ministerialrat Harald Kuhne, Federal Chancellor's Office

# Scientific Technical Council

**Members of the Scientific Technical Council (as of June 30, 2005)**

| | |
|---|---|
| - Dr. Marina Braun-Unkhoff | VT |
| - Dr. Martin Bruse | DNW |
| - Dr. Reinhold Busen (Vice Chairman) | PA |
| - Prof. Dr. Stefan Dech | DFD |
| - Dipl.-Wirtsch.-Ing. V. Harbers (Chairman) | FB |
| - Dr. Thomas Holzer-Popp | DFD |
| - Prof. Dr. Herbert Jahn | OS |
| - Prof. Dr. Alberto Moreira | HR |
| - Dipl.-Phys. P.-M. Nast | TT |
| - Prof. Dr. Karsten Lemmer | FS |
| - Prof. Dr. Stefan Levedag | FT |
| - Prof. Dr. Hans Müller-Steinhagen | TT |

# DLR affiliates and joint ventures

**DLR Joint Ventures Gesellschaft mit beschränkter Haftung, Bonn**
**100.00 %**

The purpose of the company is participating in European economic interest groupings in accordance with the bylaws of the German Aerospace Center (DLR). The company was created in 2003 and recorded in the Bonn Commercial Register on August 20, 2003.

**German-Dutch Wind Tunnels Foundation (DNW), Noordoostpolder, Netherlands**
**50.00 %**

The foundation was established as a non-profit organization with equal shares held by DLR and its Dutch partner organization NLR (www.nlr.nl). It purpose is to operate, maintain and further develop the foundation's own low-speed tunnel in Noordoostpolder as well as other wind tunnels of DLR and the NLR.
(www.dnw.aero)

**European Transonic Windtunnel GmbH (ETW), Cologne**
**31.00 %**

ETW, the European Transonic Windtunnel, built and supported by the countries of Germany, France, Great Britain, the Netherlands, is the most modern aviation wind tunnel in the world. New aircraft designs are tested and improved as miniature models in the ETW under actual flight conditions. The knowledge that is gained is vital for the success of the aircraft project.
(www.etw.de)

**T-Systems Solutions for Research GmbH, Weßling**
**25.10 %**

T-Systems Solutions for Research, a joint venture of DLR and T-Systems ITS GmbH, offers a long-term IT partnership to customers in the fields of science and research. DLR has spun off its centralized data processing to the joint venture.
(www.t-systems-sfr.com)

**Anwendungszentrum GmbH Oberpfaffenhofen, Wessling**
**25.00 %**

The purpose of the company is building and operating an application center for satellite navigation and other technologies, intensifying cooperation between research and industry for developing new products and services in these areas as well as providing comprehensive corporate consulting services. The corporation was established on April 7, 2005 as a public-private partnership and has taken over DLR's incubator for founding businesses and facilities in the field of satellite navigation at the Oberpfaffenhofen site.
(www.anwendungszentrum.de)

**Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen Bad Neuenahr-Ahrweiler GmbH, Bad Neuenahr-Ahrweiler**
**25.00%**

The Europäische Akademie is dedicated to studying and evaluating the consequences of scientific and technical developments for the individual, man's social life and his natural environment. The main focus is on examining processes that are influenced by natural and engineering sciences and the medical disciplines. As an independent scientific institution, the Europäische Akademie pursues a dialog with trade and industry, culture, politics and society. The other shareholder is the German state of Rhineland-Palatinate.
(www.europaeische-akademie-aw.de)

**TTIB Technologietransfer- und Innovationszentrum Region Bonn Verwaltungsgesellschaft mbH i.L., Bonn**
**17.33%**

The company is responsible for the business management of TTIB Technologietransfer- und Innovationszentrum Region Bonn GmbH & Co. KG, whose active business operations have been suspended. The company is in the process of being liquidated.

**ZFB Zentrum für Flugsimulation Berlin GmbH, Berlin**
**16.67%**

The purpose of the company is providing flight simulators, particularly for research and teaching purposes, in the fields of applied research for flight guidance and flight systems, system simulation and manipulation and related technological fields, training and advance training of aeronautic engineers, and the training of flight crews.
(www.zfb-berlin.de)

**ZTG Zentrum für Telematik im Gesundheitswesen GmbH, Krefeld**
**6.00%**

The purpose of this competence center is introducing modern information and communication technologies into the health care field and improving and disseminating them. The main activities are neutral advisory services and project management for customers in industry and health care, implementation of interoperative solutions for integrated care and the promotion of the transfer of knowledge between health care, business, the sciences and politics.
(www.ztg-nrw.de)

**Geophysica EEIG, Florence**
**5.10%**

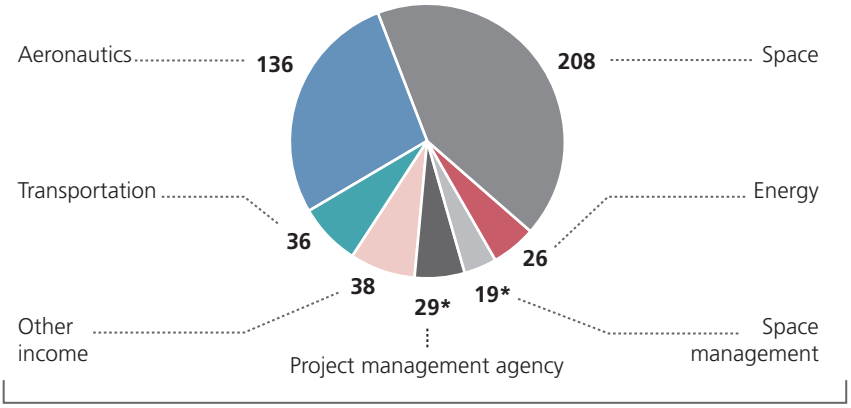
The company manages and coordinates the operation of the Russian high-altitude research aircraft Geophysica and offers participating European research institutions the opportunity to use the aircraft for research projects focused of the effects on climate changes and pollution of the ozone layer. Other shareholders are the Jülich and Karlsruhe research centers and four Italian partners including the ASI space agency and the CNR research organization.
(www.geophysica-eeig.cnr.it)

# Use of funds

## Total income in 2004 (third-party funding and basic financing)

**Total income**

Total Euro 492 million — All data in millions of Euro

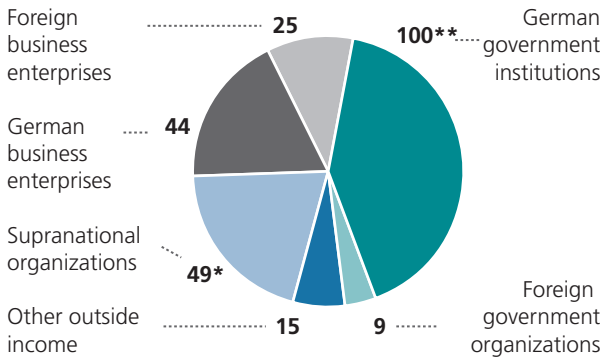



* Income for special expenditures is not included here and is reported under "other revenue and income."

## Third-party funding by source and institutional funding, 2004

**Third-party funding by source**

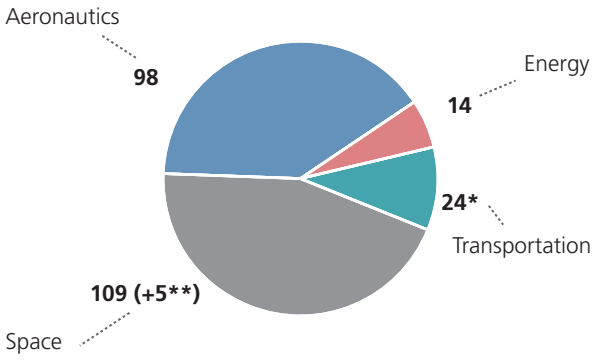
Total Euro 242 million — All data in millions of Euro




***** Of this: ESA **36,** EU **13,** other **1**
****** Of this: Project management agency **47,** national government institutions **40,** other German government R&D third-party funding **13**

**Institutional funding**

Total Euro 250 million — All data in millions of Euro

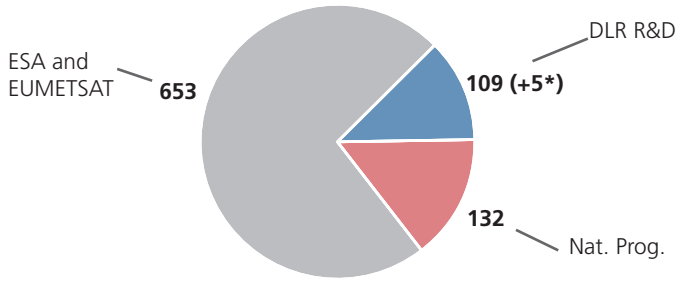



* The majority of the start-up financing for the core area of transportation which is in the process of being established is in the form of project funding and is not included here.
** DLR receives another Euro 5 million as a lump sum from the National Program, because it cannot apply for funding from the National Program.

# German public funding for space in 2004

**Public funding for space**

All data in millions of Euro




* DLR receives another Euro 5 million as a lump sum from the National Program, because it cannot apply for funding from the National Program.

Germany spent approximately Euro 900 million in public funds on civilian space activities in 2004.

Of that, about 73% was for the German contribution to the ESA (German Federal Ministry of Education and Research and German Federal Ministry of Transport, Construction and Housing) and EUMETSAT (German Federal Ministry of Transport, Construction and Housing), 15% for the German national space program and 12% for research and development in DLR's core area of space activities.

# List of abbreviations

| | |
|---|---|
| **ACARE** | Advisory Council for Aeronautical Research in Europe |
| **ATI** | Administrative und technical infrastructure of DLR |
| **ATM** | Air Traffic Management |
| **ATV** | Automated Transfer Vehicle |
| **AWI** | Alfred Wegener Institute for Polar and Marine Research |
| **BDLI** | German Aerospace Industries Association |
| **BMBF** | German Federal Ministry of Education and Research |
| **BMU** | German Federal Ministry of Environment, Nature Conservation, and Reactor Safety |
| **BMVg** | German Federal Ministry of Defense |
| **BMWA** | German Federal Ministry of Economics and Labor |
| **BWB** | German Federal Office for Defense Technology and Procurement |
| **BRH** | Federal Court of Audit |
| **CAAC** | China Administration of Civil Aviation |
| **CAD** | Computer Aided Design |
| **CAE** | Chinese Aeronautics Establishment |
| **CDA** | Cosmic Dust Analyzer |
| **CDR** | Critical Design Review |
| **CFD** | Computational Fluid Dynamics |
| **CFMU** | Central Flow Management Unit |
| **CIRA** | Italian Aerospace Research Center |
| **CNES** | French Space Agency |
| **CST** | Toulouse Space Center of CNES |
| **DDI** | Digital-Divide Initiative |
| **DFD** | German Remote Sensing Data Center of DLR |
| **DFG** | German Research Foundation |
| **DFS** | German Air Navigation Services |
| **DLR** | German Aerospace Center |
| **DNW** | German-Dutch Wind Tunnels |
| **EADS** | European Aeronautic Defence and Space Company |
| **EC** | Eurocopter |
| **ECD** | Eurocopter Deutschland |
| **ECSS** | European Cooperation for Space Standardization |
| **EDC** | Export Development Canada |
| **EMIR** | European Microgravity Research Programme |
| **ESA** | European Space Agency |
| **ESOC** | European Space Operations Center |
| **ESRANGE** | European Sounding Rocket Range |
| **ESTEC** | European Space Research and Technology |
| **ESVP** | European Security and Defense Policy |
| **EU** | European Union |
| **FuE** | Research and Development |
| **GAF** | Society for Applied Remote Sensing |
| **GASP** | Common Foreign and Security Policy |
| **GFZ** | Geoforschungszentrum Potsdam |
| **GKSS** | Forschungszentrum Geesthacht |
| **GMES** | Global Monitoring of Environment and Security |
| **GNC** | Guidance, Navigation and Control |
| **GSOC** | German Space Operation Center |
| **HBK** | High-pressure combustion chamber test bench |
| **HGF** | Helmholtz Association of National Research Centers |
| **HRSC** | High Resolution Stereo Camera |
| **HTSL** | High-temperature superconductor |
| **HU Berlin** | Humboldt University Berlin |
| **IABG** | Industrieanlagen-Betriebsgesellschaft mbH |
| **IFEU** | Institute of Energy and Environmental Research, Heidelberg |
| **ILA** | Berlin Air Show |
| **IP** | Integrated Project |
| **ISS** | International Space Station |
| **ISAS** | Institute of Space and Astronautical Science, Ibaraki University, Japan |
| **JAXA** | Japan Aerospace Exploration Agency |
| **KARI** | Korea Aerospace Research Institute |
| **LBK** | Electric arc-heated wind tunnel |
| **LSF** | Aviation Research Program on Safe and Efficient Flight Guidance |
| **MoU** | Memorandum of Understanding |
| **MPG** | Max-Planck-Society |
| **NASA** | National Aeronautics and Space Administration |
| **NASDA** | National Space Development Agency of Japan |
| **NGO** | Non Government Organization |
| **ONERA** | French Aeronautics and Space Research Center |
| **ORL** | Firma Orbital Recovery Ltd. |
| **PAC** | Polish American Congress |
| **PCB** | Printed Circuit Board |
| **PEFC** | Polymer Electrolyte Membrane Fuel Cell |
| **PIV** | Particle Image Velocimetry |
| **PKE** | Plasma Crystal Experiment |
| **PPP** | Public Private Partnership |
| **PT** | Project Management Organization |
| **RF-Agentur** | Space agency |
| **RFI** | Italian rail network operator |
| **RLV** | Reusable Launch Vehicle |
| **SAR** | Synthetic Aperture Radar |
| **SETES** | SAR End-to-End Simulator |
| **SLES** | Spacecraft Life Extension Systems |
| **SRON** | Scientific Research Organisation Netherlands |
| **SRTM** | Shuttle Radar Topography Mission |
| **SSC** | Swedish Space Cooperation |
| **STREP** | Specific Targeted Research Projects |
| **TH** | Technical University |
| **UAV** | Unmanned Aerial Vehicle |
| **UN** | United Nations |
| **UVIS** | Ultraviolet Imaging Spectrograph |
| **VIMS** | Visible and Infrared Mapping Spectrometer |
| **WÜTA 1** | Heat exchange test facility |

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www.DLR.de

# DLR at a glance

DLR is Germany's national research center for aeronautics and space. Its extensive research and development work is integrated into national and international cooperative ventures. As Germany's space agency, DLR has been given the responsibility above and beyond its own research for planning and implementing the German space program by the German federal government as well as for representing German interests on an international level.

Approximately 5,100 people are employed in DLR's 31 institutes and facilities at eight sites in Germany: Cologne-Porz, Berlin-Adlershof, Bonn-Oberkassel, Braunschweig, Göttingen, Lampoldshausen, Oberpfaffenhofen and Stuttgart.

DLR also operates offices in Brussels, Paris and Washington D.C.

DLR's mission comprises the exploration of the earth and universe, research relating to protecting the environment and environmentally compatible technologies for promoting mobility, and communication and security. DLR's research portfolio in its core areas of aeronautics, space, transportation and energy ranges from basic research to innovative applications and the products of tomorrow. In this 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 sites.

DLR **Deutsches Zentrum für Luft- und Raumfahrt** e.V.
in der Helmholtz-Gemeinschaft

**German Aerospace Center**

**Corporate Development and External Relations**

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