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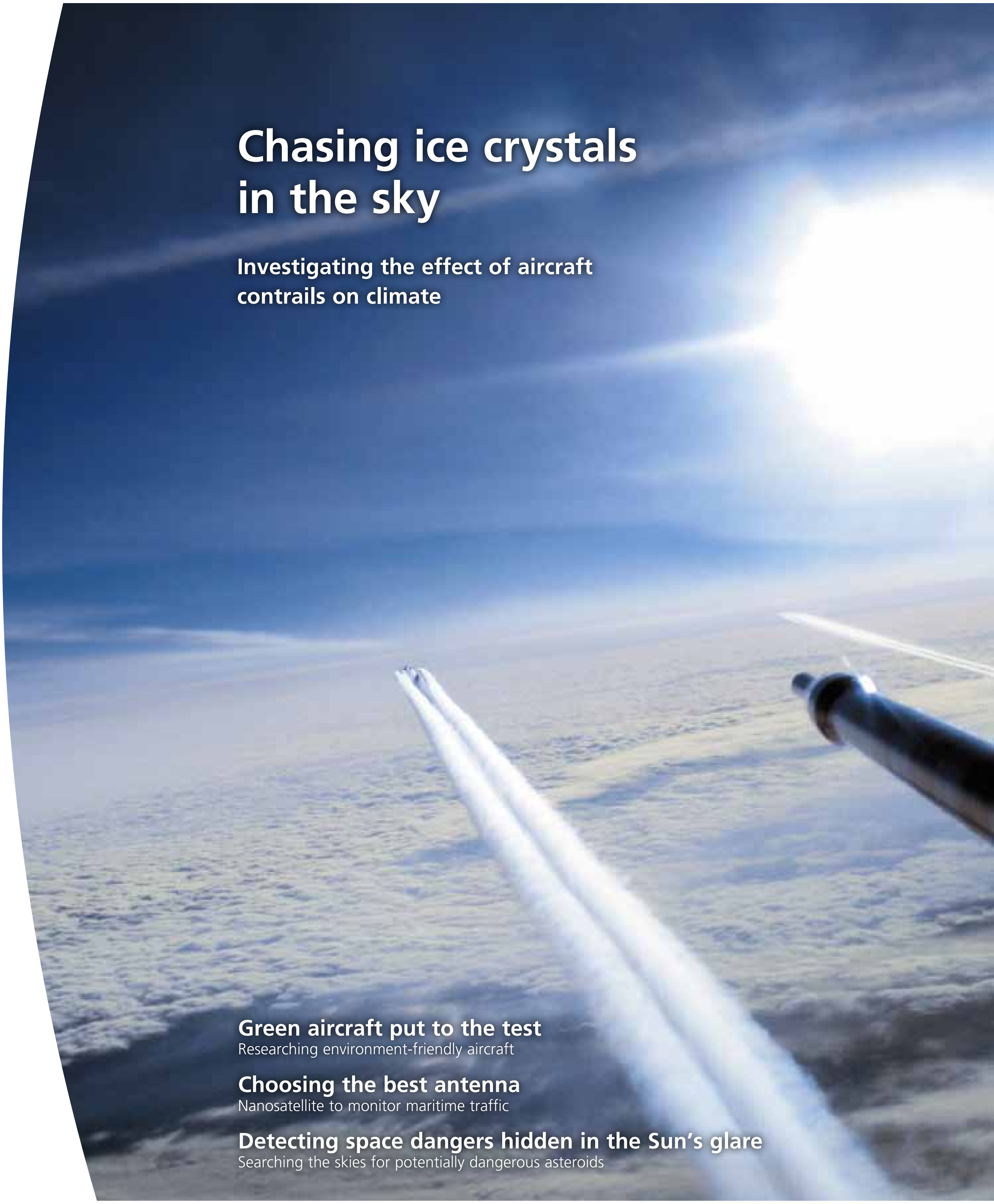
DLR magazine 126



Chasing ice crystals in the sky

Investigating the effect of aircraft contrails on climate

Green aircraft put to the test
Researching environment-friendly aircraft

Choosing the best antenna
Nanosatellite to monitor maritime traffic

Detecting space dangers hidden in the Sun's glare
Searching the skies for potentially dangerous asteroids

DLR magazine 126

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React in a flash

Thunder and lightning over Dresden. For airports like those serving this region, predicting the risk of heavy thunderstorms is of great importance. DLR researchers are investigating improved forecasting strategies: the 'RegioExAKT' and 'Weather and Flying' projects are helping to make air travel safer and to minimise the financial impact of severe weather.

Thanks to RegioExAKT, heavy thunderstorms around Munich Airport can be predicted more accurately. Storm cells are followed more closely by combining lightning and radar measurements. Researchers working on the Weather and Flying project are looking into providing customised weather information for flights at Frankfurt and Munich airports. The project is examining onboard and ground-supported control, monitoring and surveillance systems for improved flight characteristics in case of wind squalls, wake turbulence and thunderstorms.

Dear readers,

Research is exciting – sometimes very exciting. Not only because its findings frequently hold surprises that can create joy, astonishment or even disappointment, but also because a single discovery can become a historic milestone. DLR's research in the fields of aeronautics, space, energy, transport and safety has this potential.

Many of our employees enjoy working at DLR because they value its diversity. Few research facilities offer such an attractive range of subjects, with the breadth of project phases addressed at DLR – from conception to application – as well as opportunities for interdisciplinary work.

To share this excitement, showcase this diversity and awaken an appreciation of science and research – this is the goal of the new DLR Magazine. With this issue, we bid farewell to DLR Nachrichten; now we have a revised concept and a newly-designed Magazine. To us, covering the small steps on the way to new discoveries is as important as sharing key concepts of the complex subjects we research. This is why we want to offer a glimpse into the daily routine of scientists and managers at a research organisation that also functions as a space agency. In addition, we plan to tell you about DLR personnel who have unusual jobs or are enthusiastically working towards novel achievements.

We are also no longer targeting our flagship publication at only the national level; the DLR Magazine is being published in English so that we can also inspire people beyond the German-speaking world.

What more appropriate event could there be for the launch of the new DLR Magazine than the biggest aerospace exhibition in Europe, the Berlin Air Show? Air and space experts and enthusiasts are gathering here from all over the world to catch up with the latest trends and developments – for both commercial and scientific purposes.

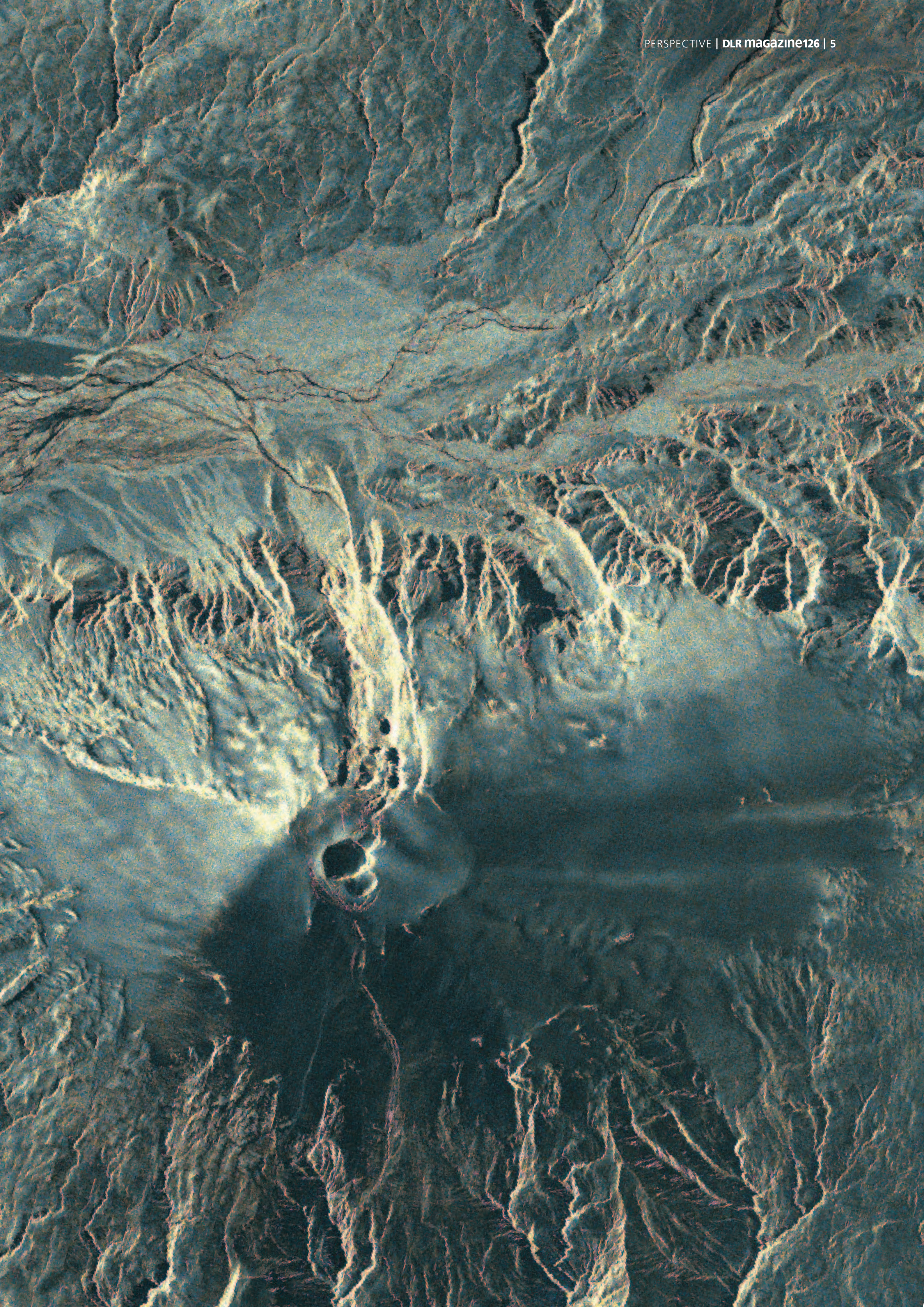
Enjoy reading!

Sabine Göge
Head of DLR Corporate Communications

Perspective

The Eyjafjallajökull volcano after its eruption

The German radar satellite TerraSAR-X acquired this image of Iceland's Eyjafjallajökull volcano on 18 Apr 2010 at 09:00 hrs. The volcano has been monitored continuously since its eruption on 15 April. The new crater openings at the summit show up distinctly in this image. Before the eruption, a thick layer of ice covered this area. The melting of the glacier caused flooding in the area to the northwest of the volcano. What remains is a wide network of runoff channels. While TerraSAR-X can see through normal cloud cover to acquire radar images of the ground, the volcanic ash suspended in the air to the east and south is clearly visible here as a dark area over the ice. The colours in the image vary depending on the surface characteristics. Smooth areas like fields or glaciers appear blue, areas with vegetation are seen in green, while sharp edges, such as crevices, are red.



Strategy for aeronautics and space, our vision for the future

By Johann-Dietrich Wörner, Chairman of the Executive Board

You are reading the new DLR Magazine, one of a family of publications being launched with the aim of reporting clearly and comprehensively on DLR's activities. This first issue is also an opportunity to share the progress made on some high-level topics. In 2009, we started a DLR-wide strategic development process. It served to position DLR, compile expectations and agree the various measures required to set goals. All our stakeholders became involved and had an opportunity to make a contribution. The considerable expenditure (on forums with DLR's institute directors, 20 discussion-oriented presentations to DLR staff and interviews with stakeholders from various areas including academia, business and politics) paid off. We now have a comprehensive set of statements that take account of the wide range of activities at DLR, yet are sufficiently focussed that they can be used as a basis for planning our next steps.

As a logical consequence, this rather organisational work must be followed by the translation of substantive strategies to our various fields of research. For aeronautics and space, national strategies take precedence over those of DLR, so as to cope with their particular industrial and political constraints. This responsibility lies with the government, especially the Federal Ministry of Economics and Technology. The coalition agreement of the current German government requires the drafting of a national space strategy within one year. As the national research centre for aeronautics and space and as the national space agency, DLR sees itself as having a special responsibility to support this process.

First, a national space strategy will be developed with the full participation of science and industry, in which the various aspects of space research and their overall objectives will be defined. In a top-down approach – based on the strategy – specific goals and priorities will be set and a space programme with specific missions and projects will be defined, with due regard for the financial resources available. Special attention must be paid to the different levels of involvement – national, European and international – so that resources are used as effectively as possible. In practice, this top-down approach is obviously influenced by consideration of the existing expertise and mission concepts when determining the priorities. It is important to clearly recognise and specify such factors, so as to not reduce the strength of the top-down approach. The time is ripe for reorientation of national efforts in space. Contacts with NASA point to new opportunities and a readiness for worldwide cooperation is discernible; Germany's efforts in space are appreciated and its special expertise is recognised.

As with space, aeronautics is characterised by special circumstances that call for particular attention at the political level; both areas are of extraordinary economic importance. This is why a suitable strategic process should be established for aeronautics, as well as space. At DLR, we are already working towards contributing our technical and strategic expertise in this field.

Johann-Dietrich Wörner has been the Chairman of the DLR Executive Board since May 2007. He began blogging about DLR, as well as some personal activities, in January 2010

www.DLR.de/blogs/en/janwoerner

The DLR Falcon 20E research aircraft proved itself once again, this time as a volcanic ash investigator

Falcon on the trail of Iceland's volcanic ash cloud

The Icelandic volcano Eyjafjallajökull erupted on 15 April 2010. Within a short time, the ash cloud ejected by the eruption spread over a wide section of Europe, leading to considerable restrictions on European and global air traffic. After only three days of preparation, the DLR Falcon 20E research aircraft took off for its first flight to study the ash cloud on Monday 19 April. The flight took place in German and Dutch airspace. The goal of the mission was to create a vertical profile of the thickness, density and composition of the cloud, as well as its spatial distribution. The resulting reports were made available to the German Federal Ministry of Transport, Building and Urban Development the following day. Concentrations of volcanic aerosols were indeed detected in the atmosphere. Investigations are ongoing.

www.DLR.de/volcanic-ash
www.DLR.de/research-aircraft

Around the world on solar-powered wings

The name says it all. Solar Impulse is the name of a solar-powered aircraft due to take off on a round-the-world flight in 2012. However, many tests need to be performed before it is ready to go. In early 2010, the DLR Institute of Aeroelasticity carried out the final ground vibration tests on the Solar Impulse prototype in Zurich.

This ambitious project imposes the most stringent requirements on the technology and construction of this aircraft. Solar Impulse needs a large wing area to generate sufficient lift. These wings also carry the solar cells which power the aircraft's four electric motors. Batteries must store enough solar power during the day to supply the propulsion units with energy through the night. To minimise the energy needed, the aircraft is extremely light – it has the wingspan of an Airbus A340, but weighs about the same as a mid-size car.

Swiss researchers Bertrand Piccard and André Borschberg were awarded the Braunschweig Prize for Research for their pioneering work in the field of solar-powered flight.

www.DLR.de/en/solarimpulse

The prototype Solar Impulse HB-SIA completed its maiden flight from the Swiss military airport at Payerne on 7 April 2010. The solar-powered aircraft climbed to an altitude of 1200 metres in front of thousands of spectators. "This first flight was the riskiest phase of the project," said André Borschberg, CEO and cofounder of the project. "An hour and 27 minutes of intense emotion after seven years of planning and testing. Such a large and light aircraft has never before taken to the air."

Year of Science 2010: showcasing DLR Energy research

Throughout 2010, science journalist Jan Oliver Löfken is answering a question every week on the subject of energy on DLR's Energy Blog. Readers can send in their questions at www.DLR.de/blogs/en/contact

In early June, 'DLR_School_Lab' took part in the 'Summer of Science 2010' event in Magdeburg, giving pupils the chance to conduct experiments on energy-related topics. Since May 2010, the travelling exhibition vessel *MS-Wissenschaft* has been sailing along Germany's inland waterways, carrying a DLR model of a solar-tower power station on board. Visitors can see how the Sun's rays are collected, how their energy is converted into electricity, and how this power is passed to the grid. DLR energy researchers are taking part in an online research exchange – 'Die Zukunft der Energie' (The Future of Energy). Participating school classes have the opportunity to invite scientists to visit their school.

Energy researchers at DLR deal with interdisciplinary projects associated with our common energy future. As part of this work, they have developed the first aircraft capable of taking off and flying on a single fuel cell. They have helped improve conventional power stations by optimising the combustion process, and are working with partners from industry to develop advanced energy storage systems. DLR researchers are renowned around the world for their expertise in testing solar power station mirrors, and they have demonstrated through a series of studies that renewable energy sources can deliver a secure energy supply.

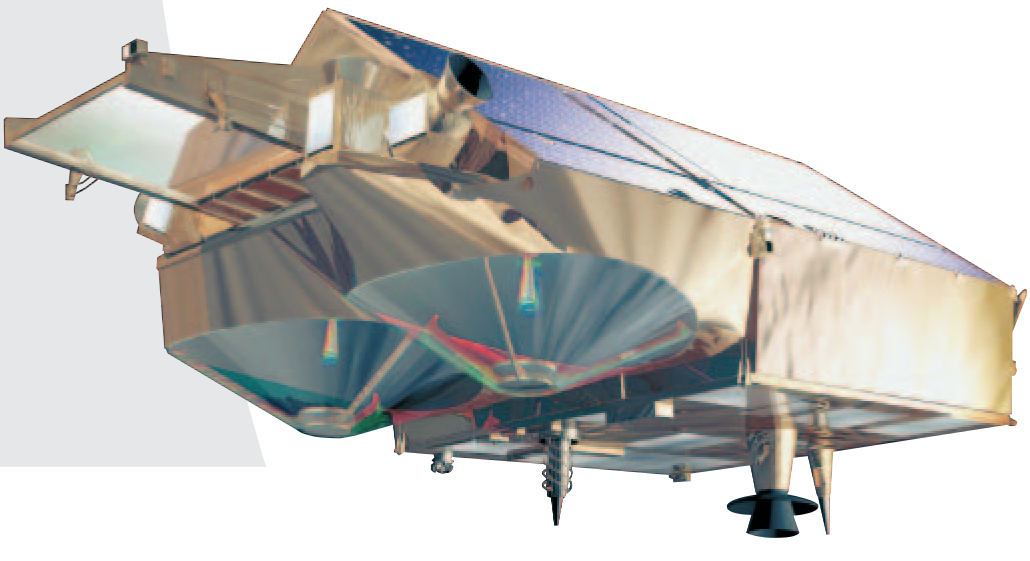
www.DLR.de/energy

CryoSat-2 measures changes in sea ice

Europe's satellite mission to measure the ice sheets of Greenland and the Antarctic has now begun. Since 8 April 2010, the Earth observation satellite CryoSat-2 has been investigating land ice sheets and sea ice from its orbit, 717 kilometres above Earth. The mission will cast new light on the relationships between global warming, melting of the polar ice caps and changes in ocean water and associated air circulation.

The German government, on whose behalf DLR supports this mission, remained committed to the mission concept following the loss of CryoSat-1, the predecessor of CryoSat-2, during its launch back in 2005. Scientists will be able to make use of the data acquired by CryoSat-2 from August 2010 onwards. The satellite's operational lifetime is five years and its results are eagerly anticipated by 18 research institutions.

www.DLR.de/en/cryosat



Air traffic tracker

Would you like to know what's passing through the skies over your head? Now you can, with this global map of current flight movements. You can even obtain information about the aircraft flying literally right above you at any given time.

www.flightradar24.com

Learning made easy

Energy, angular momentum and Schrödinger's cat – scientists from the University of Nottingham explain concepts and terms from physics and astronomy in a series of short, understandable videos.

www.sixtysymbols.com

Constellations on your PC

With Stellarium, you can download a planetarium. With it, you can see a realistic night sky, as it would look when seen with the naked eye, binoculars or telescope – guaranteed cloud-free.

www.stellarium.org

DLR labs open to schools

DLR's school laboratories in Cologne, Neustrelitz and Oberpfaffenhofen invite pupils to come and try their hand at scientific experiments. Nine of these 'DLR_School_Labs' offer pupils real-life experience of lab work. Anyone wishing to take part simply needs to enroll and plan their visit.

www.DLR.de/schoollab-animation

Particle physics rap

Fundamental physics as rap music? Dancing physicists? CERN scientists have produced an original and instructive song about the Large Hadron Collider. Particle acceleration with a twist!

www.tinyurl.com/lhc-rap-en

Science live

The latest research up close and personal, with instantaneous updates – exciting links to DLR research topics provided by online editors on DLR's Twitter channel.

www.twitter.com/DLR_en

Seeing the big picture

The task is clear – consider the whole system. It may appear simple, but appearances can be deceptive. After all, the subject under consideration is concepts for air transport systems. The 'whole system' in this context means systems analysis and the development of new conceptual approaches for aircraft and their subsystems, as well as for elements of air transport infrastructure and the operation of air transport systems. It also involves the evaluation of new technologies to ascertain the technical, economic and ecological benefits they could bring to air transport systems as a whole. To this end, for the first time, researchers are pooling DLR's expertise to form a single entity. Three years after it was founded as a cooperative venture between DLR and the Hamburg University of Technology, the DLR Facility for Air Transport Concepts and Technology Assessment has established itself as an aeronautical engineering systems institute.

DLR's Hamburg-based Facility for Air Transport Concepts and Technology Assessment fills an important gap in the development of future air transport systems

Aviation journalist Heiko Stolzke spoke to its Director, Volker Gollnick, who introduces the facility

DLR researchers view air transport as a system, and investigate it accordingly

It all started in four rooms on the campus of the Hamburg University of Technology, back in May 2007. The Facility's growth quickly reached a pace that made it necessary to move to the harbour district of Hamburg. At present, 30 researchers work there, analysing various aspects of air transport systems and concepts. Adopting the perspective of the overall air transport system, the team's main task is to design solutions for the various subsystems – aircraft, air transport infrastructure and operations – and the interfaces between them, and to evaluate appropriate technologies. This is the only way to develop solutions for subsystems that are capable of meeting requirements for the system as a whole. Hamburg joins Seattle, Toulouse and Montreal as one of the world's leading aviation development regions. Several thousand people work in the aviation business here. Lufthansa Technik and Hamburg Airport join Airbus and a host of small- and medium-sized suppliers as major employers in the region. There are also universities and colleges of advanced technology.

"Aviation systems technology is a concept that has developed over the last few years out of systems technology and systems theory", explains Volker Gollnick, Facility Director. "This term describes the insight that, whenever you set out to build new aircraft, airports or flight management systems, or to develop new transport concepts, you need to consider the 'big picture' – that is, to have a vision of the entire system working as a whole, rather than focus on individual components and subsystems."

To meet this challenge, one needs a clear view of the basic elements of the air transport system as well as of the fundamental expertise in each subsystem. The strength of the Facility of Air Transport Concepts and Technology Assessment lies in its ability to combine these areas of expertise and also to couple its own expertise with specialist knowledge that other DLR aviation institutes have acquired over several decades.

Considering the journey from door to door

"This means that we are closing a gap in the field of aviation systems technology," Director Gollnick adds. Various DLR institutes have spent several years tackling individual aspects or elements of the aviation business. Researchers in Braunschweig are developing aerodynamic design methods and solutions for aircraft. Others are looking into new concepts for operational flight safety. In Cologne and Stuttgart, research is being conducted into construction techniques and materials as well as engine technology. But in the past, there has been no organisation dealing with new 'whole system' concepts and with the integration of – and reciprocal interactions between – all these individual system components. Only now, in Hamburg, has the first such truly interdisciplinary research facility come into being. It is intended to position DLR to devise and evaluate new aviation technologies, approached from different perspectives, up to and including door-to-door transport concepts.

At present, several projects are running with the aim of expanding the capability for 'whole system' analysis. In the main cluster project, 'Efficient Airport 2030' – led by the researchers in Hamburg – different technological approaches for efficient future air transport are being examined. Under the leadership of Klaus Lütjens, the researchers are devising concepts for air transport operations. These include technologies to improve the control of passenger flows within the airport, as well as new control rooms for airside handling and aircraft movement operations. This is critical to competitiveness, especially on short-haul flights: if the journey to the airport, check-in and waiting on the taxiway take longer overall than the actual flight, rail or road will lure the customer away. While the overall concept is devised by the Facility of Air Transport Concepts and Technology Assessment, the bulk of the detailed process simulation within the terminal is a matter for DLR's Air Transport and Airport Research Facility. Control rooms are developed by the DLR Institute of Flight Guidance. Other partners from industry and tertiary education in the Hamburg area help to complete the project by modelling the links to and from the airport, as well as aircraft designs and control technologies. This research is part of the 'New aviation' strategy of the Hamburg Aviation Cluster.

Another project deals with Climate-optimised Air Transport Systems. Together with other DLR institutes, investigations are underway to establish the benefits of varying the altitude of flight paths for aircraft on long-haul flights, partly to avoid the formation of vapour trails. To this end, the Hamburg-based facility specifies representative flight missions and numerical simulations of these missions are performed using adapted aircraft designs. The evaluation of the impact on climate is being carried out jointly with the DLR Institute of Atmospheric Physics in Oberpfaffenhofen.

The VAMP project – a breakthrough for distributed design processes

One key project, Virtual Aircraft Multidisciplinary Analysis and Design Processes, VAMP, is an excellent example of the integrated approach to collaborative work. The goal is a distributed design environment, which will enable aircraft to be cooperatively developed at different locations. If this can be turned into a reality within DLR in the next few months, it would mean a technological and methodological breakthrough in the 'whole system' development of aviation systems. Development of a common description language, Common Parametric Aircraft Configuration Scheme, for the air transport system was accomplished in a previous project, Technology Integration for the Virtual Aircraft, led by the DLR Institute of Aerodynamics and Flow Technology. It also became possible to link together the first design tools. The challenge now for VAMP is to extend the scope of design methods and application-related processes to develop individual and shared ways of using these tools. The shared development objective is achieved through the Virtual Integration Platform, which depicts the full scope of air transport concepts. The DLR institutes then have the joint task of devising specific new technologies, aircraft designs and operational concepts.

These virtual integration platforms, currently being developed in Hamburg for short-haul, long-haul and supersonic business passenger aircraft, lay the groundwork for the evaluation of new technologies. The Technology Assessment and Scenario Technique Department deals with this aspect. It prepares predictions about the future of aviation, and extrapolates technological

Director Gollnick's young team has grown to nearly 30 members over the past three years requirements. The same department also devises evaluation methods and derives criteria to reflect the technical, ecological and economic benefits of any given new technology. Researchers are using this method to establish the technical performance levels of fuel cells in aircraft, and the economic and ecological ramifications of this type of application. To bring this triumvirate of technological, ecological and economic factors together under a single heading, doctoral candidate Xiaoqian Sun is working with 'Multi-Attribute Decision Making'. This method draws together several features into a single assessment. This is necessary because individual speculative glances at the future are not a basis for developing viable predictions. Instead, various strands of development need to be identified and analysed together.

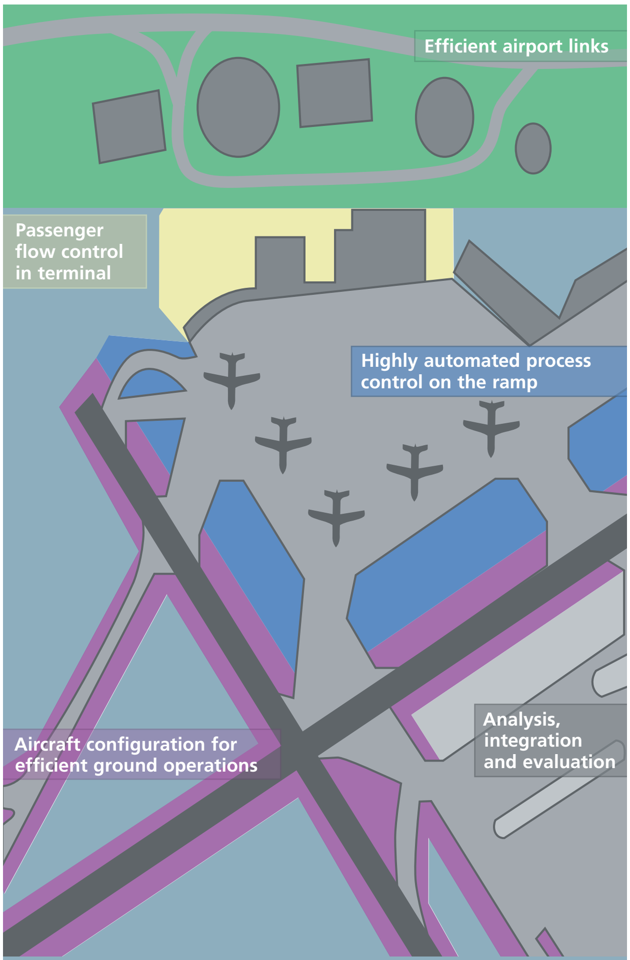
Hamburg: a great address for young researchers

Education and training are an important part of the work within DLR's Hamburg-based facility. Undergraduate, graduate and masters theses can be written in collaboration with the Hamburg University of Technology, and it is also possible to study for a doctoral degree. The integrated structure of the Facility and the University creates synergies for both partners. Along with the Hamburg University of Technology and the aviation-related institutes based there, a course of study entitled Aircraft Systems Engineering is being offered, combining aviation technology and related systems. This course also includes aircraft systems technology and cabin systems as well as production and assembly technology and air transport systems. At the time of writing, this systems-oriented and interdisciplinary course of study is unique in Germany and Europe. DLR's Hamburg-based facility makes a significant contribution through lectures on aircraft design, flight management, flight operations and technology evaluation. Over 30 undergraduate and graduate theses are a testament to the success and benefits of DLR's commitment.

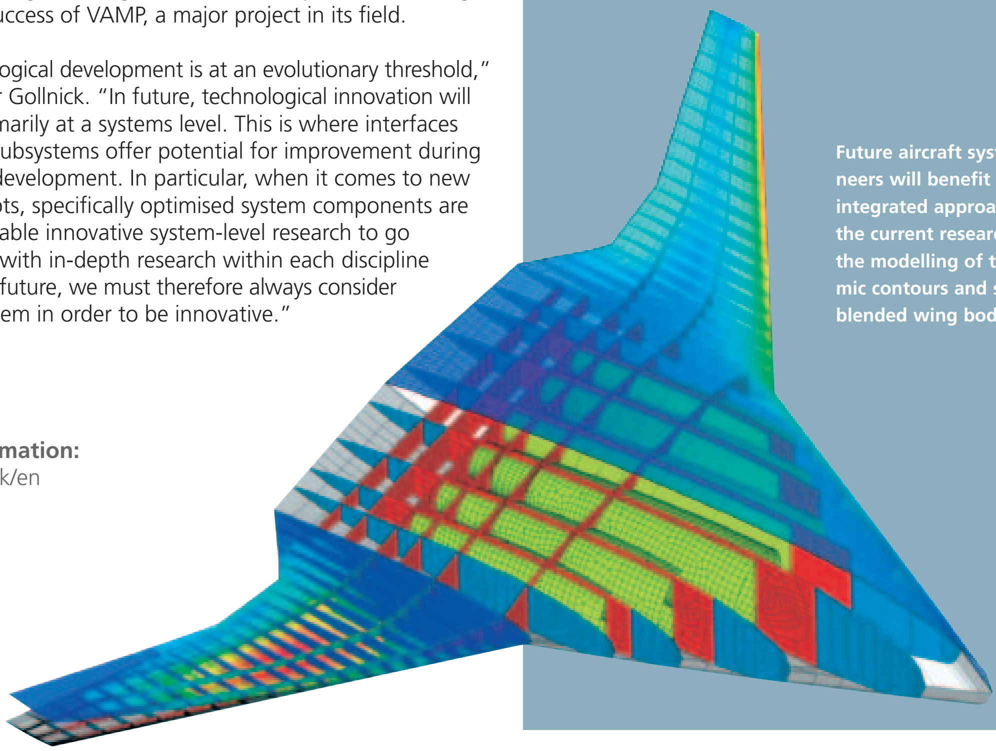
Pier Davide Ciampa, a doctoral student at the facility, deals with integrated modelling of aerodynamic contours and the associated structure of blended wing body aircraft. This configuration is likely to play a key role in the future of aircraft construction. It is, therefore, of great interest for the specialists in Hamburg to understand how a flight configuration of this kind behaves mechanically, and what can be done to optimise its structural design. Through this work, Ciampa is contributing towards the success of VAMP, a major project in its field.

"Technological development is at an evolutionary threshold," added Director Gollnick. "In future, technological innovation will take place primarily at a systems level. This is where interfaces between the subsystems offer potential for improvement during research and development. In particular, when it comes to new system concepts, specifically optimised system components are required to enable innovative system-level research to go hand-in-hand with in-depth research within each discipline at all times. In future, we must therefore always consider the whole system in order to be innovative."

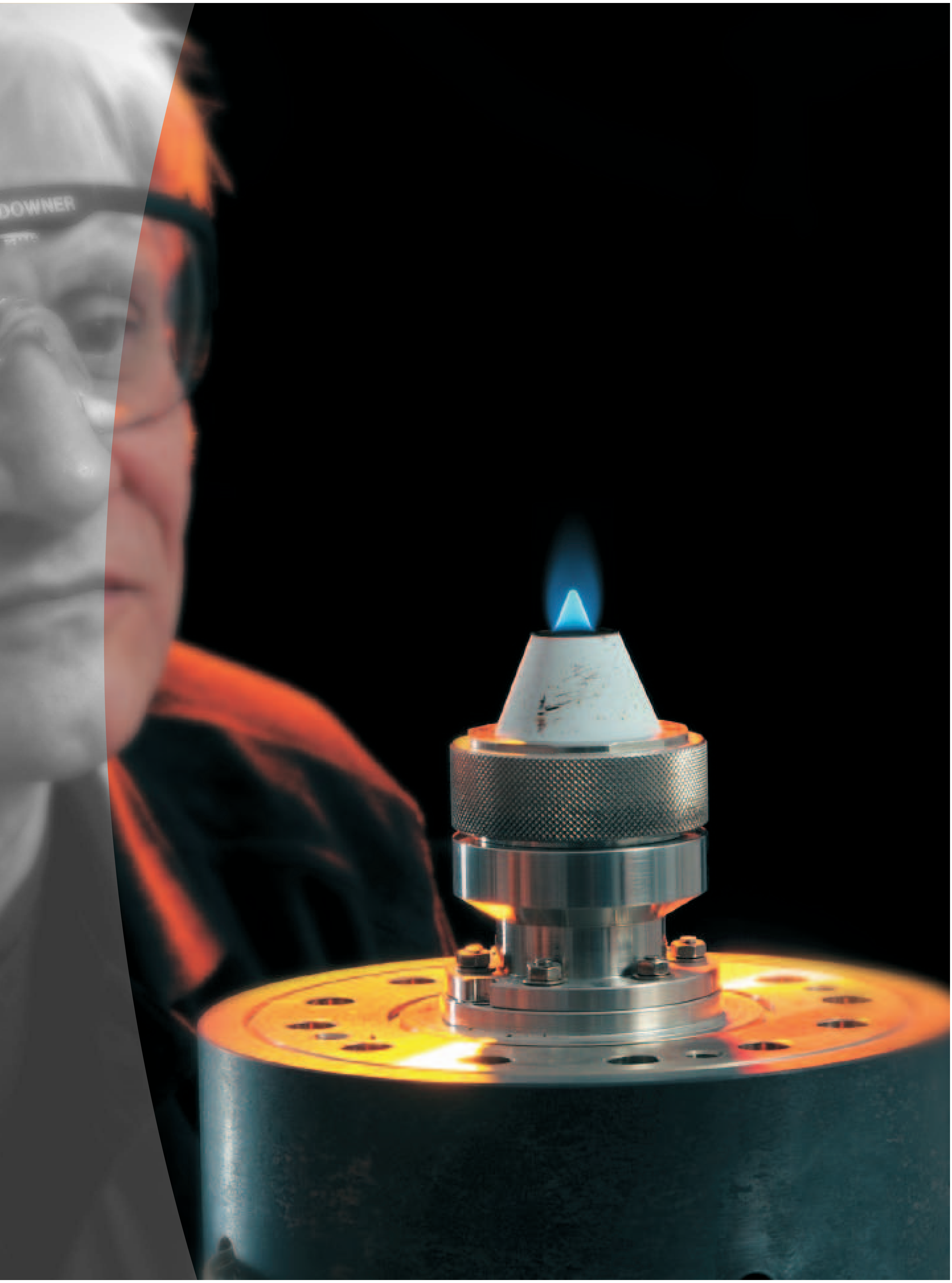
Further information:
www.DLR.de/lk/en



Different components have to be linked together for the air transport of the future



Future aircraft systems engineers will benefit from DLR's integrated approach. One of the current research themes is the modelling of the aerodynamic contours and structure of blended wing body aircraft


DOWNER

Alternative aviation fuels

Kerosene is the aviation fuel for all jet aircraft. It is manufactured from crude oil, but reserves are now dwindling. Within the foreseeable future, the rising price of kerosene made from crude oil will make it too costly as a fuel option. So, is it feasible to fly planes without kerosene? In recent years, the Stuttgart-based DLR Institute of Combustion Technology has been researching new synthetic fuels for the aviation sector in collaboration with partners from industry and the research sector. Their vision is not just to find a substitute for crude oil-based kerosene but instead, in the longer term, to develop an even better fuel. Synthetic fuels based on coal, natural gas or biomass could constitute the way forward.

DLR research into the combustion process within aircraft gas turbines

Written by Marina Braun-Unkhoff and Patrick Le Clercq

Work is progressing around the globe on finding alternative fuels for use in the civil aviation sector. Aircraft and engine manufacturers, energy companies, research institutions and airlines are all working together closely to achieve this objective. One of the main driving forces behind the whole initiative is to reduce the carbon dioxide emissions produced by the combustion of crude oil-based kerosene, which exacerbate global warming. Although air transport only contributes between two and three percent of the total problem, the European Union has decided to include the aviation sector in its emissions trading scheme with effect from 2012, and this will impact all take-offs and landings within Europe. The International Air Transport Association has announced that total carbon emissions in 2050 must not be higher than those recorded in 2005, and that any growth in carbon emissions from 2020 onwards must be rendered carbon-neutral. The only way to achieve carbon neutrality is to use sustainable fuels. Other ways forward, such as using new and more fuel-efficient engines, and more effective management of air transport cannot achieve more than a marginal reduction in carbon dioxide emissions. Airbus is assuming that, by 2020, biofuels will account for 15 percent of the fuel loads on its planes, while Lufthansa is planning to have biofuels supplying up to ten percent of its fleet fuel requirements by 2020.

Numerous test flights over the last couple of years have demonstrated that these objectives are fundamentally viable. What all these flights share in common is that any alternative fuel has been mixed, in the first instance, with kerosene, used in various mix ratios with Jet A-1 - currently the dominant fuel specification for aircraft engines. The maiden flight of a part-biofueled civilian transport aircraft took off in early 2008 (Airbus A380; Shell 50 percent Gas-to-Liquid (GtL) plus 50 percent Jet A-1; Rolls-Royce engines) and was a milestone along this path, as was the first scheduled commercial flight on 12 October 2009 (Qatar Airways A340-600, 50 percent GtL plus 50 percent Jet A-1; Rolls-Royce engines). A first test flight with a 1:1 mixture of biofuel / Jet A-1 took place in November 2009 (KLM Boeing 747-400); 40 selected passengers from the sector were there to share the experience.

The first step has therefore been taken to demonstrate feasibility. The next step is to find suitable alternative fuels. These need to be produced in sufficient volumes in a sustainable manner, to be available globally in a reliable way, at competitive

Many years of experience have gone into obtaining the perfect flame – it burns stably, with a conical shape

In this photo: measurement of heat release, performed at the Stuttgart-based DLR Institute of Combustion Technology

The first commercial scheduled flight to use synthetic Gas to Liquid (GtL) fuel: the A340-600 Airbus belonging to Qatar Airways

Particle analysis device used to examine pollutant emissions from new fuels at the DLR Institute of Combustion Technology

Research into the engine combustion chamber of the future

The impetus for DLR researchers is the prospect of improvements in the environmental credentials of new fuels. Gas-to-Liquid (GtL) fuel offers the prospect of a reduction in pollutant emissions because it releases fewer particles of soot. This would translate into improved air quality for people who live near airports. Further studies by DLR will tackle the oxidation of fuel – for example, through heat release – and its combustion characteristics, including engine relighting at high altitudes. Extensive experiments are being conducted on a wide variety of test benches, including high-pressure burners and shock tube systems. The expertise gained from this testing provides a basis for the development and optimisation of simulation tools. Last but not least, a reliable picture can be obtained of the combustion of alternative fuel in aviation gas turbines, including a description of the atomisation and vaporisation of liquid fuel, the thermal loads on combustion chamber walls and pollutant emissions. Building on this fresh knowledge, industry is developing new combustion systems for these alternative fuels. The testing of these combustion systems can then be performed at DLR, bringing the development process back full circle.

prices and without any need to convert delivery infrastructure. However, the primary objective remains the obtaining of official approval for air transport, because air traffic safety is very much the 'first commandment' in this sector. For this reason, all these 'fuels of the future' need to comply with certification standards such as the Standard Specification for Aviation Turbine Fuels. All this is assured by an elaborate and exhaustive certification process.

Research work into new fuels, from the basics up to use in aviation gas turbines

Alternative fuels will only be adopted on a widespread basis if they possess demonstrably superior environmental credentials to conventional kerosene. The aim of life-cycle assessment studies is to evaluate if this will indeed be the case. These studies take a systematic look at the entire production chain for synthetic fuels, analysing them in terms of climate-related emissions such as carbon dioxide, as well as for their impact on biodiversity and competition on the food chain. For example, all carbon dioxide emissions that occur are examined using a 'whole system' approach, all the way from initial source to their downstream impact. Applied to biofuels, this process extends from planting, harvesting, transport and processing of the raw materials, through the actual production process which converts raw materials into fuel, down the sales route for the finished product and all the way along to combustion of that fuel in the actual turbine. This is no easy matter because, until now, there has never been a common standard for producing analyses of this kind. Furthermore, the underlying business case has yet to be validated. However, systematic investigations of this nature make it easier to select raw materials and production processes.

Alternative fuels are commonly mixed with conventional kerosene, effectively as additives. The only 100 percent alternative fuel to be fully certified is the coal-based synthetic aviation fuel from Sasol. Referred to as a 'drop-in fuel', it offers the advantage of rendering modifications to the aircraft or engine unnecessary. At present, synthetic fuels are obtained from many different raw materials through one of two main processes. The Fischer-Tropsch process is used to manufacture the fuels known as XtL propellants: from biomass (BtL), natural gas (GtL) or coal.

In order to analyse the combustion characteristics of these fuels, high pressure and high temperature need to be established accurately within microseconds. This takes place in the shock tube system

The fuel known as HRJ (hydrotreated renewable jet) is produced using the hydrotreatment process, applied to vegetable oils deemed unsuitable for human consumption, such as Jatropha, as well as from waste products and byproducts. First of all, the oxygen locked into these oils is extracted; selective hydrocracking is then the key to synthesising optimum hydrocarbon mixtures suitable for use as aviation fuels. From an ecological point of view, BtL and HRJ kerosene should constitute the best means to move to more environment-friendly flying. However, they are only available in small quantities.

Widespread introduction of synthetic GtL fuel is anticipated within the next 10 years. In the longer term, it is expected that second-generation biofuels will become available, manufactured from plants tolerant of seawater. In future, this may even be extended to include algae. For biomass to cover the global demand for aviation fuel, an area the size of Germany would be required. However, if algae are vectored into the equation, the size of that area could be cut to just five times the surface area of Berlin, according to best-case scenarios.

At the very least, these newly developed fuels will exhibit the same physical properties as modern kerosene. This assures compatibility with engines and engine components, both for those currently in service and those planned for the future. This helps to avoid the need for any costly conversion, such as in the infrastructure required for refuelling aircraft. The DLR Institute of Combustion Technology is currently focusing on in-depth examinations of this coming generation of fuels, particularly in respect of their environmental credentials and operational reliability. At the same time, essential new tools are being developed to improve the composition of any new aviation fuel, for instance, in terms of an optimum number of carbon atoms and an optimal ratio of branched and long-chain hydrocarbon molecules. In a targeted design process, a new fuel can be created from a large number of individual molecules that complies fully with the stated specification and can receive official approval for use in air transport.

All this research work is conducted on a joint basis with partners. At the EU level, feasibility and the impact of the use of alternative fuels in the aviation sector are central factors, and they offer a decision-making aid for policy (EU order SWAFEA). A roadmap for alternative aviation fuels is being devised in the EU's ALFA-BIRD project to drive forward their use in the aviation sector. Other collaborative ventures are following suit, for example with Shell, Rolls-Royce, and the Qatar Science and Technology Park.

The development of new aviation fuels has now taken off; their technical feasibility has been demonstrated. The challenge is to produce them sustainably and in sufficient quantities. Major efforts are required from industry and from the research sector. Studies of GtL constitute a decisive first step towards the use of synthetic fuels in the aviation sector. They constitute an important bridge towards the long-term goal of creating sustainable biofuels. The new expertise gained can be leveraged for the development of high-performance biofuels. Sustainable aviation fuels would then be within reach. At this point, the vision of carbon-neutral air travel would become a reality.

About the authors:
Marina Braun-Unkhoff and Patrick Le Clercq work at the DLR Institute of Combustion Technology in Stuttgart on the subject of alternative fuels for the aviation sector. Their primary focus is on the description of the chemical and physical properties of synthetic fuels.
Marina Braun-Unkhoff deals first and foremost with characterising the combustion properties of fuels whereas Patrick Le Clercq is more involved with modelling and simulation of multi-phase flows and the physical properties of fuels.

Further information:
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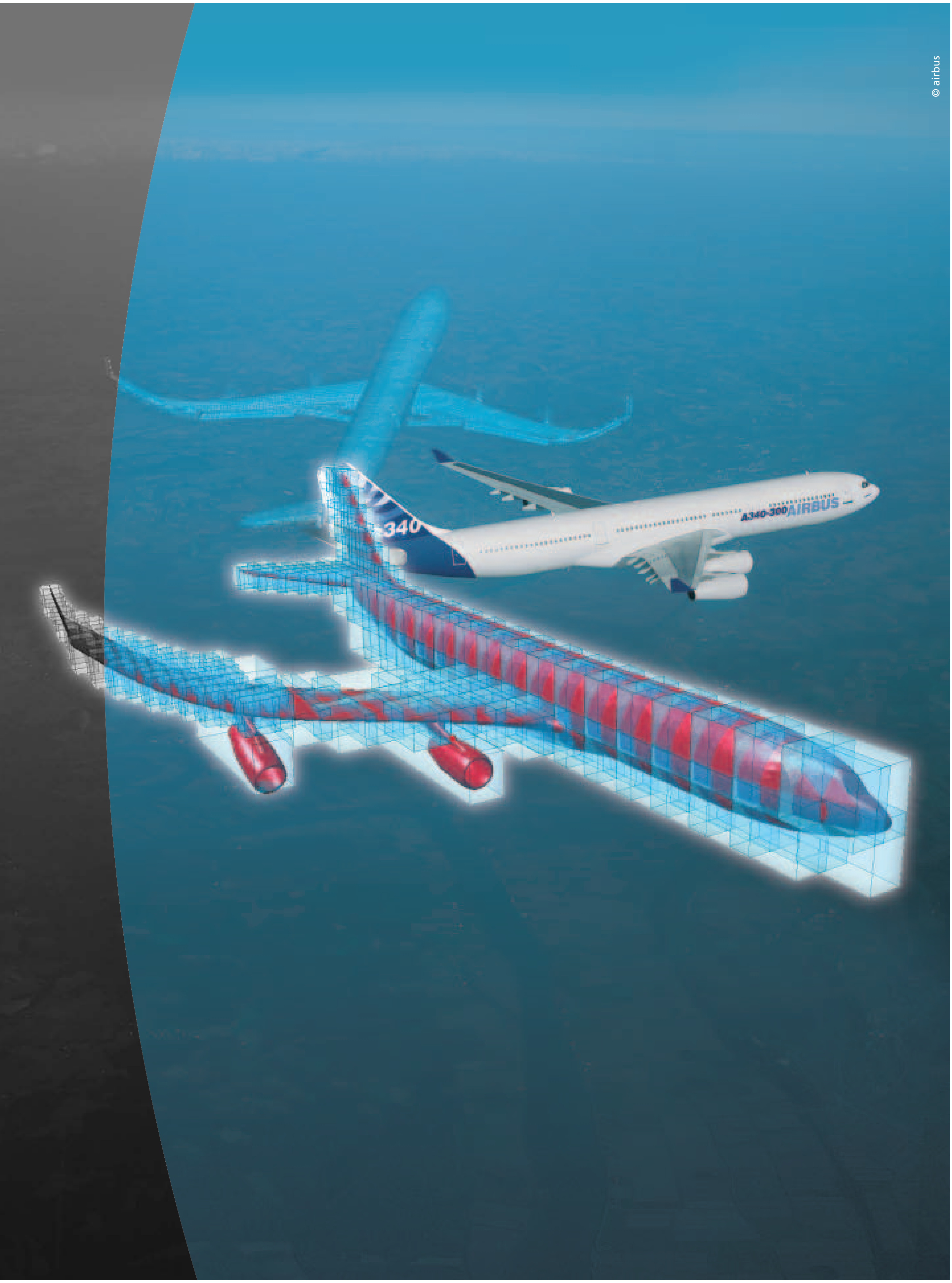


340
A340-300 AIRBUS

Green aircraft put to the test

Global air transport has grown fivefold over the last 30 years. Even so, the expectation is that further substantial growth will be seen in the the next 15 years. Experts estimate that somewhere between a doubling to a trebling will be experienced. Until now, a new aircraft design was hailed as progressive if it delivered some additional enhancement in terms of performance, economy and safety. That is no longer sufficient; in future, aircraft will have to reduce their environmental impact while increasing their social acceptability. That is what the ACARE, the Advisory Council for Aeronautical Research in Europe, a new combined European effort in the aviation sector, sets out in its Vision 2020. DLR is mobilising the expertise of several of its research institutes to achieve the 'iGreen' objective – the integrated 'green' aircraft.

Lightweight construction, better engines and optimised wings for the environment-friendly aircraft of the future

By Ralph Voss

Experts estimate that the aviation sector will grow by a factor of two to three over the next fifteen years. Aircraft of the future must lessen their environmental impact. DLR is mobilising the expertise of several of its research institutes for the development of iGreen, the green aircraft

In the past, whenever new aircraft succeeded in delivering better performance, economy and environmental compatibility, these improvements were based to a large extent on lightweight construction, high bypass-ratio engines and aerodynamically optimised wing geometries. However, these technologies caused unforeseen aeroelastic interactions between the aircraft structure and the airflow around it, some of which gave rise to safety concerns. These factors look set to play an even greater role in new types of aircraft concepts. The only way to limit the negative implications of these aeroelasticity effects is by taking full account of them right from a new aircraft's initial design stage. Promising signs are already emerging from designs for new, large engines, as well as from large aspect-ratio wings with laminar-flow profiles and multifunctional control surfaces to redistribute gust and manoeuvring loads. In order to exploit the potential of these new measures more effectively, an improved understanding of the physical phenomena is needed, and more accurate and reliable numerical simulation techniques have to be incorporated into the design process.

In DLR's integrated green aircraft iGreen project, the aeroelastic effects of these design measures are receiving serious scrutiny. The DLR Institutes of Aeroelasticity, Aerodynamics and Flow Technology, Propulsion Technology, and Air Transport Concepts and Technology Valuation are conducting this work with the assistance of DLR's Technology Systems House and the German-Dutch Wind Tunnel Foundation. Researchers are endeavouring to track down and explore specific phenomena using numerical simulations and experiments in wind tunnels. They are aided in this work by geometrically simplified 'generic' models, which are capable of separately representing each of the main factors. The results and methods are then incorporated in the design process in the form of a representative reference model for a green aircraft.

When compared to existing aircraft in the A320 class, this reference aircraft has the following design characteristics: forward-swept wings with laminar-flow profiles, large control surfaces to reduce load, a T-tail and rear-mounted engines. This overall configuration was chosen in conjunction with DLR's Laminar Aircraft project (see sidebar, right), which deals with all aspects of laminar-flow wing design. The iGreen project team first examines the aeroelastic implications of each of these individual green design characteristics in isolation, employing numerical and experimental techniques, then investigates them further with the help of generic models. Development staff focus first and foremost on minimising drag, reducing structural weight and cutting fuel consumption – without compromising aeroelastic stability in the process.

Flutter tests in the wind tunnel

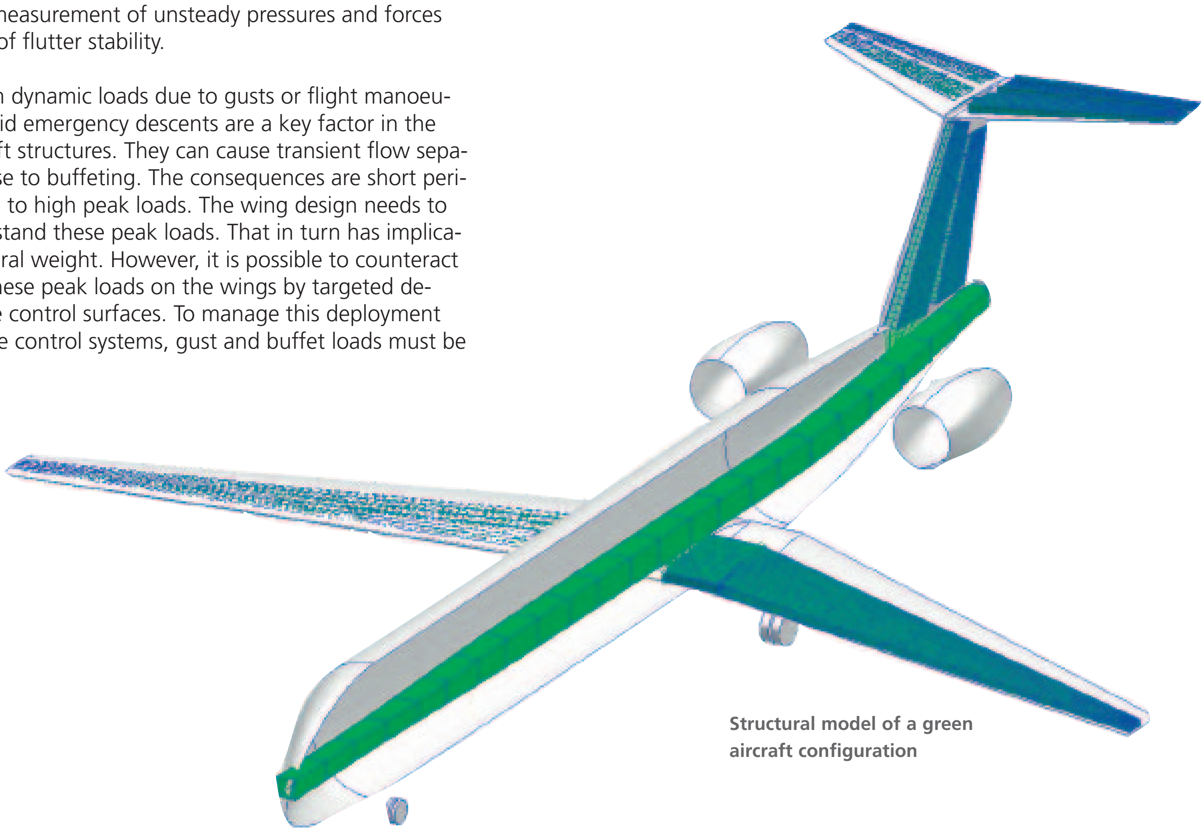
Laminar-flow wings have one great advantage: in contrast to conventional wings, the transition point between uniform airflow around the wing and turbulent flow conditions is located towards the rear part of this new wing design, rather than along the leading edge. This reduces drag and saves fuel, but it also alters static pressure distribution on the wing, as well as motion-induced unsteady pressure distribution that is critical to flutter stability. No research has so far been conducted into the implications for wing response characteristics. This is now being examined by the iGreen project on a simple wing model with laminar-flow geometry under forced vibration conditions and on an elastically-mounted configuration on the flutter test rig at the DLR Institute of Aeroelasticity and in the German-Dutch Wind Tunnel Foundation's Transonic Wind Tunnel at Göttingen. The model profile was defined on the basis of numerical simulations conducted by DLR's Institutes of Aeroelasticity and Aerodynamics and Flow Technology. Scientists collaborated with colleagues from DLR's RETTINA project (see sidebar, right) over the choice of numerical simulation techniques relating to the modelling of transition and turbulence. The wind tunnel tests are being conducted under the auspices of the Institute of Aeroelasticity, responsible for experiment design and modelling techniques for the measurement of unsteady pressures and forces and evaluation of flutter stability.

Maximum dynamic loads due to gusts or flight manoeuvres such as rapid emergency descents are a key factor in the design of aircraft structures. They can cause transient flow separation, giving rise to buffeting. The consequences are short periods of exposure to high peak loads. The wing design needs to be able to withstand these peak loads. That in turn has implications for structural weight. However, it is possible to counteract the impact of these peak loads on the wings by targeted deployment of the control surfaces. To manage this deployment with appropriate control systems, gust and buffet loads must be predicted very accurately. To this end, a generic wind tunnel model is being built for iGreen, and will be tested at the Transonic Wind Tunnel, Göttingen. Once the results are available, the numerical simulations will be checked against them.

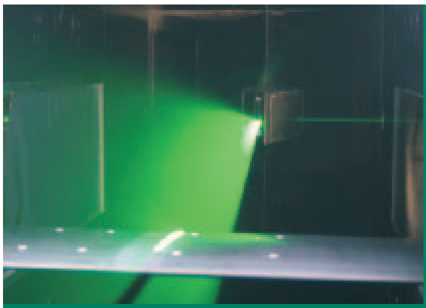
The model comprises two aircraft wings arranged one behind the other in the wind tunnel. The front wing will generate transient gusts and turbulent flow separation, either by being forced into harmonic oscillation or by deployment at a high angle of attack. On the second, downstream wing, the induced pressure fluctuations and resultant structural movements will be measured and recorded. The test layout is being designed jointly by the two DLR institutes on the basis of numerical simulations. Researchers from the Institute of Aeroelasticity measure the dynamic pressure distribution as well as loads, and observe the movements of the models. The researchers at the Institute of Propulsion Technology measure the gust fields using optical techniques.

Engines with high bypass ratios have now reached a size that causes undesirable, transient aerodynamic interference with wing and tail surfaces, and gyroscopic effects. The first of these problems has been examined by the DLR HighPerFlex project (see sidebar, right), while the latter issues are receiving attention from iGreen. In particular, the implications for an aircraft's flutter safety are being examined. The Institute of Aeroelasticity is responsible for experiments and calculations of flutter characteristics. In Cologne, the Institute of Propulsion Technology is conducting detailed numerical aerodynamic studies.

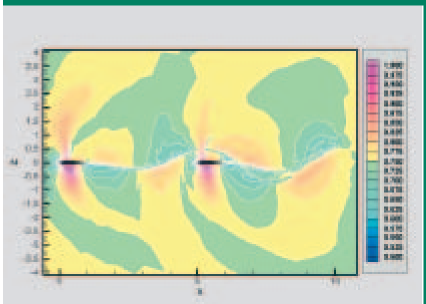
The DLR Institutes of Aeroelasticity and Propulsion Technology will incorporate the results from these separate studies in the overall design of the reference aircraft, which was defined and further developed in close consultation with the LamAIR project. There are plans to incorporate the lessons learned from iGreen and LamAIR into the joint designs of the DLR aviation institutes involved in the VAMP project (see sidebar, right). The iGreen project is scheduled to run until the end of 2011.



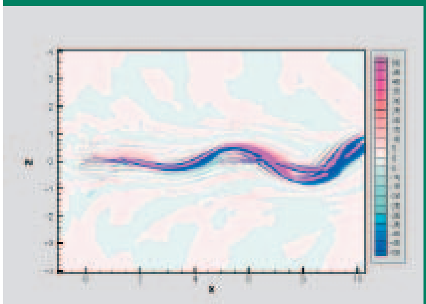
Structural model of a green aircraft configuration



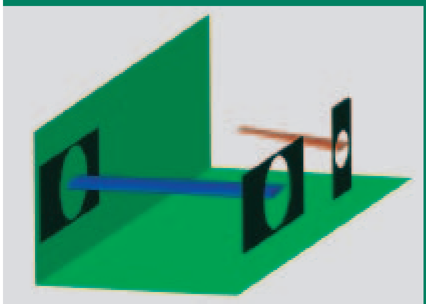
Instantaneous vorticity density distribution (positive vorticity density in red, negative vorticity density in blue) in one geometric plane, in the wake of an oscillating wing (grey). The flow is coming from the right



Flow field of two sequentially arranged aerofoils exhibiting torsional oscillation. This image shows an instantaneous plot of Mach number distribution (high values in red, low values in blue). Thick white lines emanating from the trailing edges of the aerofoils reveal the unsteady wakes



Flow field of two sequentially arranged aerofoils exhibiting torsional oscillation. This image shows the instantaneous vorticity density distribution (positive values in red, negative values in blue). High values arise in the unsteady wake behind the aerofoils



Wind tunnel model with two generic wings. Wind direction from the front. The blue wing is used to generate gusts, or turbulent flow conditions caused by buffeting. The dynamic reaction of the red wing is being measured

ACARE (Advisory Council for Aeronautical Research in Europe) Vision 2020: Environmental policy initiative for aviation, the objectives of which for the year 2020 include cutting carbon dioxide emissions by 50 percent, emissions of oxides of nitrogen by 80 percent and perceived noise pollution levels by 50 percent, as well as making the overall product life cycles of aircraft more environment-friendly

RETTINA (Reliable Turbulence and Transition Modelling for Industrial Aerodynamics): A DLR project dedicated to turbulence and transition modelling in the DLR flow simulation procedure TAU

LamAIR (Laminar Aircraft): A DLR project to make the benefits of laminar-flow technology more accessible to future generations of aircraft (the ones succeeding the Airbus A320 and Boeing B737 families)

HighPerFlex (High Performance Flexible Aircraft): A DLR project which ran from 2004-2006 and was devoted to the validation of numerical simulations of turbulent flow and flow-structure coupling for wing/engine interference and control surface deployment

VAMP (Virtual Aircraft Multidisciplinary Design and Optimization Process): A DLR project in which a multidisciplinary process for evaluating new aircraft configuration concepts has been developed

About the author:
Ralph Voss is in charge of the Unsteady Aerodynamic Modelling Group at the DLR Institute of Aeroelasticity and is also the Head of the iGreen project.

More information:
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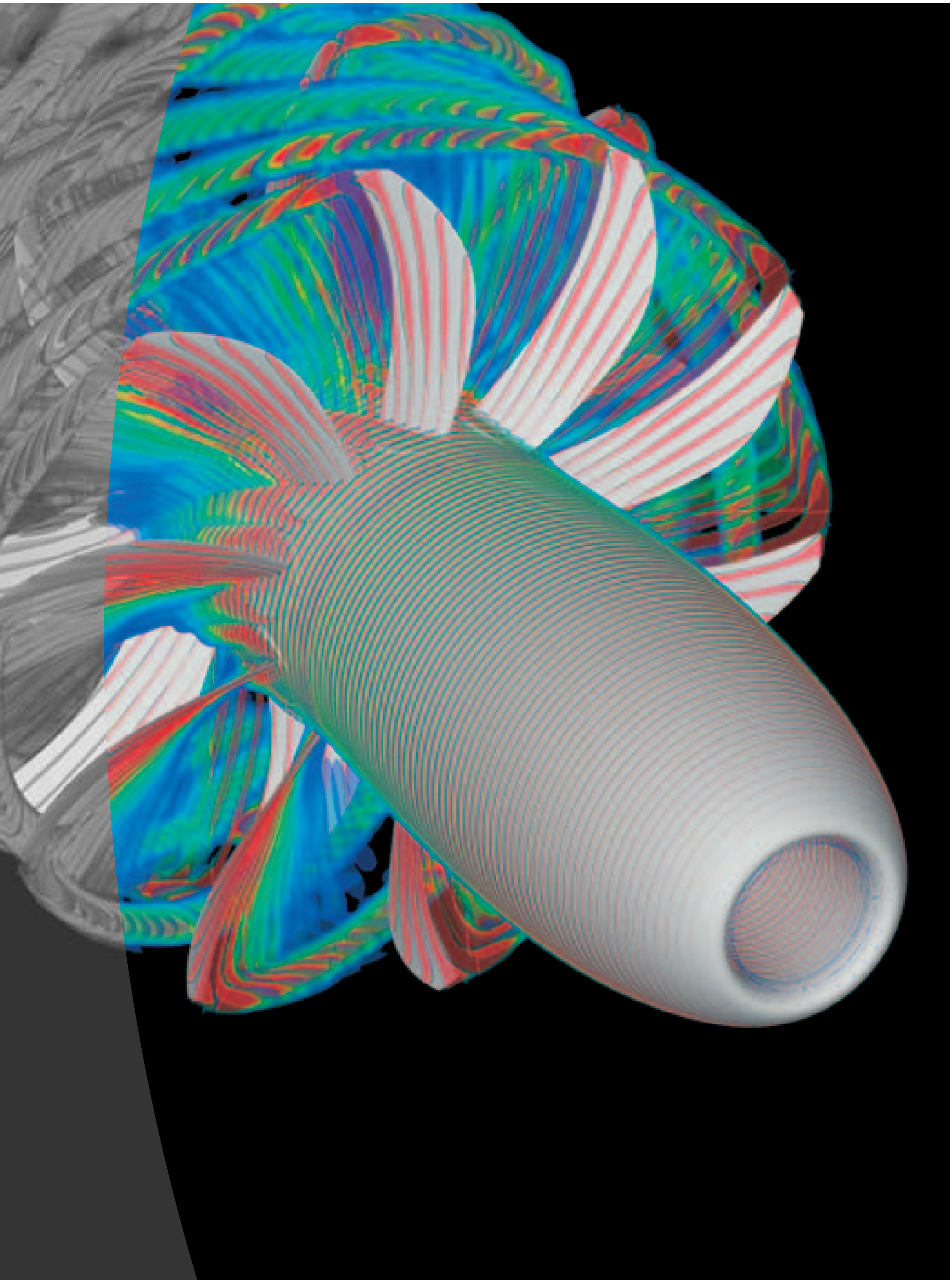


Renaissance for open rotors

The transport aircraft of the future will need to be economical while boasting impeccable environmental credentials. Among other things, this will call for a new way of thinking about aircraft propulsion. DLR researchers have undertaken an elaborate set of simulations to conduct a detailed evaluation of one very promising concept. DLR's aerodynamics and propulsion system specialists have confirmed the outcome of the studies: contra-rotating open rotors – aircraft propulsion systems without their usual fan casings – constitute a realistic, energy-efficient alternative form of propulsion for the next generation of civil airliners.

DLR simulates the propulsion systems of the future: environment-friendly propeller-driven travel

By Arne Stürmer, Rainer Schnell and Jasmin Begli

Flow-field visualisation of the complex aerodynamic interactions between two rotors of a CROR propulsion system through blade wakes and tip vortices

An especially promising idea that has emerged from the joint research efforts of the DLR Institute of Aerodynamics and Flow Technology in Braunschweig and the Cologne-based DLR Institute of Propulsion Technology is the Contra-Rotating Open Rotor, better known by its acronym, CROR. CROR is a propulsion system comprising two rotors arranged one behind the other and rotating in opposite directions, hence 'contra-rotating'. Unlike turbofan aero engines commonly used in civil airliners, CROR dispenses with the fan duct. During flight, this gives rise to a much higher bypass ratio (the ratio between airflows outside and inside the turbine), boosting efficiency. In comparison with a conventional propeller, the two contra-rotating rotors also improve efficiency levels at higher flight speeds. With a second rotor, the losses caused by velocity components that do not contribute to thrust are virtually eliminated.

Turbulence causes noise … and gives experts a real headache

At this stage, the CROR design has a few disadvantages which need to be overcome before the system is ready for widespread use. Researchers still face a number of technical challenges, both in terms of installating these propulsion systems on aircraft – with rotors that measure four to five metres in diameter – and the relatively high noise level due to the absence of a fan duct. While the arrangement of the rotors one behind the other improves aerodynamic efficiency, and is consequently more cost-effective, the resulting aerodynamic interactions – such as turbulence between the two rotors – are a significant source of noise. Researchers at the Institute of Propulsion Technology established that the blade tips of the forward rotor induce high levels of turbulence and vortical structures that impact the blades of the aft rotor. This in turn creates a noise similar to that of a flying helicopter. The aim of the researchers was to reduce this noise to a minimum. It is the influence of the forward rotor, that is, its effect on the airflow through the aft rotor – known as rotor wake vortices – that gives rise to an undesirable level of noise.

To make the complex flow-related physics of a CROR propulsion system easier to understand and to help identify specific improvements, different variants of CROR received close scrutiny through linked aerodynamic and aeroacoustic simulations. These place heavy demands on available computing power and the calculations were only made possible by the high-performance computer of the C²A²S²E (Center for Computer Applications in AeroSpace Science and Engineering) department at DLR Braunschweig. Numerical methods developed at DLR were used to simulate the different CROR variants. These simulations enabled detailed analysis of the aerodynamic and aeroacoustic phenomena involved to an unprecedented level of accuracy, helping the researchers refine their understanding of the complex flow-related physics of this form of propulsion system.

For the Institute of Aerodynamics and Flow Technology, the focus was on finding the ideal installation configuration on the aircraft and the optimal rotor blade diameter and number of blades. In contrast, researchers at the Institute of Propulsion Technology directed their efforts toward the 3D geometry of the rotor blades. To ensure that CROR powerplants can really be turned into viable propulsion systems, the researchers also paid close attention to the mechanical aspects of blade design. The resulting variants were simulated under take-off and cruise conditions.

Data evaluation showed that, in terms of aerodynamics and aeroacoustics, the most favourable CROR configuration is where the forward rotor has more blades than the aft one. Increasing the number of blades on the forward rotor makes it possible to lower the aerodynamic loads on the forward blades and reduce wake size and turbulence at the blade tips. The consequent, less pronounced, effects on the aft rotor help achieve a substantial reduction in noise emission levels. An additional benefit was achieved by reducing the diameter of the aft rotor. This prevents turbulence from the forward blade tips directly affecting the aft rotor, eliminating another source of noise.

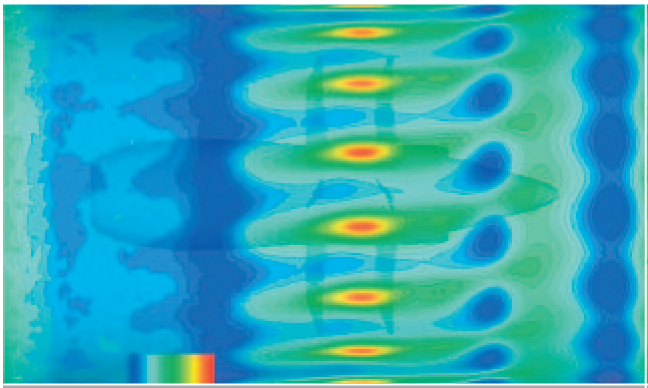
Radial twist and curvature of the rotor blades deliver a solution

During the 3D design of the rotor blades, the researchers focused on optimising the geometry of the forward rotor. In addition, they varied key geometric parameters – principally the radial twist and curvature of the rotor blades. By minimising the rotor slipstreams and the level of interaction with the aft rotor, noise levels were substantially reduced. The improved acoustic properties and the high level of aerodynamic efficiency were maintained reliably throughout all flight phases.

Despite these promising results, one thing must not be forgotten – for all variations in configuration, the ingenuity of the rotor design is the deciding factor. Under certain circumstances, a compromise has to be made between aerodynamic, mechanical and aeroacoustic requirements.

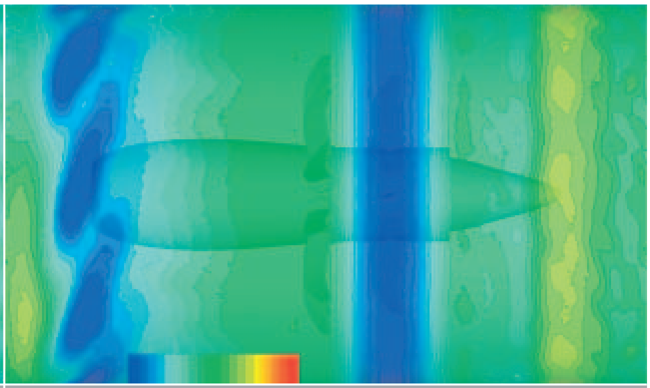
In addition to the research work conducted to date and a range of commissioned assignments, DLR's Institutes of Aerodynamics and Flow Technology and Propulsion Technology are also engaged in a large number of other CROR-related research projects. These include the EU-sponsored project valiDation of Radical Engine Architecture systeMs, DREAM, and the Smart Fixed Wing Aircraft project suported through the EU's Joint Technology Initiatives. A number of areas are covered under Smart Fixed Wing Aircraft, including passive and active noise reduction technologies. The intention is to drive these new propulsion system designs towards operational readiness in a way that will be relevant for industry.

Cooperation between the two DLR institutes combines the expertise of engine researchers in Cologne with the skills of scientists in Braunschweig working on rotor and engine integration. With its interdisciplinary analysis of various different CROR configurations, DLR has succeeded in making an important contribution towards the civil airliner of the future.



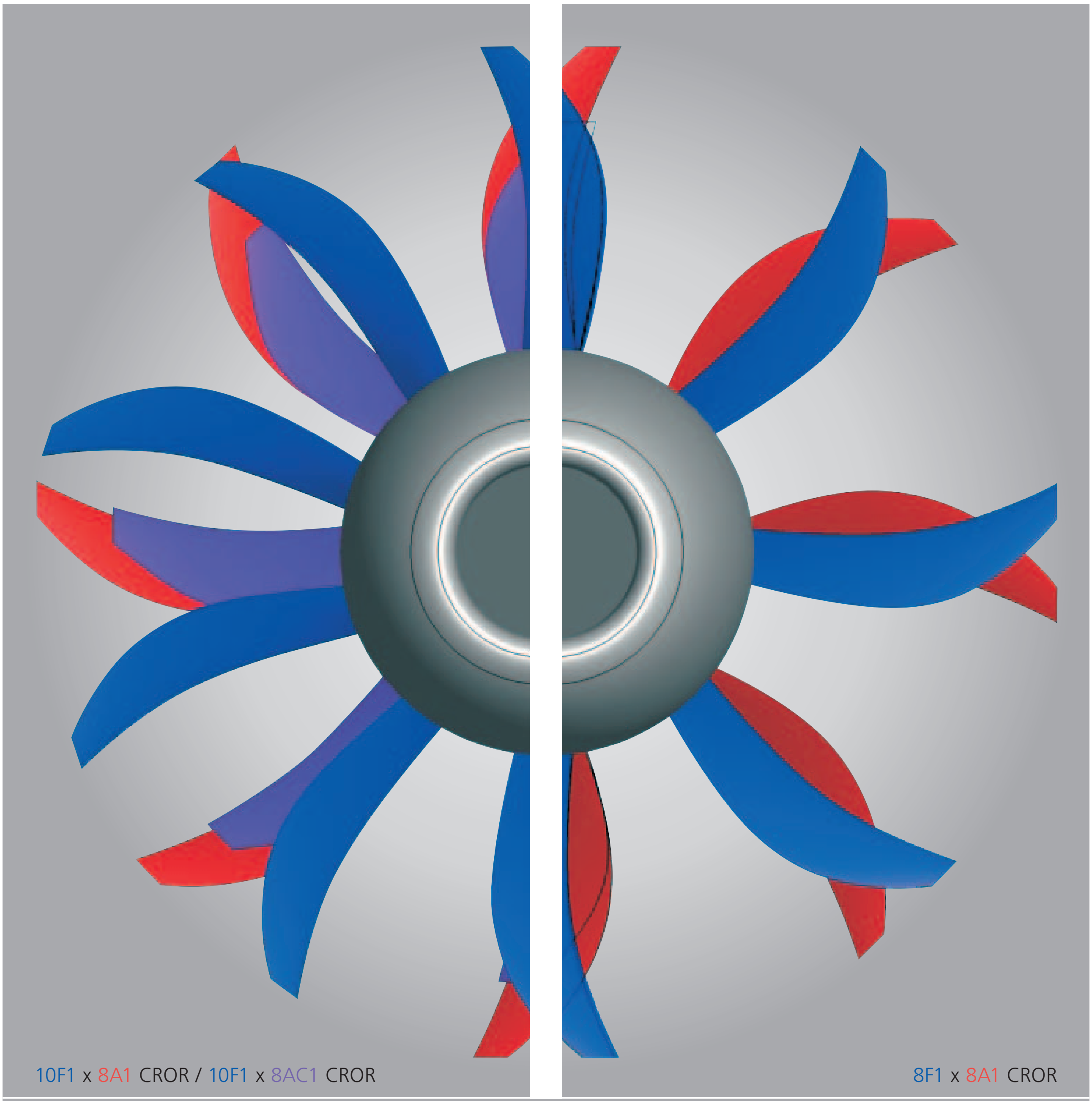
ΔL_p [dB]: -6 0 6

Near-field noise emission reductions of up to six decibels (dB) at typical take-off conditions through an increase in the number of blades on the forward rotor from eight to ten, resulting in reduced dynamic loads on the aft rotor blades



ΔL_p [dB]: -3 0 3

Noise reduction of up to three decibels (dB) in the near-field of a CROR engine at typical cruise conditions, achieved by reducing the diameter of the aft rotor. This prevents the forward rotor blade tip vortices from impinging on the aft rotor



Comparison of the configuration variants under study for a CROR propulsion system: increase in the number of blades on the forward rotor from eight to ten (8F1×8A1 CROR to 10F1×8A1 CROR) and reduction of the aft rotor diameter (10F1×8A1 CROR to 10F1×8AC1 CROR)

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Arne Stürmer, DLR Institute of Aerodynamics and Flow Technology.
Rainer Schnell, DLR Institute of Propulsion Technology.
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For further information:
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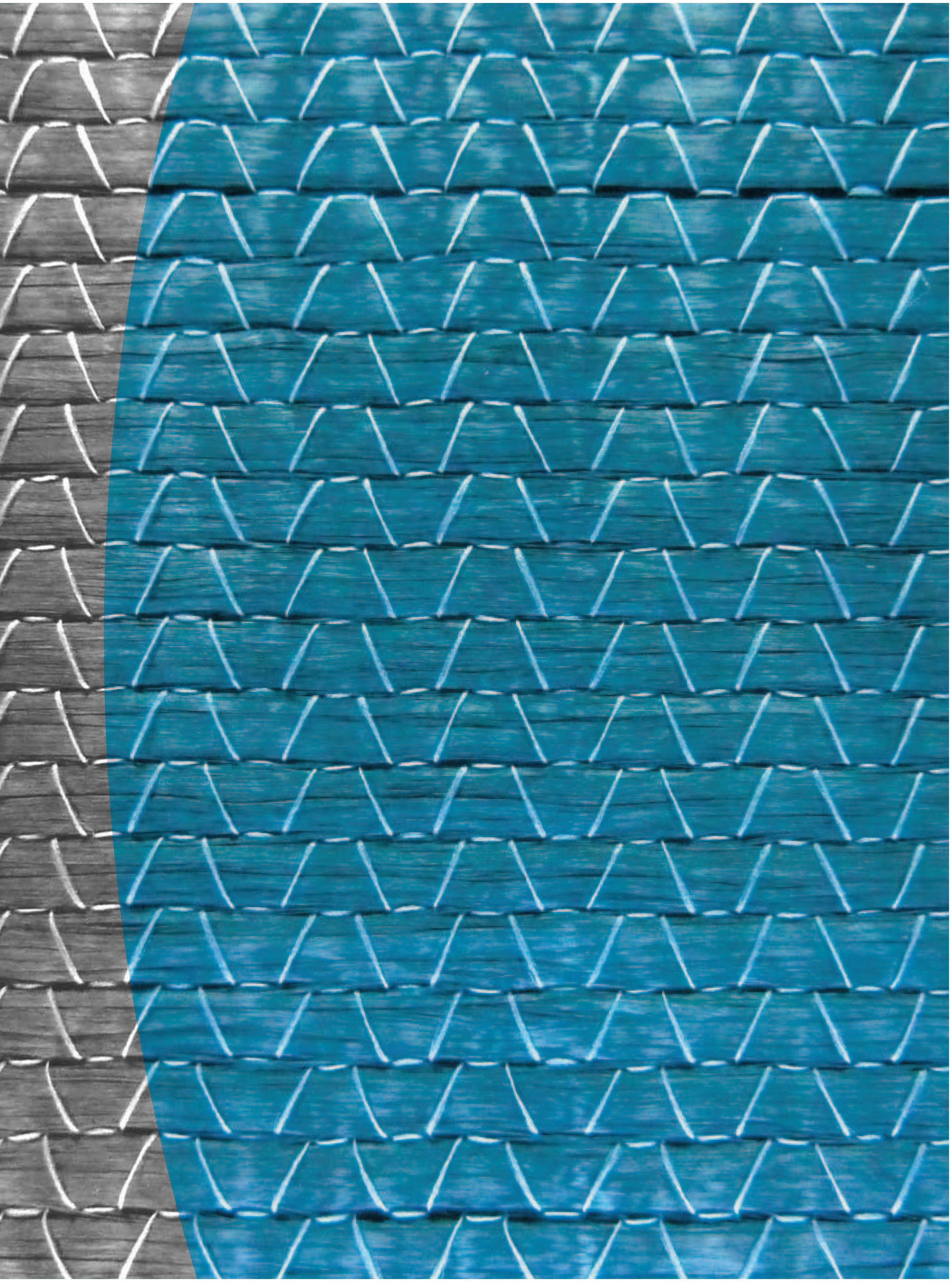


Precise down to the last detail

Quality assurance in the aircraft industry: leaving nothing to chance

A study by Thomas Ullmann and Thomas Schmidt

Future generations of aircraft must become quieter, lighter and more fuel-efficient. Their fuselage and wing structures will be made almost exclusively from carbon-fibre reinforced composites. This new type of material combines exceptional strength with very low weight, making it highly suitable for the construction of modern lightweight structures. The resulting reduction in aircraft weight leads to lower fuel consumption, which, in turn, reduces both operating costs and pollutant emissions. In addition, carbon-fibre reinforced composites are more corrosion resistant than light metal alloys currently in use. This lengthens the service life of the components, increases safety and reduces maintenance costs.

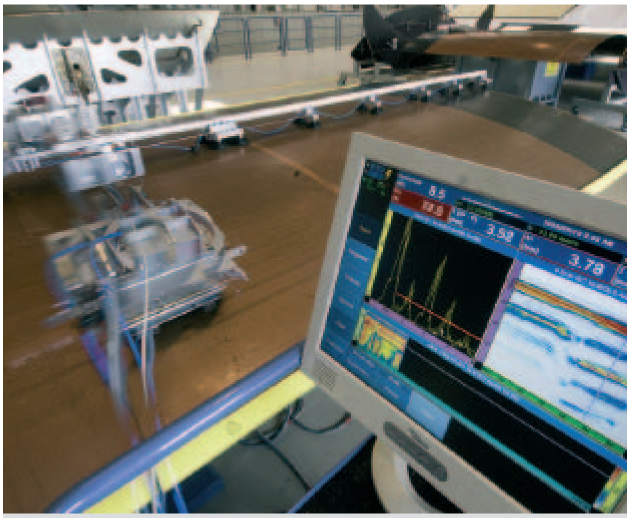
Fibre composite materials can have different properties, depending on the direction of their fibres. The image shows a material composed of several separate layers having different fibre directions, referred to as a non-crimp fabric. Typically, fine thread connects the carbon fibre layers together. Through the combination of several layers with different weights or angles, textile constructions with special mechanical properties can be achieved

However, manufacturing costs also have to be cut. Fibre-reinforced composites require a novel type of component design that has to be tailored to the material properties and the structural characteristics of the carbon-fibre reinforced material. It is true that carbon-fibre reinforced composite components have been used for a number of years for the wings and tails of the current Airbus and Boeing models, but their large-scale use for load-bearing structures in the fuselage presents totally new engineering challenges. The manufacturing, processing and quality assurance testing of the fibre-reinforced components have to satisfy entirely new criteria.

Based on the expertise gained during carbon-fibre reinforced composite prototype manufacturing and the use of targeted innovative testing technologies and automated assembly methods, it will be possible to considerably reduce the production costs of new aircraft. The aim is to move away from expensive production techniques towards cost-efficient automated manufacturing.

New design with new materials

Fibre-reinforced materials are layered materials with strongly anisotropic – that is direction-dependent – properties. The thermal expansion, rigidity and strength of the materials differ greatly depending on the orientation of the fibres. When carbon-fibre reinforced composite components are built and integrated into large structural components, fibre orientation plays a decisive role. An aircraft fuselage can be assembled from complete, core-wound carbon-fibre reinforced composite tubes, or from several large shell segments. In each case, the carbon fibres run along the surface of the fuselage body in order to make optimal use of their exceptional strength. The number of seams and joints has to be kept to a minimum, as these represent weaknesses in the structure, much in the same way as openings for windows, doors, maintenance ports and cargo hatches. Unlike light metal fabrications, the direction-dependent material properties of the carbon-fibre reinforced composites determine the geometry of the components and the structural design.



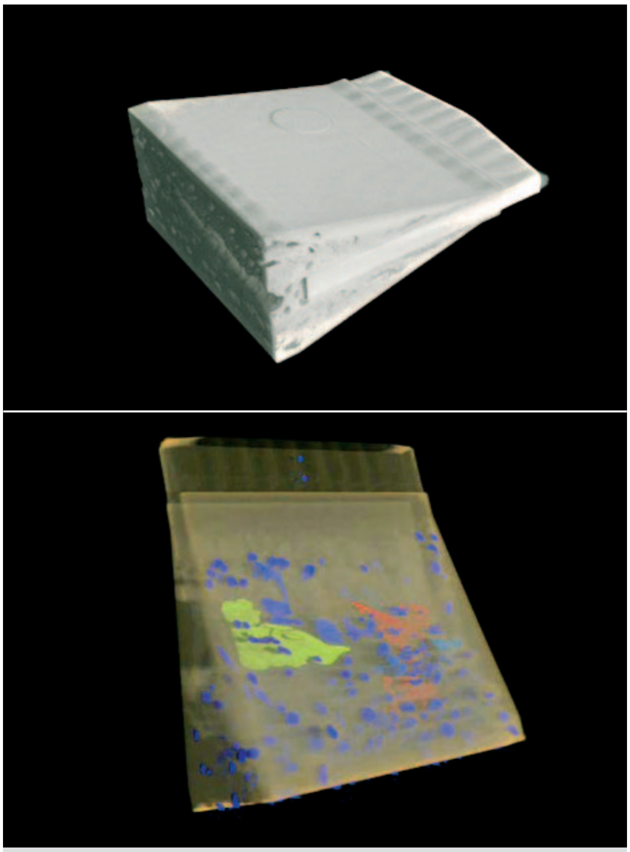
Ultrasound testing of carbon-fibre reinforced composite fuselage shells in the Nordenham plant of Premium AEROTEC (Source: Premium AEROTEC)

The joining together of two fuselage segments presents a particular challenge, as the high dimensional stability of structural components made of of carbon-fibre reinforced composites allows a tolerance of only a few hundredths of a millimetre. Fuselage shells or segments manufactured by different supplier plants located several hundreds of kilometres from each other have to be joined together with high fit-accuracy during the final assembly process. As carbon-fibre reinforced composite components cannot be welded together like light metal structures, the only possible joining techniques are gluing or riveting. For constructing an aircraft, several hundred thousand metal rivets would be required. This additional mass would significantly cut the achievable weight reduction. It would be a far better idea to glue the fuselage segments together. However, the adhesive bonding technique involved is a very demanding process, and has so far been mastered only to a limited extent. Development of an appropriate verification technique, which can be used to check the characteristics of the bond such as surface coverage, the degree of adhesive hardening and its adherence to the surface of the components, is especially difficult.

In-process quality assurance

Researchers at the DLR Center for Lightweight Construction in Stade and Augsburg, are working on improving cost-efficient, automated manufacturing and processing of large mass-produced carbon-fibre reinforced composite components. Additionally, a strategy for in-process quality assurance is being developed. This enables the monitoring and evaluation of individual processes during and between the different production stages. It also means that a non-destructive testing method can be used to fully automatically monitor compliance with previously defined manufacturing tolerances based on particular properties, and that any deviations can be recognised and assessed by the analytical software. Semi-finished products and components with properties that indicate defective structures can be removed from the production chain immediately in this manner, so as to prevent any further costly and unnecessary manufacturing steps.

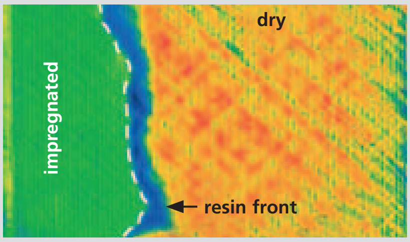
The direct benefits of a quality assurance system integrated into the production process can only be fully assessed when considering the costs of performing the additional testing alongside the enormous savings made as a result of early-stage removal of defective parts from the assembly line. The cost-effective and efficient implementation of the non-destructive testing method in the individual processing stages requires fully automated and synchronised data acquisition and assessment while avoiding any substantial impact on the production process or interrupting production for a long period.



Computed tomography analysis of a porous carbon-fibre moulded construction. Top: the 3D view of coincidence; bottom: the same component in a different position displayed semi-transparently, colour-marked and classified by pore-size distribution

Innovative methods of non-destructive testing

In the aircraft industry, non-destructive quality assurance tests have, until now, mainly been carried out on finished parts at the end of the manufacturing process. The water-coupled ultrasonic test is the most well established test for aviation applications. Unlike light metal parts, ultrasound images of fibre-reinforced structures are difficult to interpret due to the non-homogeneous structure of the material. This is primarily because of the lack of long-term experience with regard to the fault relevance and fault classification of carbon-fibre reinforced composites in typical operational conditions. Specific material structures and defect types have to be recorded accurately and their impact must be understood using the relevant analytical method. In addition to traditional ultrasonic tests, further non-contact test methods have to be used. Wet testing of a unidirectional fibre lay-up is not possible, for instance, and line-by-line scanning of large surfaces demands too much time. For the testing of semi-finished products that are manufactured from carbon-fibre fabrics, use can be made of, for example, optical image acquisition



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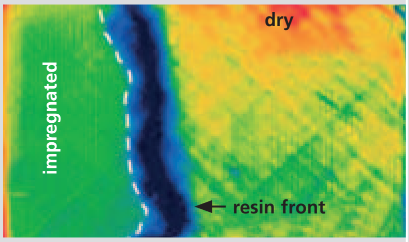
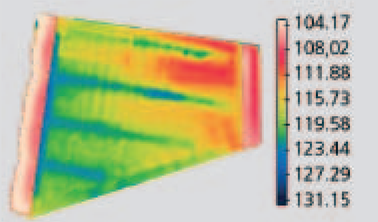


Excitation frequency of 0.6 hertz

Lock-in thermography analysis of an infiltration process in a carbon-fibre preform at different excitation frequencies. The location of the resin front, the orientation of the carbon fibres as well as the dry and already infiltrated fabric areas are clearly visible

Lock-in thermography is a method for visualising component damage. Halogen lamps apply pulses of heat energy to the component. The reflected thermal radiation is recorded as a sequence of images over several minutes by an infrared camera. The temporal change of the thermal radiation results in a colour-coded image of the component, which allows experts to detect, for example, detached bonding or pore clusters

Use of a lock-in thermography system in the test laboratory



Lock-in thermography analysis of a section of a carbon-fibre reinforced composite aircraft rudder flap. Due to varying local thermal diffusivity, areas with internal reinforcing elements and structures are clearly visible

systems or non-contact air-coupled ultrasonic tests. For technical testing of the component where the material is examined for increased porosity, visible delamination or local non-homogeneous resin distribution, laser and infrared analysis methods are primarily employed. One of these methods is optically excited lock-in thermography. This test method enables a fast and large-scale inspection of structural components, independent of their geometry. The combined use of different non-destructive test methods and their comparison with reference data from established methods, such as water-coupled ultrasonic testing or high-resolution computer tomography, renders the interpretation more reliable. This increases the validity of testing methods with a lower resolution but with faster and more extensive coverage. There will be an increasing trend toward the use of combined testing methods.

The analysis methods used in a process chain are carried out by complex measuring head systems, which are mounted on assembly robots to carry out fully automated test routines on the component. These must be adapted to the shape of the component and used on a large scale in order to be able to inspect and assess the material properties of several square metres of large structural components in the shortest possible time. The new type of test head should be adapted specifically for industrial use in the mass production of components and should interface with existing robotic systems.

About the authors:
Thomas Ullmann has worked on the enhanced development of thermal protection systems in the aerospace industry for over 10 years. Four years ago, he began to specialise in non-destructive testing of materials and components, and at present, he is the Head of Method Development at the DLR Institute of Structures and Design in Stuttgart.
Thomas Schmidt has several years of experience in the development and manufacturing of fibre-reinforced structures for aerospace applications. He coordinates and heads the activities for in-process non-destructive component testing at the DLR Center for Lightweight Construction in Augsburg.

Further information:
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It takes one smart aircrew to fly an unmanned aircraft

No matter how many different ways aircraft take to the air, they continue to arouse fascination. And if they do so with no pilot on board, it is seemingly the stuff of both 'science' and 'fiction'. Nevertheless, there is no lack of advanced ideas to realise such a goal. Those who want to put these ideas into practice do, however, need to work from solid foundations. For the researchers of the Unmanned Aircraft Department at the DLR Institute of Flight Systems in Braunschweig, devoted to intelligent flight methods, this means expert knowledge, access to expert advice, interdisciplinary research and a thorough understanding of the entire system.

Young DLR research group in Braunschweig devoted to intelligent flight systems

By Gordon Strickert

Prometheus is the youngest 'baby' of the Unmanned Aircraft Department at the DLR Institute of Flight Systems. This test aircraft will be used to demonstrate that the systems and techniques developed in the past for autonomous flight are all-purpose and can be transferred from rotary-wing to fixed-wing aircraft

"Autonomous, intelligent functions for unmanned aircraft!" This is the stock reply of researchers in the Department when asked what they are actually developing. This sounds like something far removed from the real world - until you observe how these flight test engineers stand up to their knees in the mud to calibrate a camera, struggle to obtain the latest millisecond improvement in the real-time operating system or gather reference data for a 3D scanner in sub-zero temperatures. That is when you realise that this is where ideas are put into practice. For the researchers, the road to practical applications and the validation of flight tests are all part of the job.

In order to make an aircraft flightworthy, it needs many different and complementary capabilities. Eight years ago, when the foundations for the present Department were laid, there was simply no unmanned research aircraft research. The 'Unmanned Helicopter' project group was a first step. With the development of the Autonomous Rotorcraft Testbed for Intelligent Systems, ARTIS, test stand over the years, the project group grew – both in terms of disciplines covered and in the number of personnel. The demand arose for conceptual and engineering work, mechanical and electrical engineering, and aerospace engineering. Today, the team retains one or two permanent mechatronics engineers and technicians to implement the modification requests from the researchers on unmanned systems.

Immediately after the first flights, the main field of activity shifted to sensor technology and the all-important autonomous on-board navigation capability. Highly specialist knowledge was needed to filter usable data from the vibration-corrupted measurement data for stabilisation of the helicopter. Algorithms and software development became a priority, and computer scientists

Prometheus rising

The Prometheus unmanned test aircraft performed its maiden flight in March this year, completing its first circuits of the Hildesheim airfield. Staff from the DLR Institute of Flight Systems evaluated its flight characteristics, including roll behaviour and stability. First, the researchers conducted several tests on the apron and taxiway of the airfield. They then checked the stability during take-off roll and lifting of the nose wheel. After a few adjustments, Prometheus was ready for its first flight and landed safely after circling the airfield a few times. This successful flight is a crucial step in the development of autonomous aircraft.

Prometheus is a research aircraft operated by the Unmanned Aircraft Department, and is the basis for the development of expertise for fixed-wing Unmanned Aerial Vehicles. The system technology behind the autonomous flight capability originates from the unmanned helicopter Autonomous Rotorcraft Testbed for Intelligent Systems, ARTIS, and was adapted to meet the requirements of a fixed-wing aircraft. The department's system technology components are of modular design, so that helicopters and fixed-wing aircraft can be operated with the same system and simulation environment. This is true not just for hardware components such as ground control, flight control computers, sensors or telemetry, but also for the software architecture, such as mission planning, flight control and elements of human-machine interface.

In the future, Prometheus will not only transport payloads such as image processing systems, but it will also be used to conduct research into components of future flight systems. Advanced flight control and mission planning strategies, system identification and intelligent functions such as sense-and-avoid technologies will be investigated at a fraction of the cost of operating a manned research aircraft. The aim is to better evaluate the entire Unmanned Aerial Vehicle through phased development of the system engineering capabilities.

Prometheus lands after its successful first flight

During integration, the team meets regularly for collaborative testing in the in the Unmanned Aerial Vehicle laboratory

and electrical engineers joined the team. The first flight control and mission planning methods were developed. Image processing experts were added to the team to teach unmanned aircraft how to observe their environment. Regular flights were the order of the day – to test the basic system, to record measurement data and to verify algorithms. As part of the reorganisation of the Institute of Flight Systems in 2008, unmanned flying was defined as an essential topic for future research and the present department was founded.

As a result of the preparatory work, the team is once more working on autonomous, intelligent functions. These are the building blocks that enable meaningful, safe future use of unmanned aircraft for reconnaissance missions in unknown territory – for example, for rapid environmental change detection in earthquake regions, low-altitude flights in difficult terrain with only limited prior knowledge possibly for search and rescue operations near high buildings and even for mountain rescue. Extreme flexibility was necessary to deal with the planning uncertainties of these scenarios. Also, because nobody knows exactly what the unmanned aircraft of the future will look like, the department has expanded its portfolio. Their autonomous functional elements fly on board helicopters, airplanes, parafoils and even on DLR's Shefex II atmospheric re-entry experiment.

In many of their activities, the team has not been guided by mainstream thinking, perhaps as a consequence of their young average age. A development environment has been created for real-time image processing, along with universal operating software for unmanned aircraft and a modular avionics concept. These tools can also be used in a different context, for image processing and navigation in the ATON moon landing project, which is being developed in co-operation with the DLR Institute of Space Systems, the DLR Institute of Robotics and Mechatronics, and the DLR Simulation and Software Technology Facility. Teamwork is indispensable in getting the job done: environment modelling, image processing, mission management, flight control and sensor technology can only be of use when integrated with other components. The weakest link determines the performance of the entire system. Almost all of the 14 people that are part of the team are involved in each scientific result. Enthusiasm plays a vital role, because all members of the team have the same goal: to put new ideas literally 'into the air'.

About the author:
With 37 years of experience behind him, Gordon Strickert is already a veteran in the Department of Unmanned Aircraft at the DLR Institute of Flight Systems in Braunschweig. He uses the unique infrastructure of the Department, Institute and location to carry out tests for the combined operation of manned and unmanned aircraft.


B.C D
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Tourist

Managing the future airport

Airports are the central nodes of our air transport system, and they also serve as interfaces with other modes of transport. Their collective problems can only be addressed through a thorough, comprehensive solution integrating transport carriers with air- and ground-side management. This is the goal of DLR's Total Airport Management Suite, TAMS project, in which DLR is collaborating with German aviation industry leaders to create an innovative airport management system. TAMS, which provides a platform for this area of research, is funded by the German Federal Ministry for Economics and Technology. We find out how, in future, TAMS could benefit airport managers and users alike.

DLR's Total Airport Management Suite takes on its next hurdle

By Florian Piekert and Andreas Deutschmann

While travelling, hurrying and waiting often occur in close succession. Inefficiencies in airport management often reveal themselves in waiting times. This is a nuisance for the passengers, has economic consequences for airlines and also has a detrimental impact on the environment. Better integration of airport processes is at the heart of the TAMS research project

It is a familiar problem: the different partners in aviation management are far from being ideally coordinated. Airport management, aviation companies and flight safety authorities do not work together as a seamless whole, leading to suboptimal coordination between the various processes. At present, each of these parties oversees their own area of business, under the pressure of marketplace competition.

But in many cases, these efforts are not fully thought through and the effects of individual decisions on other areas of responsibility are not sufficiently understood. This leads to increased costs for operators as well as passengers in addition to other impacts. Longer waiting times are often an additional consequence. The complexity of these interactions can become aggravated due to external disturbances such as bad weather. Complications can snowball: the effects may be transmitted to apparently separate processes, often unpredictably, and this leads to greater problems in a type of chain reaction.

As a first effort in this area of research, the DLR Institute for Flight Guidance and the Experimental Centre of the European Organisation for the Safety of Air Navigation, EUROCONTROL, have developed a holistic approach to solve this problem: Total Airport Management. Building on the tried and tested concept of Airport Collaborative Decision Making, A-CDM, it aims to implement inter-operator process planning and optimisation in airports. The implementation of A-CDM in European airports has shown that considerable improvements are possible when all operators in the aviation process are better coordinated. Not only can costs be reduced, but the environment is also protected by reduced delays and waiting time. Flight connections are also made more reliable and secure. A-CDM focuses on the flight safety and flight preparation planning processes. But the optimisation of terminal-side processes such as check-in or security checks have yet to be properly addressed.

Travelling, parking, refuelling, piloting, baggage loading and waiting – a number of processes must be coordinated to manage airport operations effectively

Cutting out waiting helps protect the environment

Reducing waiting times reduces pollution. Keeping aircraft waiting for take-off with engines running increases carbon dioxide emissions. If waiting times are reduced, it would save considerable amounts of fuel for the airlines and would contribute to protecting the environment.

Project partners speak:

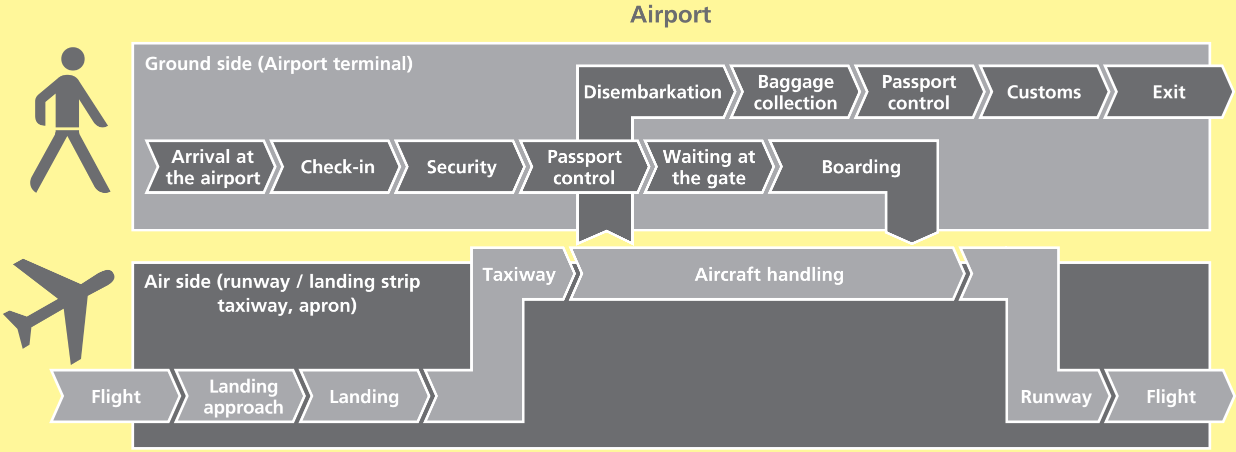
There are three good reasons to work with DLR in the area of airport management: firstly, DLR researchers produce innovative concepts which have not been developed in as much detail by industrial partners. Secondly, the team I worked with at DLR is young, sharp and motivated. And finally they also consider conceptual elements that many industrial teams would set aside due to the cost factor. So we came to a significant result: a pioneering global system support application based on the existing A-CDM concept, for all actors at an airport hub.

Gero Hoppe, project manager within Inform's airport systems business area

At ATRiCS we value the incredible objectivity of our DLR colleagues and their preparation of concepts across various areas. In addition, DLR has an extraordinary ability to simulate and evaluate complex systems. This supports us, their German industrial partners, in developing leadership in our several different business areas. The TAMS project is building a bridge between the current point of view – focused on air traffic control – to a view of airport management that takes into account the big picture.

Moritz Strasser, Business Analyst and TAMS project manager at ATRiCS

Timeline of the Total Airport Management System



Total Airport Management is therefore a large step forward, in which ground-side process chains and their mutual effects are integrated with air-side processes. It also aims to provide airport operators with a central platform where they can obtain situational awareness of problems and come to joint decisions. The aim is global, collaborative process optimisation.

This platform is an Airport Operation Centre. It combines innovative systems with their proven equivalents to promote improved situational awareness as well as analysis for the representatives in the Centre. The DLR Institute for Flight Guidance and the DLR Facility for Air Transport and Airport Research have further developed the Total Airport Management concept in the framework of DLR's in-house Future Airport Management Operation Utility System, FAMOUS project. This is the first step to linking ground and flight-side processes. Its successor, FAMOUS-2, will focus on developing these interfaces.

DLR's expertise in the area of airport management is well known to the national aviation industry. Since German aviation companies are continuously looking for new solutions so as to maintain their international technological leadership, DLR has developed a project with Siemens Barco-Orthogon GmbH, Institut für Operations Research und Management GmbH (Inform) and Advanced Traffic Solutions GmbH & Co. KG (ATRiCS), to bring the TAMS concept closer to reality. Stuttgart Airport has also been identified as a potential user.

DLR has developed the concept further with the aid of the Mobility and Transport Technology organization of the German Federal Ministry of Economics and Technology. Due to the business potential of the TAMS concept and the risks associated with such an important effort, the Ministry has selected the project as a 'beacon' project. The ambitious, three-year TAMS project was launched at the start of 2009 under the leadership of Siemens AG.

In the context of the TAMS project, DLR is creating an air- and ground-side virtual airport environment for its industrial partners, into which test systems can be integrated. This enables targeted development of coupled applications while testing the TAMS concept without disturbing actual airport processes. The researchers can explore solutions directly and communicate concepts to potential users. TAMS is also committed to solving further optimisation problems. Feasibility studies are planned, for instance, to attempt forecasts of passenger flows.

The TAMS project consists of three phases: during Phase I, compatibility of the systems will be ensured. The project partners will develop the component systems so that all systems meet the unified EUROCONTROL A-CDM standard, and the central TAMS architecture can be implemented. The partners will then integrate the adapted modules and this will provide the basis for a first system solution. During Phase II, DLR and its partners will use the FAMOUS prototypes to develop additional innovative systems. These will be employed directly in a central operations centre for collaborative airport management. DLR Braunschweig will integrate further industrial solutions into the virtual airport environment for experimentation in conjunction with operations centre activities. In Phase III, the project partners will develop the concepts needed to convert the airport systems into a TAMS solution. Training will form part of this process. TAMS will be used as a demonstrator for testing at partner airports and will be tested further with real airport data on site. DLR Braunschweig will conclude the project by demonstrating the improvement potential of TAMS under controlled conditions. The final outcome will be a set of compatible industrial products to support an integrated airport management system, determined at DLR Braunschweig. This system will comply with established international standards, but will also set a new standard due to its innovative nature.

About the authors:
Florian Piekert, DLR Institute for Flight Guidance, is TAMS Project Leader; Andreas Deutschmann is a member of the team.

Further information:
www.tams.aero


“High standards in aviation
simplify the transfer of technology
to other sectors.”

Pioneering green mobility

Commentary by Joachim Szodruch

Lilienthal, Lindbergh, Zeppelin, Junkers – great names associated with flying, all of them pioneers in the history of aviation. Over the last 100-plus years, aviation has grown from those simple flying machines ingeniously crafted by their engineers to today's efficient, reliable and safe form of transport that spans the globe. What does it take, in 2010, to still be a pioneer? What can we do to foster pioneering spirit and a culture of innovation in our modern era?

Future history books may look back on the Antares DLR-H2, the world's first manned aircraft capable of taking off only on fuel cell power, as a pioneering achievement. The Antares flies without carbon emissions and is quieter than other comparable motorised gliders. DLR has developed the fuel cell system and integrated it in the aircraft and has also steered this concept successfully through the official approval channels.

However, the Antares is just one example. The goals for DLR's aeronautics research programme are set out according to the European 'Vision 2020'. Topics encompass the entire aviation sector, from alternative fuels through to safe and environment-friendly means of flight. One of DLR's institutes oversees this entire range of topics as a single entity. That Institute is introduced at the start of this issue of the DLR Magazine. The researchers there deal with concepts associated with air transport systems, such as aircraft, airports, air traffic control and operations. With its broad expertise which includes interdisciplinary as well as system-oriented skills, DLR is well positioned to engage with universities in pioneering technological work, and to codevelop and validate application-focused innovations in collaboration with industry and business for product development. Support from the world of politics, government and society at large plays an essential role.

Within Europe, DLR is in the unique position to study the air transport system as a whole. Promising technologies from our institutes also find their way into other sectors. The transfer of technology, especially to the fields of energy supply and land-based transport systems, is enabled by the close coordination of our programme-based management system and is in great demand through our collaborative ventures with industry. Proven aviation-related technologies have an exceptionally demanding range of requirements as well as a high degree of reliability, safety and cost-effectiveness. In other words, a power supply system such as the fuel cells employed in the Antares could potentially also be used in land-based transport systems. As the aviation sector applies high safety and approval standards to its technologies, and because a high degree of reliability is achieved here, these technologies can logically be transferred to other sectors where requirements are less stringent.

The aviation sector is an 'engine' for environment-friendly technologies, and promotes the concept of green mobility; indeed it pioneers green mobility.

Joachim Szodruch is the Member of DLR's Executive Board responsible for aeronautics research. He is also a member of the steering committee of the German-Dutch Wind Tunnel Foundation, and has a seat on the Supervisory Board of the European Transonic Windtunnel (ETW). He has published more than 60 articles and publications as author or co-author. As Honorary Professor of Aerodynamics at the Technical University of Berlin, he also brings his knowledge to the teaching environment. He also holds the office of Co-Chairman of the Advisory Council for Aeronautical Research in Europe (ACARE) and is President of the Council of European Aerospace Societies (CEAS). Joachim Szodruch is an Associate Fellow of the AIAA, American Institute of Aeronautics and Astronautics.

Choosing the best antenna

DLR is hard at work on a pilot project for monitoring maritime traffic from orbit. The AISat nanosatellite measures just 60 × 60 × 40 centimetres. The satellite's principal feature is a four-metre-long, foldable and lightweight yet stable axial-mode helical antenna. During DLR's 15th parabolic flight campaign, conducted in March 2010 in Bordeaux, this highly-elastic, fibre-composite spiral antenna functioned perfectly under weightlessness.

DLR nanosatellite to monitor maritime traffic

By Elisabeth Mittelbach

Testing of the helical antenna of the AISat calls for a subtle touch. Fine glass-fibre threads keep it in the desired shape. In advance of it being stowed into a small space – as it will be for launch – Cordelia Koch, from the DLR Institute of Composite Structures and Adaptive Systems, checks the thread guide more closely

AISat is a suitcase-sized nanosatellite with a deployable fibre-composite antenna. The antenna is stowed within a small volume for launch, only to extend to its operational dimensions once in orbit. Both the antenna and the AISat project as a whole are ambitious undertakings – the DLR satellite will increase maritime safety and will precisely locate individual ships on busy sea routes. The 'AIS' in the mission name stands for Automatic Identification System – a radio system designed for the exchange of navigation, position and identification data from each and every vessel, to make global maritime traffic safer and easier to control. The system was originally conceived as an anti-collision system by the International Maritime Organisation, a United Nations agency.

DLR, the Bremen University of Applied Sciences and two industrial partners are collaborating on the AISat project. DLR's Institute of Space Systems in Bremen developed the 10-kilogram nanosatellite, and the DLR Institute of Composite Structures and Adaptive Systems in Braunschweig designed the helical antenna and built a model of the satellite. Its maiden flight is planned for late 2010; the satellite will be launched on a Polar Satellite Launch Vehicle from the Satish Dhawan Space Centre on the island of Sriharikota, India.

"Until now, the main problem with locating individual ships from space has been the fact that far too many different signals are received at once," says Jörg Behrens, head of the Orbital Systems and Safety Department at the Institute of Space Systems, and the inspiration behind AISat. "The reasons are, firstly, that many satellites receive signals from a large area because they use non-directional antennas, and secondly, many interfering signals are present in adjacent frequency bands," he adds. The cause of these unwanted signals are the enormous

The team that conceived the idea of the DLR AISat nanosallite. From left: Jörg Behrens, Head of the Department of Orbital Systems and Safety, Institute Director Hansjörg Dittus and System Engineer Lars-Christian Hauer in the electonics laboratory at DLR Bremen. This is where the electronic components for small satellites are developed and integrated

Whether or not the antenna will deploy in the correct shape in microgravity could only be tested realistically during a parabolic flight. Four different versions of the AISat helical antenna were tested during a DLR parabolic flight campaign conducted in March 2010. Annette Bäger is working with her colleagues to evaluate which antenna core material is most suitable

antenna footprints of previous satellites – some up to 6000 kilometres across, the equivalent distance across Europe from the North Cape to Sicily in Italy. By contrast AISat's helical antenna has an illumination radius of 750 kilometres. "We want to reach the lowest data collision rate possible and thus achieve greater precision," Behrens says. In addition, the antenna's coverage can be varied dynamically. High-gain helical antennas also have a unique characteristic – they are able to receive not only the Class A VHF signals from commercial shipping, but also Class B signals from non-commercial ships – as well as Automatic Identification System Search And Rescue Transmitter signals sent from survival craft or distressed vessels. This is not possible with existing satellite systems.

In comparison, the information from the global Automated Merchant VEssel Reporting system operated by the US Coast Guard has many data gaps, especially in high traffic areas off Europe, Africa and Asia. "The established systems can't solve this problem," says Hansjörg Dittus, explaining why new satellite technology was required to close the 'gaps in the map'. The advantages of using nanosatellites for this project are obvious to the head of DLR's Institute of Space Systems: "Comparatively short development times, the option to reduce launch costs by piggybacking, and the possibility to develop larger successor missions on basis of this innovative approach."

Having spent two years developing the mission, DLR researchers were delighted by the first practical success with AISat in March 2010. During DLR's 15th 'Zero-G' parabolic flight campaign in Bordeaux, a team led by Prof. Joachim Block from DLR's Institute of Composite Structures and Adaptive Systems tested the functionality of the helical antenna in microgravity. "We tried out four types and we are very happy with the results," says Joachim Block. The antenna is designed so that only the metallic covering of the fibre-composite spiral is electromagnetically active. A network of fine glass-fibre control threads limit the extension of the spiral and stabilises it in the desired final configuration – so that the satellite controls the antenna, and not vice versa.

The Automatic Identification System

Since mid-2008, all commercial ships larger than 300 gross tons operating in international waters have been required by the International Maritime Organization to carry an Automatic Identification System. Similarly, ships with more than 50 passengers on board must also be equipped with an AIS unit. The system transmits alternately on VHF channels A (161.975 megahertz) and B (162.025 megahertz), and uses the High-Level Data Link Control communication protocol. When the data is decoded, it can be presented as text or shown graphically in a radar image. The signals have a range of 20 to 30 nautical miles and carry both static and dynamic ship information as well as route data. Terrestrial Automatic Identification Systems are available only in coastal waters. The base stations receive signals from ships that are 50 to 100 kilometres from the coast, or are under way in inland waters. The navigation situation is shown by AIS in real time, and each shipping movement is visible on screen. It is also possible to see where two ships will be at their point of closest approach, how long it will take for them to reach it and how large the separation between them will be. This type of dynamic shipping information is not yet available in the open ocean.

Five questions with..

… Joachim Block, Coordinator of Space Projects at the DLR Institute of Composite Structures and Adaptive Systems, Braunschweig, and AISat Principal Investigator for the helical antenna parabolic flight experiment.

The AISat antenna looks like a spring. How did you get the idea for this design?

The spiral form of the antenna was predefined – it arose simply from the required electromagnetic directionality of the shipping signals. Our task was to optimise the composite structure – in particular, the mechanical properties required for its deployment – so it really does work like a spring. In order to get the desired directional characteristics, geometrical parameters such as coil diameter and pitch have to have a precise relationship to the wavelength of the signals. We learned the details during discussions with antenna specialists in Bremen.

What special conditions does the antenna have to deal with in orbit?

First of all, it must have a stable final configuration. When it unfolds, it extends rapidly and in doing so, it moves the satellite body, which is much smaller. Figuratively speaking, the tail really wags the dog! But when the antenna has deployed and the satellite is in its final position, the configuration should be maintained as stably as possible.

Why did you test four different designs during the 15th parabolic flight campaign in Bordeaux?

The four test antennas differed only in terms of their fibre-composite cores. We used carbon, glass and aramid synthetic fibres, and we also varied the core diameter. Testing just one design repeatedly over 31 consecutive parabolas would not have made sense, but we could not accommodate more than four types in the test process.

When will you decide which variant will be used on AISat?

We will decide that once we have evaluated the parabolic flight data along with the results of some long-term static tests – so that will be this summer.

What was the most exciting part of the project for you personally, and why?

Well, the most exciting part is naturally the parabolic flight itself. Even if you have had many 'aha' moments, they pale in comparison with three hours of flight over the Bay of Biscay, even though I have participated in such a programme before – which lessens the personal aspect. But also, and above all, from the technical point of view, it is a litmus test for the project; the moment of truth.

Interview by Elisabeth Mittelbach, an editor in DLR's Corporate Communications Department, Cologne

It is difficult to maintain the specified geometry with a high accuracy. On the ground, it can be checked only when the antenna is suspended vertically. Support threads prevent gravity-induced distortions in the antenna

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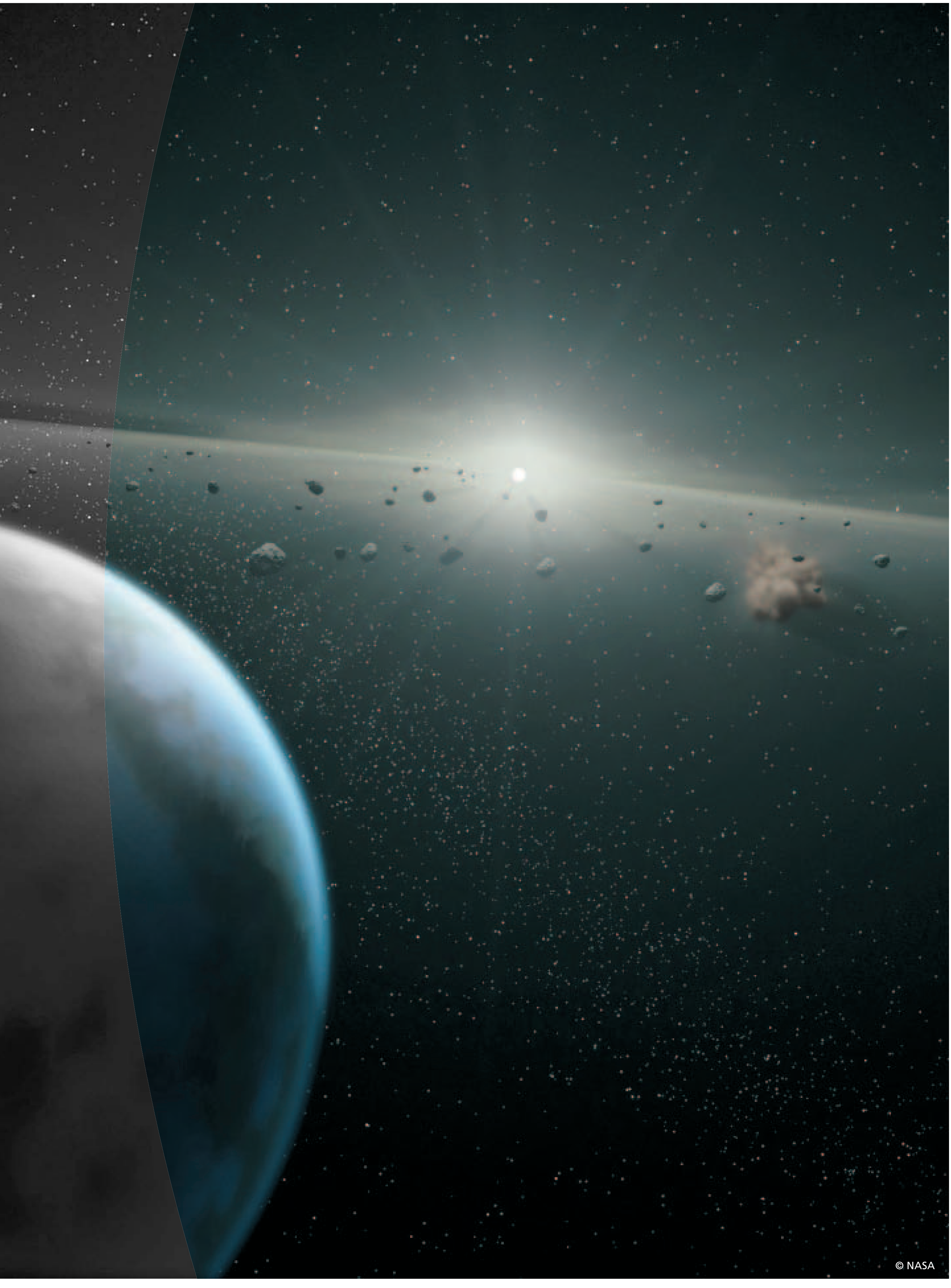


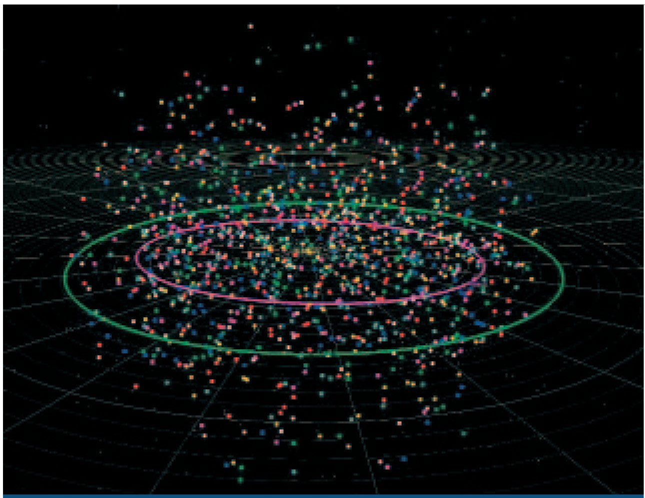
Detecting space dangers hidden in the Sun's glare

Apart from the planets, moons and comets in the Solar System, there are also a large number of asteroids. These are often only a few hundred metres across, but many of them measure several kilometres, with some even reaching up to 1000 kilometres in diameter. Each of these asteroids orbits the Sun on a distinct path. DLR has initiated the Asteroid-Finder satellite, planned to launch in 2013, with the aim of verifying the presence of a special class of asteroid that would, under certain circumstances, pose a threat to Earth.

DLR's AsteroidFinder satellite will search for potentially dangerous asteroids

By Falk Dambowsky, Ekkehard Kührt and Jan Thimo Grundmann

Most asteroids are situated well away from Earth's orbit, with the majority located between the orbits of Mars and Jupiter. Here, they orbit the Sun in the form of a gigantic ring of debris. It is impossible for them to coalesce to form a planet due to the powerful gravitational influence of the gas giant Jupiter. As it turns out, this is a stroke of luck, because it means that there is a wealth of pristine, primordial fragments, dating from the birth of the Solar System billions of years ago, available for study. Researchers are interested in these asteroids not only on account of their age, but also because they pose a potential threat to Earth. From time to time, a gravitational field or a collision can divert an asteroid closer to Earth s orbit. These 'near-Earth objects' are capable of causing massive destruction on Earth. Small fragments burn up safely in the atmosphere, but the surface impact of one measuring just a few tens of metres across can have devastating consequences. The destructive power of an asteroid of this size was demonstrated in Siberia a little over a century ago. On 30 June 1908, over the high-latitude taiga forest near the Lower Stony Tunguska River, an asteroid exploded at an altitude of 8 to 12 kilometres. It had penetrated Earth's atmosphere at a speed of nearly 70,000 kilometres per hour and is thought to have been 30 to 50 metres in diameter. The pressure wave snapped the trunks of 60 to 80 million trees over an area of 2000 square kilometres, with an explosive force equivalent to 10 to 15 megatons of TNT. An area twice the size of Berlin was devastated. According to statistical calculations, a cosmic collision of this magnitude occurs once every few hundred years. The much less frequent impact of an asteroid measuring several kilometres across could lead to a global catastrophe. It is now thought that the extinction of the dinosaurs 65 million years ago was almost certainly linked to the Chicxulub asteroid impact.



A computer simulation of inner-Earth objects: more than 1000 such objects larger than 100 metres in diameter are believed to be out there

Asteroid Eros, 19 kilometres in length, is at a safe distance from Earth

In future, every possible means will be used to protect Earth from destructive impacts of this scale. The front-line defence is provided by Near-Earth Object search programmes, which have been operating worldwide for many years. The US leads the world in funding Earth-based telescope surveys which have discovered, for example, that in 2029, asteroid 99942 – codenamed 'Apophis', measuring about 300 metres across – will pass Earth at a distance of just 30,000 kilometres away. The find caused initial alarm, but recent observations and calculations have fortunately provided grounds to scale down the warning level. Even when Apophis flies close to Earth on the next occasion, about seven years later, a collision is almost impossible.

Thousand plus nearby objects larger than 100 metres in diameter are believed to be out there

Despite an intensive search for potentially dangerous asteroids, there are still substantial gaps in the data regarding their actual number. Few asteroids have so far been discovered within Earth's orbit around the Sun. It was not until 1998 that the first of these 'inner-Earth objects' was discovered, and just 10 of these have been found to date. However, models show that there are over a thousand such objects that measure at least 100 metres in diameter.

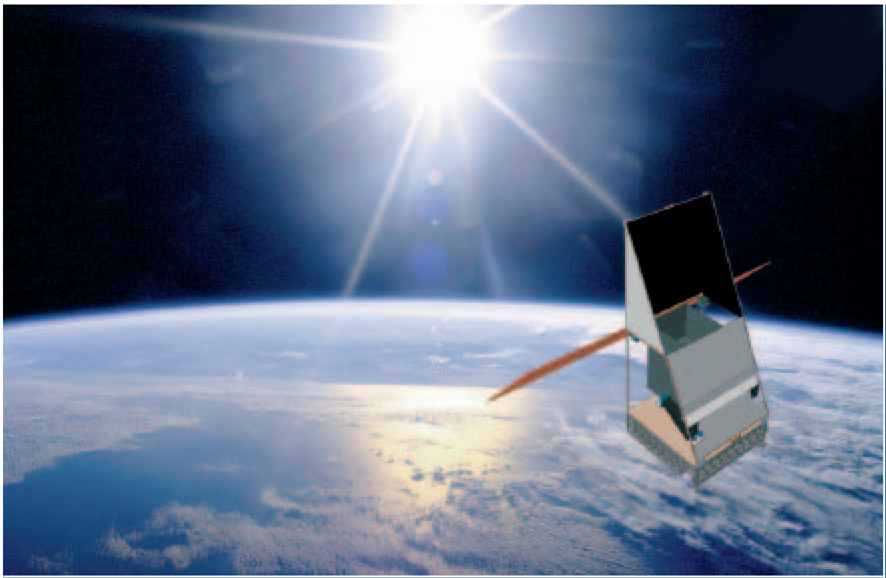
This low detection rate is due largely to the fact that inner-Earth objects, by virtue of their special orbital characteristics, appear predominantly in the bright daytime sky – similar to the planets Mercury and Venus. This problem is compounded by the fact that in the majority of cases, only the unilluminated side of these asteroids is observable. To track them despite these difficulties, DLR is planning the AsteroidFinder mission as part of the DLR Compact Satellite Programme. The mission will be used to track inner-Earth objects from space for the first time. The main advantage of such a space-based mission is that atmospheric disturbances will not affect the measurements. In addition, from its orbit above Earth's terminator (the boundary between day and night), the satellite will be able to carry out observations around the clock. This makes the discovery of inner-Earth objects much more likely than with Earth-based telescopes. Models show that at least 10 additional inner-Earth objects will be discovered during the first year of the mission. The observations will also help determine their orbits and estimate their sizes. The scientists involved, from the Berlin-based DLR Institute of Planetary Research, are hoping to gain insight into the early development of the Solar System, and for example, to cast new light on the origins of impact craters observed on Mercury and Venus.

Eight other DLR institutes are involved in the mission proposal put forward by the Institute of Planetary Research; the DLR Institute of Space Systems in Bremen leads the project. The team in Bremen has also developed the Standard Satellite Bus (SSB), which will carry the science payload. Once developed, this satellite bus will serve as the basis for other compact satellite missions. For this new generation of satellites, the Institute of Space Systems has developed an entirely new computer architecture and a sophisticated attitude control system. The satellite systems and telescope of the AsteroidFinder occupy a volume of just 80 × 80 × 100 centimetres and weigh 180 kilograms.

Comparable to seeing a candle flame in St Petersburg from Berlin

The scientific payload, with its innovative telescope and charge-coupled device camera, is being constructed at DLR's Institute of Planetary Research, in close cooperation with Kayser-Threde GmbH. The aim is to detect extremely faint objects – with magnitudes down to 18.5. The term magnitude indicates the apparent brightness of astronomical objects on a logarithmic scale – the lower the magnitude, the brighter the object. For example, Venus has a magnitude of -4.7, while – at the other end of the scale – the dwarf planet Pluto has a magnitude of 14.0. This means an object of magnitude 18.5 is 63 times dimmer than Pluto and two billion times dimmer than Venus. For the AsteroidFinder mission, this is like to trying to see a candle flame at a distance of 1500 kilometres - equivalent to seeing a small flame on the spire of Saint Isaac's Cathedral in Saint Petersburg from Berlin - and poses a tremendous challenge for the compact satellite bus and its payload.

A novel, high-performance sensor made of light-sensitive semiconductor elements will be the ultra-precise detection mechanism on AsteroidFinder. This sensor acquires 300 images of a given region of space, with each 'exposure' lasting for only tenths of a second. These images are then combined together.



The telescope of the AsteroidFinder will be placed above two service modules and will be protected by a sunshade

This technique is needed because the total exposure time required to detect the weak light from the asteroids is around one minute, and the satellite is unable to maintain the required pointing stability of about one arcsecond during this length of time. A single image with an exposure time of a minute would be blurred, in the same way as a photograph suffering from camera shake. For precise alignment of the individual images in real time, the fixed star background is used as a reference. Even so, the satellite requires a powerful data processing system to add all the images together.

AsteroidFinder is scheduled to launch in 2013. The mission will significantly expand our incomplete knowledge of the number, size and orbital characteristics of inner-Earth objects. A secondary mission objective is to demonstrate the detection of space debris from Earth orbit. Several hundred thousand items of debris, ranging in size from millimetres to metres, have accumulated in orbit around Earth as a consequence of space activities over the last half a century. They constitute a serious threat to satellites and space stations. AsteroidFinder should be able to detect debris measuring just a few centimetres across, which is extremely difficult to observe from Earth.

About the authors:
Falk Dambowsky is a physicist and media scientist at the DLR Institute of Planetary Research, where Ekkehard Kührt heads the Asteroids and Comets Department. Jan Thimo Grundmann works as a Space Systems Engineer at the DLR Institute of Space Systems.

Further information:
www.DLR.de/Asteroidfinder
neo.jpl.nasa.gov

As recommended by the UN

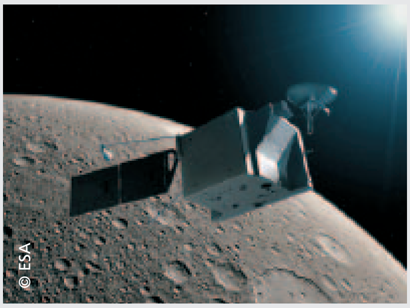
With AsteroidFinder, DLR is supporting global efforts aimed at the timely identification of potential space-borne hazards, enabling appropriate preventive action. This activity is in accordance with the Recommendations of the United Nations Committee on the Peaceful Uses of Outer Space and will complement ESA's new outer space monitoring initiative, the Space Situational Awareness programme.

Worst-case scenario: an asteroid impact

Planetary probes fanning out across our Solar System

While it is true that our Solar System is a long way from being as busy as the airspace above Frankfurt Airport, there are in fact a number of spacecraft coursing through our local planetary neighbourhood. Equipped with sophisticated instruments and imagers, they are seeking answers to a myriad of open questions concerning our cosmic surroundings.

DLR participates in several of these missions: the DLR Space Agency has partly funded the development of their instrumentation, and DLR engineers and scientists are involved in the formulation of mission concepts, as well as in processing, archiving and evaluation of newly-acquired data. While DLR activities across several current missions are ongoing, groundwork for future missions was laid some time ago, and preparations to realise them are well underway.



Unknown Mercury: Europe wants to solve the puzzles surrounding the smallest planet with the BepiColombo mission

Onward to Mercury, Mars and Jupiter

DLR scientists have long been involved in ESA's BepiColombo mission, due to travel to Mercury in 2014. Their main contribution will be a laser altimeter, to be developed at the DLR Institute of Planetary Research, in cooperation with the University of Bern, and a spectrometer devised in collaboration with the University of Münster. The exact measurements of Mercury's surface that both of these will provide should ascertain the external characteristics and mineral composition of the planet.

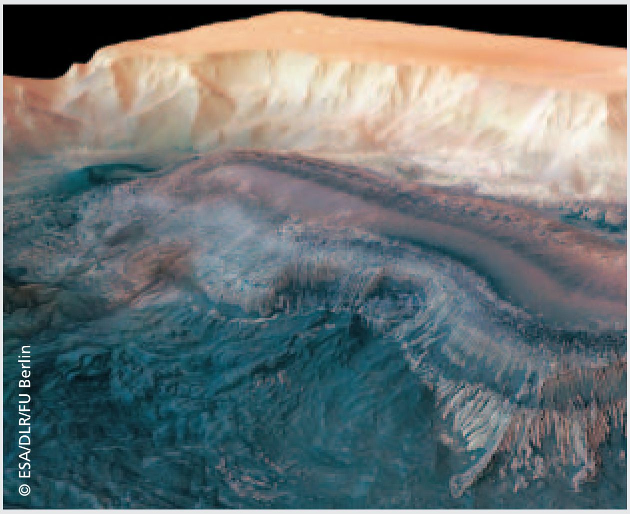
At around the same time, there will also be two missions flying to Mars within the framework of the Mars Joint Exploration Initiative, partnered by ESA and NASA. Initially, the ExoMars Trace Gas Orbiter will launch in 2016, and the Mars Astrobiology Explorer Cacher, a lander, two years later. The ESA/NASA Europa Jupiter System Mission, carrying two orbiters, is scheduled to take off for Jupiter by the beginning of the next decade. Its targets for investigation include the large moons of Ganymede (by ESA) and Europa (by NASA). These moons are particularly interesting because they possess certain requirements for the existence of life.

DLR camera brings added dimension to Mars exploration

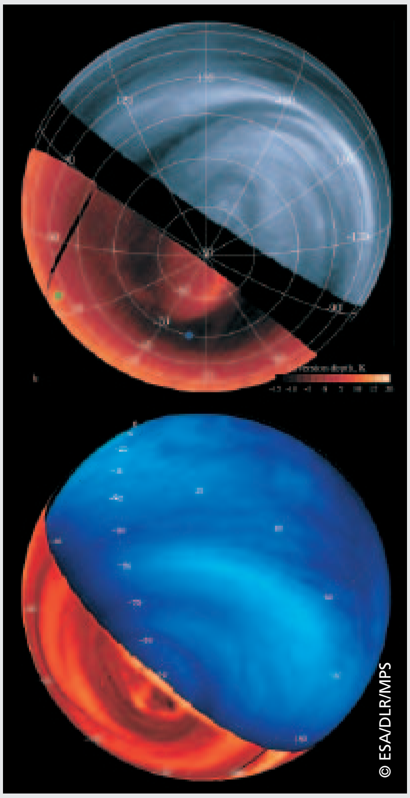
ESA's first planetary mission, Mars Express, has been orbiting the Red Planet since 2003 and is generally recognised as a resounding success. The satellite's High Resolution Stereo Camera, developed by DLR and built in concert with German industry, is gathering a systematic high-definition record of Martian landscapes, acquired simultaneously in both colour and in 3D.

DLR's Institute of Planetary Research is responsible for the camera's operation. The Institute team, in cooperation with over 50 scientists from Germany, Europe, the USA and Japan selects targets to be recorded, tasks the camera, processes the raw data into high-quality scientific products and oversees their archiving in ESA and NASA databases.

The imager is the single most comprehensive German experiment in planetary research. Researchers from DLR are amongst the imager's scientific team, based at the Free University of Berlin. ESA has extended the mission until the end of 2012 since, seven years in, all systems and instruments are still functioning reliably. Until then, the imager will continue to obtain digital terrain models of the Martian surface.



The High Resolution Stereo Camera is giving Mars researchers a totally new perspective. This image of the Hebes Chasma valley shows traces of past acitivty of water on the planet



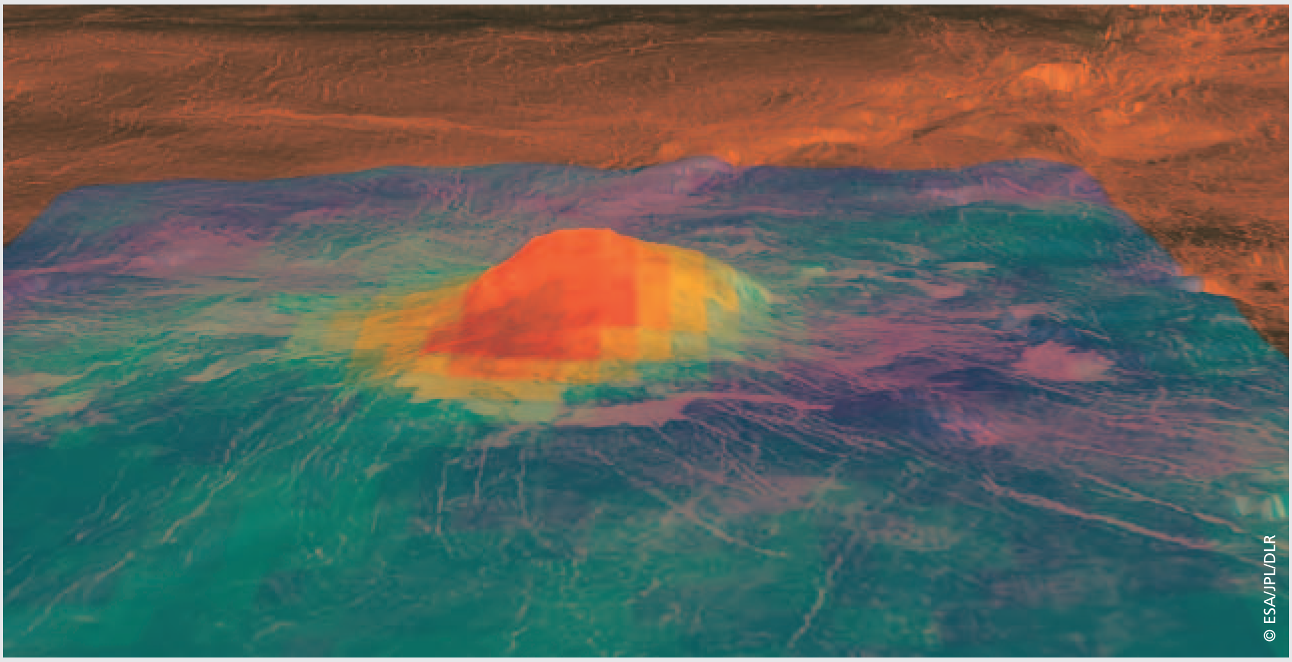
Venus Express has been investigating the turbulent weather patterns on Earth's heavily clouded twin over long periods of time

Venus Express – sister ship for our sister planet

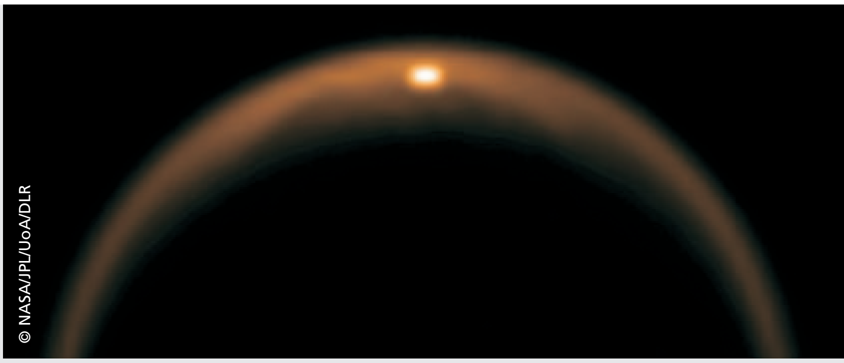
Venus Express orbits Earth's closest planetary neighbour, and is proving just as successful as Mars Express. Like its sister mission, ESA's second planetary mission (which reached Venus on 11 April 2006) has been extended until the end of 2012. Its long-term investigation of storms, clouds and weather patterns provides deeper insight into what is happening within the planet's dynamic atmosphere. The Venus Monitoring Camera, built by the Max Planck Institute for Solar System Research in Katlenburg-Lindau, the DLR Institute for Planetary Research, and the Institute of Computer and Network Engineering of the University of Braunschweig, was developed to this end.

The researchers are also seeking out active volcanoes on the 460-degree-Celsius Venusian surface with the Visible and Infrared Thermal Imaging Spectrometer, which looks at certain wavelengths that serve as windows, to penetrate the planet's dense cloud and atmosphere and zero in on volcanic hot-spots.

In April 2010, two DLR scientists working with colleagues in the USA discovered nine suspicious areas with increased surface temperatures that may indicate recent volcanic activity on the planet.



Spectrometer data from Venus Express analysed by DLR researchers shows elevated temperatures at the volcano Idunn Mons, in red, suggesting that Venus is volcanically active



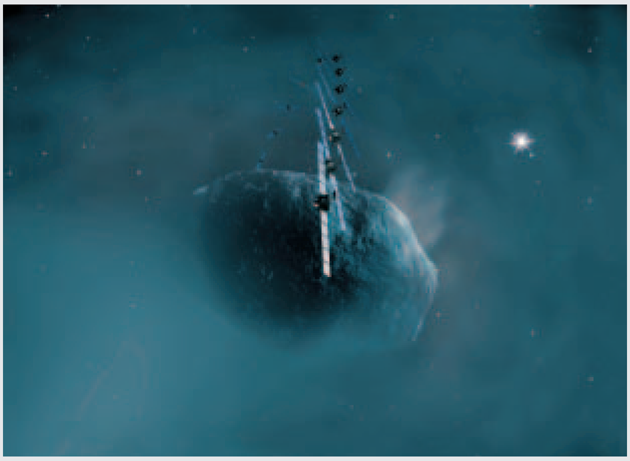
In 2009, DLR researchers detected the reflection of sunlight off a lake on Titan's North Pole. With a temperature of –180 degrees Celsius, the lake harbours liquid hydrocarbons

Water is sprayed into space at high pressure from these fissures at the South Pole of Saturn's moon Enceladus. The droplets freeze immediately, which is why researchers refer to this process as cryovolcanism

The saturnian system in a new light

The Cassini-Huygens mission to Saturn has already made history. Orbiting the second largest planet in the Solar System since July 2004, the NASA mission has yielded an impressive array of image data and test readings from Saturn's frozen environs and its moons. In 2005, Huygens, the ESA probe that piggy-backed on Cassini, plunged through a dense atmosphere to land safely on Titan, the largest and most enigmatic of Saturn's moons. Cassini had already reached the end of its first mission extension, dubbed Equinox, when in August 2009 it performed unique observations of Saturn's gossamer rings directly illuminated by the Sun from the side during the planet's equinox.

Its second mission extension, commencing September 2010 and lasting until May 2017, will be known as the 'Cassini Solstice Mission'. During the next seven and a half years up until the summer solstice, the Sun's rays will fall on Saturn's northern hemisphere and those of its moons at an ever-steeper angle, enabling detailed observations at this latitude. The cartographers at the DLR Institute of Planetary Research will benefit, as they are responsible for computing the atlases for the Cassini project. Additionally, DLR researchers who discovered a large liquid hydrocarbon lake near Titan's North Pole in 2009 will now be able to observe that area in greater detail.



The European comet chaser Rosetta will reach its destination in 2014, and the spacecraft will release the DLR-built lander Philae onto the surface in 2015

Rosetta – hibernation precedes comet landing

ESA's Rosetta comet chaser is the most ambitious, long-lasting and fascinating of all the European space science projects to investigate the Solar System. Rosetta took off on 2 March 2004 from the European spaceport in Kourou with the objective of reaching comet 67P/Churyumov-Gerasimenko in 2014 and then to land on it. The spacecraft has circled the Sun four times, flying by Earth three times and once past Mars. These fly-by manoeuvres have helped the spacecraft reach and match the elliptical orbit of the comet. By the time it crosses the Asteroid Belt, Rosetta will become the farthest solar-powered man-made object from the Sun. By the end of 2009, the mission had completed half of its several billion kilometre-long journey to the comet. A year ago, it flew past 2867 Šteins, a small Main Belt asteroid with a diameter of around five kilometres. The spacecraft was only 803 kilometres away at closest approach. Rosetta is due to pass another asteroid, 21 Lutetia, 100 kilometres in diameter, on 10 July 2010. During this flyby Rosetta will acquire images and carry out detailed measurements of its target.

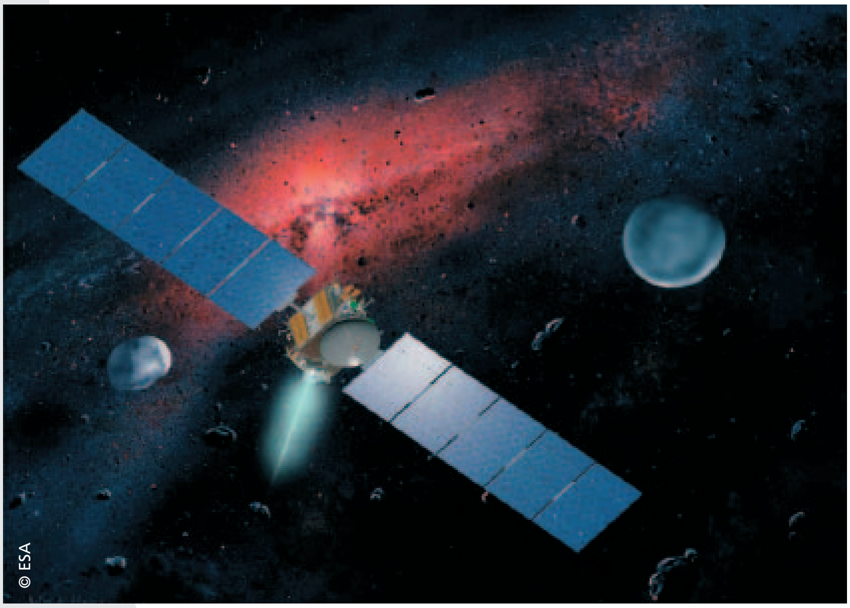
Following this, ESA's ground control centre in Darmstadt will switch the spacecraft to hibernation mode and reawaken it in 2014 to commence orbiting 67P/Churyumov-Gerasimenko. In November of that year, Philae, the lander built by a DLR-led consortium, will touch down on the comet – an unrivalled feat. Philae's control centre is located in Cologne, from where DLR scientists will command three experiments on the lander: a camera, a thermal probe to investigate the comet's tail and a seismic experiment to ascertain the nature of the comet's nucleus. DLR scientists will then participate in a multitude of experiments, both with the orbiter and the lander.

Dawn – past time traveller

To date, the media has shone relatively little light on Dawn – this NASA spacecraft was launched from Cape Canaveral on 27 September 2008 and is headed towards the large Main Belt asteroids Vesta and Ceres. Dawn is part of NASA's Discovery Program, which provides innovative missions within strict cost limits to address fundamental questions about our Solar System. It will be fascinating when, after a 2.8 billion kilometre journey in 2011, Dawn reaches the Asteroid Belt and navigates into orbit around Vesta. After nine months in situ, in April 2012 the spacecraft will then continue on to Ceres – the Solar System's largest asteroid with a diameter of about 1000 kilometres – where it will settle into orbit three years later.

This will be the first time that the same spacecraft will orbit two different celestial bodies in the Solar System within one single mission. It will also be the first time that a NASA mission travelling to the depths of the Solar System will not be employing an American camera. Instead, high-definition imagery of both asteroids will be acquired by a pair of German cameras and relayed to Earth.

These identical cameras are the result of cooperation between the Max Planck Institute for Solar System Research and the DLR Institutes of Planetary Research, and Computer and Network Engineering. Development of the cameras has been financed by the DLR Space Agency. By exploring Ceres and Vesta – two primordial bodies – scientists hope for insights into the dawn of the Solar System, 4.6 billion years ago. Hence the mission's name.



NASA's Dawn spacecraft – equipped with two German cameras – is on its way to the Asteroid Belt to explore Vesta and Ceres, two of the three largest minor planets

The DLR Institute of Planetary Research has, for 25 years, operated the Planetary Image Library, a branch of NASA that has an extensive image and mission archive (in German):
www.DLR.de/rpif

A comprehensive and well-structured collection of images of the Solar System with excellent descriptions can be found in the NASA Planetary Photo Journal:
photojournal.jpl.nasa.gov

Background information, reports and pictures of the ESA missions Mars Express, Venus Express and Rosetta are available on their web site:
www.esa.int

DLR hosts news and information about the Mars Express mission, especially the High-Resolution Stereo Camera, on a special page:
www.DLR.de/mars/en/

Under the heading 'Solar System' on ESA's Science and Technology website, scientifically- and technically-oriented readers will find additional background information:
sci.esa.int

The imager on Cassini is managed at the Space Science Institute in Boulder, Colorado, which usually places the first raw images online immediately after receiving the data:
ciclops.org

The Dawn asteroid explorer's scientific team is active in its efforts to inform the public, teachers, students and young people about the aims and activities of the mission:
dawn.jpl.nasa.gov

About the author:
Ulrich Köhler is a planetary geologist, also responsible for science communication at the DLR Institute of Planetary Research, Berlin.

React in a flash

Severe thunderstorms bringing hail, heavy rain, gale-force winds, tornadoes and lightning threaten human life and safety and cause substantial damage annually. The insurer Munich Re estimates total damage from thunderstorms at two billion Euro per year for Germany and at between five and eight billion Euro for Europe as a whole. Weather conditions contribute both directly and indirectly to accidents and delays in air transport. Assessing the risks posed by severe thunderstorms in a changing climate is therefore essential. To this end, DLR is coordinating the Regional Risk of Convective Extreme Weather Events: User-oriented Concepts for Trend Assessment and Adaptation, RegioExAKT, research project. It is funded by the Federal Ministry of Education and Research with the objective of determining occurrence and risk potential trends of severe thunderstorms in Germany. Part of the project aims at developing best practice adaptation strategies for project participants Munich International Airport and Munich Re.

Thunderstorms throw up particular challenges to aviation. DLR projects RegioExAKT and Weather and Flying are tackling this stormy issue

By Nikolai Dotzek, Hartmut Höller and Thomas Gerz

Storm over Dresden – for airports such as those serving this city, predicting the risk of severe weather is of great significance. DLR researchers are investigating improved forecast strategies

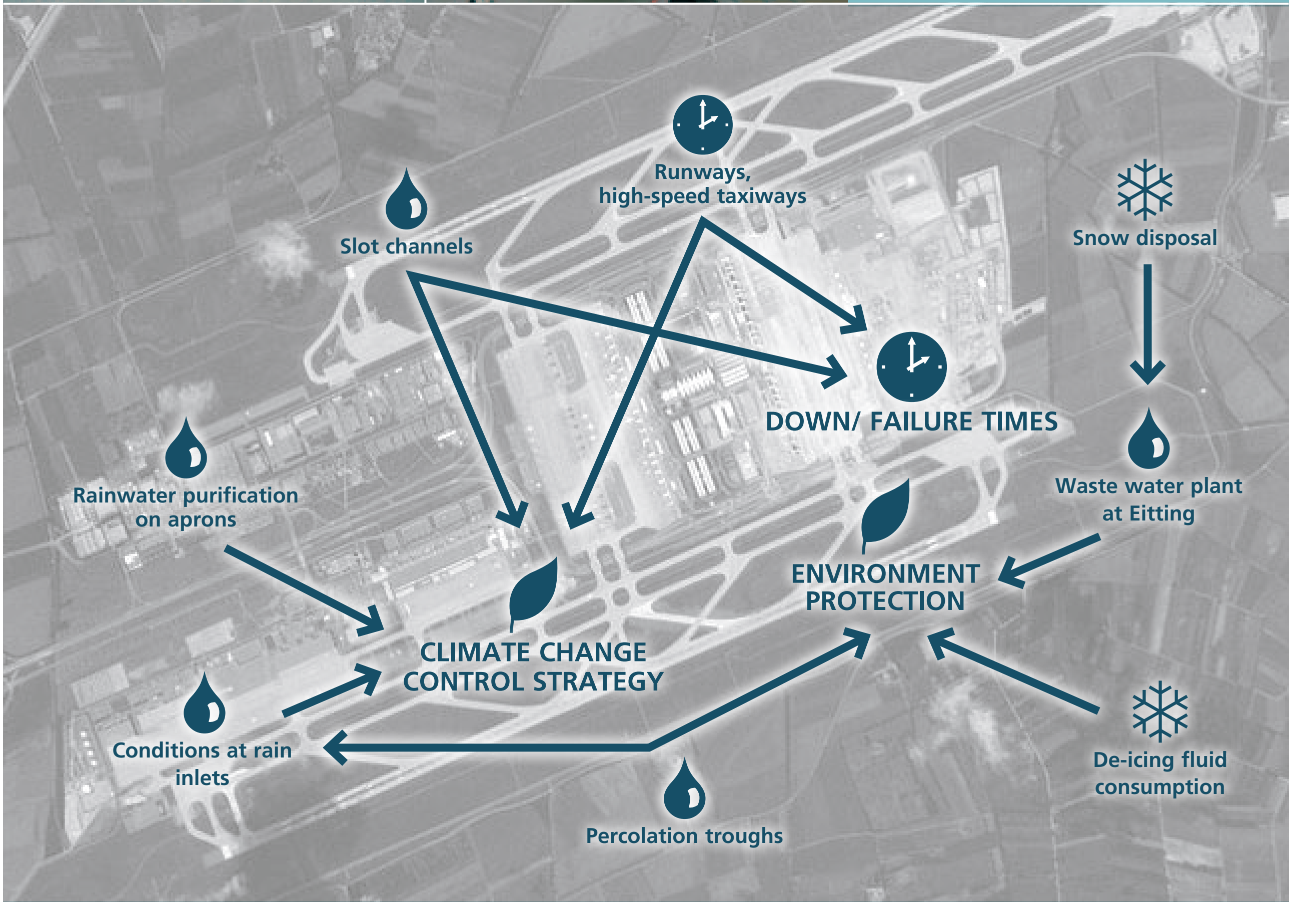
Weather-sensitive commercial sectors such as aviation, insurance, construction and water supply involve regional risk analyses and adaptation strategies. The German Weather Service is also working towards optimising its thunderstorm forecasts and early-warning procedures. For the commercial sector, it is important that building codes are adapted to account for climate trends in wind loads and extreme precipitation.

Climate change and severe thunderstorms

Thunderstorms require conditions such as instability, moisture and lift. Severe thunderstorms add wind shear to the equation. Large-scale datasets exist whose long-term trends can be traced from meteorological analyses and modelling of the past to make estimates of the future. The link to actual severe weather events can be established, for instance, via the European Severe Weather Database operated by the European Severe Storms Laboratory, a spin-off of the DLR Institute of Atmospheric Physics.

Observational findings for severe thunderstorms in Germany since 1950 indicate neither a significant nor an area-wide trend towards hazardous meteorological development. The appreciable upward trend of damage from such events is currently, and will over the next few years be, conditioned to a large extent

Examples of air traffic interference due to severe weather:
Flash flood at Munich Airport (left)
Hail damage



Drainage adaptation measures identified by RegioExAKT and implemented by RWTH Aachen University and the Institute for Underground Infrastructure at Munich Airport

by the growth in the concentration of assets, exposure and vulnerability. Regional climate model simulations for the 21st century show that thunderstorms may become even less frequent, but the storms that actually form may be more severe. Alongside the modelling of extreme wind climate and wind loads, RegioExAKT has examined the link between extreme weather events and specific weather situations. Here, the focus was placed on drainage modelling in the case of heavy precipitation at Munich International Airport under the conditions of future climate changes.

Already, one significant outcome of RegioExAKT has been the reduction of precipitation-related downtime at the airport, which has a sealed surface area of 500 hectares. This has been achieved by adapting its current drainage system to changing weather conditions.

Project partners RWTH Aachen University and the Institute for Underground Infrastructure carried out detailed simulations of the drainage system including hydrodynamic modelling of surface run-off on the runways, so changes to surface drainage systems and installations could be reproduced more realistically than before. In particular, this includes the opportunity to increase drainage rates through the use of grooves on runways and taxiways. RWTH Aachen University's drainage model enabled the modelling of individual adaptation strategies. Drainage measures (downtime) and environmental protection can therefore be evaluated in advance of changes in the weather.

The installation of an ultrasonic anemometer network at Munich Airport is another notable achievement of the RegioExAKT research project, delivering local wind speed measurements. The four meteorological masts are arranged in the form of an isosceles triangle with 100-metre long sides. There is a 10-metre mast in each of the three corners, and a 20-metre mast at the centre of the triangle (shown in the figure, top right opposite page). A total of six ultrasonic anemometers are fitted to the masts, one at the apex of each of the 10-metre masts and the remaining three at the five, 10 and 20 metre points on the 20-metre mast.

Continuous measurements have been made at a rate of 32 hertz since August 2008, with a spatial network structure that is globally unique. They facilitate the description of wind fields in thunderstorms and gust fronts and support the modelling of extreme wind climate and wind loads. Another DLR project, called 'Weather and Flying', hopes to derive wake vortex structures from the turbulence data. The German Weather Service already benefits from this network. In the iPort-WX project, the masts will be supplemented with temperature and humidity sensors in order to study fog formation.

Short-term forecasting and nowcasting

RegioExAKT contributes to timely forecasts of severe thunderstorms at Munich Airport, both by short term forecasting (two to six hours, project partner: Free University of Berlin) as well as nowcasting (zero to two hours). The LINET Lightning Detection Network (project partner: NowCast mobile GmbH) which covers southern Germany permits discrimination between ground and cloud lightning, and fixing the altitude of the latter. DLR's Polarisation diversity doppler Radar, POLDIRAD, can differentiate between hail and rain. Combining these lightning and radar measurements allows for precise tracking and nowcasting of storm cells.

A practical example was the squall line embedded in the winter cyclone 'Emma', which affected the airport between 10:20 and 10:50 hrs on 1 March 2008. Its large-scale structure allowed for tracking and prediction over a relatively long period. Additionally, selected parameters in the lifecycle of the radar and lightning cells were recorded separately and evaluated for forecast indicators. Thus, the minimum downtime of Munich Airport could be forecast two hours ahead of the weather front arriving.

The Weather and Flying project

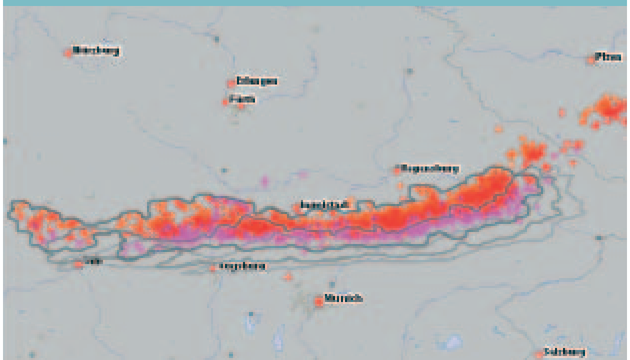
The more air traffic increases, the more it becomes vulnerable to adverse weather conditions. At the same time, weather is not a technical problem that can be controlled, so every effort must be made to detect atmospheric changes as precisely and as early as possible, both at the airport and around the aircraft, now and for air traffic procedures in the future. DLR's Weather and Flying project seizes these challenges with a view to enhancing security and efficiency in aviation. Developments will be:

- Integrated Terminal Weather Systems for Frankfurt and Munich Airports, comprising wake vortex, thunderstorm and winter weather components to provide tailored weather information in the airport vicinity.

- Onboard and ground-based control, monitoring and information systems for the enhancement of aircraft behaviour in wind gusts, wake vortices and thunderstorms, comprising aspects of automatic flight control systems, aircraft sensors for the recognition of wake vortices and gusts, as well as pilot information systems.

Between them, the RegioExAKT and Weather and Flying projects contribute to targeted adaptation of air traffic and the airport operation to the evolving threat posed by severe thunderstorms. For this, planning and control measures in air traffic management, air traffic control and on the aircraft are required to minimise the influence of weather as a disruptive factor. This is ensured by, among other things, the recently developed nowcasting method, which helps to maximise the capacity of the airport both now and as air traffic increases in the future. Alongside Munich Airport, airline companies benefit most from this work, as well as the German air traffic control agency and the German Weather Service.

The 20-metre main mast of the ultrasonic anemometer network, sited at the northwest corner of Munich Airport



Predicted progression of the squall line of cyclone 'Emma' on 1 March 2008 at 10:17 hrs, based on lightning detection (LINET, coloured symbols). Lightning contours (grey lines) represent the observation and the 15 or 30-minute nowcast, respectively, in the vicinity of Munich Airport

About the authors:
The authors work at the DLR Institute for Atmospheric Physics. Nikolai Dotzek coordinates the RegioExAKT project, Hartmut Höller is one of the participating scientists and Thomas Gerz is dedicated to the Weather and Flying project.

Further information:
www.regioexakt.de
www.pa.op.DLR.de/poldirad
www.pa.op.DLR.de/wirbelschleppe
www.essl.org/ESWD

Chasing ice crystals in the sky

It is well known that humanity generates huge amounts of atmospheric carbon dioxide, and that this has an impact on Earth's climate. But what is the effect, if any, of aircraft contrails? What is going on inside those white trails, soft spiralling clouds or wide, bold stripes across the sky, which look so similar to natural cirrus clouds? DLR researchers are investigating contrails with their international partners – and they are doing this right up there in the sky. Christiane Voigt, scientist at the DLR Institute for Atmospheric Physics and Assistant Professor at the University of Mainz explains what they are up to and what surprises they have already found.

Christiane Voigt flies through aircraft contrails to investigate their impact on climate

Interview by Manuela Braun

The circular ice clouds seen in this picture, documented for the first time, were a surprise for researchers. DLR atmosphere scientists and researchers are looking into how such structures form in cold air

You're really hunting contrails for your research. What's that like?

We investigate the climate impact of contrails. We chase aircraft in their flight and sample their contrails with DLR's Falcon research aircraft at altitudes of 8000 to 11,000 metres, at a speed of around 700 kilometres an hour, roughly 200 metres a second. We keep a distance of at least 18 kilometres from passenger aircraft, so that passengers are in no danger.

What exactly are you measuring during these flights?

The nose of the Falcon is equipped with a meteorological mast to measure wind speed and direction. The wing pods contain particle probes, which measure the ice crystals and aerosols in the contrails. And then there is more instrumentation inside the aircraft to measure the composition of the air: nitrogen oxides, ozone and sulphur dioxide for example. These instruments are operated by international teams, including colleagues at DLR. In November 2008 we completed the measurements with the Falcon during the Contrail and Cirrus Experiment Campaign, which gave us a large dataset of contrails.

What has been the most difficult flight manoeuvre so far?

It was particularly challenging to perform measurements behind two planes flying in parallel. Contrail formation depends on meteorological conditions like temperature, pressure and humidity. To keep these parameters as constant as possible, a small charter plane had to fly very close to a large passenger plane, so that we could take measurements in both of their contrails. This flight pattern required extensive preparation: we had to discuss the flight pattern in detail with the pilots, the instrumentation had to be completely reliable and, of course, the weather conditions had to be right for contrail formation – this mostly occurs

at temperatures below –40°C and in high humidity. Without the support of Lufthansa and German air traffic control, we could never have done it. And the pilots as well as the DLR Flight Facility really did a great job to ensure that the experiment was a success. Another exciting flight was chasing the Airbus A380, the largest passenger aircraft in the world. We followed it for 15 minutes across Germany during its flight from London to Singapore. The A380 formed a massive contrail, and the flight was very turbulent.

Why are you measuring the contrails of so many different aircraft?

During the Campaign we studied 22 contrails from 11 different types of aircraft, from a lightweight Fokker to a 500-ton A380. So now we have lots of data on a wide range of contrails. We want to know whether the type of aircraft – including its size, weight and fuel consumption – affects the properties of young contrails. No one's looked into this before, but it is important to understand their impact on climate.

How do contrails affect Earth's climate?

Contrails are like a blanket laid over Earth. They reduce Earth's albedo, that is, the emission of terrestrial radiation up into space, and therefore contribute to global warming. This adds to the natural greenhouse effect. On the other hand, contrail ice crystals reflect incoming sunlight back into space. This means they also have a cooling effect. But their overall effect is to warm the atmosphere.

Air traffic is growing by 5.3 percent every year which means that passenger traffic will double in under 20 years. So reducing the impact of contrails on the climate is very important. We must understand and calculate their effect on Earth's radiative balance.

What do you observe during your flights?

Contrails are linear ice clouds. The ice crystals are distributed unevenly through the cloud. We were able to observe contrail circles or pipes for the first time – in which the ice crystals are distributed in a circular structure. We still don't know how these circular structures form – perhaps it's due to the centrifugal force acting on the rotating particles. But it may also be that cold air drawn along in the contrail's outer boundary creates more or bigger crystals.

Can you say how much of the sky is presently covered by contrails?

Satellite measurements show that over Central Europe, around 0.5 percent of the sky is covered by young, line-shaped contrails on average. In cold, humid air, these fresh contrails can last for several hours and spread out like cirrus clouds. It is hard to observe persistent contrails from satellites, because the contrail cirrus clouds look just like naturally occurring cirrus clouds. But the coverage of the sky with persistent contrails is much greater, perhaps by as much as a factor of ten, compared to linear contrails. So persistent contrails must have a considerable effect on the climate.

You have completed a lot of flights in the meantime. What new conclusions have you come to?

It was not clear whether the type of aircraft had an effect on the properties of contrails, such as dimensions, particle sizes and particle concentrations. We need to know these properties to calculate the radiative forcing. Our measurements show that the dimensions of young contrails – their height and width – are dependent on the aircraft type. The size of the ice crystals, on the other hand, is not affected by the aircraft type. But meteorological and atmospheric conditions play an important role in the formation and persistence of contrails. Before our work, not many measurements of contrails existed, so our results are laying the foundationsfor a better understanding of their impact on climate. Our work is pioneering in this area.

Can you tell us what the contribution of persistent contrails is to global warming?

The latest estimates, arrived at in collaboration with DLR, put the radiative forcing of persistent contrails at 33 milliwatts per square metre, which is greater than the effect of carbon

Ice crystals in the contrail of an A380-800 measured with a particle probe from Université Blaise Pascal in Clermont-Ferrand. The tiny ice crystals with diameters greater than 0.1 mm come from surrounding cirrus clouds and have got mixed into the contrail. The form the ice crystals take affects the radiative effect of contrails

Photos of contrails and contrail pipes taken by the pilots from the cockpit of DLR's Falcon research aircraft during the Contrail and Cirrus Experiment Campaign in November 2008

dioxide emitted by air traffic, equal to 28 miliwatts per square metre. Overall, air traffic contributes about five percent to anthropogenic radiative forcing due to contrails in particular, with an error of 2 to 14 percent. For sustainable air transport in the future, we must continue to research this field.

About the interviewee:

Christiane Voigt, born in 1971, has three children. She studied Physics at Heidelberg and Oxford. After her doctorate at the Max Planck Institute for Nuclear Physics in Heidelberg, she worked as a Research Associate at the Danish Meteorological Institute in Copenhagen, then at the Swiss Federal Institute of Technology, Zürich, and finally at the DLR Institute for Atmospheric Physics in Oberpfaffenhofen. Since 2007, she has been the Head of the Junior Research Group 'Impact of Aircraft Emissions on the Heterogeneous Chemistry of the Tropopause Region', with a scientific focus on the impact of aviation on the atmosphere and climate. Along with Ulrich Schumann, Director of the Institute, she led the international Contrail and Cirrus Experiment Campaign as part of the DLR's Climate Compatible Air Transport System project in November 2008.

Contrails:
Contrails form when the hot, humid exhaust of an aircraft mixes with cold ambient air. This increases the relative humidity of the exhaust gases. If the saturation point of water is not reached, water vapour condenses on soot and sulphuric acid particles from the engine exhausts, and small water droplets form. As the droplets cool further by mixing with cold air, they freeze into ice crystals. If the surrounding air is supersaturated with respect to ice, the ice crystals grow by condensation of ambient water vapour and persistent contrails can develop, which influence the natural cloudiness as do the soot particles themselves.

Aerosols:
Aerosols are tiny particles suspended in a gas. For example, an aircraft's exhaust contains nanometre-sized soot particles or sulphuric acid droplets.

Radiative forcing:
Radiative forcing is the change in the radiative balance of Earth's atmospheric system due to perturbations.

About the author:
Manuela Braun works as an editor in the Crossmedia Section of DLR's Corporate Communications Department in Cologne.

Further information:
www.DLR.de/pa/en/

Travelling light

Approximately one million airfreight containers are in circulation globally. The Deutsche Post DHL group uses these 'Unit Load Devices' for its logistics services. However the Aviation Group of Deutsche Post DHL is considering the further development of a lightweight airfreight container in order to save costs and protect the environment. Less weight to transport means lower fuel consumption, resulting in a reduced carbon footprint. In the framework of the existing Strategic Innovation Partnership between DLR Technology Marketing and DHL Solutions and Innovations, DLR was commissioned to perform a feasibility study, titled 'Design Innovations for Airfreight Containers'.

A new construction technique for airfreight containers – results of a DLR study for Deutsche Post DHL

By Ute Gerhards

Currently, a multitude of container types are used for airfreight. Most share the same basic structure: base plate, frame, sidewalls, top and a lockable opening for loading and unloading. Depending on the particular sections of their structure, the construction materials used are either aluminium or plastics. The container shapes vary to match the aircraft interior and the position of the container in the aircraft.

Deutsche Post DHL defined reduced weight achieved through the use of advanced materials as the most important requirement for the further development of an airfreight container. Robustness, fire resistance, ease of repair, suitability for radio frequency identification and foldability are additional criteria.

DLR scientists analysed the problems and procedures associated with handling Unit Load Devices. This included an on-site study at the DHL air hub in Leipzig, Europe's most modern airfreight transhipment centre. They analysed the everyday requirements for an airfreight container, including ground transport and damage repairs. Based on this analysis, they developed various innovative concepts for future airfreight container design. Weight reduction will primarily be achieved by the use of carbon-fibre reinforced composites and sandwich structures, and therefore the design effort will be focused on the development of a significantly lighter baseplate that could also be used as a pallet.

In addition to the feasibility study, DLR Technology Marketing performed a qualitative market review for a new, lightweight airfreight container. For the manufacture of a prototype, industrial partners from the materials supply and container construction sectors were sought and identified.

Strategic Innovation Partnerships – spin-in for successful products

Enterprises such as Deutsche Post DHL benefit greatly from DLR's research activities. DLR Technology Marketing forms a bridge between science and innovation; since 2007, it has systematically developed Strategic Innovation Partnerships as a new and more promising type of cooperation with industry. An innovation platform has been created to support the development aims of both partners. An agreement fixes the working methods and objectives of the collaboration at the start of an innovation project. Strategic Innovation Partnerships are characterised by spin-in from both partners. This means that the partners work closely with each other in the run-up to a technological development, to identify opportunities for a systematic joint implementation and to harmonise their research and innovation processes as early as possible. To that end, it is not just DLR's technology that is used, but also DLR's evaluation procedures. In this way, new products can be developed earlier, more efficiently and with less risk.

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For more information:
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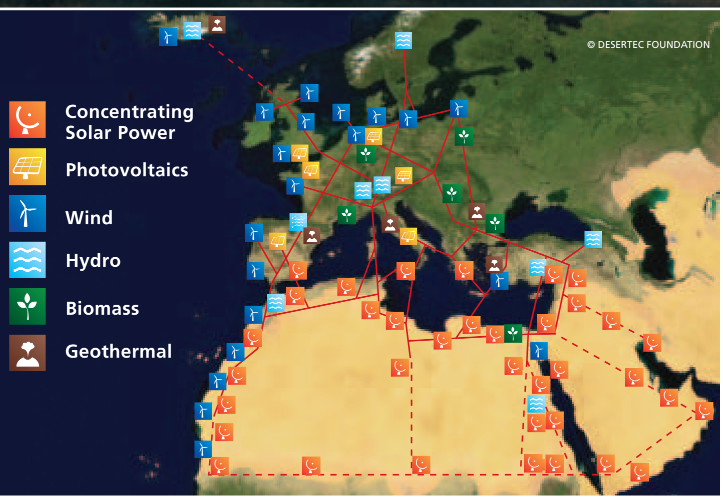


Design concept for an energy network of the future. North Africa and the Middle East are rich in solar energy. The clean electricity generated in North Africa could be transported to Europe via a distribution network. In addition, desalination plants operated with energy from solar-thermal power plants could produce drinking water for the desert states

Desertec Industries

On 30 October 2009, Desertec Industries, an initiative of industry and the Desertec Foundation, commenced work. The initiative, which comprises 17 organisations from 8 countries and 16 enterprises, aims to deliver safe and climate-friendly energy from the deserts of North Africa and the Middle East. It is currently establishing the parameters for supplying the Mediterranean coast with solar and wind power. The aim is to provide electricity for the region itself, and by 2050, to meet 15 percent of Europe's electricity needs.

"We have the technology, the concepts and the contacts"

Interview by Dorothee Bürkle

You have been elected Chairman of the first Management Committee of Desertec Industries. What has been accomplished since Desertec was set up?

A great deal. The Desertec business premises have been set up in Munich, two CEOs – Paul von Son and Rainer Aringhoff – have been appointed, and staff members have been recruited. In addition, numerous meetings have been held with representatives from politics, trade associations and business communities in the appropriate countries. The number of companies involved in Desertec Industries has now risen to 19 members and 16 associate members. Also, Klaus Töpfer has been headhunted as a strategic consultant.

When will the first power station be built?

That is not the Initiative's task. Desertec is here to prepare the way forward, and to create the political, regulatory and economic framework conditions for progress to be made at a future date. Nevertheless, solar-thermal power stations are already under construction in Morocco, Egypt and Algeria. Many other locations have also been identified, and these sites are already the subjects of discussion between corporations and governments.

Desertec is one of the largest industrial and infrastructure projects ever undertaken. Why are corporations taking on a project of this magnitude?

Two things motivate the companies involved: by the year 2050, the countries of North Africa and the Middle East are on course to effectively quintuple their energy needs. This means that power stations need to be constructed, irrespective of the technology employed to meet that need. Furthermore, supplies of crude oil, natural gas and coal are becoming scarce, making them more expensive – and add to this their emissions, which have a negative impact on climate. Many companies see a clear market here. In response to the Spanish energy feed-in law, several projects have already been initiated, while in the USA various projects are now reaching the implementation phase. This means that this technology is starting to play a worldwide role in the energy business. In 10 to 15 years, solar-thermal power stations will become competitive with conventional power stations. Corporations such as Siemens, Eon, RWE, MAN and Solar Millennium share the opinion that anyone who enters this market today, in its early stages, has very good prospects when the market matures in the next decade, by which time a great deal of money will be made through these technologies.

It is not automatically expected that the Director of a research Institute would be appointed Chairman of a Management Committee of this kind. What contribution can DLR make to Desertec?

DLR has been working on solar-thermal power stations for about 30 years now. We are one of the world's leading research organisations. Furthermore, our detailed energy system analysis on behalf of the German Ministry of the Environment is the information platform upon which Desertec Industries was founded. We have the technology, the concepts and the contacts in the various countries as well as the corporations involved.

What contribution can DLR researchers make?

Our workload looks set to grow enormously. We are already running courses for staff members newly recruited to Desertec Industries. We will be updating our studies and site analyses for new power stations. It is here that DLR's access to satellite data stands us in very good stead. We are also continuing to drive the development of these technologies in order to devise more efficient and lower-cost solar-thermal power stations. We are working with the companies involved to improve individual components as well as the overall system, and we are also working on applications such as desalination and hydrogen production.

Hans Müller-Steinhagen is Head of the Stuttgart-based DLR Institute of Technical Thermodynamics

About the author:
Dorothee Bürkle works as an editor in DLR's Corporate Communications Department in Cologne.

Further information:
www.DLR.de/tt/en/
www.desertec.org


Cityring Süd
Messegelände
Magni

The city as a laboratory

How does one avoid traffic jams that come out of nowhere? Can my navigation system incorporate local public transport? Will it show me the way to the nearest free parking place in the city centre? Is it possible to adjust the timetable so that the tram is waiting for my train? Which congestion rerouting is best for me? When is the best time to leave? Why can my car not tell the traffic light that I am almost there? Will there be an autopilot for my vehicle? Issues concerning mobility affect our lives every day. The goals and solutions are diverse, and so are the questions concerning mobility. In order to provide answers, DLR has converted an entire city into a 'mobility laboratory'.

Integrating regional transport research with DLR's Application Platform for Intelligent Mobility

By Sascha Bauer and Jan Schulz

Personal mobility is a fundamental element of modern life and links our everyday activities: living, working and leisure. However, mobility also has a dark side – traffic congestion, accidents and environmental damage. One aim of transport policy and research is to decouple mobility from these negative effects, while focusing on safety, efficiency, sustainability and comfort.

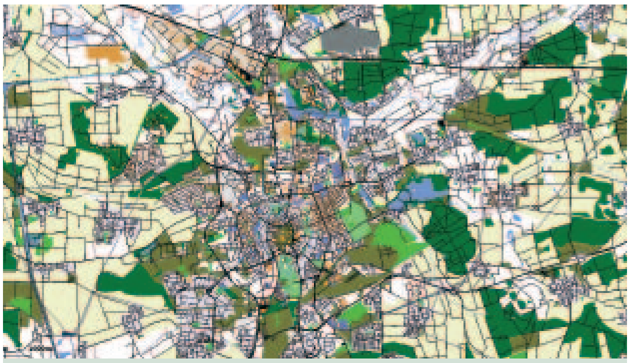
AIM bundles transport research activities

The Application Platform for Intelligent Mobility, AIM, supports the entire cross-spectrum of transport research, including all combinations of interactions. AIM is unique – previous laboratories and testing grounds have been based around individual topics and are generally temporary in nature. AIM combines research, technologies and applications in a real long-term environment as an open, neutral platform for research and industry. This combination of investigations on a single platform reduces investment costs for research projects and creates a significantly wider arena for investigating issues and applications addressing mobility. However, AIM is more than merely a large-scale research facility – it is also a service provider that coordinates, supports and takes part in research projects. With AIM, DLR is concentrating investments and consolidating diverse interest groups from research institutions, public institutions and industrial enterprises.

Ready for novel and complex phenomena

The combination of innovative transport, technologies and methods is what makes the research portfolio of AIM unique. There is a substantial emphasis on 'multimodality' – the idea that instead of favouring single modes of transport, a combination should be deployed in order to convey goods and passengers efficiently. This can only be achieved by an intelligent interplay between transport assessment and comprehensive traffic management covering road and rail, as well as an increased use of cooperative systems. For example, vehicles communicate with one another with the help of such systems and exchange information with the transport infrastructure. In this way, traffic lights can inform vehicles when they will be red and vehicles can warn each other about dangers.

Where routes cross and different transport systems meet, as is shown here in front of the castle in Braunschweig, it is an ideal situation for traffic research to examine how mobility can be managed intelligently



Augmented with supplementary information, the refined network offers a foundation for traffic simulation and a variety of investigations without interfering with the actual traffic flow

How does one organise transport such that waiting times are minimal? The Application Platform for Intelligent Mobility aims to answer this question

Transportation is a complex system of interactions and relationships between diverse modes of transport, different groups of users (from the schoolchild to the commuter), as well as varying types of use – a pedestrian's employment of the transport system is quite unlike that of the motorist, for example. It therefore sets an enormous challenge to any form of traffic management, and transport research field trials are correspondingly complex. However, mobility phenomena are hard to generate in an artificial environment. This is why DLR's Institute of Transportation Systems is taking a new approach with AIM – it is converting an entire region and its transport links and road network into a research laboratory.

The laboratory: the city and surroundings of Braunschweig

Close to a million inhabitants of the region of Braunschweig contribute to AIM through their travel behaviour. Their differing routes to school, work or shopping, with the use of cars, buses, trams, trains or bicycles, create a complex transport matrix. Its diverse transport infrastructure, together with its highway and rail connections, allows Braunschweig to satisfy the requirements for answering diverse questions in transport research. In addition, the region is home to the Automotive Research Centre of Niedersachsen, Braunschweig University of Technology, Volkswagen AG and DLR's Institute of Transportation Systems, with their comprehensive professional skills in the road, rail and traffic management sectors – and with a multitude of technology-oriented small and medium enterprises – the region is a recognised mobility research environment.

AIM is a flexible platform that, equipped initially with basic functionality and services, may be expanded or enhanced for specific research projects according to demand. The core is comprised of a research centre, uniting basic functions such as data acquisition, management, processing and visualisation. One central component is a virtual model of the transport network, where traffic can be simulated. This allows traffic predictions to be generated and permits novel traffic management proposals to be tested without interfering with the actual traffic flow. Another key element is the Traffic Data Management System that consolidates heterogeneous data and information from sources such as traffic sensors, traffic radio updates or announcements of schedules and delays by public transport operators. The various data is collated with the System so as to be available to those who are using AIM via standardised interfaces. A visualisation tool enables presentation of general and traffic-relevant data, such as status information for online data sources and the availability and quantity of traffic and metadata.

In one of its first projects, DLR is laying the foundation for an AIM research fleet. Taxis will transmit their position to the research centre at regular intervals via a satellite-based positioning system. The data provided by a multiplicity of taxis moving and acting as traffic sensors will reveal travelling times and the traffic situation in a particular road network. In future projects, the research fleet will be extended to include the vehicles used by public officials, pharmacies, ambulances, car fleets, refuse lorries and similar groups of vehicles. A further project will entail the installation of sensors at several intersections that will then be linked to research routes.

After two years of preparation and planning, the official launch of the Braunschweig region research area took place in January 2010. This marked Braunschweig's expansion into a platform for applied science research and development of traffic for the future.

About the authors:
Sascha Bauer and Jan Schulz are scientific staff members in the Traffic Data Acquisition Group of the Traffic Management Department at DLR's Institute of Transportation Systems in Berlin. During his time at DLR, Sascha Bauer has specialised in the calibration and evaluation of sensors. As a traffic engineer, Jan Schulz's skills lie in the interdisciplinary field of traffic research, especially in the areas of traffic sensors, navigation and route guidance.

Further information:
www.DLR.de/ts/en/

Driven by experience: older drivers react better to distractions

By Martin Baumann

Driver distraction and inattention are the most common causes of accidents. Traffic experts estimate that these factors play a role in 25 – 50 percent of all accidents. However, distraction is not caused only by taking one's eyes off the road but also by visual distractions, such as reading a road sign. A driver may also be cognitively distracted from driving by other things, being mentally absorbed in a matter that is irrelevant to driving – for example, when using a telephone. Based on these findings, the DLR Institute of Transportation Systems examined the effects of cognitive distraction on driving behaviour in a series of experimental studies – mostly conducted in a driving simulator.

The DLR researchers have determined that reaction times are increased as a result of cognitive distraction – for example, if braking manoeuvres by the preceding vehicle are not adequately anticipated. Observations and interviews indicate that drivers often admit to being conscious of the negative consequences of distraction. They employ compensation strategies in order to counteract the extra demands of tasks such as telephoning while driving. Some drivers lower their speed and avoid complex driving manoeuvres such as overtaking, or they interrupt the call when the demands of the driving task increase.

The objective of one of the studies performed by the Automotive Department of the DLR's Institute of Transportation Systems in Braunschweig was to discern possible differences in compensation strategies employed by older and younger drivers. The investigation was part of the EU Integrated Human Modelling and Simulation to support Human Error Risk Analysis of Partially Autonomous Driver Assistance Systems, ISi-PADAS, research project. Driver models were constructed and evaluated on the basis of empirical investigations of driving behaviour, both with and without driver assistance systems. Ten participants completed the study in the Institute's test vehicle, ViewCar, during an approximately three hour long journey on a dual carriageway. The ViewCar allows precise recording of driver behaviour and important aspects of the driving situation. The test subjects were confronted with a secondary task several times during the journey. It turned out that older and younger drivers react differently to distraction. Older drivers compensate for the increased risk arising from the distraction by adapting their driving behaviour. The researchers believe that one reason for this is that older drivers are more sensitised to the risks associated with distraction because of their experience. They also possess practical experience that the ability to process information for several tasks simultaneously declines with age. Older people evidently act based on this knowledge by paying more attention.

About the author:
Martin Baumann leads the 'Understanding Drivers' Group at the DLR Institute of Transportation Systems in Braunschweig.

Evidently sensitised to distractions, a DLR study found that older drivers are more cautious than younger ones

About DLR

DLR, the German Aerospace Center, is Germany's national research centre for aeronautics and space. Its extensive research and development work in aeronautics, space, transport and energy is integrated into national and international cooperative ventures. As Germany's Space Agency, the German Federal Government has given DLR the responsibility for planning and implementation of the German space programme, as well as international representation of Germany's interests in this field. In addition, DLR functions as the umbrella organisation for the implementation of the largest national projects.

Approximately 6500 people work for DLR. The Center has 29 institutes and facilities at 13 locations in Germany: Cologne (Headquarters), Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also has offices in Brussels, Paris and Washington D.C.

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