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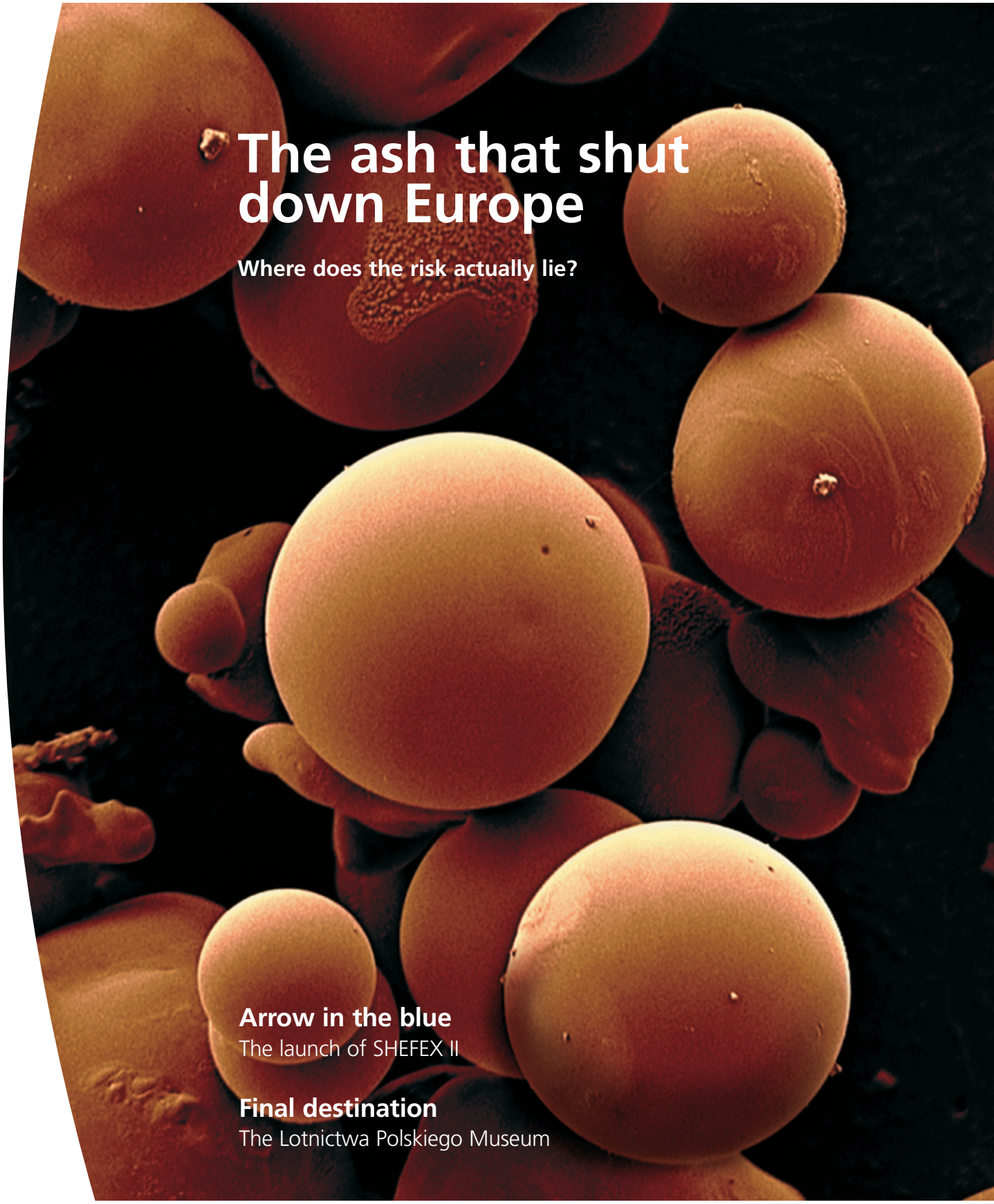
DLR magazine 134·135



The ash that shut down Europe

Where does the risk actually lie?

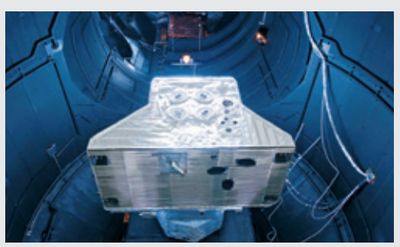
Arrow in the blue
The launch of SHEFEX II

Final destination
The Lotnictwa Polskiego Museum

DLR magazine 134·135

Arrow in the blue

As the roof of the hall on the Norwegian Andøya Rocket Range slid open, the view of a bright summer evening came to sight. The countdown for the launch of the SHEFEX II spacecraft had begun. After seven years of research and development work, the day had come to test the performance of another sharp-edged spacecraft. DLR Magazine was there as researchers from seven DLR institutes anxiously awaited the launch of SHEFEX II, and as it rocketed into the sky.



Dear readers,

It really is taking place! A bit later in the year than usual, the ILA Berlin Air Show 2012 opened its doors on 11 September. With a novel look and in a new venue, the Berlin ExpoCenter Airport, it has been organised jointly by Messe Berlin and the German Aerospace Industries Association (Bundesverband der Deutschen Luft- und Raumfahrtindustrie; BDLI). The modern exhibition centre, south of Schönefeld Airport, is showcasing a vibrantly exciting trade fair, where every major player in the aerospace community is participating.

This 'home match' is an opportunity for DLR to present its research topics in a stand extending over almost 500 square metres and an open-air exhibition area that is almost as big. Inside Hall 4, we are presenting cutting-edge research and results from our aerospace institutes, in collaboration with our French partner, CNES; outside, we are displaying our fleet of research aircraft. HALO, a customised Gulfstream G550 that has been modified by our research groups for use as an atmospheric research aircraft, is not to be missed. It is making its big public debut in Berlin before setting off on its first purely scientific mission.

DLR is also playing a part in yet another highlight, one found only at ILA and no other aerospace exhibition – the Space Pavilion. With our partners, the European Space Agency and the German aerospace industry – represented by the BDLI – we have created 'Space World', with all current satellite missions for environmental, weather and geographical information. Here, we present practical applications of technologies developed for planetary rovers that have already found their way into modern road vehicle development. Also, we draw attention to problems down here on Earth, such as the melting of the Arctic and Antarctic ice caps. Here too, satellites are of assistance; they not only enable us to watch these processes unfold, but help us to understand them as well. Space is now part of our daily lives. We watch television without concerning ourselves about how the signals actually reach us, and we listen to that pleasant GPS voice that guides us through unknown territory; navigation systems have become an accepted feature of modern life. These services are founded on incredible engineering skills. In the Space Pavilion, we are able to experience that early amazement while learning more in the process, just as you can with this edition of DLR Magazine.

The partner country at this year's ILA is Poland. Logically enough, we journeyed there to give you an insight into one of Europe's most extensive aircraft collections. We also give you a peek of the next German astronaut's training and tell you all about when SHEFEX II tested a completely new shape for spacecraft. DLR researchers also tell you precisely what happens when volcanic ash enters an aircraft engine; forewarned is forearmed. In this spirit, I wish you a safe and exciting read…

Sabine Göge
Head of DLR Corporate Communications

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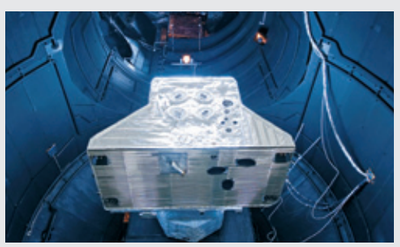

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Perspective

Image: DLR/J.Heinrich

Off to space

The lift-off of the Russian Soyuz launcher was not exactly as quiet as the flight of a butterfly! Nevertheless, the picture-perfect launch on 22 July 2012 brought the partners in the German small satellite project TET-1 at Baikonur, Kazakhstan, and in the control centre at Oberpfaffenhofen, their summer fairy tale. The TET (Technologieerprobungsträger; technology test bed) is part of the 'On Orbit Verification' programme with which DLR provides a platform for experiments in orbit. The picture was taken three days before the launch, as the Soyuz-FG rocket was being installed on launch pad 31 at Baikonur Cosmodrome.

Appealing, yet challenging

By Johann-Dietrich Wörner

Johann-Dietrich Wörner,
Chairman of the Executive Board

www.DLR.de/janwoerner

The aeronautics and space industry has always been and remains fascinating to many. But the practical challenges involved in this field leave no room for dreamers. Competition in the sector is increasing, and has long since gone global. In addition to purely economic matters, socio-political aspects now also have a role to play. In aviation, requirements to reduce emissions have grown, and the impact on our climate is now an issue in the public eye. Restrictions on night flights as well as the use of take-off and landing procedures to minimise the number of people affected by noise are indications of fundamental changes in the industry. The mobility of individuals is one of the great benefits of our current lifestyles, although it is clearly at odds, in particular, with the concerns of people affected by noise.

Yet, at the same time, the dilemma posed by the complex and sometimes contradictory requirements of technology, economics, environmental protection, and society presents an opportunity for research and innovation. New aircraft designs that enable environment-friendly flight must be extensively researched before they can be deployed in the near future. Activities in this regard have been initiated at the European level – Flightpath 2050 and the ACARE strategy paper set out clear responsibilities for ensuring mobility through aviation while taking the environment, the economy and society into consideration.

European spaceflight activities are in the competition. The ESA Ministerial Council Meeting in November this year will set important projects on their way. From a German perspective, the areas of future launchers and the successor to the Automated Transfer Vehicle, ATV, are of particular relevance. With launchers, the central matter is the reduction of the annual expenditure for support services as quickly and extensively as possible. But of course, the development costs necessary to achieve this must also be considered. Ariane 5 has an especially successful history, but it is important to look to reliable solutions for the future. In this respect, the pressure of global competition in both East and West has recently been significantly increased by the latest successful flight of Falcon 9, the US launcher developed by SpaceX.

Now that the International Space Station has been largely completed, with a considerable expenditure of resources, the matter at hand is to make as much use of it as possible. European activities have to be viewed in the light of the services ESA is required to perform as its contribution to the station. The ATV programme will end with ATV 5, contrary to the original plans, and discussions concerning a possible follow-up programme are currently in progress. The service module for the US Orion capsule currently looks to be the most promising. Financially feasible in terms of the compensatory measures to be provided, the Multi-Purpose Crew Vehicle Service Module (MPCV-SM) provides both the opportunity for cooperating with the United States on a demanding mission and for laying the foundations of future European robotic missions.

The ILA Berlin Air Show 2012 will showcase the full range of the aerospace sector. The mainstream exhibition will be complemented by research work that forms a basis for the future. The fact that the opening of Berlin Brandenburg International Airport has been postponed until 2013 is – as ironic as it may sound – perhaps somewhat advantageous for ILA, as this will largely isolate commercial air traffic from the trade show activities.

ILA 2012 is not only a trade fair and exhibition, but also an important discussion forum for all sectors of the aerospace industry. The intended audience for the exhibition are politicians, trade visitors and, particularly, the general public. ●

In brief

Simultaneous measuring flights to investigate thunderstorms

DLR researchers are studying the effects of thunderstorms on the formation of ozone as part of a campaign in the United States. To accomplish this, they carried out the world's first simultaneous measuring flights in thunderstorms at different altitudes, and repeated those flights 12 to 48 hours after each thunderstorm had abated. They recorded how much ozone was produced and how the chemical composition of the air was changed by the thunderstorm.

The objective of this joint collaboration with partners from the US National Center for Atmospheric Research and NASA was to gain a better understanding of thunderstorms and extend the scope of existing data. Thunderstorms exert a substantial influence on the formation of ozone at a global scale: lightning strikes create nitrogen oxides that, along with other chemicals, trigger the formation of ozone in the upper troposphere (at altitudes of roughly 10 to 15 kilometres). The strong winds inside thunderstorms also transport emissions directly from ground level and into the upper troposphere, where they may produce additional ozone. Investigations focus on these transport processes as well as on the influence exerted by different types of thunderstorms; the power, number and length of lightning strikes can vary greatly, from relatively short with a length of just a few kilometres to horizontal or 'sheet' lightning, which can exceed 100 kilometres in length. All of these elements can have an impact on ozone production. Previous measurements led scientists to conclude that thunderstorms produce five times as much nitrogen oxide as does global air traffic.

http://s.dlr.de/36vb

View from the cockpit of the DLR Falcon research aircraft during a measuring flight

The potential of renewable energies

Image: Novatec Solar GmbH

In a solar thermal power station, mirrors concentrate rays of sunlight on an absorber tube through which heat is directed into a conventional power station process to generate electrical power.

Over 80 percent of primary energy could be obtained from sustainable energy sources; it is possible to conclude that by 2030, more than 40 percent could be obtained in this way. By 2050, it should be feasible to meet 60 percent of the global demand for electricity using only wind, solar, and geothermal power. Building upon the 2010 scenario, researchers were able to acquire new data with regard to transport and potential efficiency gains in industry, and in respect of other consumers. According to these studies, it may prove possible to dispense with oil and gas resources even faster than the computations back in 2010 suggested. The calculations for the transport sector were produced by the DLR Institute of Vehicle Concepts. The project management for this scenario was provided by the DLR Institute of Technical Thermodynamics.

According to DLR researchers, the necessary investments in new power stations would amount to 1260 billion US dollars per year by 2050. But the expansion of renewable or sustainable energy sources, in keeping with the assumption made by the Greenpeace International scenario, may create 23.3 million jobs in the energy sector, which is almost five million more jobs than indicated in the comparative scenario based on the World Energy Outlook by the International Energy Agency (IEA). The energy [r]evolution scenario foresees that, by 2030, 65 percent of employees in the energy sector will be working in the wind, solar, solar thermal and biomass energy sectors.

http://s.DLR.de/5317

DLR robot arm works with the power of the mind

The DLR robot hand responds to signals from the brain

Extensive media attention came to play when, in May 2012, the scientific journal *Nature* reported that a woman with a physical disability was able to control a robot arm, developed at DLR, solely through the power of her mind. The 58-year-old US woman, who has been affected by a nearly complete paralysis for the last 15 years as a result of a stroke, is now capable of getting the robot arm to give her a bottle. As she imagines performing these actions herself, her brain communicates with a computer by sending signals via an implant just four millimetres across. The DLR robot arm and its five finger hand decipher these encrypted instructions and perform the function of hands for the semi-paralysed candidate.

The implant (a Neural Interface System) was installed in the patient back in 2005 by the US Brown University, and initially helped to operate a computer keyboard. The results of this study show that, even people who have been almost paralysed for a long time are able to use neuronal signals to such a degree that they can control robots with the power of their mind.

http://s.DLR.de/80nq

Data from space for safety on the seas

Remote sensing data can help to make our seas safer. This is why two German ministries and four German states have agreed to sponsor the research and development project for maritime safety and related real-time services until 2021 with 70 million Euro. The aim is to support coastguard and sea protection, to improve the safety of maritime transport and to ensure harbour and offshore safety.

With the assistance of satellite data and real-time images from space or from unmanned land and sea-based aircraft, DLR researchers wish to improve the monitoring of our seas. Furthermore, a secure-access 'Automatic Identification System' (AIS) was investigated and developed. For this, among other things, a form of encryption technology has been developed that only allows the ships themselves and the positioning centre to establish precise locations. In the navigation sector for ships in harbour areas, improved GPS or Galileo satellite data and ground-based correction systems are employed to navigate ships to within a centimetre and to avoid collisions with other ships or with the harbour infrastructure.

The entire airport at a glance: TAMS links up passenger and airport processes.

Management system optimises airport processes

TAMS, the Total Airport Management Suite project, was completed successfully within a three-year timescale. This enabled DLR researchers to develop a new management system for airport processes. All individual systems operated by airport staff are incorporated into this new system, interference sources are displayed, and it offers appropriate solutions to resolve issues. The long-term and already proven advantages of TAMS include lower costs, shorter waiting times for passengers, lower pollutant emissions and lower noise levels.

Together with the passenger management system, also developed by DLR, it is now possible, for the first time, to show airside and landside airport processes alongside one another. To check these systems, DLR scientists employed real flight data to create a near-real virtual airport environment. Simulated traffic flows into the networked standalone systems. The TAMS system derives key performance parameters such as resource availability and delivers these to the central airport management facility, known as the 'control room'.

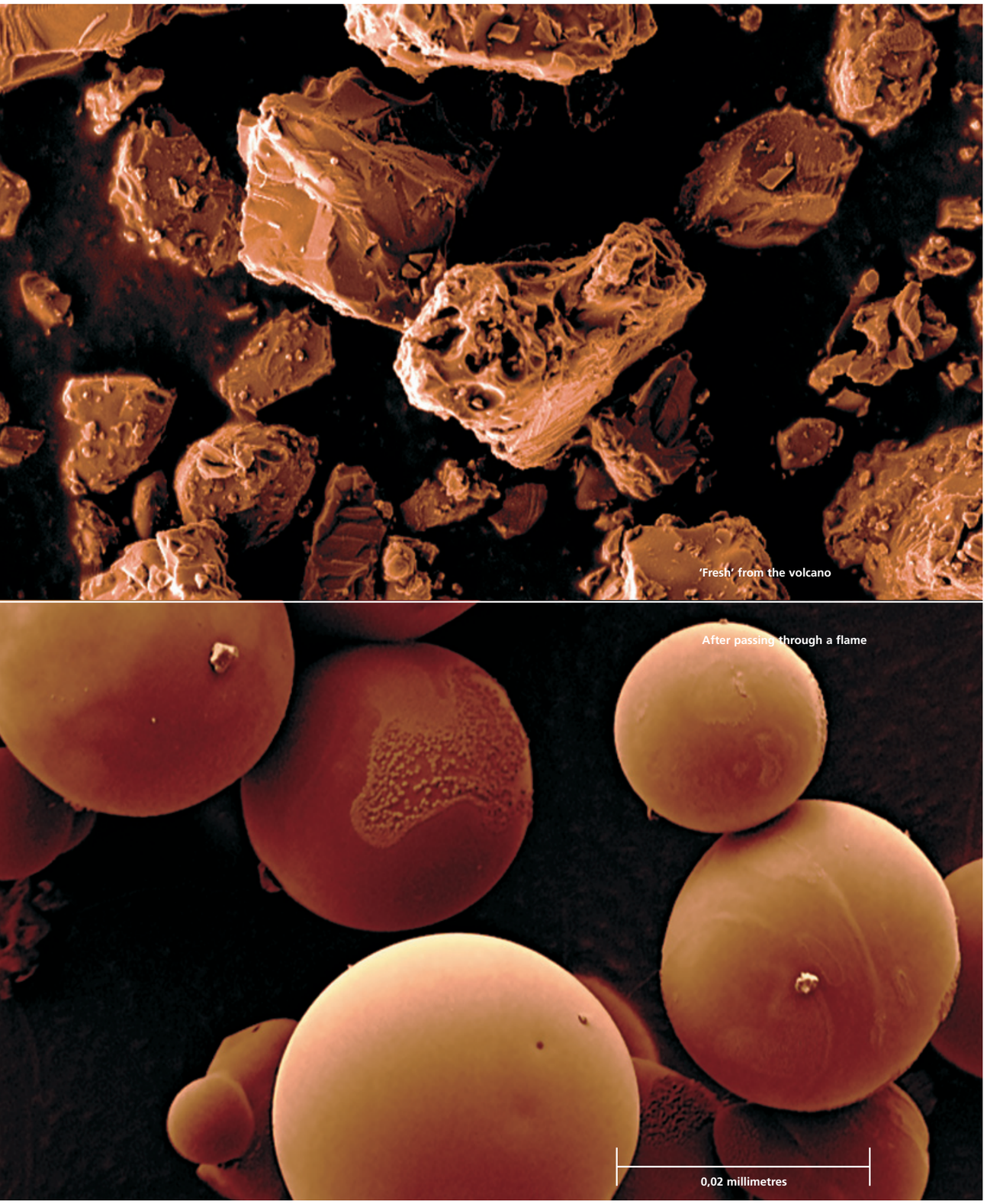
ACROSS THE UNIVERSE
http://static.flabber.net/files/scale-of-the-universe-2.swf
Great fun! From small to tiny – ants, cells, atoms and elementary building blocks. And the other way around – large, larger and far out into the Universe. Click on the objects to learn more about them. 'The Scale of the Universe 2' surprises us more than its predecessor. Here, beautifully achieved images and music make for a fun journey to the edges of the Universe as we know it.

SOLAR ENERGY FOR ALL
www.desertec.org
The DESERTEC Foundation's website is a 'must' for anyone interested in energy and environmental issues. DESERTEC is working on a concept of a worldwide solar power system that will provide safe and environmentally friendly energy for Europe, the Middle East and Northern Africa. DLR is involved in this project. If you would like to become a part of the solution, their website tells you how you can help.

SPACE NEWS ON THE GO
www.space.com
This website offers the latest news about space and space exploration, along with a great deal of background information; a compilation of articles, stunning images and fascinating videos. From cutting-edge research through to trends and ideas for the future of space travel, an excellent source of information, all in all.

THE WORLD AT NIGHT
www.twanight.org
There is one sky, regardless of nations and regions, which attests to the unified nature of Earth as a planet rather than separate human-designated territories. The TWAN initiative has the objective of spreading this message by offering views of the world's most amazing landmarks against nighttime backdrops of stars, planets and more. This collection of jaw dropping images and time-lapse videos manage to bridge art, humanity and science.

PREPARING TO PROTECT OUR PLANET
www.neoshield.net
Collisions with objects are common in the history of Earth and planets in our Solar neighbourhood. Although there have not been major impacts in our recent history, there are many Near Earth Objects that could change this. We must prepare! The NEOShield project has been set up precisely for this reason. The objective is to perform a detailed analysis of the open questions relating to realistic options for preventing the collision of a NEO with Earth. In their recently created website, you can find out about the project, the latest developments, the technology used, and get answers to questions about asteroids, NEOs, collisions and much more. Don't miss out on this great initiative, which will run until 2015.



Splinter-like particles of ash from the volcano Eyjafjallajökull (top left). After passing through a 1700 degree Celsius flame, the particles appear spherical (bottom left).

The ash that shut down Europe

The unusual spectacle of a condensation trail-free sky was seen above large parts of Europe at the end of April 2010. Around 100,000 flights were cancelled following the eruption of the Icelandic volcano Eyjafjallajökull. The fear that aircraft engines would be damaged if they ingested volcanic ash resulted in a ban on flights with far-reaching consequences for airlines, airport operators and passengers. But where exactly did the risk lie? When not one dark grey volcanic ash cloud is in sight, doubts arise. This was reason enough for scientists and engineers at DLR to delve into the issue because danger is not always visible.

When volcanoes meet aircraft engines

By Peter Mechnich

A modern aircraft engine can take in up to 100,000 cubic metres of air per minute. Even when the level of air pollution is apparently low, the engine can ingest large quantities of volcanic ash particles. Air containing ash is compressed and flows into the combustion chamber, where kerosene is burning at temperatures of up to 1700 degrees Celsius. This melts the volcanic ash particles, which consist of silicate-rich minerals, similar to glass. After blowing past the combustion chamber, the stream of hot exhaust gas impinges on the turbine blades, where the volcanic ash particles can be deposited. If these glass-like deposits become too thick, a threat arises – the engine might stall. Although this extreme case is somewhat unlikely, it is important to determine the impact of the ingested and deposited volcanic ash on the lifetime of engines and the materials used within them – because even small effects can have serious consequences in the long term.

From the sky to the laboratory

To determine the effects of volcanic ash in the air, the obvious approach would be to fly an aircraft through the nearest accessible ash cloud, and subsequently examine the engine. But no one is willing to take this risk without good cause. Although complete aircraft engines could be exposed to small quantities of volcanic ash in a targeted manner on the ground, this would be very expensive. Laboratory experiments offer a practical alternative where the effects of volcanic ash can be studied under controlled conditions, to acquire a basic understanding of the processes involved.

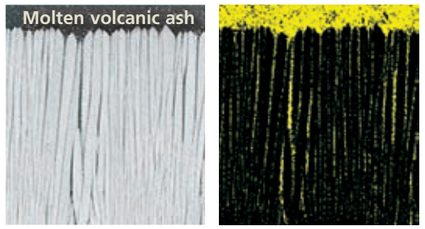
Collecting adequate quantities of volcanic ash for a laboratory experiment was not a problem. Shortly after the eruption of Eyjafjallajökull, a volcanic ash sample was taken at Reykjavik airport by a team from the DLR Institute of Atmospheric Physics as part of DLR's Falcon research aircraft mission, and passed on to the DLR Institute of Materials Research. Under a scanning electron microscope, the volcanic ash particles revealed their sharp-edged, splintered nature. How might such particles behave when passing through the combustion chamber during flight? Observing them directly in the engine is almost impossible, but the volcanic ash particles can be passed through the roughly 1700 degree Celsius flame of a standard gas torch. Under a scanning electron microscope, the resulting particles appear almost spherical and partially fused into larger globules. Although this model cannot be transferred 100 percent to an engine, the brief transit through the combustion chamber is certainly sufficient to change the volcanic ash particles into viscous droplets. These then encounter the turbine blades, where they can quickly accumulate due to their honey-like consistency.

What is happening to the turbine blades?

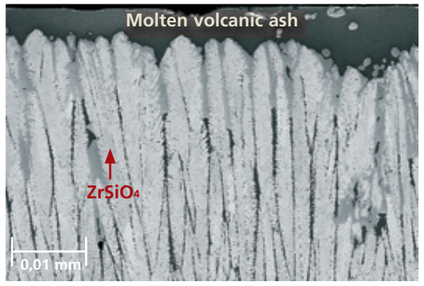
The metal turbine blades in modern aircraft engines are coated with thin, high-performance ceramics to enable them to operate at the highest possible temperatures to enable efficient combustion. If these thermal protection layers, only 0.2

A view of the Eyjafjallajökull ash cloud from the Falcon research aircraft

Reaction of volcanic ash in conventional thermal protection layer (zirconium)

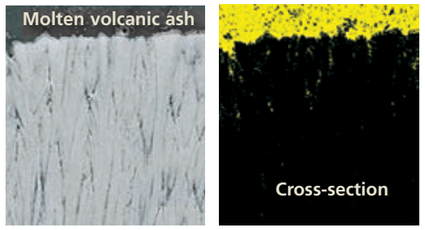


Penetration of molten volcanic ash (yellow) into the thermal protection layer

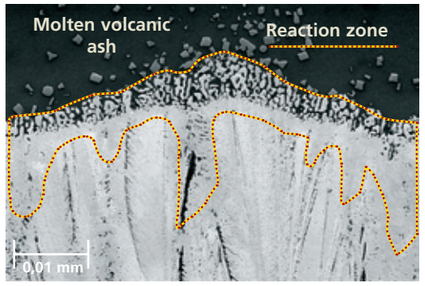


Zirconium silicate $ZrSiO_4$ forms in the gaps of the columnar structure

Reaction of volcanic ash with a new thermal protection layer (gadolinium zirconate)



The molten volcanic ash (yellow) penetrates less in the $Gd_2Zr_2O_7$ thermal protection layer



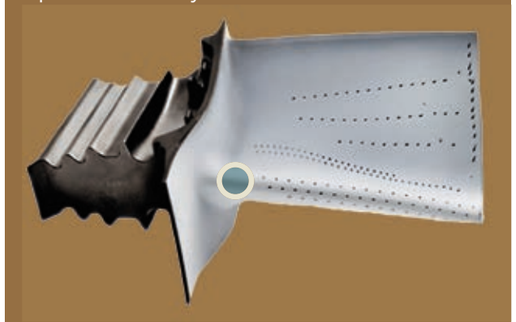
A reaction is produced in the contact zone with gadolinium apatite $Gd_8Ca_2Si_6O_{26}$ (below)

millimetres in thickness, are badly damaged, the turbine blades will need early replacement. Thermal protection layers made of zirconium oxide are in general use today. These are produced using a special coating process – electron beam physical vapour deposition. Yttrium oxide is typically applied as part of such thermal protection layers, for which reason the material is known as yttrium oxide stabilised zirconium oxide, or YSZ. One special property of these coatings becomes apparent under the microscope; unlike thick enamel-like coatings, they are columnar in nature. This is very advantageous because small elastic deformations of the metal turbine blades do not necessarily cause the hard, non-elastic ceramic layer to crack or spall. Even rapid temperature changes, known as thermal shock, can be withstood without damage. Such ceramic thermal protection layers can be custom made in the coating facilities at the DLR Institute of Materials Research.

In the laboratory experiment, DLR scientists simulated the behaviour of the thermal protection layers with volcanic ash deposits and then observed the results using a scanning electron microscope. The wetting of the YSZ thermal protection layers starts at around 1000 degrees Celsius, a temperature easily reached in an aircraft engine operating at moderate thrust. If the temperature is increased to 1100 degrees, typical of cruising speed, the volcanic ash can melt to the extent that it forms a continuous layer, like an enamel, penetrating between the columns of the thermal protection layer. By 1200 degrees, which is reached during periods of high engine output – such as when climbing – the molten volcanic ash penetrates deep into the thermal protection layer. At the same time, chemical decomposition of the YSZ occurs, first into yttrium oxide-free, unstable zirconium dioxide and then into a zirconium silicate.

What does that mean for the lifetime of a real thermal protection layer on a turbine blade? Large parts of the previously columnar, flexible structure are now completely solidified or fused. If the turbine blades are mechanically deformed or there is a sharp change in temperature, there is an increased risk of the thermal protection layer cracking or spalling.

Turbine blade with a ceramic thermal protection layer



Metallic turbine blade with a ceramic thermal protection layer. The microscope reveals the columnar structure during evaporation.

Unfortunately, preventing the deposition of volcanic ash altogether is currently not an option. But is it at least possible to slow down the penetration of molten volcanic ash? This might be achievable using a particular type of seal, for example by fusing the surface with a powerful laser. But, on closer technical and economical consideration, this idea has proven impractical. Most recently, DLR scientists have been investigating new ceramic materials for thermal protection layers. Known as rare earth zirconates, these consist of zirconium dioxide and rare earth oxides. These elements include lanthanum and chemically related lanthanides, such as neodymium, gadolinium or lutetium. In fact, rare earth zirconates are much more chemically unstable in the presence of molten volcanic ash than state-of-the-art YSZ. But, paradoxically, this instability in the material is the key to increasing the resistance of the thermal protection layer; the rapid chemical reaction between molten volcanic ash and the rare earth oxides produces new compounds, called rare earth apatites. These immediately accumulate at the point of contact, slowing down further penetration of the molten volcanic ash. This effect is significant with the use of gadolinium zirconate, which reacts quickly with volcanic ash at between 1000 and 1200 degrees Celsius, turning into gadolinium apatite. However, whether this mechanism can provide long-term protection against spallation is still an open question; after all, turbine blades are intended to operate for thousands of hours under strongly fluctuating loads – something that cannot be simulated realistically in the laboratory.

Many unanswered questions remain

In the absence of a threshold value for air pollution by volcanic ash, a zero tolerance approach with a ban on flights was initially applied during the Eyjafjallajökull eruption. Using operational experience gained from engines contaminated with desert dust, a general threshold value for volcanic ash of two milligrams per cubic metre of air was established. Yet the question remains as to whether a reasonable threshold value can be determined for air polluted with volcanic ash that is uniform for all aircraft. This is because there are numerous types of engine, and more will be added in the future, including ones made using new materials. Also, not all volcanoes are the same; the chemical composition of their ash varies greatly, and is of significance for both melting and for reaction with thermal protection layers. And to further complicate the issue, the absolute concentration of volcanic ash particles is less critical than the amount active in the engine at any given time. At high thrust, for example during ascent, a brief passage through a volcanic ash cloud could cause significantly more contamination than a much longer transit at low thrust, for example when cruising.

This initially unmanageable complexity will be investigated using interdisciplinary research involving engine technology, materials science and atmospheric research/geoscience – all disciplines that fall within DLR's areas of research. •

About the author:
Peter Mechnich is a mineralogist and is part of the scientific team at the DLR Institute of Materials Research working on inorganic, non-metallic, high temperature materials. The focus of his work includes ceramic composites, ceramic coating materials and high temperature corrosion research.

More information:
www.DLR.de/WF/en
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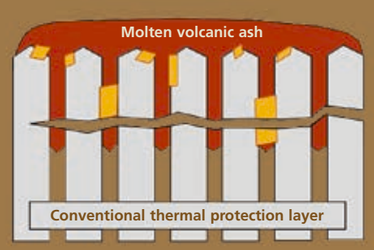
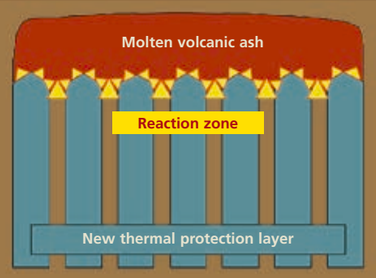
www.DLR.de/AT/en
Falcon research aircraft:
http://s.DLR.de/u7sn
Volcanic Ash Advisory Centres:
www.metoffice.gov.uk/aviation/vaac/
National Oceanic and Atmospheric Administration:
www.ngdc.noaa.gov/hazard/volcano.shtml

A little chemistry for thermal protection layers

Zirconium dioxide	ZrO_2	Gadolinium zirconate	$Gd_2Zr_2O_7$
Yttrium oxide	Y_2O_3	Zirconium silicate	$ZrSiO_4$
Gadolinium oxide	Gd_2O_3	Gadolinium apatite	$Gd_8Ca_2Si_6O_{26}$



Molten volcanic ash penetrates, reacts and leads to spalling of the thermal protection layer



The penetration of molten volcanic ash is slowed down by a reaction zone (below)

Almost real – in the ATS360 control tower, pilots simulate aircraft take-offs and landings under realistic conditions.

An office with a view

New approach procedures are tested in the new TowerLab

Thick clouds mar the visibility high above Frankfurt airport as the tower controllers make contact with an inbound Airbus A320. Coming in from the north, it traces a broad arc across the sky and then banks in the direction of the northern runway. The controllers maintain visual and radio contact as the aircraft performs a very steep but smooth descent, proceeding to clear the pilot for the gentle, precise landing that follows. It brakes and leaves the runway. Following the controllers' guidance it taxis to its parking position – and then abruptly disappears.

Testing new ideas for tomorrow's air traffic management

By Sven Kaltenhäuser and Michael Drews

The simulation is over: the exercise has been a complete success. The controllers are actually researchers at the DLR Institute of Flight Guidance and, while they appear to be working in a 70-metre-high-tower whose glass façade provides a 360 degree view, they are in fact in a windowless room on the ground floor. The ATS360 simulator at DLR site in Braunschweig is something special. Its rounded walls are fitted with 13 high-definition projectors arranged in circular fashion. These project a smooth video image that completely fills the field of view of the room's occupants, realistically reproducing the controller's-eye-view at Frankfurt airport.

In the centre of the room, DLR researchers occupy three air traffic controller positions. They are part of a team conducting feasibility tests on a new approach procedure employing particularly steep angles of descent. The researchers take on the role of tower controllers throughout the test run and ensure a safe landing using direct visual contact with the aircraft. At the same time, the data gathered in the process helps reveal the relative strengths and weaknesses of this novel approach. "We can actually simulate any airport here, allowing for great flexibility," says Sebastian Schier, responsible for the facility. "Even future airports pose no problem." Upon completion of the test run, the simulation is reset and another test begins. The aircraft reappears as a small point in the sky and sets a fresh course for Frankfurt.

A sky filled with aircraft

Meanwhile a second team, made up of researchers and 'real' air traffic controllers, monitor radar screens on which the A320 appears as a lettered point. They are sitting in the Air Traffic Management and Operations Simulator, ATMOS, a long room with high ceilings down in the basement of DLR Braunschweig. ATMOS replicates a standard air traffic control centre: in such a site, controllers monitor flight arrivals and departure routes within specific airspace sectors. Unlike a control tower, only radar screens are relied on; there is no direct visual contact. ATMOS simulates a control centre with multiple controller working positions, providing all the virtual air traffic simultaneously for a realistic test. "ATMOS is a very powerful air traffic simulator," says Tim Stelkens-Kobsch, overseeing the site. "Its infrastructure was updated this year, enabling its use for even better and more realistic experiments."

The ATMOS researchers resume radio contact with the pilot of the A320 in the just-started second simulation run. As they transmit the final instructions for the descent that is about to occur, they can view the aircraft slowly approaching the airport on their radar screens. Other aircraft can also be seen in the airspace over Frankfurt, with each screen covering a specific sector of sky. The controllers must now arrange a smooth flow of traffic while ensuring the approaching aircraft do not come too close to one another. All these virtual aircraft are controlled not by a computer, but by what are referred to as 'pseudo-pilots' in the next room over. Here, a pseudo-pilot guides several aircraft through the airspace simultaneously using a keyboard and mouse. As they do, their movements are guided by instructions received from the controllers by radio. Accordingly, the communications between the control centre and the aircraft are reproduced realistically. But while the pseudo-pilots simulate the background air traffic above Frankfurt, a 'real' pilot controls the central aircraft involved in the landing test, the A320.

Validation: what does this mean? Testing of a new system or process under development, with regard to its suitability for practical use. This involves examining both whether the system functions technically and whether it can deliver the expected improvements in practice.

Hands on the controls of an Airbus A320

Authentically simulating the landing of the A320 demands an extremely realistic working environment, with all the controls, instruments and displays needed for the aircraft's operation. Such an environment is to be found at the other end of the DLR building in the Generic Experimental Cockpit, GECO, where a third research team is participating in the simulation. GECO is an egg-shaped construction, several metres across. A curtain at the simulator's entrance conceals an accurately equipped representation of the cockpit, including all instruments and controls, as well as seats for the pilot and co-pilot. The facility's highlight is a special mirror system that portrays the outside view in such a realistic fashion that inexperienced occupants might well feel somewhat queasy during extreme flight manoeuvres.

The pilot team prepares for another steep approach run. Once the simulation has been restarted and the participating teams have signalled the other simulators, the test begins. The pilots in the cockpit find themselves back in Frankfurt airspace, the city already visible on the horizon. At first the autopilot navigates the A320 along the approach path. Then, after receiving permission to make the steep approach under study, the necessary cockpit settings are made. From here on, the aircraft is flown manually, following the instructions from the controller needed to maintain the descent angle. Speed, altitude, engine thrust and position relative to the calculated glide slope – the imaginary line taking the aircraft down onto the runway – are continuously checked. The pilot then raises the nose of the aircraft shortly before landing and gently sets it down on the runway. Each new landing yields fresh data for analysing the approach path under study. "With this simulator and the realistic behaviour of the participants, we can reproduce a real flight experience very closely," says Bernd Korn, Head of the Pilot Assistance Department.

Upon completion of the various test runs, the results from each simulation facility are compiled and analysed over the following weeks. They provide the researchers with new information regarding the feasibility of this new approach procedure, from the point of view of both pilots and controllers. "We are expecting a great deal from new types of approach procedures," adds Korn. "They will make an important contribution to reducing noise over residential areas."

The Institute's simulations represent a significant step towards testing the new descent procedure. If such a concept proves successful at this stage, the next step will be to carry out multiple real-life research flights at the neighbouring Braunschweig-Wolfsburg airport. This will involve the use of the largest aircraft in the DLR research fleet – the Airbus A320 Advanced Technology Research Aircraft, ATRA. Such flights bring testing even closer to reality, but are also considerably more complicated and expensive. In recent years, DLR has equipped the research airport at Braunschweig with advanced sensor systems for precise position determination and approach support. Hence, using DLR research aircraft, the next steps for implementing new procedures and technologies for everyday use can be taken.

Air Traffic Validation Centre in Braunschweig

Collectively, the simulators, sensor systems and flight test equipment form the new Air Traffic Validation Centre at the DLR Institute of Flight Guidance, which was inaugurated on 27 June 2012, in the presence of a large audience of international guests. It offers researchers all the tools required for testing and analysing new ideas, concepts and technologies for all areas of air traffic management. The validation centre allows ongoing review across every stage of development, from initial ideas to prototype testing and investigating their use in realistic conditions. With its versatile usage options and large bandwidth, the centre offers one of the best testbeds for air traffic research in Europe.

In the past four years the centre, with its simulators as well as other facilities, has been extensively rebuilt and expanded. Researchers can use it to realistically simulate complex air traffic systems involving many participants to fully and safely investigate new air traffic management solutions. The new methods trialled here demonstrate the extent to which they can meet the expectations placed upon them, without compromising actual air traffic. ●

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Sven Kaltenhäuser is head of the Air Traffic Management Simulation Department at the DLR Institute of Flight Guidance. He and his colleagues are responsible for the Institute's experimental infrastructure. Together with other departments, they are involved in the planning, execution and analysis of complex air traffic management experiments.
Michael Drews is responsible for Communications and Public Relations at the Institute of Flight Guidance.

More information:
www.DLR.de/fl/en/

Left: a DLR researcher in the GECO cockpit during testing of a new approach procedure

To the right, research in realistic conditions – a comparison between the real control tower (left) and the ATS360 simulation tower (right)

Image: Solar Impulse | Jean Revillard

Flying with the Sun

Air travel has become an integral part of everyday life. It is necessary, yet, as with much of the ever-increasing energy consumption of the growing world population, it is based on the use of fossil fuels. Not only are fossil fuel resources limited, but they also affect the environment and the climate. Why not choose solar energy? While solar receivers can be seen today on many houses as a source of thermal or electric energy, their use for mobile applications is more difficult. But, could a purely solar-powered aircraft be realised?

DLR supports record flight with solar-powered aircraft

By Marc Böswald and Martin Hepperle

Solar Impulse did it! Since 2003, a team of creative mechanical and electrical engineers, physicists, IT experts, aerodynamicists and composite material specialists have applied their skills to designing and building this innovative aircraft, capable of coming close to perpetual flight. This core team was supported by external experts, including engineers and researchers from the DLR Institute of Aerodynamics and Flow Technology and the DLR Institute of Aeroelasticity.

SB-HIA technical datasheet

Wingspan	**63.40 metres**
Length	**21.85 metres**
Height	**6.40 metres**
Power source	**4 x 10 HP electric engines**
Solar cells	**11,628 (10,748 on the wing, 880 on the horizontal stabiliser)**
Weight	**1600 kilograms**
Average flying speed	**70 km/h**
Take-off speed	**44 km/h**
Stalling speed	**35 km/h**
Cruising altitude	**8500 metres max.**

The Solar Impulse aircraft 'Sisi'

A revolutionary project

The available power per square metre of solar cell area is low compared to the power needed to move a vehicle on the ground or in the air. In particular, the power requirements of an aircraft combined with the relatively low efficiency of the photoelectric conversion process require large cell areas, and therefore large wings. In addition, if a solar-powered aircraft is to fly uninterrupted day and night, its design becomes even more challenging. During the daytime, the aircraft must harvest enough power to fly and, at the same time, to store energy for the night.

A Swiss team led by Bertrand Piccard and André Borschberg took up this challenge, with two main objectives in mind – to show how sustainable development and alternative sources of energy can be used in our everyday lives, reducing our dependency on fossil energies, and to fly around the world, leg by leg, using the mission aircraft HB-SIB, which is currently under construction. On 8 July 2010, and for the first time in the history of manned flight, the HB-SIA demonstrator aircraft succeeded in flying throughout night and day, powered for 26 hours by nothing but solar energy. This flight brought the initial phase of the Solar Impulse adventure to a successful conclusion, demonstrating the enormous potential of new technologies for saving energy and using renewable energy. Since then, the team has been performing additional flights, in which the distances travelled have been continuously extended to places like Brussels, Paris, Madrid and, recently, Morocco.

Design challenges

Aircraft structures may be affected by deformations, vibrations and even flutter. The HB-SIA prototype, with a 63-metre wingspan and weighing as much an average car, presented constructional and aerodynamic challenges never before

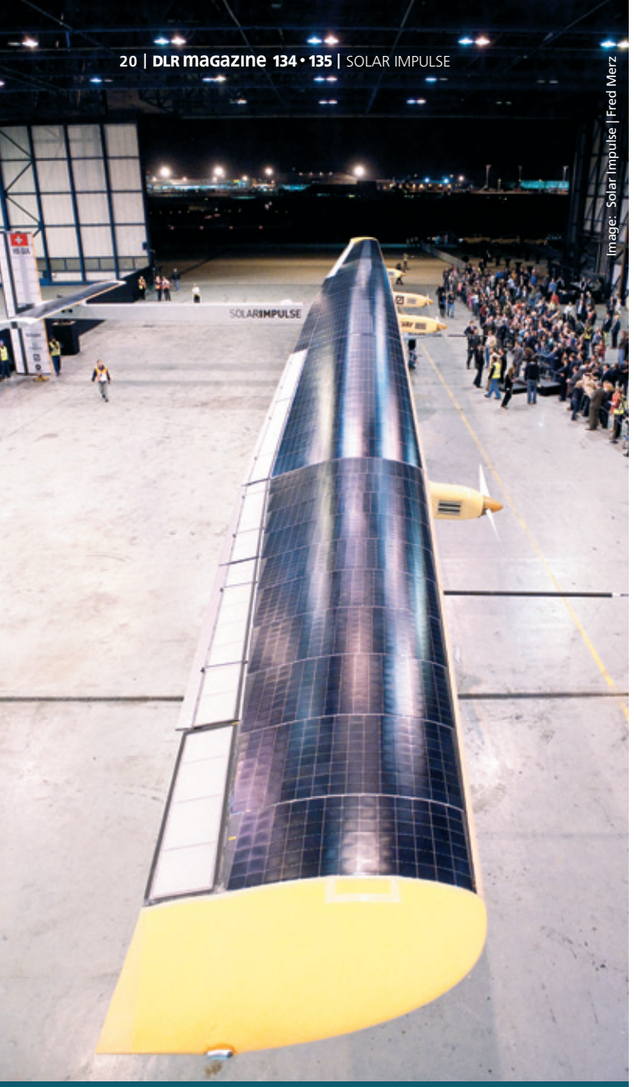


Image: Solar Impulse | Fred Merz

Solar cells on the wings of Solar Impulse

Installation of a vibration exciter (shaker)

encountered. The carbon-fibre reinforced structure, propulsion chain, flight envelope and instrumentation – everything had to be rethought and designed to save energy, resist high altitude factors hostile to both materials and pilot, and to combine the constraints on weight with the need for strength. All of these features lifted the challenges to a new level.

The success of this project is strongly linked to finding optimum solutions in all disciplines of aircraft design, be it aerodynamics, structures or propulsion, often working close to the limitations imposed by current technology. But the key in such developments is to find the best compromise, balancing individual efficiencies to achieve the most favourable overall solution. In doing this, the normal airworthiness and safety standards have to be complied with. Besides numerical analysis during the design, the ultimate validations of the structural design are loading and vibration tests. Over the last few years, DLR has supported this with specific activities.

Assessing performance

The design of SB-HIA is driven strongly by its aerodynamic performance. Such an energy-efficient high performance aircraft must have long and slender wings to minimise drag and maximise lift. Also important are efficient propellers and the optimum integration of the propulsion system into the overall design, as well as the layout and integration of the tailplanes.

The Institute of Aerodynamics and Flow Technology used its Computational Fluid Dynamics (CFD) simulation code, TAU, to assist in the design of the flight controls as well as to assess the aerodynamic performance. These computer simulations allow the prediction of forces and moments by solving the nonlinear Navier-Stokes equations of fluid flow, and make use of the largest German computer cluster dedicated solely to aerospace applications. The Center for Computer Applications in AeroSpace Science and Engineering, $C^2A^2S^2E$, in Braunschweig consists of 8000 processor cores and makes the efficient analysis of complex flow fields possible.

Before conducting such analyses, a detailed computer model of the aircraft shape has to be created. Next, the air around the aircraft is split into small-volume cells, forming a very fine three-dimensional mesh. Finally, the flow equations are solved in each of the more than 20 million cells to determine the local flow velocity, the pressure as well as the lift and drag forces acting on the complete aircraft. The results allow the designers to study and understand the complete flow field around the aircraft and to identify local problems such as flow separation.

The large span of the slender wings proved to be a challenging test case for the application of the TAU code, which is normally used to design and analyse large passenger aircraft and space vehicles. In 2009, first analyses for the demonstrator aircraft were performed to validate the aerodynamic database and to establish the limits of acceptable flight conditions. The shape of the engine nacelles and their integration was optimised using the CFD code. The knowledge gained was applied again in 2011 to assess different fuselage shapes and tailplane configurations for the mission aircraft, HB-SIB.

One of the essential features of aircraft structures is their lightweight design. As with other lightweight structures, aircraft are prone to vibration. Vibration of an aircraft may occur as a response to a gust, turbulence, or a flight manoeuvre – all sources of excitation for vibration. Once excited, the vibrations will occur at some particular frequency and with a characteristic deformation shape; they will decay and finally disappear after some seconds. For this reason, an analysis of vibrations and deformations of elastic structures that can interact with a surrounding aerodynamic flow field is required.

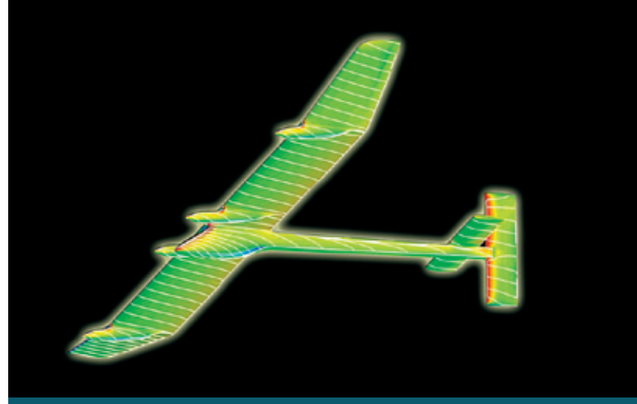
To analyse the vibrations of structures, modal parameters are required; they comprise eigenfrequencies, mode shapes, damping ratios – a measure for the duration of vibration decay and an amplitude limiting quantity – and generalised mass. Most of these parameters can be determined from numerical simulation models, but the damping ratio can only be determined experimentally with a GVT. This is conducted very late in the development of an aircraft, when the prototype is fully assembled and ready for the first flight.

In contrast to aircraft vibrations on ground, the surrounding flow field in flight may adversely affect the vibration characteristics. More specifically, eigenfrequencies and damping ratios may change with flight speed or with flight altitude. The damping ratio of some mode shapes can be reduced if the flight speed is increased, so that vibration amplitudes may become larger or occur for longer time. A critical flight speed exists where the damping ratio of a particular mode shape is reduced to zero – if the flight speed is increased beyond this limit, the damping ratio could even become negative. In this case, a vibration, once excited, will not be damped, but rather amplified and the vibration will increase. This aeroelastic phenomenon is known as ‘flutter’. Flutter analysis is required by the certification authorities in order to obtain permission to fly. It is crucial to demonstrate that this phenomenon will not occur at any combination of flight speed and flight altitude (and also for different payload scenarios) included in the flight envelope of the aircraft prior to its first flight.

Ground vibration testing

In 2009, the DLR Institute of Aeroelasticity in Göttingen conducted two GVT campaigns to ensure the aeroelastic and aeroservoelastic stability of the Solar Impulse prototype. During a GVT, the aircraft is vibrated in a controlled manner at different positions, such as engine nacelles, wings, and fuselage. To achieve this, electrodynamic vibration exciters, referred to as shakers, are connected to the structure. The excitation forces introduced into the structure are controlled using software operated by the test team. Because Solar Impulse is so different from typical transport aircraft of a similar size, two GVT campaigns were performed. The first test, lasting one week, took place in December 2008 on the primary structure only (just the load carrying structure). Eighty accelerometers were installed to measure the vibrations of the wing box, the engine nacelles, the fuselage and the box beams of the horizontal and vertical tail surfaces. The objective of this test was to provide experimental data (modal parameters) for the calibration of the numerical simulation model of the primary structure. A second, two-week, GVT campaign was performed in January 2010 on the fully assembled prototype, to demonstrate compliance with the applicable certification requirements and obtain a permit to fly. For this test, 160 accelerometers were installed to analyse the complicated dynamic vibrations of the aircraft structure and its control systems.

With the modal parameters obtained in the GVT, it is possible to analyse the vibration response of the aircraft in other excitation scenarios. In the case of the Solar Impulse project, the modal parameters measured on ground were compared with corresponding results from a numerical simulation. When there were nonconformities between experimental data and simulation results, the numerical model could be adjusted in such a way that it was able to reproduce the experimental modal parameters obtained in the GVT, a process known as ‘model updating’. After model updating, all subsequent numerical simulations can be performed with improved confidence in the accuracy of the results. Using the modal parameters obtained, a flutter analysis was subsequently performed for Solar Impulse by Swiss engineering consultants AeroFEM GmbH.



Pressure distribution with flow lines across the surface of the Solar Impulse prototype

A real challenge

The extreme lightweight design of Solar Impulse introduced some challenges into the GVT campaign. One of the major difficulties was the mass of the surrounding air. When a structure is vibrating, it induces vibrations in the surrounding air. In the case of Solar Impulse, the mass of the surrounding air that is vibrating is not small compared to the mass of the structure; this can lead to incorrect experimental modal parameters. Since it was obviously not possible to evacuate the air from the hangar, it was decided to determine the influence of the surrounding air on the modal parameters using numerical simulation.

Another difficulty was the vibration excitation. It was not possible to determine which points would be best suited to excite the aircraft in the GVT by pre-test analysis, because only a few points on the structure were designed to accept concentrated loads. It was therefore necessary to identify all modal parameters with just a few excitation points. In addition, the force levels used were very small. Since the structure is very light, very small forces can generate significant acceleration responses. This was a challenge both for performing the excitation and measuring the excitation forces.

All in all, one year of studies, four years of design work, two years of construction and one year of testing were needed before the HB-SIA prototype could validate the target concept by achieving the first-ever solar powered night flight. The lessons learned from the prototype are now being incorporated into the development of the second aircraft, HB-SIB, which will attempt to fly around the world as soon as in 2014. DLR will follow the project’s progress and offer support where its expertise may be required. Sisi, as HB-SIA is known, has been and will continue to be the protagonist of many firsts in the history of flight, powered only by the Sun. •

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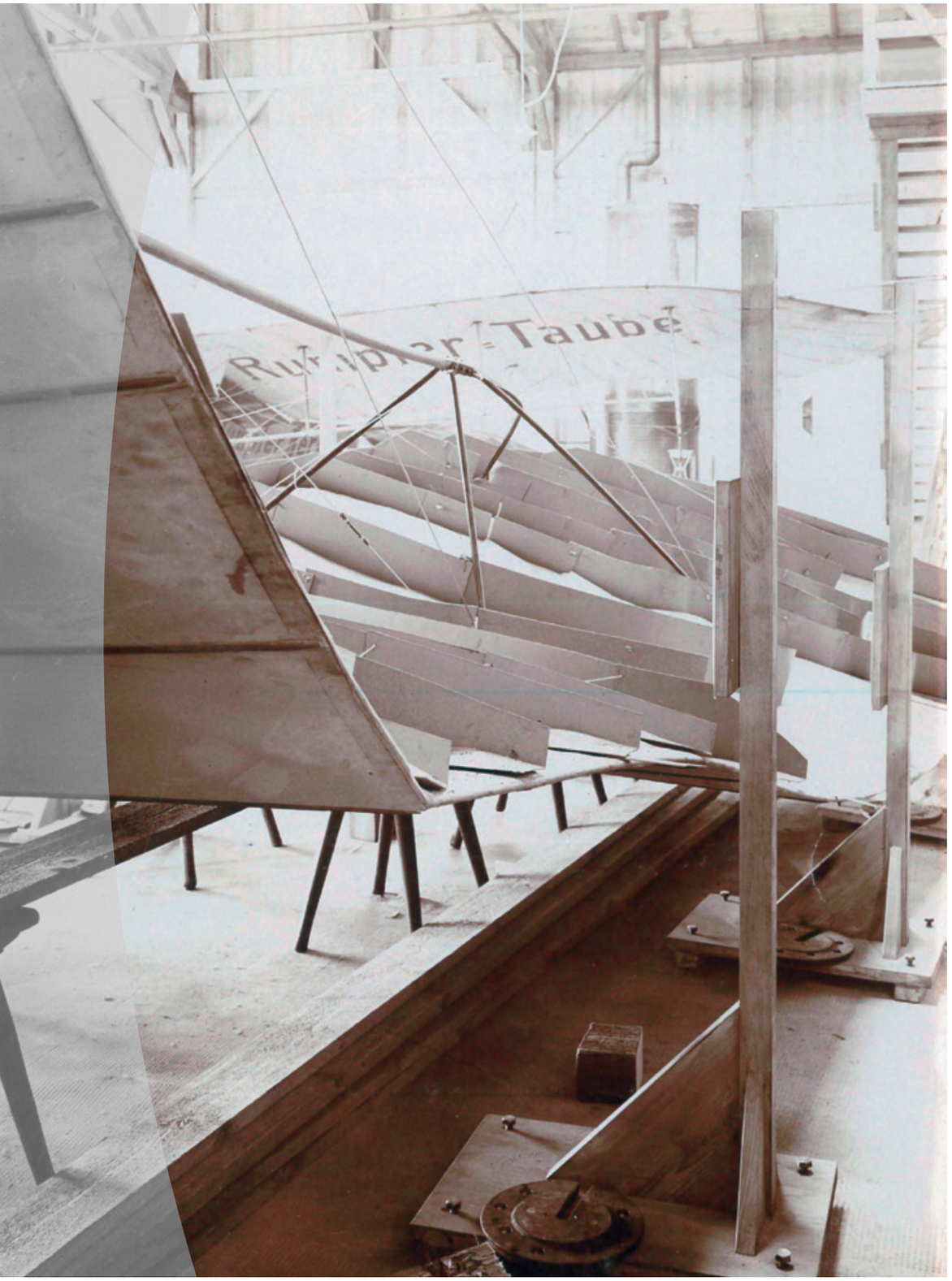
More information:
www.solarimpulse.com
http://s.DLR.de/4p3j



Wings for an Albatros Taube, made of wood and fabric, undergoing a stress test some time between 1912 and 1914 at the DVL in Berlin-Adlershof.

… such stuff as dreams are made of

Selecting the right materials is of considerable importance in aviation, as Icarus found out to his cost. According to legend, his father, Daedalus, was clearly aware that there were load limits for the materials he was using – wax and feathers – but he was unable to define the thresholds accurately.

Aviation materials through time – a journey through a century of materials research

By Michel Winand

The classically educated founders of the German Aviation Research Centre (Deutsche Versuchsanstalt für Luftfahrt; DVL) might not have had this old story in mind when they started approaching the subject of aviation more scientifically in 1912, but they certainly understood the significance of materials research in aviation. In their very first year there was already a 'Department for Materials Research for Airship and Aeroplane Construction'. This department marked the beginning of institutional materials research in Germany.

'Material' could be taken quite literally in the early days of aviation. Impregnated fabric made up both the hull of balloons and airships, as well as the skins of aircraft. Light and inexpensive, this fabric was perfectly adequate for withstanding the flight loads of that time. Textiles were also used to reinforce the basic structure. The wooden structural components of fuselages and wings were partly built up of multiple layers that were glued together. Textiles between the layers of wood provided greater strength; an effective principle already understood in antiquity.

The Geest Möwe, or Seagull, had a wooden fuselage and wing structure covered with fabric. It is seen here at the DVL test site in Berlin-Adlershof.

Different types of wood were used for the wooden struts; balsa wood where the material needed to be light and bore little load; willow where flexibility was needed; and, finally, ash where stiffness and a certain amount of elasticity was required. The materials were used according to their known properties but, as these were natural, organic materials, there were large differences in composition and hence, durability.

Higher and faster means tougher and more flexible

The swift advances in aircraft development at the start of the twentieth century quickly demonstrated the limitations of the materials in former use. In the first 15 years, engine performance improved rapidly. With an increase in the speed and regular use of aircraft, issues such as fatigue and the need for damage detection rose to prominence.

Steel tube construction promised better quality in terms of rigidity, service life and higher breaking strain. But the problem was its weight; impairing the flight characteristics of the still relatively low-powered aircraft.

The solution: a material with similar properties to those of steel, but lighter. In 1827, chemist Friedrich Wöhler succeeded in extracting a metal with similar properties to iron but three times lighter. However, the material, named 'aluminium', was softer than iron and very expensive. At the turn of the last century, the price of aluminium dropped significantly, and the material properties were improved through the use of special, heat-treatable aluminium alloys. Carl Berg, the owner of a Westphalian copper smelter, ultimately deserves thanks for making aluminium the material predominantly used in aviation today. As an entrepreneur, he made extensive use of aluminium alloys in airship construction and, in so doing, inspired its use in aircraft construction as well.

The use of lighter yet more stable materials, in turn, enabled changes in aircraft design. Hugo Junkers was not the first aircraft manufacturer to use aluminium sheets instead of

Proud of the first high performance microscope: DLR scientists Roland Borath (left) and Horst Kohler, during the end of the sixties.

Photographs from the seventies: To the left, researcher Meyer in materials testing. On the right image, Adolf Donner, Günter Staniek and Helmut Mangers.

the canvas covering more typically employed. His developments, however, essentially pointed the way forward to techniques still in use today. Milestones in the use of new materials were the Reissner Ente (Duck) tested by Hans Jacob Reissner in 1912, which Junkers worked on, as well as the 1915 Dornier Rs. II flying boat and Junkers J1. The profiled aluminium sheets that Junkers developed afforded stability and character to the structures of these legendary aircraft, from the J3 (1918) and the F13, the first all-metal civilian aircraft (1919), to the Ju 52 (1932), which is still flying today.

Materials research between the wars

The years after the First World War were marked by inflation and restrictions for aviation researchers and manufacturers. Under the Treaty of Versailles, aviation research and aircraft manufacturing was forbidden in Germany. The bans were relaxed in 1922, and civilian research was back to full speed from 1925.

A new era began for the DVL in Berlin-Adlershof. Civilian air traffic grew constantly in significance from the mid-1920s, a fact reflected in the materials research sector. From the spring of 1926, the DVL materials department was responsible for the 'testing and investigation of construction and operational materials of every kind for use in aviation'. Besides investigating materials, the focus of activity was now clearly testing materials for fatigue as well. The tragic crash of a Lufthansa aircraft in 1927 highlighted the importance of this work and encouraged the acquisition of new equipment for mechanical testing of materials.

The reorganisation of the DVL in 1936 led to the foundation of the Institute of Materials Research from the materials department. The focus of the research was clearly on metallic materials, specifically light metals, ferrous alloys and heavy metal alloys as used in friction bearings, for example. Nevertheless, research on non-metallic materials still continued, including plastics and bonding agents, as well as wood and fabrics. Additional research groups were devoted to surface protection and to mechanical testing of materials.

New beginning and new materials

The Second World War followed soon after, leading to the end of the newly established facility after an initial increase in the research budget caused by the armaments programmes. There was no Institute of Materials Research again until 1961 – 16 years after the end of the war. The new beginnings were modest, comprising six staff members working in a rented building in Aachen until a new institute building was completed in Cologne in 1963. The move to Cologne also marked the inclusion of a new subject area in the Institute's research portfolio – spaceflight. The scientists saw this as a major area of application for glass-fibre reinforced composites.

Glass-fibre reinforced composites had been in use since the 1940s, as they were tough and light, like laminated wood, yet did not rot when damp. From 1945 onwards, these materials were initially only used in gliders, due to – among other things – the constraints imposed by the Allies, under which German aviation activities were restricted in the first decade after the Second World War. In 1957, 'Phoenix' – the first glider with a structure made entirely of glass-fibre reinforced composites – took to the air for its maiden flight.

In subsequent years, carbon-fibre reinforced composites were used more and more instead of those employing glass fibres. Its material properties met the requirements of the aviation industry even better, with low weight and high strength.

The dominant materials in aircraft construction at the moment are still aluminium alloys, the material properties and manufacturing methods of which have become increasingly sophisticated throughout the last 100 years. However, in the period from 1970 to 2005, the proportion of carbon-fibre reinforced composites incorporated in aircraft constantly increased from under 10 percent to around 20 percent. Since 2005, the proportion used in the construction of new aircraft models has risen dramatically to around 50 percent. Of key significance in this development are aircraft such as the Airbus A380 (over 20 percent), the Airbus A400M (around 30 percent) and finally the Boeing 787 Dreamliner, the structure and wings of which are made of 50 percent carbon-fibre reinforced composites. Only time will tell whether this strong upward trend will continue or whether there will be a balanced coexistence between the two materials. ●

More information:
www.DLR.de/WF/en
www.DLR.de/FA/en

Stefan Reh knows there are many paths to efficient and environmentally friendly flight

Revolution in lightness

Discussion of current developments in aircraft construction with Stefan Reh, Deputy Director of the DLR Institute of Materials Research.

Professor Reh, developments in aircraft construction have seemingly become smaller in scale since the mid-twentieth century. Is that how you see it too?

With any new technology, developments at the start are very big; there is still a lot to discover and improve. Later on, the steps appear to be smaller, because aircraft today are so complex that developments take place 'under the hood', so to speak – so for outsiders they hardly seem noticeable. But significant evolutions – even revolutions – are taking place. One example is the use of new materials such as carbon-fibre reinforced composites. These materials have been used for individual components in aircraft for some time now, but we are moving on, for example manufacturing entire aircraft fuselages out of carbon-fibre reinforced composites. For a long time, the proportion of carbon-fibre reinforced composites used has been slowly but steadily increasing. However, in recent years the proportion of this material being used has increased dramatically. The revolution is not simply the fact that aluminium was partly replaced by carbon fibre, but also the potential weight saving by so doing.

Could the use of carbon-fibre reinforced composites as an aviation material be seen as something of a milestone?

The costs are also important; in this sense, aluminium is once again ahead. Generally, when considering whether to use aluminium or composites, it comes down to which material is best suited for use in a particular place. So it is a sort of coexistence. Both materials have different properties that we understand very well nowadays through materials research, so we can select accordingly for a specific application. A precise understanding of the material properties is also important for high-temperature applications. Besides special alloys that are lighter and more robust, we are also researching coating processes that can extend the service life of components such as engine turbine blades.

It is a principle we know from garden fencing: a non-galvanised fence rusts faster than a galvanised one…

Exactly. Corrosion and oxidation protection are just two aspects. Materials in the engine construction must also be protected against the effects of thermal stress. Our Institute has been active in the area of thermal insulation layers since the late 1970s. At that time, we worked with a company called VON ARDENNE to develop one of the first coating facilities capable of applying thermal insulation layers to turbine blades. In this process, ceramic layers are evaporated onto the material. Combustion chambers are coated as well, increasing the service life, on the one hand, and increasing the efficiency of the engines on the other. This also reduces fuel consumption and, with it, operating costs and pollutant emissions.

What role do pollutant emissions and environmental protection play in your research?

Pollutant emissions and meeting the ACARE (Advisory Council for Aviation Research and Innovation in Europe) goals – which means developing more economical, quieter and cleaner aircraft – are priorities for our research. To achieve these goals, we cover a broad base in terms of content and work on both the ongoing development of metallic alloys and on improving coating processes. DLR is also working on the production of fibre-reinforced composites.

When you look back on the development of materials, which milestone in the history of aviation would you have most liked to be involved with?

Although helping the Wright brothers build their aircraft in 1913 would have been an interesting challenge, here and now is still extremely exciting!

Intelligence on wheels

At DLR, those researchers who advance an idea to the market-readiness stage then have the option of taking it even further, and founding their own company to do just that. Researchers Thomas Strang and Andreas Lehner became entrepreneurs with the technology from the Railway Collision Avoidance System, or RCAS, research project.

Preventing train collisions – a business idea
Interview with company founders

By Elisabeth Mittelbach

In April 2012 you founded your own company to exploit RCAS technology. What were the reasons for this?

Thomas Strang: The basic motivation is clear – serious rail accidents still occur across the world quite frequently. In the RCAS research project, we have been working with colleagues from two other DLR institutes to develop an innovative system to prevent these collisions. For this to work, trains must be able to determine their positions and provide a timely warning about critical situations. Our technology complements the existing safety systems.

Andreas Lehner: Each RCAS installation consists of a communications component and a position determination component. These units can be integrated directly into the trains and operate independently of the local railway infrastructure. Extensive testing has proven their operational capabilities. With colleagues in DLR Technology Marketing, we have been preparing to set up the company for the past 18 months.

What motivated you to take this step? Were you starting to lose interest in research?

Thomas Strang: No, quite the opposite. We have both been working for DLR for many years now, and value the opportunities it provides. Even after founding our company 'Intelligence on Wheels', we wanted to remain involved and cooperate with DLR over the long term. For our new venture, we definitely need the close relationship with the research performed at DLR, and the resulting theoretical background, which we are looking to combine even more strongly with a 'hands-on' approach in the private sector.

Andreas Lehner: At the moment, we are still 100 percent DLR staff members, but the goal is to make our findings available outside of DLR and, ultimately, save lives. Once we launch our first projects, we will adjust our working hours accordingly – we are very grateful that DLR has allowed us to take up this option. Our vision is that we will be sufficiently successful with our spin-off company to grow and soon create new jobs.

Who will adopt which role in 'Intelligence on Wheels', and how have you prepared yourselves for this?

Thomas Strang: As the CEO, I am currently acting primarily as a communicator, especially in dealing with potential customers. I have also attended several entrepreneurship seminars, to prepare myself professionally to manage a company – so that I can understand a balance sheet, know which legal issues to consider when founding a legal entity... and a lot more.

Andreas Lehner: I am the Technical Director. I am currently working on railway standards compliance and approvals processes and augmenting our system design so that it meets the reliability requirements for real-time operation. At this time, it is crucial that, among other things, the correct technology strategy is developed. ●

More information:
http://s.DLR.de/s2i5
http://www.intelligence-on-wheels.com

Thomas Strang has a doctorate in natural science and has been working at the DLR Institute of Communications and Navigation for 12 years. He has also served as Professor of computer science at the University of Innsbruck since 2004 and, since 2007, he has been head of the RCAS research project. His activities as a private pilot gave him the idea of transferring the well-known Traffic Collision Avoidance System, TCAS, from aviation to rail transportation.

Andreas Lehner has been at the DLR Institute of Communications and Navigation since 2001 and primarily works with radio-based position determination systems and satellite navigation. He has been working with Thomas Strang on the RCAS project since 2007. As an active volunteer paramedic, he has also been of assistance in rail accidents.

Andreas Lehner (left) and Thomas Strang are confident that, with their company 'Intelligence on Wheels', they will market launch a system to prevent train collisions.

Step into tomorrow's train

From 18 to 21 September, DLR's rail transport research will be presented at InnoTrans, the leading international trade show for transport technology, being held at the Berlin Exhibition Grounds. The researchers are taking the show's theme, 'The Future of Mobility', literally; at the centre of the 100-square-metre DLR stand (No. 215, Hall 4.2), there will be a double deck, walk-in 'Generic Laboratory' – a life-size model of a carriage body where various lightweight construction techniques will be on show. This is one of the outputs from the Next Generation Train, NGT, research project that can be experienced 'live'. DLR rail transport researchers have been working on the NGT project since 2007, systematically investigating all the requirements for future high-speed trains.

Light, fast, safe and economical – DLR transport researchers will present the 'Next Generation Train' to the international public

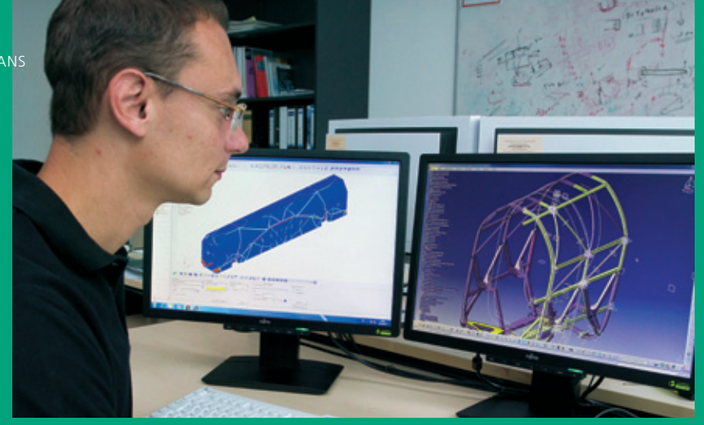
By Elisabeth Mittelbach

In search of the optimal topology for the next generation train – PhD student Jens König (left) and Michael Zimmermann from the DLR Institute of Vehicle Concepts.

Green makes for happiness – Martin Holzapfel (left) and Markus Kaden from the DLR Institute of Structures and Design, with the 1:3 scale 'original mould' of the new crash energy absorbing railway vehicle nose. From this, a tool will be manufactured for production of the actual noses.

The dimensions are impressive; the model NGT centre coach – built by an engineering company to a scale of 1:1 over recent months in accordance with specifications provided by DLR railway vehicle researchers – is almost five metres high and 12 metres long. "The Generic Laboratory is designed to give trade show visitors a better understanding of our ideas and of the research results from the NGT lightweight construction sub-project," explains project leader Joachim Winter. After InnoTrans, DLR transport researchers will continue to use the carriage body as a test laboratory: "to investigate the performance of air conditioning systems, for example, and destructive structural testing," adds Winter.

PhD student Jens König developed the technical basis for the research laboratory on a computer. He worked out the space required and the optimum topology, determined the materials to use, and from this derived a carriage body structure that also takes into account maintenance work and the effects of accidents. Hence a 'standard space' for studying the interior environment has been integrated into the general access carriage body model. Steel, aluminium and fibre-reinforced composites dominate the exterior. There is also a bogie module and a passenger module. The bogie module is constructed like a honeycombed tube and includes a model of the NGT Einzelrad-Einzelfahrwerk (EEF) wheelset. The passenger module consists of a foam core assembled in the style of brick bonding and enclosed in fibre-reinforced composites. There are also window units and intermediate floors. The 'passenger' or trade show visitor can access both floors of the double-deck carriage; there are no interior stairs.



Jens König integrates the NGT topology model (left) into a detailed design of the bogie module

The NGT lightweight construction concept has a modular design. At the core is a framework load-bearing, double-skin structure with lightweight infills that use multiple materials. These rely on frames to separate the carriage body into its various sections at specific points. This creates the entrance, bogie and passenger modules. The passenger module is located in the centre. "Because of its flat structure and the distribution of forces applied across the frames, this is especially suitable for constructions heavily based on fibre-reinforced materials," explains Winter. "In this way the weight can be reduced by around 30 percent in comparison to metal constructions."

Carriage bodies made of diverse materials

"Optimised topology is another fundamental goal on which we base our methodology in the design of the carriage body," recounts Winter. The optimisation here relates to the total static load on the carriage body. It is intended to enable 'distribution' of material according to specific framework conditions that are both economical and comply with the safety requirements of high-speed trains. The DLR researchers calculate the loads that occur across given locations on the carriage body and then decide the best materials to be used in each area. The visible result is the framework-style structure. The DLR researchers are opting for a multi-material design, a combination of materials that offer better flexural rigidity than conventional materials while also being significantly lighter.

Lightweight structures and joining technology also play a part in adhering to the maximum axle loading and saving energy during acceleration and braking. "This enables us to directly reduce our impact on the environment through emissions," states Winter. The interior design of next generation trains will also be marked by significantly reduced material usage and, therefore, weight.

The nature of the connection between the carriage body and track is largely evident in the mechatronic EEF wheelset, with an electric motor and a regenerative brake adjacent to the wheel. This truck is integrated into the bogie module of the Generic Laboratory. Applying mechatronic track guidance here has the advantage of offering greater safety and comfort for the train – and therefore the passengers, according to Winter. This is evident in reduced wear on the wheelset and rail and smoother running of the wheels along the track: "Vehicle design, lightweight construction and running gear cannot be considered separately. Optimum coordination of all component designs is the only way we can achieve our goal of carrying more passengers faster and at lower cost."

But the integrated double-deck trains, which are expected to travel at speeds averaging 400 kilometres per hour and which can accommodate up to 1600 people, pose another challenge to the DLR researchers: "We have to consider the European standard that specifies a maximum axle load of 17 tons on high speed lines. This simply cannot be achieved without lightweight construction methods," states the aerospace engineer.

Glass-fibre reinforced composite nose

The researchers are also paying particular attention to the multiple unit noses, which are particularly affected in the event of a collision. For this reason, Markus Kaden and Martin Holzapfel from the DLR Institute of Structures and Design have developed a new type of vehicle nose made of glass-fibre reinforced composites. This does not need to open because there is no coupler; therefore, it can be used as an additional crash element. The designers have tested various scenarios to see what energy is imparted to the vehicle nose in an impact and how this can be absorbed by the crash elements distributed throughout the train. The structure behind the crash elements must remain free from deformation. "Both the speed and the mass of the vehicles involved in the accident play a critical role in a collision. This means that heavy vehicles should provide a crash area for light vehicles that absorbs a portion of the energy to be dissipated, so that the crash energy absorbers in the light vehicle can more easily perform their task," explains Winter.

In doing this, the researchers distinguish between areas with static loads – including, for example, the passenger module, which acts as a safety cell in the middle of the carriage body and should not be deformed in a crash – and the parts of the carriage body that are subject to dynamic loads. These include the crash areas in the entrance modules of the central carriage. "Overall the construction methods we prefer demonstrate excellent rigidity and stability due to their special mechanical properties," concludes Winter. In addition, various other systems, for example ventilation, climate control and supply channels can be easily and functionally integrated. Heat and noise can thus be effectively isolated. ●

More information:
http://s.DLR.de/6825

A crash-absorbing nose consists of several layers, which must withstand the different loads. For this purpose, individually pre-cut parts (shown in the image) are custom made, the design of which is the outcome of a Drapier simulation.

Models of a crash-absorbing nose (1:10) in their original state and after a simulated frontal collision. In a crushing of one metre and with a component mass of around 500 grams, the energy dissipated is about six kilojoules.

The Next Generation Train research project

The NGT project, which runs from 2007 to 2013, combines DLR's expertise in rail vehicle research; its focus is on the vehicle. Adjacent areas, such as track design and automatic train control systems, are also included in the research work. Added value is primarily gained from whole-system consideration of research areas and high synergy potential. These areas, from integrated running gear assemblies and materials qualification to design, construction, simulation and verification using product-specific components can be worked on in an integrated manner. In total, researchers from 18 departments in nine DLR institutes are working on trains of the future. As well as high-speed variants, running at up to 400 kilometres per hour, since 2010, concepts for fast shuttle trains on regional networks and, in future, high-speed freight traffic are being adapted for on-track use.

Joachim Winter, leader of the 'Next Generation Train' project.

Nuptse on a USB stick

Six – that is the number of times that mountaineers have reached the summit of Nuptse, in the Himalayas. On many days people queue on the slopes of Everest to get to the summit. On Nuptse that is a very different story. It is a very steep, difficult mountain, according to mountaineer Gerlinde Kaltenbrunner. Yet she has conquered it. On 17 May 2012 she stood on the summit, at 7861 metres, looking across at Everest and Lhotse. The view, though spectacular, was not entirely new: Kaltenbrunner had previously seen the enormous mountain region during her route planning, in three-dimensional elevation models that the DLR Earth Observation Center (EOC) had computed from satellite imagery.

Three-dimensional elevation models show even the hidden aspects of mountains

By Manuela Braun

A careful fingertip traced the mountain ridge. "That is the east ridge of Nuptse," explained Ralf Dujmovits. "Nobody has climbed it yet." Gerlinde Kaltenbrunner looked over his shoulder. In front of both these mountaineers were detailed images created by DLR, which chart the looming peak. This married couple had actually planned on climbing Nuptse together, but in the event Dujmovits would be struck down by ill health – so Kaltenbrunner would make her ascent with David Göttler. They were targeting the, as yet, unconquered east ridge, which the pair had picked out during these preparations, based on DLR data.

There are few good maps of the highest mountains on Earth, explained Dujmovits. Nature does not make it easy to make maps up there. In the late eighties, a relatively good map of Everest was published; it continues to be the best map available today. But anyone wanting to climb the other highest peaks must often rely on old maps, reports of the experiences of other climbers and their own gut feelings. The thin air makes it difficult for helicopters to get to the peak regions to acquire photographs or video, but then vacuum is the standard situation for satellites. The United States WorldView-2 satellite, which provided the basic data for computing the DLR elevation model, orbits at an altitude of 770 kilometres above the Himalayas. Its perspective of the Nuptse region and the narrow, as yet unclimbed, east ridge is therefore quite uninterrupted. Kaltenbrunner pointed to another image: "On this elevation model, we first discovered that there is another pillar going down from the east ridge on the rear side of Nuptse."

Summit-chaser – Gerlinde Kaltenbrunner, the first woman to conquer Nuptse, one of the rarely climbed mountains in the Himalayas.

A mountain of data

True mountains of data are obtained through Earth observation. At the DLR Earth Observation Center (EOC), this is not only analysed, but also visualised. Although computers perform the extraction of information from satellite data, the end users are humans. A team of geoscientists and highly specialised visualisation experts at the EOC takes care of this last, crucial interface. Data and their contexts are treated so that they both inform scientists and can be understood by non-experts. Geo-science and visualisation technology from the film industry transform columns of complex data into understandable pictures and fascinating views – stunning images that are only possible with computers.

Satellite view of the east ridge

The Austrian is the first woman to have conquered all 14 8000-metre mountains without supplemental oxygen, but it is less the opportunity to make records that spurs her on than the chance to set foot where no one has been. "Such routes are really exciting," said Kaltenbrunner with a smile. And so the married couple scrutinised this unconquered route to the summit, studying the 3-D DLR elevation models and considering the mountain from the perspective of the satellite. "You just cannot believe that these are not photographs," said Dujmovits. As the two mountaineers pondered the image once more, they both remarked in unison that the east ridge would be a wonderful route. But, of course, it turned out quite differently.

In her expedition diary, Kaltenbrunner wrote: "On 26 April, we climbed to the bergschrund on our planned ascent route, via the north side of Nuptse towards its east ridge. Unfortunately, our suspicion that the route was very dry, clear of snow and, as a consequence, covered with unstable rock falls was confirmed. Huge rocks lay right at the base of the wall. We quickly agreed that this route could not be considered for reaching the east ridge; it is too dangerous." The DLR researchers' interactive elevation model accompanied the climbers on a USB stick: at Base Camp, they reconsidered the most suitable route to conquer Nuptse. Equipped with a solar-powered laptop, the mountaineers were able to rotate the model and look closely at every corner and edge of the massif. "You have such a good overview and can see things that you would otherwise have missed," explained Dujmovits.

Overflight with the click of a mouse

Three separate satellite images, acquired at the same time from different points of view, were required to enable the researchers at the EOC to generate their three-dimensional model. "One image needs to be acquired directly downwards towards the Earth, as far as possible; the other two should be taken slightly to the side," explains Stefan Dech, Director of the German Remote Sensing Data Center, DFD. The satellite was specially tasked to acquire the necessary images. The three-dimensional terrain model was then computed from these satellite images using a DLR-developed technique. "Such elevation models are the basis of any geo-information application," explains Dech. "Without them, there could be no modelling of urban climate and species distributions, no planning of high-speed roads and telecommunications masts, and no risk modelling of impending floods or tsunamis." The elevation model can be rotated in all three dimensions with the click of a mouse. Viewed through 3-D glasses, Nuptse seems almost close enough to touch. Rocks down to 50 centimetres across are depicted on Nuptse's virtual 3-D slopes.

When it came to preparing for Kaltenbrunner's last eight-thousand metre mountain – the notorious K2 – the mountaineering couple sat in front of a DLR topographic model wearing 3-D glasses. With one hand on a joystick, they 'flew' around the rock and ice pyramid, on the summit of which Kaltenbrunner would finally stand at 18:18 local time on 23 August 2011. The extreme mountaineers saw the north face of K2 for the first time. "We figuratively had our socks blown off," recalls Dujmovits. "And were a little overwhelmed by the intricate detail of the model." They could see narrow crevasses that enabled a slightly easier ascent, and even small ledges on which to erect their tiny bivouac tents at night. Each scouting activity on the mountain consumes energy, but with the 3-D view from space, Kaltenbrunner and her team were able to avoid at least some of this laborious climbing work.

"The world's highest mountain regions are of interest to us for a number of reasons," explains Dech. "They are 'seismometers' for climate change processes on our planet, because they

Gerlinde Kaltenbrunner

The minister in Gerlinde Kaltenbrunner's home parish of Spital am Pyhrn in Austria took her with him on mountain hikes. Although she later trained as a nurse in Vienna, skiing, ice climbing and mountaineering began to take up more and more of her time. At 23, she reached the summit of her first eight thousand-metre mountain – the secondary summit of Broad Peak in Pakistan. When she climbed K2 in August 2011, the 41-year-old Austrian reached all 14 summits of over eight thousand metres without using supplemental oxygen. Reaching the summit of Nuptse has set another record; she is the first woman to climb this mountain.

Ralf Dujmovits

The 50-year-old is the first German to reach the summits of all 14 eight thousand-metre mountains and has carried out over 40 expeditions worldwide as a professional mountaineer. He broke off his medical studies after eight semesters to devote himself to his passion for mountaineering. Mountaineering has taken him all over the world, to sites including Nepal, China, Peru, Ecuador, Kenya, India and Antarctica. He is principally known to the general public for a 33-hour live broadcast of an ascent of the north face of the Eiger in September 1999. He first reached the summit of Mount Everest in October 1992.

react very quickly to changes." But mountains are not easily accessible. Satellite remote sensing is of great help in the observation of these geographical processes. Everest, Nuptse and K2 are not just challenges for mountaineers, but also for DLR researchers. "We have to deal with extremely steep and also – as a result of the snow and rock – very high-contrast terrain. This makes the derivation of accurate altitude data very challenging." Dech thinks for a moment: "K2 was, so to speak, our ultimate testing ground. Three flyovers were needed before this eight-thousand-metre mountain could be captured completely free of clouds."

Like sleeping in an eyrie

In front of the laptop at Base Camp on Nuptse, the decision was made to climb the North Pillar, known as the Scott Route, which Ralf Dujmovits used for his ascent to the summit in 1996. Since the route to the east ridge was not traversable, another route had to be found. Climbing Nuptse formed a long-term dream for Kaltenbrunner. "The mountain is more technically challenging than Everest," remarked the 41-year-old. The Austrian made high demands on herself in the process; there were no porters to haul her pack up the mountain, and no oxygen bottles to facilitate the ascent in the thin air.

In mountaineering, this meant carrying a 16-kilogram backpack. Many tourist rucksacks weigh the same, but holidaymakers are not climbing steep mountain slopes. And the climbers had to camp out on the tiniest ledges of flat ground. "Like being in an eyrie," is how Kaltenbrunner described the final shelter at the upper end of the north pillar, at an altitude of 7250 metres. A quick point at a still image from the DLR visualisation shows a small yellow triangle where Kaltenbrunner and Göttler spent the night before reaching the summit. The interior of the tent quickly turned into an ice cave. Even though the wind was blowing at only 30 kilometres per hour, the wind chill came to minus 40 degrees Celsius. Furthermore, at altitudes above 7000 metres, the body can no longer sleep. "It is more like a snooze, or a rest," says the Austrian. And how was her composure prior to the important day? "Very nervous. But it was a positive nervousness!"

First woman to climb Nuptse

On 17 May at 13:30, the great moment arrived; Göttler and Kaltenbrunner stood on the summit of Nuptse. Only 14 people have previously set foot on this place. Kaltenbrunner became the first woman to look from Nuptse, across the east ridge, to neighbouring Lhotse and on to Everest. The petite but athletic woman beams as she remembers this moment. A long cherished desire is fulfilled, she wrote in her expedition diary a few days later at Base Camp. The cold, long hours of melting snow to make water, the lack of appetite when faced with food which was nevertheless essential for survival – baby food mixed with water and raw fruit and vegetable bars – was all forgotten. "There is a very powerful solitude up there," recalls the 41-year-old.

Their next goal has already been selected; next spring, Kaltenbrunner and Dujmovits want to climb Mount McKinley, in Alaska. It is only about 6200 metres high, but this time other challenges are attracting them: "Mount McKinley is the coldest mountain on Earth," says Dujmovits. Its low temperature record is minus 73 degrees Celsius. Strong winds drive the temperature of the highest mountain in North America down to the extreme. "And there are still plenty of opportunities for first ascents," adds Dujmovits. Kaltenbrunner nods. "We are not short of ideas." The two professional mountaineers agree on this. "And, if possible, we will not use the same route twice." But the DLR visualisation still has a job to finish. Kaltenbrunner smiles and points to the east ridge, a route that nobody has yet traced. "This is still on our list." ●

More information:
http://s.DLR.de/p4lx
www.DLR.de/EOC/en

Arrow in the blue

On 22 June 2012, SHEFEX II shot skyward like an arrow from the Norwegian Andøya rocket base. After a 10-minute flight, the angular spacecraft re-entered Earth's atmosphere to land in the ocean close to Spitsbergen. Seven years of preparations for the project concluded with a launch campaign in Norway that lasted just weeks. The final days before the launch were a nervous time – assembling, testing, waiting for results and conducting practice countdowns. Then, more waiting – this time for a windless, rain-free day to ensure a perfect launch – until the critical moment finally arrived. The DLR Magazine accompanied the researchers during their preparations and launch.

Near the Arctic Circle, the sharp-edged SHEFEX II spacecraft flew into the bright summer night sky

By Manuela Braun

Launch preparations at the Andøya Rocket Range. In the integration hall, DLR researchers assemble the various parts of the spacecraft.

The roof of the launch hall has moved aside and the launch tower with SHEFEX II rises to the vertical position

Saturday, a few days before launch

In science, the devil is in the details, and that implies a close up view. In the integration hall at the Andøya Rocket Range, a group of scientists crawl across the concrete floor on all fours. They have spent all morning assembling the various components of SHEFEX II, carefully positioning edge on edge, tightening screws, and measuring everything measurable. Suddenly, a tiny metal pin falls out of a special tool. Project leader Hendrik Weihs shuffles his upper body under the trolley that is supporting the dart-like spacecraft. All eyes are directed to the ground in concentration. Just where did it go? Hannah Böhrk, who is responsible for the porous heat resistant tiles on the angular edges of SHEFEX, carefully moves her hand across the concrete floor. Design engineer Henning Elsäßer crawls on his knees. Without the metal pin in the tool, and without the final adjustment, there will be no launch; and with no launch, there will be no data on the fiery re-entry of this new type of vehicle into the atmosphere. "Have you…?" No, nobody has, so the search goes on. "Aha!" Weihs triumphantly holds up a tiny piece between his thumb and index finger, grinning; work in the integration hall can continue.

Today is assembly day; one component after another is put in position until the nose can finally be placed on the vehicle. Measuring instruments, cabling, locking rings – everything must be precisely positioned to the millimetre. Researchers from Stuttgart, Braunschweig and Oberpfaffenhofen are at work around the vehicle. SHEFEX II is a project to which seven DLR institutes and facilities are contributing their knowledge. Andreas Bierig from the Institute of Flight Systems climbs onto the transport vehicle and gets up close to the canards. These small wings, which will steer SHEFEX during re-entry, must be precisely aligned prior to launch. When SHEFEX is flying, the scientist from Braunschweig will be among those sitting in the control room carrying out the flight manoeuvres. Hannah Böhrk

Prior to the launch of SHEFEX II into the sky above Andøya, the little 'wings' are carefully aligned and the thermal insulation tiles stroked once again.

from the Institute of Structures and Design runs a hand over 'her' heat-resistant tiles once again. During the flight, nitrogen will flow out of small holes in the tiles to cool the spacecraft. The nose of SHEFEX will have to withstand temperatures of over 2000 degrees Celsius as friction generates heat during re-entry. This nitrogen will form a protective layer between SHEFEX and the scorching environment.

Outside, in front of the hall, the Sun has almost reached its lowest point. Here, north of the Arctic Circle on the Vesterålen archipelago, the soft afternoon light will last all night. The Andøya Rocket Range lies in a bay between mountains and a white sandy beach. It is actually the most beautiful rocket range in the world, according to a somewhat rapt Kjell Bøen, Head of the Sounding Rocket and Balloon Department at the rocket range. Those without a role in the integration hall, stand in front of the hall entrance, freezing in the icy wind but enjoying the view.

It is finally time to roll the six-metre-long space vehicle on its transporter towards the launch platform. A black and yellow foam protector has been stuck on the sharp nose at the front so that no one will be hurt on the angular vehicle. Mobile phones, cameras, anything that can take a picture is pulled out. The majority will never get this close to their spacecraft again. But they can only go as far as the access road to the launch platform: "Only those who need to work on the launcher, on this side of the barrier now please," says Peter Turner, Head of the DLR MoRaBa mobile rocket base. The payload is going to be mated with its Brazilian-made launcher. This is too dangerous for spectators, so access is strictly forbidden. SHEFEX II rolls slowly out of sight and disappears into the launch hall.

Tuesday – all antennas ready to receive

A day of waiting. Waiting for confirmation that the payload and engines are assembled and all the connections to the instruments in the nose are functioning. Waiting for the practice countdown. Waiting for a favourable weather forecast. It is the nerve-wracking calm before the storm for scientists with experiments on SHEFEX II. Meanwhile, the staff of the MoRaBa mobile rocket base are working frantically. Among other things, they are responsible for the two-stage launch system and for controlling the rocket.

Two minutes' drive from the rocket range is the DLR telemetry station, which will record the data during the flight. There are screens, keyboards and bundles of cables. On a tray is a box of sweets – comfort snacks for MoRaBa staff members Frank Hassenpflug and Anke Stromsky. Hassenpflug opens cupboards within which hundreds of cables and connectors are arranged in an orderly manner. "We have set all this up over the last few weeks," he explains. In front of the door is the satellite dish that will track SHEFEX II during its flight on Friday evening.

In the meantime, Dietmar Kail and his colleagues are sitting in the DLR MoRaBa radar station near the rocket range. It is cramped and a little sombre in the mobile container. On top, a large dish antenna turns and tilts during the practice run. It will follow the spacecraft's flight path and record it using multiple cameras. It is relatively calm around the launcher itself. In the interior of the hall, SHEFEX is attached horizontally to the extendable launch platform, while MoRaBa staff work with Brazilian colleagues on the vehicle and rocket engines. Five tons of fuel will accelerate the sharp-edged vehicle into the sky.

Finally the voice of Kjell Bøens rings out over the loudspeakers; SHEFEX II is going to be lifted into the vertical position on the launch platform for the practice run. Now, everyone can approach the launch complex for the first and last time. SHEFEX is attached to the launch tower, resembling a large, dark grey

SHEFEX II has to be assembled with millimetric precision. John Turner of the DLR Mobile Rocket Base, MoRaBa, pays attention to cabling, measuring instruments and locking rings.

arrow. The roof of the launch hall opens with a loud thumping noise. The two halves of the roof move apart, and powerful hydraulic motors slowly raise the launch tower and its dart-like passenger. Thick clouds cling to the mountains as the wind whistles around the launcher.

Thursday – the rehearsal

You could cut the control room's atmosphere with a knife. The practice countdown has been running for almost four hours. John Turner, Project Leader for SHEFEX at the mobile rocket base – not to be confused with MoRaBa Department Head Peter Turner – is concentrating on four screens simultaneously. On the screen over their heads, a clock counts down the final three minutes. Everything happens as it would during a real launch; only the final push of the button to ignite the rocket engines will not occur. Kjell Bøens' voice can be heard over the headphones. "Start the data storage systems." Every station gives its status in order: the telemetry station, the radar station, and the receiving station on Spitsbergen, in the Svalbard Archipelago. Recording equipment is now running everywhere. Finally there is a sound like an old-fashioned doorbell. Everyone laughs. During a real launch, they would now be hearing the sirens that announce the evacuation of the launch area around the launch platform. Sixty seconds remaining. A computerised voice marks

A rehearsal for the big day at the control room – where all things come together

the 10-second intervals in the countdown. Even though this is just a rehearsal and everyone knows that SHEFEX must spend another night on the launch platform; the mood in the control room is one of concentration and tension. Tomorrow, the weather conditions are at last expected to be suitable. Then, everything will come together for a smooth countdown.

"Three, two, one, fire." Those will be the critical seconds before SHEFEX is launched into space on its 10-minute flight, making its way through the atmosphere then returning. Numbers are called out throughout the control room; John Turner keys data into his PC. "Canards activated," calls Andreas Bierig. This is the tensest phase for the scientists: "Re-entry at 100 kilometres," says the announcer. Hannah Böhrk is standing right behind John Turner. "Gas on," she shouts. Nitrogen gas now flows through the heat-shield tiles on the vehicle. The computer voice stoically announces how many seconds have passed since the launch. "OK, thank you, we are finished," says John Turner. The tension drops, and celebrations start – even though SHEFEX did not actually launch. Launch date – Friday. The real countdown is scheduled to start at 16:30.

Friday – lift off!

Lift-off minus 01:10. Just over an hour until the rocket is ignited. SHEFEX II is the biggest rocket to be launched from the Andøya Rocket Range. Those not actively working at the rocket range must now leave the area. They drive in convoy to the telemetry station. From there, at a safe distance, the spectators can watch the ascent. A screen shows what the cameras on board the spacecraft are transmitting back to Earth. Now only those staff members who have actual jobs to do during the flight of the spacecraft are sitting in the control room and the tower. The launch platform is precisely aligned. L minus 00:12. The countdown continues as police block the adjacent road between the small island towns of Andenes and Bleik. L minus 00:08. During the final eight minutes before the launch, it is forbidden for car engines to be running, and mobile phones must be switched off. Scientists, tourists and locals gather at the telemetry station. The Norwegian range launches up to 40 rockets a year; but the SHEFEX launch has attracted quite a few curious onlookers all the same.

L minus 00:03. Everything that was practiced in the rehearsal is now happening for real. As soon as all the participants have given their green light via radio, SHEFEX will start its flight. The warning siren echoes over the surrounding area. Then it's "GO", and a burst of smoke and flame appears under the slender vehicle. Even before the sound is audible, at 21:18, the rocket with SHEFEX on top starts climbing into the sky. A powerful noise then rolls towards the mountain. In a flash, SHEFEX disappears into the clouds towards Spitsbergen. Seven years of planning and preparation are rewarded with a perfect launch. The spacecraft will now fly at 11,000 kilometres per hour to an altitude of 180 kilometres, before plunging back through the atmosphere.

On Spitsbergen, a search aircraft takes off to try and locate the spacecraft in the sea as it returns. Several days beforehand, a recovery ship set out from Andenes to be on station in good time. On the range, hands are shaken and congratulations exchanged. But finally there is disappointing news – the aircraft has picked up the signal, but has not found SHEFEX. Three-metre waves are making it difficult for the recovery ship to reach the landing area. Also, the station on Spitsbergen was unable to track the spacecraft on the very last part of its journey and record the relevant data. Five seconds of the experimental phase below an altitude of 29 kilometres are missing. This gives the team pause for a moment. However, the critical phase during which the angular vehicle flew through the atmosphere began at an altitude of 100 kilometres. "We have 95 percent of the data," says project leader Hendrik Weihs reassuringly. All of the scientists will be able to work on the data from the SHEFEX flight and carry out research. The tension reduces. There is nobody without a smile in the corridors of the rocket range. "The recovery of SHEFEX now would be the icing on the cake," says Weihs.

Sunday – post-launch is pre-launch

Although the aircraft picked up the signals from SHEFEX, the space vehicle has not been recovered. The search is finally abandoned. The researchers know the parachute opened: "Otherwise the probe would not have sent a signal," says Hendrik Weihs. "But the heavy swell, the wind and the poor visibility were against us." The scientists will now use the data they have acquired to research a spacecraft that can use angular edges to create aerodynamic benefits when re-entering the atmosphere and withstand high temperatures while doing so. The design resembles a mini-space shuttle, but with flat protective tiles providing extra benefits. "We are on the way to having a spacecraft that is as easy to build as a space capsule but has control and flight capabilities," he adds. Then experiments could fly in microgravity for days and return safely to Earth. Plans for the next mission, SHEFEX III, will now start. Launch date – 2016. ●

More information:
http://s.DLR.de/fj5j

Hand in Hand

The SHEFEX experiment platform was a collaboration between a number of DLR institutes and facilities. The Institute of Aerodynamics and Flow Technology was responsible for the aerodynamic design of the vehicle, numerous wind tunnel tests and the computation of the flow field during re-entry, together with instrumentation to measure temperatures, pressures and thermal loads on the vehicle. The Institute of Structures and Design manufactured the vehicle and designed and produced, among other things, the ceramic thermal protection systems. In one of these systems, nitrogen flows through porous tiles and cools the vehicle during re-entry. The Institute of Flight Systems conducted the test of the canards, which are the control surfaces used for active flight control of SHEFEX II. The Institute of Materials Research made the ceramic tiles for the thermal protection systems. The Institute of Space Systems created simulation software and technology and developed a navigation platform for determining the position of the spacecraft during its flight. DLR's Mobile Rocket Base MoRaBa contributed to the two-stage launch system, controlled the rocket and received the data sent by SHEFEX during the flight.

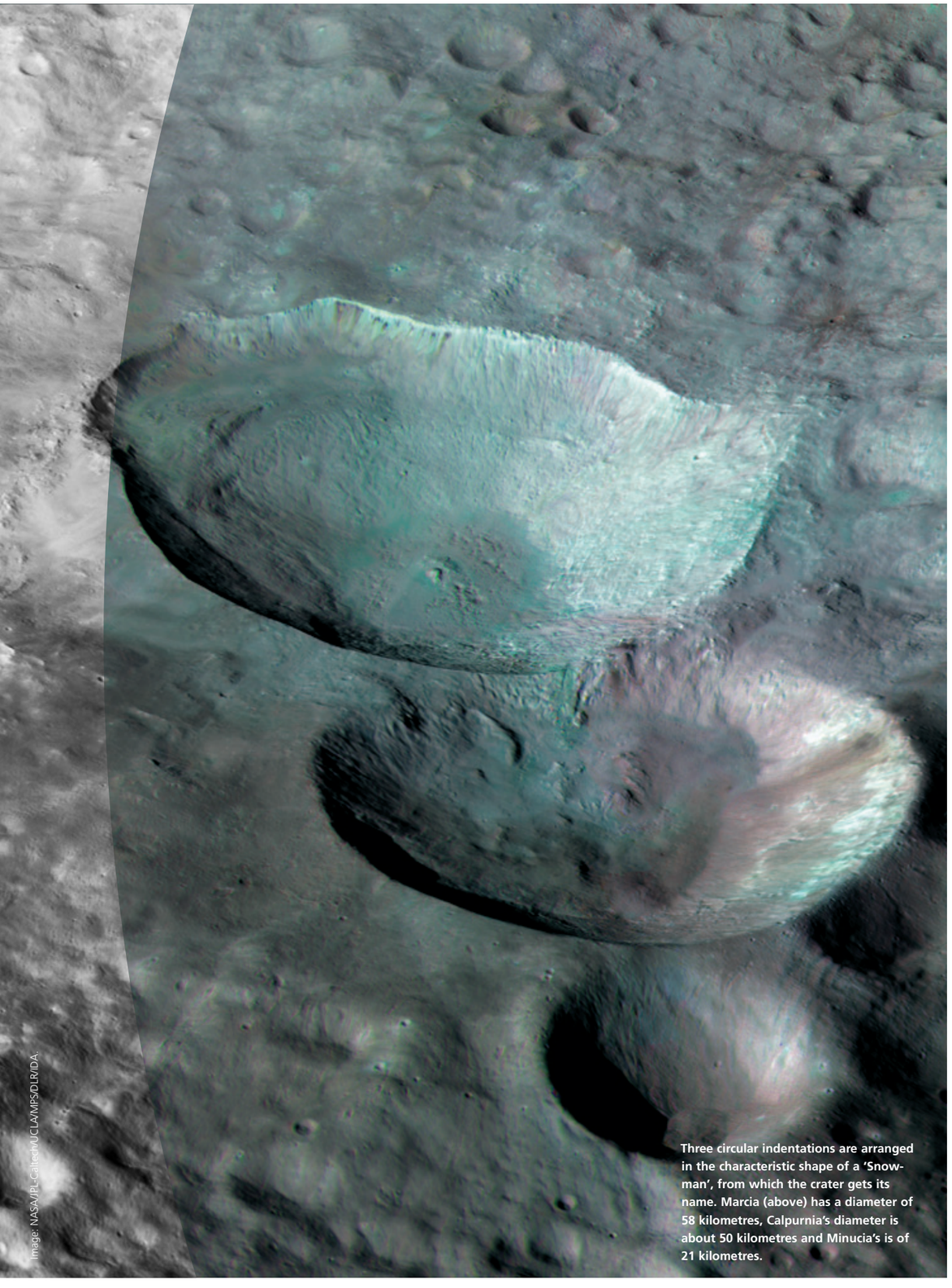


Image: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

Three circular indentations are arranged in the characteristic shape of a 'Snowman', from which the crater gets its name. Marcia (above) has a diameter of 58 kilometres, Calpurnia's diameter is about 50 kilometres and Minucia's is of 21 kilometres.

An interrupted world

When the Dawn spacecraft approached the asteroid Vesta in the middle of last year, planetary researchers only had a vague understanding of the second most massive and third-largest body in the Main Asteroid Belt. As the first part of the mission comes to an end, it has become apparent that Vesta is not a typical asteroid, but rather a would-be planet, a kind of planetary embryo. This result is principally based on images acquired by the German cameras on board Dawn.

Close-up examination by the Dawn mission shows that asteroid Vesta is a far from typical example of its kind

By Ralf Jaumann and Ulrich Köhler

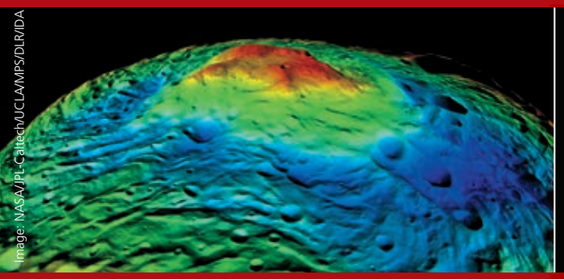
Ralf Jaumann and the DLR Dawn team look back on an exciting and busy year for the exploration of asteroid Vesta

Dawn is the ninth mission in NASA's Discovery programme, a series of smaller, less expensive but scientifically highly successful Solar System research projects. The Jet Propulsion Laboratory, JPL, heads the mission; the University of California Los Angeles, UCLA, is responsible for the scientific part of the mission.

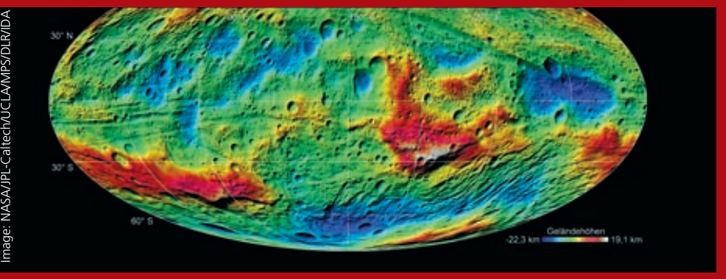
Besides the question of whether there might be life elsewhere in the Solar System or on extrasolar bodies, the second biggest motivation for planetary researchers is the quest to understand the origin of the Solar System. Why did the various bodies in our cosmic neighbourhood develop so differently? One of the objectives of NASA's Dawn mission is to give an insight into the early history of the Solar System – in a way, to capture and analyse its first light, or 'dawn'. To achieve this, Dawn's mission includes visits to study two of the Solar System's primordial bodies at close quarters – in 2011/2012, the asteroid Vesta and, from 2015, the dwarf planet Ceres. Scientists are primarily interested in the processes that took place during the formation of the first major bodies from the material of the cloud of gas and dust around the protostar, which predetermined the development of these young planets.

Many questions arise. Above what critical mass do differentiation processes start to take place? At what point do the elements in a young planetoid separate out into heavy components that form a metallic core and a lighter silicate mantle, within which molten rock can also occur? Does that lead, in turn, to volcanism that reshapes the outer crust? What role do volatile elements and especially water play in the subsequent development of protoplanets as a function of their distance from the Sun? And finally, what role did external influences have – especially the collisions that were much more frequent in the early Solar System and the resultant impacts of millions of pieces of rock debris – on these early planetesimals, left over after the planets formed?

In August 2012 Dawn will slowly start releasing itself from Vesta's gravitational field. It will then accelerate and set off on a long, parabolic path that will gradually take it further away from the Sun and to its final destination, the dwarf planet Ceres, in



Perspective image of the south pole of Vesta; its topography is revealed using false colours. The blue area is the 500-kilometre Rheasilvia impact basin. In its centre is a distinctive and more than 20-kilometre high mountain massif, shown in green, yellow and red.



This global topographic map of Vesta, created by the Dawn cartographers at DLR, also shows low-lying areas.

Aricia Tholus is a dome-shaped mountain that rises 5000 metres above the region north of Vesta's equator. The mountain is named after a town in the ancient region of Latium. The vertical scale is exaggerated by a factor of two.

2015. At present, the first part of the mission, which included the study of Vesta from three polar orbits at altitudes of between 2700 and 210 kilometres, is virtually complete, so the scientists can begin to publish their initial findings.

The most striking result thus far is that Vesta is a planetoid whose development has stalled; it is more similar to the Moon or perhaps even Mars than to the majority of other bodies in the Main Asteroid Belt. The images obtained show an unequivocally diverse surface peppered by a wide range of impact craters that are surrounded by overlapping ejecta blankets. What is more, enormous grooves stretch around nearly the entire asteroid's surface, which shows signs of large magnitude mass displacements. The surface material has a heterogeneous composition and, above all, outstanding topographical extremes, with elevated areas towering up to 20 kilometres and depressions down to 22 kilometres below the average surface level; such height differences are rarely seen elsewhere in the Solar System.

Vesta – surprisingly complex

Vesta is indeed 'differentiated'; after its formation, its heavy and light constituents separated out. During this process, a metal-rich core, a rocky mantle and a crust covered with a substantial layer of dust and debris was formed – Vesta's current surface. For this reason, the asteroid is not at all a primitive, homogeneous, unstructured body, like the majority of its smaller companions between the orbits of Mars and Jupiter. Instead, during its early life, it underwent a development similar to that of our young Moon. It is also fairly certain that Vesta was once larger, but lost mass as a consequence of many substantial collisions. The material ejected by these collisions continues to orbit the Sun as a group of bodies in the Main Asteroid Belt – the family of asteroids known as Vestoids.

Spectral analyses of Vesta's surface confirm yet another suspicion; that numerous pieces of the asteroid have reached Earth. This is known because Vesta's spectral characteristics are identical to those of a class of rare meteorites found on Earth, whose origin can now be explained. These meteorites, known as HED meteorites (from the initials of the three types of rocky meteorite – Howardite, Eucrite and Diogenite) clearly originate from a differentiated asteroidal parent body, which had a 'hot' past, as they were at least partly molten when they were formed. It is therefore possible to conclude that Vesta was subjected to intense heat after its formation, at which point its constituents separated out, causing the body to differentiate – a fundamental process that was first detected on Earth's Moon and that is characteristic of the early history of bodies of a sufficient size – including large asteroids. It is likely that many of these differentiated small bodies populated the early Solar System, but were destroyed in mutual collisions leaving Vesta as the only survivor.

HED meteorites and the Vestoids were probably ejected into space when a huge body struck the south pole of Vesta, creating a 500-kilometre wide and 10-kilometre deep basin there, now named 'Rheasilvia' after one of the Vestal Virgins of ancient Rome.

Crucial test at the south pole

At the centre of the Rheasilvia basin is a mountain over 20 kilometres high, the like of which has not been found anywhere else in the Solar System. Its formation is thought to have occurred as a consequence of the massive impact that led to the formation of Rheasilvia. The impact area reacted elastically to the enormous amount of energy released by the collision process, causing a rebound in the crust that was somehow 'frozen'. There is more; on the topographical maps that have been produced by DLR researchers, it is clear that a large asteroid must have impacted once before where Rheasilvia formed. This second basin has a diameter of 400 kilometres and has been named Veneneia, also one of the Vestal Virgins.

Vesta must have endured quite a lot in its past; the two impacts at the south pole alone would have shocked it thoroughly. They were presumably also the cause of a phenomenon for which there was, at first, no good explanation. Vesta is encircled by several dozen parallel grooves that are over 10 kilometres wide, several kilometres deep and run for hundreds of kilometres. These structures run partly exactly parallel to the equator, partly at an angle of 30 degrees to it. From this it can be concluded that the pressure waves that emanated from the two impacts at the south pole were so intense that they spread powerfully throughout the entire body, causing these systems of faults to occur both at the equator and offset from it.

Overall, Vesta has a tremendously rough topography, with extremely steep slopes with a gradient of over 40 degrees. This shows that, beneath its uppermost dust layer, the regolith, the asteroid consists of solid rock that lends certain stability to the topographical structure. However, the regolith is thought to be up to several kilometres thick in places, which poses a real handicap for answering one of the most fascinating questions concerning the geological development of Vesta – is the asteroid sufficiently internally differentiated to be capable of generating enough heat for the formation of magma and the presence of volcanism on its surface? There is evidence for this in the molten HED meteorites and theoretical models based on laboratory work, but the layers of geological debris on Vesta's surface make it difficult for the scientists to locate volcanic deposits.

So far, no volcanoes have been found on the surface of Vesta, but what are the dark marks and streaks seen on it? Strikingly dark, almost black material is found in numerous locations, sometimes in clusters, and elsewhere in isolation, mostly mixed with the lighter regolith and often as ejecta radiating from relatively recent impact craters. The Dawn scientists have not yet found a convincing explanation for this; it might be volcanic material, or substances originating from the impacts themselves, for example the constituents of dark, carbon-rich comets.

What applies to every other Solar System research mission also holds true for Dawn's more than one-year-long visit to Vesta; large volumes of data, excellent results – but, as ever, (at least) one 'hard nut' to crack, which will represent a major challenge to researchers for a long time after the mission.

German-made camera system and 3D cartography by DLR

Four experiments are being carried on board Dawn. Besides two spectrometers (from Italy and the United States) and a radio wave experiment, a camera system that was developed and built in Germany is providing images. Two 'Framing Cameras' of identical construction are taking both monochrome and colour images through seven narrow-band filters in visible light and the near infrared.

The Framing Camera, funded by DLR's Space Administration, is a joint project developed and built by the Max Planck Institute for Solar System Research (MPS) in Katlenburg-Lindau, in tandem with the DLR Institute of Planetary Research in Berlin-Adlershof and the Institute of Computer and Network Engineering at the Technische Universität Braunschweig. The electronic unit in the camera, together with the optical sensors and readout electronics were provided by DLR.

German scientists from DLR, MPS, Freie Universität Berlin and Westfälische Wilhelms-Universität Münster are participating in the Dawn mission. In the context of its scientific participation in Dawn, the DLR Institute of Planetary Research is contributing substantially to the mapping of Vesta and is using stereo photogrammetry to calculate the precise shape of this celestial body. The researchers are deriving a highly accurate surface model from this, which is being used as a basis for geomorphological interpretations. ●

Vesta in figures

After Ceres and Pallas, Vesta is the third largest and second most massive body in the Main Asteroid Belt, which is located between the orbits of Mars and Jupiter. DLR researchers have used data from Dawn to recalculate Vesta's dimensions along the three principal axes as 572.6 × 557.2 (equatorial plane) × 446.4 kilometres (polar diameter) and its period of rotation as 5.34213 hours.

Vesta was discovered in 1807 by Bremen-based doctor and astronomer Heinrich Wilhelm Olbers (1758-1840). The asteroid orbits the Sun in three Earth years and 320 days, on an elliptical path inclined at 7.13 degrees to the ecliptic (the plane of Earth's orbit around the Sun), and at a distance from the Sun of between 322 and 385 million kilometres (Earth = 149.6 million kilometres). Its average density is 3.456 grams per cubic centimetre – a relatively high value for an asteroid; this is due to the heavy elements, such as iron, that are presumed to make up the core.

About the authors:
Ralf Jaumann heads the Planetary Geology Department at the DLR Institute of Planetary Research and is a Co-investigator on the Dawn science team.
Ulrich Köhler coordinates public relations for the sizeable DLR Dawn team.

More information:
http://dawn.jpl.nasa.gov/
www.DLR.de/en/dawn

The joint DLR/ESA stand at the International Congress Center in Munich featured a scale model of the Sentinel-1 satellite, scheduled for launch in 2013.

Image: Alejandro Morelon

Watching over our changing planet

We live on a dynamic Earth: every day, every hour, every minute, something changes – forest fires, deforestation, floods, glacial melting, earthquakes… Remote sensing, with its global capability, is the only technology able to capture these dynamic processes in a timely manner, which allows us to better understand our shared home. With this in mind, the theme for the 32nd IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2012), which took place between 22 and 27 July 2012 in Munich, had to be 'Remote Sensing for a Dynamic Earth'. The conference was jointly organised by the Institute of Electrical and Electronics Engineers Geoscience and Remote Sensing Society, DLR and ESA.

A report from the world's premier geoscience and remote sensing symposium

By Karin Ranero Celius

In constant motion along their orbits, Earth observation satellites keep a continuous eye on our planet. At times, their presence is vital for dealing with great societal challenges. On 11 March 2011, Japan fell victim to its largest earthquake and the subsequent tsunami that swept onto its north-eastern coast, destroying villages, towns, and lives within minutes. Immediate action was required, but this action needed guiding. Some 63 satellite observations were made in the initial 48 hours following this event. The high spatial resolution radar and optical data provided was key in assessing the extent of damage and flooding, and the location of debris. Major efforts were required – the satellites had to be tasked, the resulting data needed to be processed by geoscientists, and passed on to relief organisations that could make use of the final data products. Collaboration between these parts was essential, but so were the satellites, the teams behind them and the innovative technologies – all which have taken years to develop and improve, in part thanks to symposiums like IGARSS.

IGARSS 2012 was attended by more than 2700 delegates from 68 different countries, clearly demonstrating the tremendous growth in remote sensing activities. A great opportunity to meet experts in similar fields and a platform for cooperation and networking – this year's IGARSS offered a venue for the Earth observation and remote sensing community to further progress and develop their research activities, to present scientific papers, to foster applications and to prepare for operational services.

DLR was very strongly represented in Munich. A joint booth with ESA showcased the latest remote sensing developments and, with an impressive relief projection model, gave visitors the ability to see Earth through the eyes of the satellites. Special technical sessions were organised that included reports from TerraSAR-X and TanDEM-X and the scientific exploitation carried out by DLR and in collaboration with ESA. At the DLR_School_Lab, secondary school students were able to test out remote sensing and learn about its underlying technology.

Training the next generation of scientists is vital, as is the move from scientific activities focused on a single aspect of remote sensing towards a more integrated, interdisciplinary approach. At present, research groups could be the SAR group, the LIDAR group and so forth. The future should see the combination of these expert groups in a way that the end users – other researchers, government organisations or other entities with no specific knowledge of remote sensing – can interpret the information in a way that addresses their requirements.

This field is evolving rapidly. Europe is a major player in space technologies; taking a look at the development of radar satellites in the past 20 years, from ERS-1 to TerraSAR-X and TanDEM-X, it is easy to see vast differences in both spatial and radiometric resolution, as well as in the resulting images and information products. Techniques such as polarimetric interferometry have made new types of sensing and retrieval of geo/biophysical information possible. The ground segment processing capacity has had to keep pace with these developments in space, becoming fast enough to deliver the processed data in near real-time and keep it available for the long term in archives. The data must be translated directly after reception and the necessary information layer provided to the end user as soon as possible.

The future of remote sensing was a hot topic at IGARSS 2012. Thirty more satellites will be launched within the next 10 years, including the Sentinel missions underpinning Europe's Global Monitoring for Environment and Security (GMES) programme. Another possible launch, tentatively scheduled for 2019, will add a new dimension to remote sensing. DLR is currently working on the Tandem-L mission, which would offer an innovative interferometric L band radar instrument that, using advanced techniques and technologies, would enable the systematic monitoring of dynamic Earth processes. Its applications? Monitoring global forest height and biomass, as well as soil moisture and ocean surface currents, measuring Earth deformation due to tectonic processes and/or anthropogenic factors, observing ice/glacier velocity fields and 3-D structure changes, among many others.

Tandem-L will be one of many future missions providing a new quality of information and understanding of these dynamic processes, perhaps even data to help us predict them. The conference heard how it is of crucial importance that this data is made available in a very user-friendly way, that it is free, that the scientific community can use it for research and for supporting industry, and for evaluation purposes. And on top of that, satellite missions must become less expensive to remain sustainable – an important task for national industries as well as the various European collaborations is to make this technology more affordable in the coming years.

The one-week conference came to an end, but these matters will continue to be discussed by the scientific community at IGARSS 2013, which will take place in Melbourne, Australia. The breakthroughs and collaborations will surely be just as exceptional as at this one, but this year's location cannot be beaten in a few aspects; not only is Munich home to a renowned research centre for radar remote sensing – the DLR site in Oberpfaffenhofen – it also has the finest beer, as Bavaria's is the best in the world! ●

More information:
www.igarss2012.org
www.DLR.de/igarss

Setting the scene for science

Scientific experiments and data analysis do not occur by themselves – first of all, everything must be organised and plans have to be made so everything will run smoothly. At the DLR Institute of Aerospace Medicine, the 'Operational Study Team' is used as an additional assistant for this. "It is an exciting job," says group leader Melanie von der Wiesche; the pendulum swings between the laboratory and the office, paperwork and preparing test subjects, bed rest studies and centrifuge runs – this way, the scientists can concentrate more on their research.

Through the eyes of Melanie von der Wiesche and the test team at the DLR Institute of Aerospace Medicine

By Manuela Braun

During a team meeting, the group leader, Melanie von der Wiesche (fourth from left) discusses the procedures for future studies.

The volunteer should feel okay – prior to the centrifuge run, the team at the DLR Institute of Aerospace Medicine care for the participant once again.

08:00: everything is still quiet in the corridors of the physiology laboratory at DLR Cologne. In only four hours, the human centrifuge with test subject Kristina will start up. But before the research can begin, everything must be organised, information passed on, concerns allayed and cables attached. The group leader has assumed these tasks for this test. "We will stay in constant contact with you during the centrifuge run," she assures the test subject in the examination room. The participant is nervous, did not sleep well last night and is afraid that things might not go well for her as the centrifuge accelerates. Melanie waves it away: "Most of the time it will be really exciting for you." Then the significant statement: "We have not made anyone sick yet." Kristina's face relaxes – test subject reassured, mission accomplished.

Service provider for science

Melanie von der Wiesche set up the Operational Study Team at the Institute of Aerospace Medicine just over four years ago, and she has been the group leader since October 2011. With her colleagues, she conducts inpatient and outpatient tests on behalf of scientists at DLR, ESA and various universities. For the biologist and her team of seven, this means providing services that range from looking for test subjects, preparing proposals and providing advice in designing new tests, to actually wiring up the test subjects and even repairing the air conditioning equipment. "The range of tasks we have is incredibly diverse," the group leader says, adding: "Paperwork, talking to test subjects, running the tests – the work could hardly be more varied."

This time around, research is being carried out on the centrifuge to see how the human cardiovascular system reacts to the 'hypergravity' induced by its spinning. Could astronauts at the International Space Station train on a centrifuge in prepa-

ration for their return from microgravity, thereby preventing their circulatory systems from being weakened when they return to Earth? Melanie explains the science behind the test. In the meantime, Francisca May, the doctor in the test team, establishes access to the test subject's vein. If anything should happen and should Kristina require medical attention, the doctor would be able to administer the necessary fluids immediately. "Okay? Shall we head to the centrifuge?" asks the group leader. The 45-year-old attaches electrode after electrode to the test subject's body, connects the measuring instruments, ensures that Kristina is relaxed and positioned on the centrifuge properly, and walks out of the room. She is back two minutes later with heated cherrystone pillows and carefully places them around Kristina's bare feet. Since she is volunteering her participation, at the least she should not be cold.

Test subjects, scientists and data at a glance

As test coordinator, Melanie is responsible for ensuring that everything runs smoothly, that the test subjects are doing well, that the scientists get usable data and that all safety provisions are complied with; and that the right member of her team is at the right place at the right time. But with so many parties involved, there is still another task at hand: "Sometimes 40 or 50 people with very different requirements and expectations have to be accommodated – we become mediators between all the parties involved," she says. "That is the difficulty and the challenge."

The physiology laboratory slowly fills up. Umpteen hands tug and pull at the test subject. "Is that too tight?"; "Are we getting a good reading for the blood pressure?"; "Reheat the cherrystone pillows!" The group leader's instructions and questions are short and sharp. The team is coordinated. The first run on the centrifuge can finally begin. The scientists show up now too, to follow the actual experiment. Melanie puts on headphones. Before her on the console is the schedule that sets out the precise test sequence for the test team, down to the second. Francisca May is one seat away – she will monitor Kristina's vital signs during the centrifuge run and stop the experiment as soon as the load becomes too great for the test subject. "Centrifuge starts in one minute," says Guido Petrat, responsible for the technical tasks in the test team. Silence fills the room, and Kristina's face appears on the monitors. The group leader and her team will carry on working on the centrifuge until 15:00 today.

All-rounders and team players

Next day: team meeting. Normally everyone uses small magnets on a white board in the corridor to mark where they will be: centrifuge, Occupational Medicine Research facility, office. An employee photo is stuck to every magnet. Anyone going to the centrifuge quickly pushes their photo forward into the relevant field before going out. Now, however, everyone has gathered in the meeting room. Melanie points to the year planner: eight tests are set for 2012 alone. Biologist Alexandra Noppe has already been entrusted with a three-week bed confinement test focusing on nutrition. Andrea Nitsche is planning and organising an isolation test in which the test subjects are set to live with robots. Can robots respond to humans and motivate them? "This will definitely be exciting," says Melanie.

The work of the team is diverse: from technical support to laboratory activities to the medical supervision of the centrifuge run. Of course, the volunteer should not get cold feet.

Vanja Zander has already carried out one centrifuge test this year, in which researchers are investigating how artificial gravity affects brain functions during spinning. He is now planning and designing the scientific aspects of the new centrifuge that will be used at the Institute's ':envihab' facility. Also at the table are the doctor, Francisca May, the two technicians Guido Petrat and Wolfgang Doering, and student assistant Anja Simon, whose tasks include searching for test subjects. Announcements on the website, advertisements or simple word-of-mouth ensure the availability of sufficient test subjects. But it is not always easy to find the right person for a specific test.

The project leader taps on the planner in front of her: "This is being pushed back, so this test can start later." They all put their heads together, briefly nod; then come the first task allocations and questions. The test team consists of all-rounders and team players. Anyone appointed as coordinator for a test is responsible for the entire work package, from start to finish. Anyone needing technical support will have to be assisted by the technicians. Melanie wants flat hierarchies. "The team functions well because there are short paths between each contact, because they are so close," explains Wolfgang Doering, who is also responsible for managing the test data.

The main thing – human contact

Careful planning must be carried out so that the deployment of personnel, available time on the Institute's research facilities, the search for test subjects, as well as maintenance of the equipment and facilities come together seamlessly. The detailed approval applications that the team submits to organisations such as the Ethics Commission of the North Rhine Medical Association take time to prepare. These set out the exactly what the test aims to accomplish, how it will be run and, of course, the required criteria for the test subjects. Even the number of electrodes and volume of blood samples must be specified precisely. "A bit tricky sometimes, but essential," says Melanie. "It only stops being fun when the time spent on paperwork is too long." But that is all part of the job, and the group leader takes it in her stride.

"The best thing is that I get to deal with so many different people – scientists, test subjects, team colleagues, clients." Before joining the test team, the biologist worked in the gravitation biology section at the Institute. However, two children, combined with scientific research and publishing proved a challenge. "It did not work well." Now, she and her team take pressure off scientists and reduce planning and organisation for them. "It has turned out to be a perfect combination: I still have a scientific aspect to my work, I learn a lot, and no working month is like another." ●

More information:
http://s.dlr.de/4jv2
www.DLR.de/ME/en/

Prepare for take-off

If Alexander Gerst were superstitious, his lucky month would be May. The 36-year-old was born on 3 May 1976 in Künzelsau, in the Hohenlohekreis district of Baden-Württemberg in Germany. On 20 May 2009, the European Space Agency (ESA) presented him to the public as the only German among six new astronaut candidates. And in May 2014, the geophysicist and volcanologist is expected to set out on his first long-duration mission – six months on the International Space Station (ISS), in low Earth orbit, at an altitude of around 380 kilometres. The 1.86-metre-tall sport and nature loving scientist has done most of his training for everyday life in microgravity at the European Astronaut Centre in Cologne, the NASA Johnson Space Center in Houston, Texas, and the Yuri Gagarin Cosmonaut Training Center of the Russian space agency Roscosmos in Star City, 30 kilometres east of Moscow.

Alexander Gerst trains for the adventure of his lifetime

By Elisabeth Mittelbach

Against an evocative soundtrack of summer birdsong, the espresso machine in ESA's meeting room in Star City is bubbling away. It is 08:30. ESA liaison Yuri Kargapolov sits in front of his computer, typing emails between taking phone calls. The Russian has been working in the Gagarin Cosmonaut Training Center, GCTC, for 40 years. He knows every blade of grass in the four-kilometre-square historic site, and has accompanied countless cosmonauts and astronauts during their training periods here. Russian, European, Japanese, United States and Canadian spacefarers have learned about the specifics of Russian space travel systems in the GCTC. Their main course of study concerns the Soyuz launchers and spacecraft, the only current mode of transport for ISS crewmen, which ESA astronaut Alexander Gerst will be riding to the station in less than two years.

On 18 September 2011, ESA announced that Alexander Gerst would complete his first spaceflight as the onboard engineer on ISS Expeditions 40 and 41, from May to November 2014. Since the beginning of 2012, the 36-year-old has been undergoing specific mission preparation that he will complete in July 2013. After that, the ESA astronaut must prepare as a backup crew member for ISS Mission 39.

As if he had heard his name called out, Gerst emerges from one of the doors leading to the main corridor of the ESA floor. Flashing a smile, the next German ISS astronaut has just left his one-room apartment. Wearing blue ESA overalls and with a black rucksack on his back, he bounds down the stairs and jumps onto his white mountain bike. As he hits the pedals, he tells us that his training session in the Soyuz spacecraft begins at nine o'clock. I climb into Yuri Kargapolov's car and we take the same route, but on four wheels. We meet the astronaut five minutes later at the Soyuz training centre. At the end of the long hall stands the 'scene of the crime', where Gerst will spend the next three hours. Trainer Viktor Spirin will accompany him to familiarise the 36-year-old astronaut with the technology and life support systems in the Soyuz capsule. This Russian spacecraft has easily been the most robust and reliable taxi into space since the1960s. But no technology is infallible. Alexander Gerst will be intensively trained to deal with every possible critical situation.

So, with shoes off, he passes through the circular hatchway into the space capsule's cylindrical launch module. There is not a lot of room here for the three astronauts. On a real flight, wearing bulky spacesuits, they are jammed into their bucket seats like babies, their legs bent and their backs curved. Every centimetre of the cramped 3.5 cubic metre volume fulfils a function. Life support, control and parachute systems, among other things, are crammed within it. "We are in here during the many hours of launch preparation and for the first eight minutes after launch," explains Gerst. That is the time between the initial ignition of the rocket engines and the spacecraft

Done, for now: Alexander Gerst exits the Soyuz space capsule after his training session at the Yuri Gagarin Cosmonaut Training Center near Moscow,

achieving an initial, temporary orbit, before it continues on to the ISS. Orbit is a function of speed, of course: the Soyuz reaches a speed of around 28,000 kilometres an hour after leaving the atmosphere. Such a speedy trip into airless void has to be treated with respect: Gerst is methodically training for his first spaceflight, planned for May 2014, through physical exercise and the ability to handle on-board equipment in a safe, proper way. "The spacesuit is also part of our life support system. It provides us with oxygen, among other things, and is critical for survival in the event of a fire, for example," the geophysicist explains. There are no conventional fire extinguishers on board Soyuz. "In the event of fire, we close our visors, pressurise our spacesuits and vent the capsule atmosphere into space. This extinguishes the fire because there is no longer any oxygen for it to consume."

Alexander Gerst goes through this and other scenarios with his trainer multiple times – first in his blue ESA overalls, then in a Russian Sokol spacesuit, which in the event of an emergency he must be able to put on in the dark and in under three minutes. His concentration is total as he listens to the explanations in Russian, his eyes fixed on the numerous controls in the Soyuz capsule. He familiarises himself with the spacecraft in the truest sense of the phrase: every hand movement must be precise. If a procedure is unclear, he asks for clarification– in Russian, of course. The German astronaut and his teacher are in almost constant radio contact with another trainer in the neighbouring control room. "Again, this is like reality," says the 36-year-old. "We are in contact with the ground control station in Moscow at regular intervals and have alarm and warning systems on board to inform us of any malfunctions, if there was a problem with the ignition of one of the rocket engines, for example. On our way to the Space Station, we must regularly carry out boost manoeuvres to raise the orbit of the spacecraft and set it on the correct path to rendezvous with the ISS."

Food is served cold in Soyuz

Alexander Gerst and his two colleagues will spend most of the two-and-a-half day flight to the ISS in the habitation module of the Soyuz spacecraft. Slightly larger than the launch capsule (returned to for re-entry), it has everything required for life in space: four days' worth of dry food, water supplies, an easily stowable toilet designed for microgravity, and a change of clothes. Everything has its place. The astronauts must each consume 3000 calories per day – bread, cereal bars, meat, vegetables or fish; all vacuum packed and preserved. In addition, there are exactly 2.5 litres of liquid on hand per person – water and juice. "In the Soyuz spacecraft, food remains cold, but on the ISS we have an oven in which we can heat food up. There are also hot drinks such as tea or coffee there," says Gerst, describing the supply situation. But the prospect of a special diet does not trouble the scientist one bit, as it means he will be on his way to fulfilling his greatest dream.

Even as a small child, Gerst was fascinated by space. His grandfather was an amateur radio enthusiast. A radio message that he sent towards the Moon for the young Alexander lit the spark for the enthusiasm that has carried through to today. During his geophysical studies, his curiosity and evident 'explorer gene' took Gerst to remote volcanoes in New Zealand and Hawaii and on research expeditions to the Antarctic. Here he learnt to get by in very difficult conditions. Not such a bad preparation for survival training in the wilderness, which was also on his astronaut-training to-do list. Throughout his 16-month basic training, Gerst coped well in the wilds of Sardinia for several days without food.

His Soyuz training in Russia also included a 'survival' module. "In the course of four days we simulated various landing manoeuvres and practised appropriate procedures next to a lake in the vicinity of Star City," recounts the ESA astronaut. After a dry run on land, they took to the water with the floating Soyuz space capsule. Gerst and two kindred spirits, including crewmate Reid Wiseman then had to complete various tasks. "If time permits, we take off our heavy spacesuits in the capsule and put on more flexible thermal dry suits in the event of a water landing. If we have to abandon the capsule because of a problem, these suits will stop us from cooling down so quickly – something critical for survival in cold water. If we do not have time, for example if the capsule has a leak, we have under seven minutes to get out of the spacecraft and into the water in our spacesuits with our survival equipment and then save ourselves."

In training the splashdown was successful. However, the next German astronaut hopes that he can exit the spacecraft after landing without having to swim. In the event of an emergency landing, which could take place almost anywhere on Earth, it could be a few days before the rescue team finds the spacefarers. Therefore, Gerst has also learned how to make a tent out of his parachute, make a fire using meagre materials and catch fish. "In our three and a half years of preparations, we are prepared for a vast range of eventualities – on board the ISS, on the flight there and on the return journey to Earth. The aim is not just to completely familiarise ourselves with the operations and tasks on the Space Station, but also to get to grips with adverse conditions on Earth," says the geophysicist, radiating impressive inner calm and composure.

A scientist at heart

Alexander Gerst has respect but no fundamental fear of extreme and unusual situations. He experienced this for the first time at a seismometer station on a 4000-metre-high ice plateau in Antarctica, where, in his own words, he understood "the true meaning of solitude." His doctorate degree took him to the crater rim of Mount Erebus, the most southerly active volcano on Earth, where he spent six weeks at minus 45 degrees Celsius in a small tent. A modern Alexander von Humboldt? Yes, in a certain way. Like his famous namesake, Alexander Gerst is a scientist at heart. His thirst for knowledge drives him to Earth's frontiers. Accordingly, the third German ISS astronaut is looking forward to the next 12 months: "Then, I will be informed about the experiments that I will need to complete during my stay on the Space Station." One thing is certain – his research work will be spread across three modules: the European Columbus module, the United States Destiny module and the Japanese Kibo module. And he also knows that his experiments will deal with key areas: investigating how astronauts can best survive in microgravity, preparing for future deep space missions and using the lack of gravity in space to find ways to improve terrestrial ways of working. "So, for example, we want to use fluid dynamics tests to get a better understanding of combustion processes in power generators. This can ultimately help to save fuel and reduce carbon dioxide emissions on Earth. Other experiments will help us improve the treatment of medical conditions such as osteoporosis or strokes."

The scientist will work on some 50 to 60 experiments covering widely differing areas during his long stay on the ISS – from medicine and biology to materials science. But that is still in the future. For now, the next German astronaut must master the Soyuz test... ●

More information:
ESA: http://is.gd/PUKlWs
DLR: http://s.DLR.de/sa3v
Alexander Gerst homepage: www.planet3.de

Every bit of the 3.5 cubic metre space in the launch module is used

During the flight to the ISS, the astronauts will go into the habitation module of the Soyuz, which Alexander Gerst knows very well. His trainer, Viktor Spirin, explains among other things, the menu and how the toilet works on Soyuz.

The DLR Magazine is not the only one interested in Alexander Gerst

Germany's eye on Mercury

2015 marks the start of the European Space Agency's BepiColombo mission to Mercury. After a six-year interplanetary transfer phase, the twin probes making up the mission will enter orbit around the innermost planet of the Solar System. As of 2022 the Mercury Planetary Orbiter, MPO, will spend at least one year exploring Mercury's Sun-scorched terrain, whose surface temperatures can reach a blazing 470 degrees Celsius. The data acquired by the orbiter's various instruments will provide scientists with new information on the planet's composition and properties. These include MERTIS, an advanced thermal infrared remote sensing instrument, its development led by DLR and the University of Münster. German academia and industry teamed up to produce the instrument, along with Polish researchers. MERTIS is being delivered to ESA for integration into BepiColombo in 2013.

German-Polish infrared spectrometer for the European/ Japanese BepiColombo planetary exploration mission

By Jörn Helbert and Gisbert Peter

The MErcury Radiometer and Thermal Infrared Spectrometer, MERTIS, is one of 11 scientific instruments aboard Europe's MPO. It is based on a novel highly-integrated instrument concept, with a three kilogram mass and power consumption of only 10 watts. Fifteen years ago, the mass and power consumption of comparable spectrometers for use in space – such as ESA's Rosetta comet rendezvous mission, launched in 2004 – were around five times higher.

The imaging spectrometer will be used to map the mineralogical composition of Mercury's entire surface. This involves capturing hyperspectral data within the thermal infrared region of the spectrum – the heat radiated back from Mercury's rocks – which is light at a wavelength of between seven and 14 microns. In addition, a microradiometer in the same optical path enables the instrument to measure the temperature and thermal inertia of the planet's surface, even on Mercury's much colder night side. While in orbit the system will be calibrated continuously: alongside the spectral data from Mercury's surface, data from three calibration sources – two onboard 'blackbody' sources kept at different temperatures and the extreme cold of deep space – will be tracked.

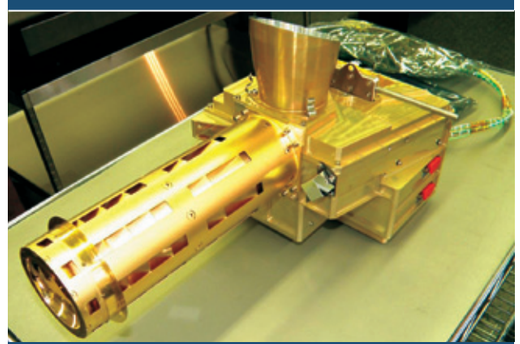
DLR designed the system on the basis of theoretical sensor models, and is calibrating the instrument and verifying its optical performance in a specially-equipped infrared laboratory in Berlin. The Planetary Emissivity Laboratory has been specially set up to provide scientific support to the MERTIS instrument, and enables spectral measurements of minerals to be made at 'Mercurial' temperatures of up to 500 degrees Celsius. ●

About the authors:
Jörn Helbert is a member of the scientific staff at the DLR Institute of Planetary Research and Co-principal Investigator for MERTIS.
Gisbert Peter is a member of the scientific staff at the DLR Institute of Robotics and Mechatronics and is the Project Manager for MERTIS.

More information:
http://is.gd/Vm58tT
http://s.DLR.de/ip7h

Making of MERTIS

MERTIS was developed in close collaboration with partners from German academia and industry, under the scientific leadership of the University of Münster in tandem with the DLR Institute of Planetary Research and the Department of Optical Sensors and Electronics of the DLR Institute of Robotics and Mechatronics in Berlin. Also involved were ESA, Kayser Threde GmbH (Munich), the Fraunhofer Institute for Applied Optics and Precision Engineering (Jena), Astro- und Feinwerktechnik Adlershof GmbH (Berlin) and Ingenieurbüro Ulmer, (Frankfurt / Oder). The Polish Space Research Centre in Warsaw is an international partner, and is responsible for developing the highly reliable rotating mirror system that enables constant onboard calibration of the two infrared sensors.



Structural and thermal model of MERTIS

What's in a name?

The BepiColombo mission is named after Italian mathematician and engineer Giuseppe Colombo (1920 – 1984) who was nicknamed 'Bepi'. Colombo became forever associated with Mercury when he calculated the orbital path for NASA's Mariner 10, humanity's first mission there.

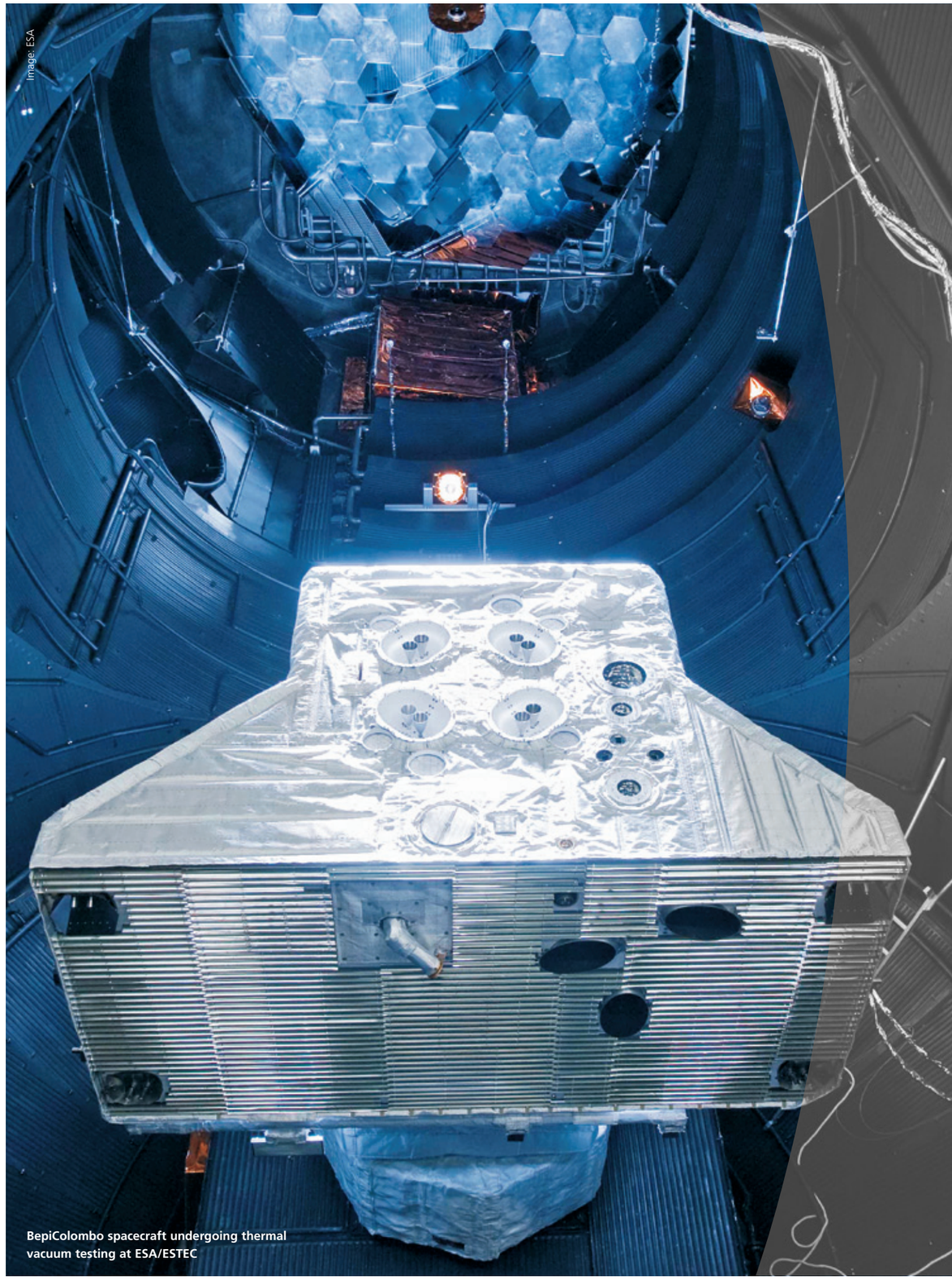


Image: ESA

BepiColombo spacecraft undergoing thermal vacuum testing at ESA/ESTEC

Siemens-Halske rotary engine from 1917. In this type of engine, the cylinder block – 11 cylinders arranged in a star formation – rotated around the fixed crankshaft. These engines did have a weight advantage, but were problematic for pilots due to the strong gyroscopic forces they generated and their high oil consumption.

Final destination

Technology museums, especially aviation museums, have a growing attraction. Nowadays, aircraft are largely taken for granted as a means of transportation, but people leap at the chance to find out how such modern technologies came to be. It is not surprising, then, that such museums attract more than just aviation enthusiasts. Their popularity with the general public is clear, and they are often used to teach children more about the world of aviation. At present, there is a wide choice of interesting aviation museums in Germany, filled with excellent exhibits. But other European cities with an aviation history are also making a name for themselves. Unusual in a number of respects, the Lotnictwa Polskiego (Polish Aviation) Museum in Kraków is high on the list.

The Lotnictwa Polskiego Museum near Kraków celebrates the history of aviation in Poland and Germany

By Hans-Leo Richter

The modern reception building, designed by the Berlin architect Pysall, is a harmonious combination of concrete and glass.

With more than 200 aircraft and an entire hangar full of historical aircraft engines and numerous individual components, it is more than just the biggest aviation museum in Poland: this vast collection can definitely be considered as one of the largest aviation collections in Europe. Even the site is steeped in history. The Rakowice-Czyzyny airfield was established in northeast Kraków before the First World War. As far back as 1892, the site was being used by an Austro-Hungarian regiment to launch observation balloons. The first airport in Poland, it underwent continuous expansion over the years. However, in the 1960s a completely new airport was built to the west of Kraków, and the old airfield was closed. Polish aviation enthusiasts took advantage of this opportunity and established the first aviation museum in Poland on the abandoned site.

Today the Lotnictwa Polskiego Museum is firmly established in the field of aviation, and is known primarily for combining Polish and German aviation history. Its extensive collection includes more than 20 aircraft and numerous engines that were once part of the German aircraft collection in Berlin, famous in the 1930s for being the largest aviation museum in the world. At that point, Berlin was home to almost everything of note in aviation history, from the Lilienthal glider to the huge (by the standards of the time) Dornier Do X, a flying boat, with an amazing 12 engines.

As the German capital began undergoing more frequent bombings during the course of the Second World War, those in power came up with the supposedly clever idea of moving the

More than 20 different MiG fighter jets are on show in 'MiG Alley'

Prototype of the PZL MD 12F, a Polish-developed aerial photography plane.

A real rarity is the PZL M 15 'Belphegor', the world's only jet-powered agricultural aircraft. The columns connecting the upper and lower wings house the chemical tanks.

national treasures to Pomerania, which was still relatively peaceful at the time. The collection was largely transferred in three chartered rail shipments in 1943. With the looming chaos at the end of the War, nearly all of this splendid collection disappeared – except for the 20 or so exhibits currently displayed in Kraków. Those that remained in Berlin mostly fell victim to the bombing raids.

At present, aviation historians, museum curators, diplomats and lawyers from both countries have differing opinions regarding the ownership of the ageing treasures, which has led to anger and misunderstanding on both sides. There is still no foreseeable agreement on the matter, but none of this can or should take away from the museum itself. For aviation enthusiasts – especially those interested in history – the concern is that these remarkable aircraft and aeroplane components are fully restored and publicly displayed, and today a suitable venue has been found in the museum near Kraków. Since the autumn of 2010, the museum no longer displays its exhibits solely in old hangars and workshops; following five years of planning and construction work from a design by Berlin architect Justus Pysall, a new reception and central building have been constructed. These set an impressive new standard in modern museum design, featuring a bold, futuristic concrete and glass architecture. From the air, the building resembles an origami model of an aircraft. The construction itself suggests a shape like that of a triangular wing, a wind turbine or a propeller.

Visitors first notice the enormous concrete elements that, to a large extent, encircle the glassy reception and exhibition halls. In these, visitors can see the first treasures and models as well as their history in fully stocked display cabinets. A Lilienthal glider, a replica of famous aviation pioneer Louis Bleriot's monoplane and other aircraft – suspended from the ceiling as if in flight – also greet the visitors. Of particular interest to children and teenagers is a small model wind tunnel, a somewhat primitive flight simulator and also the famous aerotrim, or pilot/astronaut training gyroscope. In addition, the futuristic reception building contains a small cinema, a library and numerous event areas.

But the real treasures in this spacious museum are actually found in the open air and in the preserved hangars and workshops. The eye is quickly drawn to a vivid blue, single-engine light aircraft, the 'Kukulka', or 'Cuckoo', which its creator Eugeniusz Pieniazek built at home using parts from two gliders, and in which he later flew from Poland, across Yugoslavia and on to Sweden. Another significant exhibit from Polish aviation history is the single-engine jet trainer 'Iskra', or 'Spark'.

Of course the famous protagonists from the Cold War – the MiGs, Antonovs, Yakovlevs and Sukhois – have not been left out. Numerous types of MiG can be admired on their own in 'MiG Alley', but there are also representatives of the, then, rival air forces of the People's Republic of Poland: a Saab Draken, a Fouga Magister, a Mirage and even a somewhat stripped down Starfighter. However, the aircraft are left out in the open air, apparently at random and with little in the way of explanation, unshielded from the weather – and it shows, with canopies that have turned opaque, faded or peeling paintwork, perished rubber seals, amidst other signs of decay. With no sign of any restoration work being done, this area is sadly more reminiscent of a graveyard than a museum.

A wealth of rarities

Thankfully, the real treasures have been sheltered from the harsh weather in the old hangars and halls, some excellently restored, but some in an antiquated, even ruined, condition. Besides Polish and Russian aircraft, other highlights include the long, delicate wooden fuselage of the Levavasseur Antoinette (1909), a 1913 Geest Mowe (Gull), a Friedrich Taube (Dove) – a copy of the Etrich Taube – and a 1916 Halberstadt CL.II, the camouflage paintwork of which was designed by contemporary impressionist artists at the Munich Academy of Art. Several Albatros aircraft are also on display, as are the fuselage of an Albatros C.1, a twin-seater Albatros B.II, and the fuselage of a once-planned Albatros H.1 high-altitude experimental aircraft, the wing of which was broken during taxiing tests.

Another rarity is a British biplane fighter, the Sopwith Camel, with a rotary engine, which was captured in 1918 and extensively investigated by the German Aviation Research Institute (Deutsche Versuchsanstalt für Luftfahrt; DVL) in Berlin-Adlershof, a precursor organisation of today's DLR. Finally, one famous exhibit is the surviving fuselage of the former world-record holding Messerschmitt Me 209 V1. Test pilot Fritz Wendel reached 755 kilometres per hour in this sleek, high-speed aircraft in the spring of 1939, an incredible speed for a piston-engine powered plane. This record was not broken until 1969. German wartime propaganda tried to popularise the idea that standard Me 109 fighters could reach such a speed, but this was never the case in level flight. And one other real rarity should not go unmentioned: the fuselage of a Curtiss Hawk, a 1933 American biplane capable of dive-bombing. This was one of two models privately owned by flying ace Ernst Udet, Director General of Equipment for the Luftwaffe, who was given permission to import these two fighter planes by the German authorities, mainly for propaganda reasons. The exhibit is somewhat hidden away in the corner of a hall; this is no surprise, with its clearly authentic yet disreputable insignia painted on the side. The engine cowling sports the Olympic rings, Udet used this plane to demonstrate his impressive aerobatic skills at the opening of the Olympic Games in Berlin in 1936.

A bridal couple in front of a warplane – a 'must have' wedding photograph.

Real heavyweights

But the attraction of this museum is not restricted to historical aircraft. Another hall showcases some 100 aircraft engines – paradise for technology enthusiasts. A small V8 engine from the Antoinette mentioned above various rotary engines (Clerget, Gnome Rhone, Siemens-Halske) and high performance aircraft engines from Daimler, Maybach and Junkers can be admired and inspected. Of particular interest is the cutaway model of the legendary Jumo 205 two-stroke diesel engine with opposing pistons. Furthermore, there are numerous assemblies from Rolls Royce, Bristol, Renault, Mikulin and Argus that both eyes and camera lenses struggle to get enough of. One of the largest and heaviest aircraft engines must be the Argus As 5, a water-cooled 24-cylinder engine in a double-W design. But at 1100 kilograms, this engine turned out to be much too heavy for any actual aircraft…

Visitors will also enjoy driving through the extensive outdoor area, even though the impressions they receive here can sometimes be mixed. The Tupolev 134 transport aircraft on display looks run down, a real disappointment. More interesting – and in significantly better condition externally – is the PZL M 15 Belphegor, a very robust biplane. This Polish domestic development with the wide twin tail is the only jet-powered agricultural plane in the world – an experiment as unusual as it was expensive.

Many might want to find out more about the exhibits. Although the English language explanations are at times rather scanty, those with a thirst for more can get a guided tour offering detailed information from curator Piotr Łopalewski. The lively expert, originally a graphic designer and artist, serves as a right hand to museum director Krzysztof Radwan. Łopalewski has interesting stories to tell about almost every exhibit; he feels at home within this unique aviation collection and is an excellent contact for anyone interested in it.

Numerous restoration projects are planned for the future, and the annual 'Aviation Picnic' – a flying day with an accompanying museum evening – has proved popular with the general public.

Even though the museum information could be improved here and there, this extraordinarily extensive collection of unique exhibits is a must for anyone wanting to learn more about the history of Eastern European and, especially, German aviation. ●

More information:
www.muzeumlotnictwa.pl

This still-unrestored Etrich Taube from 1910 gives an impression of great authenticity. The lightweight monoplane was later built under licence with the name 'Rumpler Taube'.

A somewhat primitive cockpit mock-up engenders enthusiasm for aviation in the young

The attraction of historical aviation lies in detail – the picture shows the propeller and the first two cylinders of a Benz Bz.IIIa six-cylinder engine from the single-seat Roland D.VIb fighter of 1918.

It could hardly be more minimalist – experimental Polish design for a light helicopter.

Here they are in an orderly arrangement, the few remaining items from the lost German aviation collection in Berlin – Roland, Halberstadt, Aviatik, Albatros; lightweight single-seater fighters from the time of the First World War. Names that hardly anyone knows today…

In the entrance hall of the Lotnictwa aviation museum stands an outstandingly restored B.IIa Albatross, a trainer dating from 1917 and one of the few remaining aircraft from the German aviation collection in Berlin – the rest of which are on show in one of the hangars.

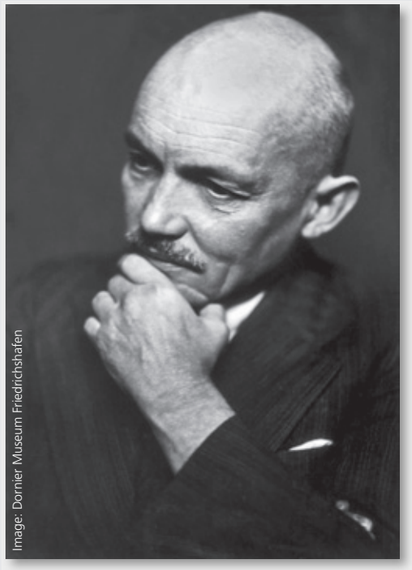


Image: Dornier Museum Friedrichshafen

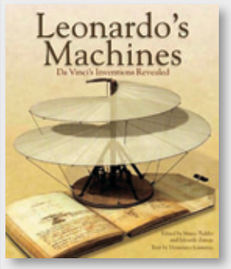
A life in aviation

Claude Dornier's 1966 autobiography, **'My life in aviation' (2007)** shows him to be a creative engineer as well as a resourceful entrepreneur. Despite emphasising early in the book that "had it not been for the need to provide for my parents, brothers and sisters, my engineering career could well have been over before it had started," his personal narrative reveals a passion for designing and improving flying boats. After obtaining a degree in Mechanical Engineering at the University of Munich, a young Dornier had trouble finding work. Many unsuccessful job applications and some unsatisfactory positions later, he finally landed a job at the Zeppelin Airship company in Friedrichshafen in September 1910. His career really took off when he designed a prize-winning revolving hangar for airships, which attracted the attention of Count Zeppelin.

Dornier explains how, after the outbreak of the First World War, the production of airships was terminated, as they were deemed unsuitable for military deployment. Count Zeppelin suggested that aircraft design should be the new focus, and a separate company was set up. Dornier's increasingly successful attempts to construct flying boats were interrupted as the war came to an end and the Treaty of Versailles prohibited the construction of any type of aircraft in Germany. By arguing that the design of aircraft was not expressly forbidden, Dornier managed to keep his own department operational. He moved its assembly division to Switzerland and acquired a shipyard near Pisa for testing. He was able to attract and fulfil orders from the Netherlands, Spain, Japan and ultimately Germany, which secured the survival of the company. Increasing difficulties with the Zeppelin Airship company were resolved when Dornier bought their shares and became sole shareholder in 1932.

He tells us about two attempts on his life, two near-death experiences, and a mob attack. Dornier's descriptions of the company's attempts to buy the Marina de Pisa, the negotiations for the Spanish contracts and his time in Japan are the most vibrant and interesting sections of the book. **My Life in Aviation** offers a rare glimpse into the formative years of Claude Dornier's career. He proudly reveals his transformation from a poorly salaried employee developing a conveyance system for a crematorium into an independent engineer who flew his famous Do-X aircraft across the Atlantic to meet the president of the United States. His passion for design and the strive to give his thoughts a tangible form has also found expression in this autobiography, which is well worth the read.

Merel Groentjes



Revealing Da Vinci's designs

For years, **Mario Taddei** and **Edoardo Zanon** have studied Leonardo da Vinci's original drawings and notebooks, and used digital imaging to generate accurate, computer generated models of his inventions. Together with science historian **Domenico Laurenza** they present over 30 of Leonardo's inventions in their book **Leonardo's machines: Da Vinci's inventions revealed**. The models range from flying machines to musical instruments.

Each invention in this book is accompanied with original drawings and notes. The annotated diagrams by Taddei and Zanon show details of the models and their possible uses in contemporary life. Every model is complemented with Laurenza's fascinating background information about Da Vinci's work. The magical combination of original notes and drawings with modern, computer imaging results in a book that is a must, not only for those interested in Da Vinci's machines, but also for those who are inventors at heart.

Dirma van Eck

Exploring Earth on thin ice

With Planet Earth, the BBC has released a series of modern, yet classic documentaries. The series **Frozen Planet – Ice Worlds** does not cease to surprise; it shows the bizarre beauty of a frost-covered landscape in motion. Up close and from the air, we are shown beluga whales indulging in a mass body scrub to slough off their skin on the stony seabed in the Canadian Arctic. The BBC succeeds in informing, while telling stories; some seem almost cruel, like teams of orcas creating giant waves to wash seals from ice floes. Some are almost cliché showing a newly formed penguin couple wobbling along through the colony.

The photography is also fascinating, obtaining a careful balance between science and emotion. Seven episodes (50 minutes each), such as 'To the ends of the Earth', 'Spring', 'Autumn', 'Winter', 'The last frontier' and 'On thin ice', show animals fighting, mating and rearing their young over and over again – but the camera work is so impressive that one really never gets bored.

Manuela Braun

Flying solo

Amelia is a thrilling account of the extraordinary life of adventure and continuing mystery of legendary aviation pioneer Amelia Earhart. In 1928, her flight across the Atlantic as a passenger in a Fokker F7 named Friendship, made her the first woman to make the trip – airborne. From that moment on, Amelia Earhart's live focused on aviation. Her solo journey began on 20 May 1932, when she took off from Harbor Grace in Newfoundland, en route to Paris. Although harsh weather conditions and mechanical problems forced her to land in a pasture in Ireland, she made it. This extraordinary feat awarded her with the first Distinguished Flying Cross ever given to a woman.

Earhart's knack for adventure is clearly portrayed in the film. In the years that followed she also became the first person to fly solo across the Pacific. With her 40th birthday around the corner, Earhart felt she was prepared for a monumental, and final, challenge: to be the first woman to fly around the world. On 1 June 1937, Earhart and Fred Noonan began the trip in the twin engine Lockheed Electra. About a month later, she mysteriously disappeared. To this day, there is no proof of her fate, but the world will always remember the aviatrix for her courage and ground-breaking achievements in aviation. The film is truly a series of events, at times less exciting than one would expect, but with exceptional photography.

Karin Ranero Celius

A chronology of aircraft

At around 450 pages, **The World's Greatest Aircraft** is a comprehensive guide to the aircraft of all nations, from the First World War to the present day. In addition to a catalogue of aircraft there is a chronology of flight from around 843 BC to the present day. Accompanying a large coloured drawing of each aircraft viewed from the port side are smaller monochrome drawings and a photograph. A history of the aircraft and a table with details of dimensions, weights and performance rounds off each page. The catalogue is divided into sections such as piston-engined fighters, civil turboprop transports and racing/sport aircraft. A comprehensive index makes finding a particular aircraft easy.

The chronology begins, unfortunately, with the first aviation fatality. King Bladud of England died while attempting to fly using feather wings. Not a good start! But things improve as the Montgolfier and Wright brothers get things 'off the ground'. Later entries also cover space activities – both manned and unmanned. In summary, a handy reference. The DLR Magazine editors keep a copy on their bookshelf for reference.

Peter Clissold

About DLR

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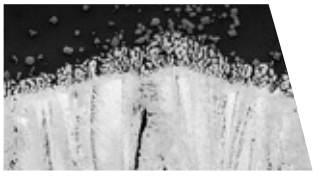

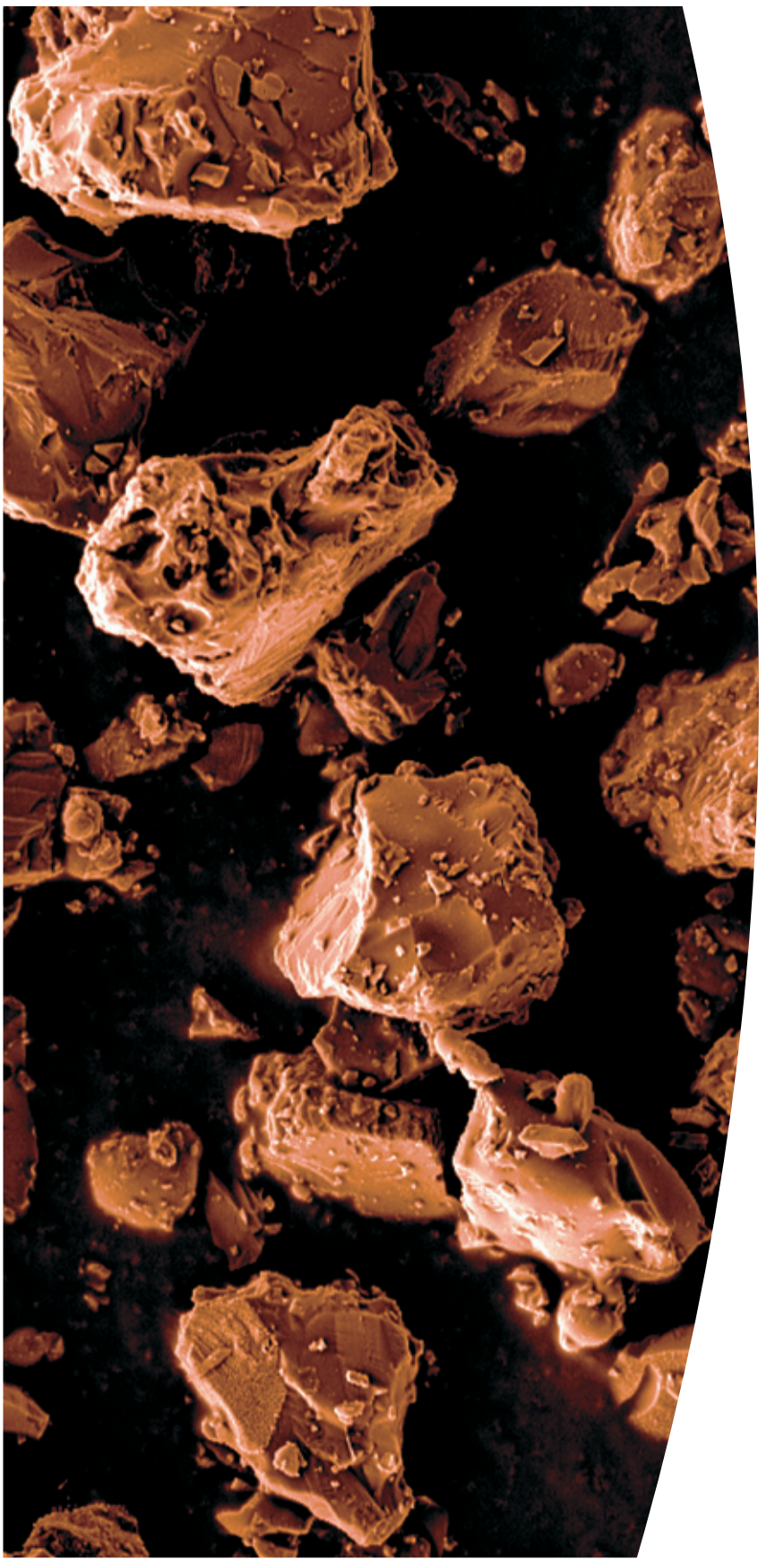

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