DLR magazine

of DLR, the German Aerospace Center · No. 146/147 · September 2015

SUMMIT FLIGHT IN THE MIDNIGHT SUN

THE WIND HAS THE FINAL SAY – MAPHEUS-5

LIFE IN SPACE FOR LIFE ON EARTH – Bed-rest studies at :envihab

A MATTER OF PERSPECTIVE – Seeing materials and wild orchids

DLRmagazine 146/147

Image: DLR/Gesine Born

Dear readers,

Let's hope that this unusually warm summer – for our latitudes – lasts a little while longer. We would very much like some dry and sunny weather on 20 September – German Aerospace Day. The aircraft exhibition, the stage programme for our visitors – big and small – and everything else that we have planned for you, will be even more enjoyable if the Sun is shining. The weather has been known to put a damper on research campaigns, too – for instance, the launch of the MAPHEUS-5 research rocket from the Swedish Esrange Space Centre, in the Arctic Circle, where the wind challenged the researchers – more than once.

Even the best laid plans of mice and men sometimes go awry, and painstakingly prepared flight tests are not immune to setbacks. A faulty door, temporarily grounding our Falcon research aircraft in a hangar in Iceland, can leave everyone on site bathed in a cold sweat. After all, the plan to conduct atmospheric wind measurements was only possible within a defined 'weather window'.

But DLR researchers do not spend their days globetrotting. This edition of the magazine reports on various daily events and people at DLR, and they are never short of a story or two – Albert Manero, for instance, who conducts non-destructive tests on materials intended for use in aviation and aerospace, is also at the heart of an initiative supported by The Collective Project. Here, 3-D printing is used to manufacture prosthetics and the designs are available free of charge. He is driven by the idea that no child should have to pay for a prosthetic limb. At DLR, people are also willing to participate in long-term bed-rest studies for the benefit of mankind – on Earth and in space – at the medical research facility :envihab.

Here, we will also meet the materials researcher Klemens Kelm, who works with the intricacies of scanning electron microscopy, but enjoys photographing wild orchids on the DLR grounds after work. A lot to do with perspective and, again, weather permitting…

Sabine Hoffmann
Head, DLR Corporate
Communications Department

THE WIND HAS THE FINAL SAY – MAPHEUS-5 8

SUMMIT FLIGHT IN THE MIDNIGHT SUN 28

COMMENTARY 4

A 'MOLE' TO TAKE MARS' TEMPERATURE 26

EUROPE'S FLAGSHIP WIND TUNNEL IS IN COLOGNE 50

COMMENTARY 4

IN BRIEF 5

THE WIND HAS THE FINAL SAY 8
MAPHEUS-5 – mission into microgravity

LIFE IN SPACE FOR LIFE ON EARTH 16
Bed-rest studies at :envihab

THE 'GOLDEN SNITCH' OF RE-ENTRY 22
Thermal protection system ensures cool core of capsule storing images of ATV-5 re-entry

A 'MOLE' TO TAKE MARS' TEMPERATURE 26
InSight – a NASA mission to learn more about terrestrial planets

SUMMIT FLIGHT IN THE MIDNIGHT SUN 28
The Falcon flies over Iceland and Greenland

AT THE CROSSROADS – MEGACITIES 36
Interview with traffic engineer Alexander Sohr

ABOUT STARS AND AIRPORTS 38
Astronomers and aviation researchers – united by more than just the sky

SMALL PARTICLES THAT CAN WREAK HAVOC 40
New test rig to study the effect of volcanic ash on aircraft engines

A MATTER OF PERSPECTIVE 42
Interview with Klemens Kelm on prepared specimens and wild beauty

MAKING A DIFFERENCE 46
Albert Manero – a materials researcher with a touching project

A COMET LANDING – THE STORY CONTINUES... 48
The Philae lander on 67P

EUROPE'S FLAGSHIP WIND TUNNEL IS IN COLOGNE 50
Part 4 of the series 'The Wind Machines'

AT THE MUSEUM 54

REVIEWS 57

INTO THE FUTURE WITH DLR

By Pascale Ehrenfreund

Pascale Ehrenfreund, Chair of the DLR Executive Board since August 2015.

2015 – a year of change! For me, personally, this transpired in the form of a new job. In society, we are facing developments that challenge our knowledge and creativity as a whole. There are global questions that our previous experience does not even come close to finding suitable answers for.

Taking over as Chair and leading the German Aerospace Center (DLR) is truly a major new task for me – one inevitably linked to change. I am now responsible for 8000 employees at 16 locations in Germany that work in the fields of aerospace, energy, transport and security – some of which are new to me. But, will everything be different? As an astrophysicist, I am very familiar with spaceflight. I have been involved in numerous space exploration missions and experiments on the International Space Station. My professorship at the Space Policy Institute of George Washington University (DC) has given me real experience in space policy. As President of the Austrian Science Fund (FWF), I have been closely involved with promoting the advancement of fundamental research and its effect on the innovation chain.

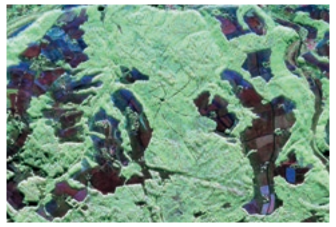
But this is not about me – this is about DLR. With its portfolio of research activities, DLR is one of the world's leading scientific institutions. I am honoured and fascinated to have been given the opportunity to guide DLR into a future filled with challenges – this has been a major aspiration of mine. The research results achieved here do not only strengthen key areas of the national German industry – DLR also provides important solutions for tackling today's major global challenges: climate protection, utilisation of new forms of energy, sustainable mobility, unprecedented levels of quality for communication and navigation. Frontier research is essential for a leading research centre such as DLR. The increasing importance of radical innovations requires more willingness to take risks in research – in the long run, progress is not possible without it.

DLR boasts a treasure of more than 100 years of experience in aviation. In Germany, it is the home of space research and administration. In recent decades, DLR has also acquired important core competencies in energy and transport research. As a research institute, space agency and project management agency, DLR is a one-of-a-kind institution with a high potential for synergy. If we exploit this potential through intensive collaboration in all areas, I am certain that DLR can achieve even more. In addition, I consider it highly important to strengthen DLR's European and international ties. No nation can solve the current problems of the world alone.

2015 is a year of change – for me and for DLR. But DLR does not need to reinvent itself for this. Important foundations for future developments have been laid by its strategic orientation. Bringing these to life, seeing international collaboration as a major opportunity, encouraging the spirit of innovation in industrial collaborations as once in Silicon Valley, generating knowledge for tomorrow in this ONE DLR – what a magnificent task.

THROUGH TANGLES OF TREETOPS AND BRANCHES

Three-dimensional visual representation of forest areas



Polarimetric radar image of the test area near Traunstein, in south-eastern Bavaria, acquired by the F-SAR sensor. Forest areas appear in green; surfaces with low vegetation are shown in blue / red.

In an attempt to develop three-dimensional pictures of forest areas, DLR and NASA have successfully tested new radar technologies and their ability to infer parameters, such as the height and vertical structure of forests. The F-SAR system, which was developed by the DLR Microwaves and Radar Institute, was used to acquire the images. SAR technology (Synthetic Aperture Radar) scans surfaces using electromagnetic waves. The data collected can then be used to generate a three-dimensional image. But this is no easy task with forests because there are few sensors that are able to look through the dense foliage. In creating the F-SAR system, DLR developed radar technology that can visually represent forests in high resolution and in three dimensions, from the crowns of the trees down to the ground, enabling the structures to be seen. The system allows simultaneous measurements at several wavelengths. This means that F-SAR only needs one overflight to map different levels of the same terrain.

A forest's structure also reveals the biomass it contains. As a natural storage mechanism for carbon, biomass directly influences the greenhouse effect. Radar tomography opens up entirely new and efficient avenues to identify one fundamental climate factor. Following this, the DLR scientists are keen to establish 3D radar mapping as a standard operating procedure – and also to install the technology on satellites.

s.DLR.de/6l9y

VOYAGE TO THE EDGE OF THE SOLAR SYSTEM

NASA's New Horizons spacecraft reaches the Kuiper belt

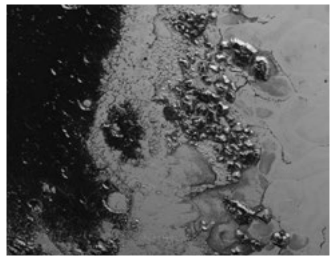


Image: NASA/JHUAPL/SWRI

Pluto at a distance of 768 kilometres, captured by the Long Range Reconnaissance Imager, LORRI, on board New Horizons.

Lower image: The mountain range in the dwarf planet's 'heart'

This is the first ever mission to the outermost edge of the Solar System. NASA's New Horizons spacecraft also passed by the dwarf planet, Pluto, and its moons on its way through the Edgeworth-Kuiper belt. When passing the planet, the probe managed to capture details and surface structures, and render these clearly visible in a way that has never been possible before.

On 14 July 2015, after a nine-and-a-half year journey and at a distance of approximately 4.9 billion kilometres from Earth, New Horizons flew past Pluto and its icy moon, Charon. Seven scientific experiments acquired images and recorded spectra and physical parameters from a distance of 12,500 kilometres.

"What is particularly startling is Pluto's geological activity, which makes it especially interesting for planetary scientists. Its surface is characterised by volcanism far younger than for example, Jupiter's moon Callisto. The structures did not arise by silicate lava, as on Earth, but rather a series of liquid ice mixtures on Pluto's surface," says Tilman Spohn from the DLR Institute of Planetary Research. At the request of the German Federal Government, the DLR Space Administration encouraged the participation in the Radioscience Experiment (REX), designed to obtain the temperature and pressure profiles of Pluto's atmosphere while measuring radiometric temperature, gravitational moments, ionosphere structure and determine the masses of Pluto and Charon. In addition to REX, there are three optical instruments, two plasma instruments, a dust sensor and a radio science receiver/radiometer. Having successfully flown by Pluto, the spacecraft is now continuing its journey through the Kuiper belt, where it will collect and deliver more data from the edge of the Solar System – and send it back to Earth.

s.DLR.de/1bct

SPACE CAMERAS AS EARLY WARNING SYSTEMS FOR FOREST FIRES

Up to 10,000 square kilometres of forests are destroyed by fire in Europe every year. Early warning and fast extinction of forest fires are the only ways to avoid major casualties and damage to nature. For this purpose, DLR developed the FireWatch camera technology 20 years ago. In recent years, a small DLR team at the Institute of Planetary Research – supported by DLR Technology Marketing – has been cooperating with industrial partner IQ wireless GmbH to take the development of FireWatch to the next level. Five federal states in Germany have installed 180 cameras based on technology found in the ROLIS camera on the Philae lander, which acquired spectacular images of Comet 67P. Today, nearly 100 percent of endangered German forests are monitored by FireWatch. Due to the success, foreign forest services have become interested in the system. Installations have been made in several European countries, Mexico, Kazakhstan and the United States. Currently, the systems monitor about five million hectares of forest and scrubland around the world.

s.DLR.de/zrbn

NEW EUROPEAN WEATHER SATELLITE

Since 15 July 2015, the climate sensors in space have been strengthened with the addition of a new satellite: MSG-4 (METEOSAT Second Generation) was sent into space on board an Ariane 5 rocket, which was launched from the Space Centre in Kourou, French Guiana. MSG-4 is the last of four satellites in the second METEOSAT Generation, and will be the first data source for weather forecasts and real-time warning systems for the German Meteorological Service (DWD). One of the main tasks of the MSG satellites is the prediction of extreme meteorological events such as heavy rain, hail and storms, and reduce damage that could result from severe weather situations. The 2.4-metre, barrel-shaped satellite spins counter-clockwise at 100 revolutions per minute around its longitudinal axis, which is aligned with Earth's rotational axis.

Image: 2015 EUMETSAT

FASTER TREATMENT IN AN EMERGENCY

Faster communication between health care professionals, patients and individual specialist clinics is the aim of the project MA-RIKA. It responds to the increasing risk of suffering a stroke and heart attack in an ageing society. For this reason, DLR, the University of Münster, opwoco GmbH and metacrew consulting GmbH have developed the smartphone application MA-RIKA. The pilot project in the Münsterland region provides the user with information on the nearest suitable medical facility – vital in the event of life-threatening emergencies in the elderly. The close cooperation and intensive exchange of information between certified hospitals and emergency services via a mobile application ensure a rapid and reliable assistance in emergency situations.

Image: www.udo-geisler.de

SOLAR-MELTED ALUMINIUM

South Africa has plentiful solar energy and – at the same time – possesses a large aluminium processing industry. Researchers and industry are cooperating within the SOLAM (solar melting of aluminium in a directly radiated rotary kiln) project to develop a method by which aluminium foundries could use solar energy to melt this metal. The method would allow the companies to reduce their electricity consumption to a great extent and substantially lower their carbon dioxide emissions. A 'rotary solar kiln' will be used to melt and recycle aluminium. The rotational movement of the rotary kiln continuously mixes the aluminium that is deposited in the drum, ensuring an even distri bution of heat. Solar energy is used to heat the aluminium. Using solar mirrors, the researchers will focus the solar radiation, achieving the necessary temperatures of approximately 700 degrees Celsius.

s.DLR.de/9925

LESS NOISE AND BETTER HELICOPTERS

NASA and DLR have agreed to continue their ongoing cooperation in aeronautics. They want to create accurate noise predictions for two virtual aircraft configurations. Acoustic measurement data will be used as a basis for this research. The data was gathered by DLR during previous scientific flights conducted using DLR's now decommissioned research aircraft, the VFW / 614 ATTAS. They also want to develop a new imaging technique to study the airflow over the rotor blades of a helicopter in flight in order to find out exactly where on the rotor blades the flow becomes turbulent and the lift weakens. The new imaging technique should also help to determine the structure of the main rotor tip vortices in forward flight. These agreements are a further step in the now traditional cooperation between DLR and NASA. Both institutions pursue their research with the goal of environment-friendly and efficient future aviation – with low emissions as well as increased safety and efficiency.

s.DLR.de/lqbf

MULTI-PURPOSE SATELLITE FOR PICTURES FROM SPACE

Since its launch on 25 March 2015, the 'Korean Multi-Purpose Satellite', KompSat3a, has been performing well. Analysis of its images has shown that the electronic camera unit is working with great precision. The satellite, which has a high-resolution optical sensor, as well as an infrared sensor on board, is part of a satellite programme being conducted by the Korea Aerospace Research Institute (KARI). The DLR Institute of Optical Sensor Systems developed both the focal plane array and the active focus control system. Kompsat3a is used in a variety of applications, such as Geographical Information Systems, environmental, agricultural and oceanographic monitoring, as well as urban planning, resource management and disaster relief.

FLYING HIGH WITH A SOLAR GLIDER

Researchers at DLR have successfully conducted a stratospheric flight with HABLEG (High Altitude Balloon Launched Experimental Glider), in which the glider was lifted by a helium balloon to an altitude of 20 kilometres, where it was released. With this aircraft, DLR seeks to develop and test new technologies needed for unmanned stratospheric solar airplanes. The aircraft and its systems were developed, built and tested by a team at the DLR Institute of Robotics and Mechatronics. The technology significantly reduces effort and costs in comparison to unmanned solar platform test flights, while also opening up new possibilities for scientific applications by offering controlled flight paths and safe return of balloon payloads.

Image: EU Project I-CVUE

TIME TO SWITCH TO AN ELECTRIC VEHICLE?

Taxi companies, car-sharing providers, company cars – vehicle fleets play a very important role in bringing electromobility to the roads and making it visible. But replacing traditionally fuelled vehicles with electric vehicles must also make sense financially. DLR researchers have developed an online tool that fleet operators can use to calculate the conditions under which the use of electric vehicles will be worthwhile. The software developed by researchers at the DLR Institute of Vehicle Concepts under the I-CVUE (Incentives for Cleaner Vehicles in Urban Europe) EU project can be used for free after registration. It is initially aimed at fleet operators and can, in minutes, calculate the total cost per vehicle. Besides the free online tool, the project partners are offering independent, personalised advice for operators of vehicle fleets and decision-makers in government and public authorities.

s.DLR.de/78gb

PLASMA RESEARCH – NEW LABORATORY ON THE ISS

In June 2015, the PK-4 Plasma Crystal Laboratory was installed on the International Space Station (ISS) to conduct research into plasma. The DLR Complex Plasmas Research Group has tested and confirmed the functional capability of the laboratory unit. The Plasma Crystal Laboratory enables observation of the movement of individual particles in microgravity. Physical processes occurring at the atomic or molecular level become visible and can be investigated in a targeted manner. The next PK-4 experiments are expected to determine, among other things, particle charges and ion drag forces. These figures are essential for understanding the experiments on the ISS. With PK-4, the Complex Plasmas Research Group is operating a laboratory on the ISS for the third time.

s.DLR.de/4qt2

MEET DLR AT …

INTERNATIONAL ASTRONAUTICAL CONGRESS
12 - 16 October 2015 • Jerusalem, Israel
DLR will be present at the 66th IAC, which has the theme 'Space – The Gateway for Mankind's Future'. Founded in 1951 to foster the dialogue between scientists around the world and support international cooperation in all space-related activities, the IAC continues to connect people in the space industry. The organiser, the International Astronautical Federation, is the world leading space advocacy body with 300 members, including all key space agencies, companies and institutes across 62 countries.

TECHNET EUROPE 2015
20 - 22 • October 2015 Berlin, Germany
With its focus on environmental, geopolitical and security-related developments and specific requirements on sensor technologies and data fusion, the First European Geoinformation Symposium offers a forum for a constructive dialogue between representatives from industry, research, administration and the armed forces. Challenges connected to urbanisation, migration and disaster relief are addressed here. Frequently, critical or crisis-related aspects are in the foreground, including expanding megacities, migration flows triggered by economic and violent conflicts and inadequate or delayed disaster relief.

7TH EUROPEAN AERONAUTICS DAYS
20 - 23 October 2015 • London, United Kingdom
The 7th European Aeronautics Days is the European flagship event in aviation research and innovation, which takes place one time during each EU Research Framework Programme. Designed to present strategic perspectives for aviation – including research and innovation – the goal is to share achievements of collaborative research and innovation in aeronautics and air transport within Europe and worldwide international cooperation.

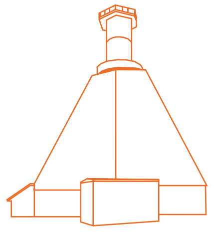
INTERNATIONAL AEROSPACE EXHIBITION ILA
1 - 4 June 2016 • Berlin, Germany
ILA is held biennially at the Berlin ExpoCenter Airport. Here, trade visitors can visit the exhibitors' stands and enjoy air shows. Visitors can also see aircraft up close and attend a varied programme of conferences. Industry representatives from around the world will also be given numerous opportunities for networking and establishing new business contacts. The event will be open to the general public on the last two days (Friday and Saturday).

FOLLOW THE LATEST NEWS BY VISITING THE DLR SITE AND SIGNING UP FOR THE DLR NEWSLETTER

All articles can be viewed online in the news archive with pictures or videos. To receive the latest news via e-mail, please subscribe to our newsletter.

DLR.de/News DLR.de/en/Newsletters

THE WIND HAS THE FINAL SAY



MAPHEUS-5 – mission into microgravity

By Manuela Braun

A Bavarian flag on the wall. Paper cups marked with felt-tip pen. Screws. Wires. Boxes of gloves. One week earlier, the teams of the Mobile Rocket Base MORABA, the Institute of Materials Physics in Space and the Institute of Aerospace Medicine unloaded the containers and took the contents to the 'Church'. But this 'Church' – located 200 kilometres above the Arctic Circle in Sweden's most northerly city, Kiruna – is neither solemn nor peaceful; it is a workshop and a laboratory. The DLR scientists and engineers regularly launch high altitude research rockets carrying scientific experiments from the Swedish Esrange Space Center. June 2015 saw the fifth campaign in the MAPHEUS project (Material Physics Experiments under Microgravity Conditions – MAterialPHysikalische Experimente Unter Schwerelosigkeit). In the 'Church', four experiments of the DLR Institute of Materials Physics in Space and the DLR Institute of Aerospace Medicine are being prepared and assembled for their flight into microgravity. In one corner of the hall, a MORABA team is working on the recovery system, which will ensure that all of the experiments return to Earth safely by parachute. The team responsible for the service module – and thus for communications with the rocket during the flight – is set up in the far right corner. The 'Church' has now been transformed into a type of home-like laboratory.

The MAPHEUS-5 rocket flight will enable six minutes of microgravity. A total of four experiments will be conducted inside the golden modules. In MEGraMa (Magnetically Excited Granular Matter), eight magnets will be used to excite 2500 small spheres during the flight. A camera will record how collisions cause the spheres to lose speed and assume an ordered pattern in microgravity. In the electrostatic levitator (GOLD-ESL; Gravity Impact on Liquid Drops – Electrostatic Levitation), samples will be melted while floating, without coming into contact with the wall of the crucible. The X-RISE X-ray system is designed to record diffusion and solidification processes with a camera during every second of the flight into microgravity. The biologists, on the other hand, are exposing Arabidopsis Thaliana – thale cress – to microgravity and investigating how these plants respond to the absence of gravity.

Parcel from Brazil

Music streams from a radio in a corner of the hall. The coffee machine is just a corridor away. In the hall, a neon light shines – outside, the Sun is gleaming. But, when is there no daylight here? The Midsummer Night is approaching – and then, it will never get dark. The mission alone gives the day a structure. It begins at 08:30, meeting with colleagues at the Swedish Space Corporation (SSC). Frank Scheuerpflug, project leader of MORABA for MAPHEUS, has good news for the team, which gathered in the small meeting room. The nozzle constructed in Brazil for one of the

The rocket with the four experiments is transported to the launch pad on a trolley two rocket engines will arrive tomorrow afternoon, so the second engine can be assembled on MORABA. The Brazilian partner has very rarely been late in the production of this critical component for the S30 engine.

Several balloon launches will simultaneously be carried out at Esrange Space Center. MAPHEUS-5 will have to accommodate to the requirements and schedules of these launches. "No worries," says Frank Scheuerpflug. "The balloons need a wind specified within very narrow tolerances, so it is not improbable for a situation to occur where it is not worthwhile running a countdown for a balloon launch, but we definitely have a chance with our rocket." At this time, however, no one is aware of the extent to which the wind will complicate things for the MAPHEUS team – in a week's time, the entire team will work through the night, only for the countdown to be cancelled early in the morning due to unfavourable wind conditions. Ultimately, the launch will have to be postponed until 30 June – and be picture-perfect.

Readying the payload – piece by piece

But at the moment, everything looks okay. The crane whirrs permanently below the sharp-angled roof of the 'Church'. Four separate experiment modules, a recovery system, a service module, a cold gas system and a nose cone – this metre-high payload will be transported to an altitude of almost 260 kilometres. Marcus Hörschgen-Eggers pushes a button – the second element is lifted in the air and placed on top of the first experiment module. Screw after screw is tightened, golden module mounted on golden module. The payload grows in height. The nose cone hangs just below the ceiling. While Jürgen Knof tightens the final screws from the top step of the mobile ladder, Philipp Koudele, Frank Scheuerpflug and Nils Höger stand on top of the platform to maintain the nose cone in the correct position.

Meanwhile, in the adjacent hall, the MORABA launch team are busy at work assembling the Brazilian nozzle that has arrived. 'Tillträde Förbudet' – no admittance – warns a red neon sign. A sign is stuck to the metal door leading to the engine hall: Danger Area. Anyone entering the hall is required to leave their mobile phone in the wooden box by the door and wear antistatic clothing. 1566 kilograms of explosive lie dormant in the engines and should not be awakened ahead of time.

With the evening come some bad news – the MEGraMa 2.0 experiment causes problems in the flight simulation test, where the complete payload has to be linked to the communication unit on the ground and

Tightening the last screws at the 'Church'

"EVERYONE OFF THE LAUNCH RAMP!"

must work. The camera designed to record the collision of the 2500 spheres in microgravity is not functioning properly. What is more, one of the hard disks inside an experiment is not functioning and must be replaced. The payload must be dismantled – the crane whirrs again, screws are carefully tightened – only to be loosened again moments later – and the bottom-most module is separated from the payload. Despite the setbacks, the team from the Institute of Materials Physics in Space are keeping their cool. The payload in the high altitude research rocket is fundamental research and no routine. "Off-nominal issues are an inevitable part of launching research rockets and handling them professionally is essential to success," comments DLR engineer Frank Scheuerpflug.

The Brazilian-developed nozzle, ready for assembly.

It is getting late – but, as ever, it is light outside. The team from the Institute of Aerospace Medicine disappears once again to the laboratory to prepare the specimens for the flight. The module for the plants is still empty – the living samples, together with the unit, will not be installed into the launch-ready rocket until a few hours before launch.

Variety in everyday mission life at Esrange is limited to the occasional visits of elk at the forest edge or in the parking areas. Three elk live on the extensive grounds of the rocket launch site, unexpectedly making their presence known by the assembly hall every now and then. Apart from that, the team's lives are played out between the neon-lit hall, the accommodation area with a pool table and table football and the kitchen – Bavarian sausage and some bottles of beer from home, sent in a container to Sweden, a couple of ingredients from the supermarket 45 kilometres away or simple instant soups are on the menu. Esrange is well off the beaten track from a German perspective, but just around the corner from Kiruna from a Swedish point of view – just a 45-minute car drive away through the forest and along the scenic lake.

Climbing the steel cathedral

While the hard disk in the MEGraMa instrument is being replaced, the second stage motor of the two-stage rocket is rolled through the tunnel to the launch tower. A loaded trolley is taken to the Skylark tower at walking pace. The 1566 kilograms of explosive are set upright and assembled in the 30-metre high platform. Everything is proceeding as planned. At the weekend, it will be Midsummer in Sweden – for the Swedish colleagues helping with the launch platform installation, work will stop. But the term 'launch platform' falls short – the Skylark is like a rust-coloured cathedral – steel beams, steep steps and platforms make up the construction in which the 13-metre tall research rocket is being installed. Voices echo in the steel cathedral and bright lights shine on the team as they climb amongst the beams – wearing helmets and equipped with tools. With a creaking sound, the trolley is moved to place the first rocket engine into a vertical position. Hands are now stretched out towards the rocket engine on every level of the massive tower. As soon as the first part of the rocket has been lifted up with the steel cable, the next, lower parts follow. Then, all that will be missing is the payload itself, which is placed at the top – last of all.

But then come the first warning calls – the steel cable with which the rocket engine is being lifted up is not running smoothly in one place and is starting to splay. "Everyone off the launch ramp!" shouts Per Baldemar, the Swedish safety officer. 'Morabist' Wolfgang Jung climbs down the last steps. "Now the Swedish colleagues need to get a new steel cable and install it," he says. This is double the bad news, as this steel cable is hard to find – especially on the Midsummer weekend, when every supplier is closed. But nobody wants to risk pulling extremely heavy rocket parts and explosives with a slightly damaged steel cable. And so, they are all forced to take a break. Project leader Frank Scheuerpflug finds a positive note to the situation at hand: "Everyone has been working non-stop the last few days. For the first time since the campaign began, we have a break." The SSC team follows through, managing to obtain a steel cable for the launch tower – despite the holidays. The cable will be installed and tested on Monday. For the DLR engineers and scientists, this means time for a brief excursion to Kiruna, maybe do the laundry at last, or do things that had been put to one side in recent days. Until now, the mission has set the pace.

At last, the unit in the Skylark tower is ready for launch – the MAPHEUS-5 campaign can continue. The MEGraMa experiment is reinstalled and the team has run another flight simulation test to check whether the assembled payload components will communicate with each other and with the ground during the flight. The DLR team is ready – the two rocket engines are brought into the Skylark tower and lifted up with the new cable. The payload gets the lettering 'MAPHEUS-5', and Scheuerpflug rounds up the mission team for the traditional team photograph. The arrival of the payload in the Skylark tower marks the beginning of precision work at a great height and in the tightest of spaces. The MORABA men do acrobatics as they climb between the beams, narrow platforms and uppermost levels of the launch tower. If a tool is dropped here, it will hit the ground 30 metres below. They work together intently, placing the payload on the two engine components and screwing it in place.

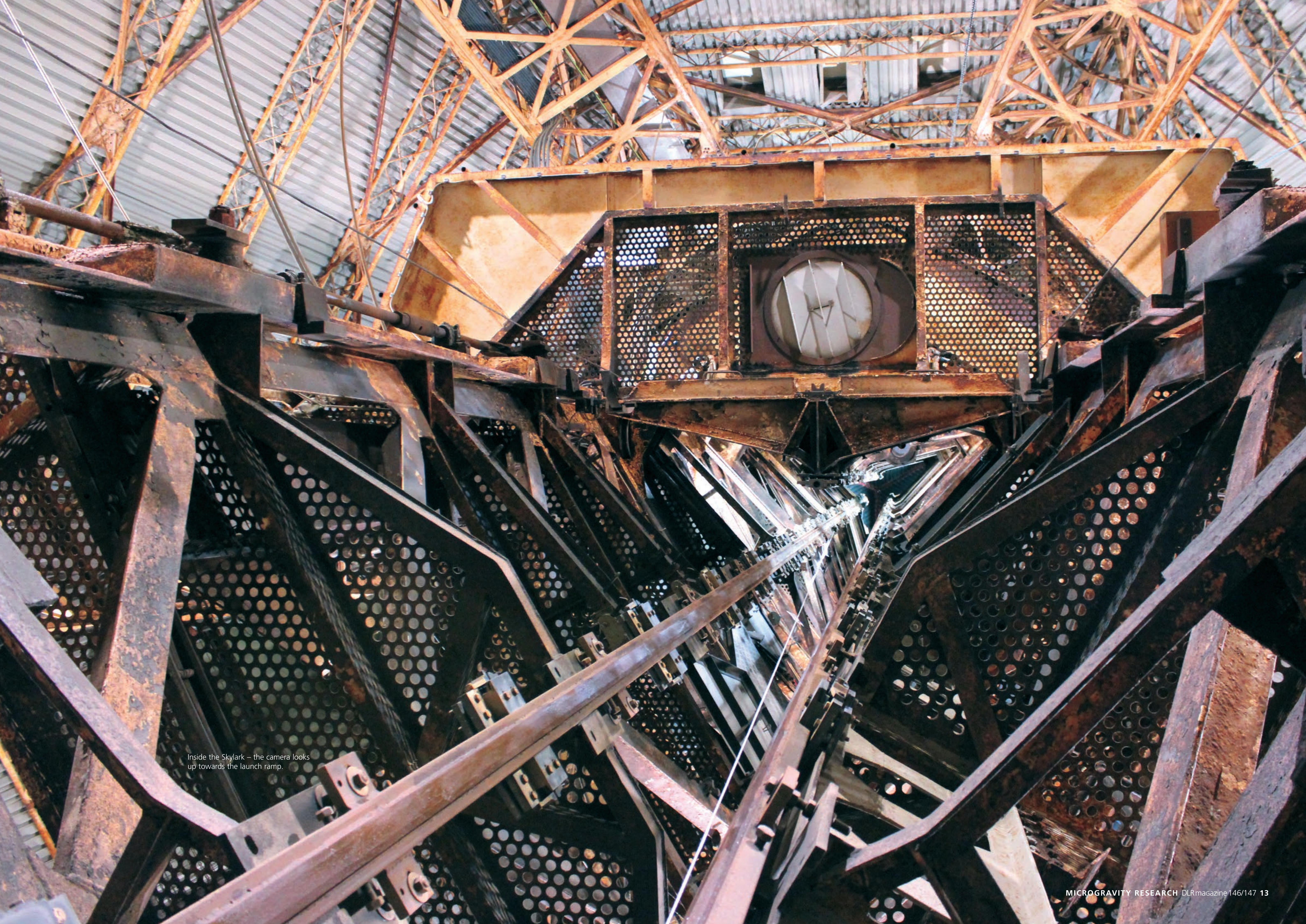
THE EXPERIMENTS ON BOARD THE RESEARCH ROCKET

MEGraMa: eight magnets will be used to excite 2500 small spheres during the flight. A camera will record how they lose speed and come to rest in microgravity.

X-RISE: X-ray system designed to record diffusion and solidification processes with a camera during every second of the flight into microgravity.

GOLD-ESL: In the electrostatic levitator, samples will be melted while floating without coming into contact with the wall of the crucible.

Biological experiment: How does Arabidopsis Thaliana – thale cress – respond to microgravity?



Inside the Skylark – the camera looks up towards the launch ramp.

“IN ANY CASE, WE CANNOT LAUNCH BEFORE 02:00.”

Assembly in the Skylark tower:
precision work in confined spaces and at great heights.

One day later, everyone sits at the consoles during the test countdown, a four-hour dress rehearsal of the live launch. There is a temporary communication problem with one of the experiments – but it can be resolved. There are a few delays, which will later be discussed and included in the improved schedule for the upcoming live countdown. Then, the wait begins – the wait for wind conditions that will allow the rocket to land safely inside the 5200-square-kilometre area of the Swedish range, and not in Norway or Finland.

An endless night

Friday looks bad. Saturday morning does not look good either. Only in the night from Saturday to Sunday, the wind might give the research rocket a chance. So, on Saturday, everyone unwinds – some lie in bed as the sunlight streams in, to get some sleep before the sleepless night ahead. Some play pool at half speed. The four-hour countdown is scheduled for 22:00.

The countdown begins. Nobody would suspect that it is about to get serious – the atmosphere is calm, yet completely concentrated. “If the countdown is delayed, it’s not a big deal,” says Wolfgang Jung from MORABA. “In any case, we cannot launch before 02:00.” The communications channels are checked, the recovery system is armed, and the biologists bring their plants to the rocket and install their experimental unit. Everything is okay. Now, the final 50 minutes of the countdown should begin – this is when the experiments are switched on and the first samples melted. But the countdown is stopped, and the team must now hope and wait for a moderate wind. It is quiet in the blockhouse – behind its doors, the team would be safe in the event of a failed launch. A launch-ready rocket is now standing in the Skylark tower – ready to be ignited.

The ‘Church’ is not a place for meditation

The telephone rings inside the control room – the wind forecast has changed and will probably be most favourable at approximately 04:00. Two hours to spare. The first put the armrests of their chairs back and doze off or snooze. It will not be at 04:00 – 05:30 might now be the time at which they can proceed. The Sun shines brightly in front of the hall. Inside, time seems to be at a stand still. Now and then, the hum of the coffee machine is heard and somebody prepares a sandwich. Dinner? Breakfast? Something in between. Then all is quiet again. The wind is not behaving as expected – instead, it continues to vigorously blow from the north. Now, 07:30 is the time at which things might work out. Everyone hopes for the research rocket to take off.

The bad news is announced at 07:40 over the loud speaker: “The countdown for MAPHEUS-5 has been cancelled.” The latest weather balloon has shown that the wind conditions are not optimal. A whole night of waiting for countdown with no launch – hopes are not high. But waiting games are not new for engineers and scientists. Ultimately, the weather always has the final say.

The MAPHEUS-5 high altitude research rocket is now scheduled for launch on Tuesday morning, 30 June, at 06:55. Even on that night, nobody can say whether the wind will once again thwart their plans. But the MAPHEUS-5 team wants to take the chance and starts the countdown. All occupy their seats at the rocket system consoles – in the telemetry station, the DLR team is preparing to track the flight with the antenna and receive the data. The scientists sit before the monitors displaying their instrument data.

Seven minutes before launch, the countdown stops unexpectedly. DLR physicist Christoph Dreissigacker has to prove strong nerves during his first mission: the furnace is not functioning optimally. He takes manual control over the furnace and starts the experiment via remote control from the ground.

Flight into microgravity

The rocket finally makes its way to an altitude of 253 kilometres in glorious sunshine and returns to Earth by parachute, onto dry land directly next to marshy wet ground.

Now, analysis of the experimental data and learning for the next missions can begin. The MEGraMa experiment worked as the scientists hoped it would: the experiment was subjected to microgravity four times. Later, in the home laboratory, the first data analysis will show that the particles moved as planned in flight and that the camera recorded the subsequent collisions in 3D. In the electrostatic levitator, many control parameters were tested thoroughly. However, the electrostatic levitator did not enable the samples to float in a stable manner – with new settings it may now be tested again on a parabolic flight, before it is used once again on a high altitude research rocket. Data shows that the X-RISE X-ray worked flawlessly at first – but switched off unexpectedly after two minutes of operation, so the scientific goal was not fully achieved. The biologists safely recovered their thale cress and removed it from the research rocket. The plants that experienced microgravity are now being closely examined in a laboratory on Earth. The next MAPHEUS mission is due to launch in May 2016.

Wind permitting …

s.DLR.de/gnti

Picture-perfect – the launch of MAPHEUS-5.

Relieved after the safe and dry landing of the research rocket, the team shows the last feat of strength.

The corridor leading to the 12 single test subject rooms at :envihab's Living and Simulation Area.

LIFE IN SPACE FOR LIFE ON EARTH

Bed-rest studies being conducted at :envihab

By Nikita Marwaha and Colin Brace

Imagine lying in a bed that is tilted backwards. Now, imagine eating, showering and sleeping there – for 60 days – but all the while, contributing to the advancement of science. This is today's reality for the 12 participants selected for a bed-rest study at DLR's :envihab – and the closest experience to being an astronaut in space – physiologically speaking. The human body changes in space, adapting to the microgravity environment, and the changes to the metabolism, organs, muscle and bone could be detrimental in the long term. At :envihab, the effects of microgravity are simulated by tilting the head downwards whilst in bed rest for extended periods of time; here, the physiological adaptations can be observed, recorded and countered, so that eventually, humans can travel further than the International Space Station and remain healthy – both in space and on Earth.

DLR has been involved in long-term bed-rest studies for almost 20 years. It recently inaugurated a new, state-of-the-art bed-rest research facility at :envihab – a medical research centre of the DLR Institute of Aerospace Medicine in Cologne. :envihab is a research powerhouse, where the effects of extreme environments on the human body are being investigated. Since opening in July 2013, it has been conducting innovative research within its walls – an environment comprised of eight modules, each of which tackles subjects such as ageing, bedriddenness, isolation and adaptation to various atmospheric conditions. Here, the medical, biological and psychological effects of the space environment on humans are studied and possible countermeasures developed – all under one roof.

Bed-rest studies are conducted in Module 3: The Living and Simulation Area, which is equipped with single rooms for 12 volunteers – 13 square metres per person. "We are able to shield the subjects completely from the outside for months," says Edwin Mulder, Lead Project Scientist of the Institute's Space Physiology Department. Before the facility was operational, subjects had to be physically transferred to nearby hospitals for tests – either in a taxi or an ambulance – for MRI and radiological examinations.

Sixty days in bed

In August, on behalf of ESA, a research team embarked on DLR's first long-term bed-rest study within the new facility. During the study, the participants lie down with their heads tilted at an angle below the horizontal, allowing for the effects of microgravity – such as fluid shift and immobilisation – on the human body to be explored as physiological reactions are monitored over time. The first volunteer test subjects will remain at the facility until the end of the November – for 60 days of bed-rest out of a total of 90. Bed-rest studies typically run for five, 21 or 60 days (or even

The common room of the Living and Simulation facility is a space where collaboration and coordination can take place between scientists, subjects and visitors.

Bed-rest study subjects can use the Internet to work and stay in touch with family and friends online.

longer), depending on the type of research being conducted. "If we are studying muscle and bone, we would need 60 days or longer in order to be able to measure the impact," Mulder explains. "If we are studying the cardiovascular system, five or 21 days could be sufficient. We use a six-degree tilt, as that is regarded as the international standard for these kinds of studies."

Alexandra Noppe, member of the Study Team and Project Manager of the RSL study, explains the procedure of recruiting test subjects: "In the case of this study, we have a lot of criteria the test subjects must fulfil, and they must undergo a lot of tests before we can select them. For this first campaign, we found 12 healthy males, and while this campaign is running we are looking for 12 more test subjects for the second campaign, which will start at the end of January 2016."

"OUR GOAL IS TO COME UP WITH COUNTERMEASURES THAT ARE BOTH EFFECTIVE AND EFFICIENT."

Bed-rest studies are based on a carefully regimented set of daily protocols. Volunteers typically wake up at 06:30 and undergo basic tests (their vitals are checked) – their wake-up blood pressure, body weight and body temperature is measured. They then have to take part in a series of experiments that depend on the study being conducted. They eat highly standardised meals at predetermined times. Everything is scheduled and they have to live according to this plan. Like astronauts, bed-rest subjects also have time for themselves; at given times of day they can watch television, play computer games, read, surf the Internet, or keep in touch with friends and family.

Space on Earth, and Earth in Space

The long-term goal of these studies is to support a manned mission to Mars – but this is still a long way away. "From both the technical and medical perspectives, many hurdles need to be overcome – not only to ensure a safe arrival but also, even more importantly, to guarantee a safe return," Mulder observes. The primary health concern related to spending long periods of time in space is the effect of microgravity and idleness on bone and muscle, and this is the main focus of DLR's on-going bed-rest studies. However, other research topics, such as adaptations in cognitive function and cardiovascular fitness are also being explored. Recently, it was discovered that older astronauts undergo slight changes to their vision during spaceflight. "We think that this may be related to changes in blood volume going to the brain," Mulder says. "We want to learn whether we can stop this and prevent changes that may not be easily reversible."

It is not only the impact of space travel on the human body that interests the DLR team. "Our goal is to come up with countermeasures that are both effective and efficient," Mulder says. "Astronauts typically need to train for two or three hours a day while in space. Dedicating that amount of time to training may be acceptable for professional athletes, but astronauts are also doctors, scientists and engineers who have experiments to conduct. Here, the challenge is to come up with countermeasures that are not so time consuming."

SCHEDULE BED REST STUDY

Phase	Baseline data collection (BDC)	Head down tilt (HDT)	Recovery
Study day	**BDC-13**	**HDT14**	**R+0**
6:30	Body temperature, Blood pressure	Blood draw, Body temperature, Blood pressure	Body temperature, Blood pressure
6:45	Sleep EEG stop	Blood gas analysis	Actimetry
7:00		Saliva testosterone	Urine 64, Body weight
7:15	Urine 1, Body weight	Urine 27, Body weight	Breakfast
7:30			
7:45	DEXA		Holter ECG start
8:00		Breakfast	Tilt table + LBNP
8:15			
8:30	SBIS		
8:45			
9:00	Breakfast	CPT test	
9:15			
9:30			
9:45			
10:00	pQCT		
10:15			
10:30		Snack	
10:45			
11:00	Eye examination II		
11:15			Holter ECG end
11:30			
11:45			PG, DGI
12:00			
12:15			
12:30			
12:45			Lunch
13:00	Lunch	Lunch	
13:15			Eye examination I
13:30			
13:45	Eye examination I		
14:00		ICB	
14:15			
14:30			
14:45			
15:00			Neuromuscular
15:15			
15:30		Countermeasure (Training)	
15:45			
16:00	Countermeasure (Familiarisation)	Snack	
16:15		Shower	
16:30	Snack		MVC, muscle fatigue
16:45			
17:00	Shower	24-hour ECG start	
17:15			
17:30	36-hour CIR		ILP
17:45			
18:00			Shower
18:15			
18:30			
18:45			
19:00	Dinner	Dinner	Dinner
19:15			
19:30	LOG	LOG	LOG
19:45		Questionnaire 2	
20:00	Questionnaire 1	Questionnaires 3-5	
20:15	Questionnaire 2		
20:30		Sleep EEG	
20:45			
21:00			
21:15			
21:30	Snack	Snack	Snack
21:45			
22:00	Bedtime	Bedtime	Bedtime
22:15			
22:30			
22:45			

A day in the life of a bed-rest subject includes a 06:30 wake-up and a variety of medical tests and examinations.

ABOUT :envihab

A one-story, 3500-square-metre, state-of-the-art space, :envihab (from the words 'Environment' and 'Habitat') will be used to explore the effects of extreme environmental conditions on humans and to determine possible countermeasures. Eight separate modules, built according to a 'house within a house' design, include a short-arm human centrifuge to, for instance, conduct cardiovascular, bone and muscle research, laboratories for studying the effects of oxygen reduction and pressure decrease on test subjects, MRI/PET analysis facilities, rooms for psychological stress simulations and rehabilitations, microbiological and molecular biological research tools, as well as places to house and monitor test subjects.

:envihab modules

M1 *DLR short-arm centrifuge*
M2 *Prevention and rehabilitation lab*
M3 *Sleep and physiology lab*
M4 *PET-MRI*
M5 *Psychology lab*
M6 *Biology lab*
M7 *Infrastructure*
M8 *Auditorium*

Indirect calorimetry in order to measure the individual nutritional energy needs of the test subjects.

Image: Arnold Glas

Rooms with a view – bed-rest study rooms overlook a rock display in the :envihab building, so that subjects can enjoy its aesthetically pleasing views during bed-rest.

ABOUT THE INTERVIEWEES

Edwin Mulder is the Lead Project scientist; he is in charge of all scientific issues of the study and has the final decision about any changes to the study protocol. The project scientist is also the representative of the group of selected scientists towards ESA. **Alexandra Noppe** is the Project Manager; she is responsible for the on-site project management, including organisation and coordination of the RSL study, as well as internal planning. **Petra Frings-Meuthen**, in addition to being the deputy Project Scientist, is in charge of managing all things around biological samples and nutrition. **Melanie von der Wiesche** is Head of the Study Team.

One countermeasure with great potential is the creation of 'artificial gravity' in space, which can be seen in science fiction movies where a rotating space vehicle allows the people inside to walk normally. "We have a long-standing hope that we will be able to determine how to develop tolerable artificial gravity," says Mulder.

"Until now, we have tended to focus on developing individual countermeasures – one for muscle, one for bone, one for the cardiovascular system," he continues. "But eventually we need to move towards a whole-system approach that is beneficial for all the affected biological components. Artificial gravity could be key in this regard."

While the research that is being carried out by DLR's bed-rest study team primarily addresses astronauts in space, much of the knowledge gained is applicable to life here on Earth. "The microgravity environment has some parallels to the ageing process, for example," Petra Frings-Meuthen, a scientist in the Institute's Space Physiology Department, points out. "We have an experiment on board the ISS studying the effect of high salt intake on bone metabolism. We have conducted bed-rest studies on this as well, and the outcome is relevant to the study of osteoporosis in the elderly." The results achieved from simulating the physiological effects of microgravity on humans could also be useful for handling people that are bed-ridden, for example, immobilised in other ways or have reduced physical activity – something increasingly common in modern society among both the young and elderly.

Another area being looked at is metabolic changes. Research in this field is applicable to both long-duration space flight and as medical treatment here on Earth. Frings-Meuthen explains: "Astronauts may suffer from insulin resistance, which can be a precursor to type II diabetes. We are searching for countermeasures. This will be a combination of training and nutrition, and it can also be applied to Earth conditions."

A mighty team for a mighty project

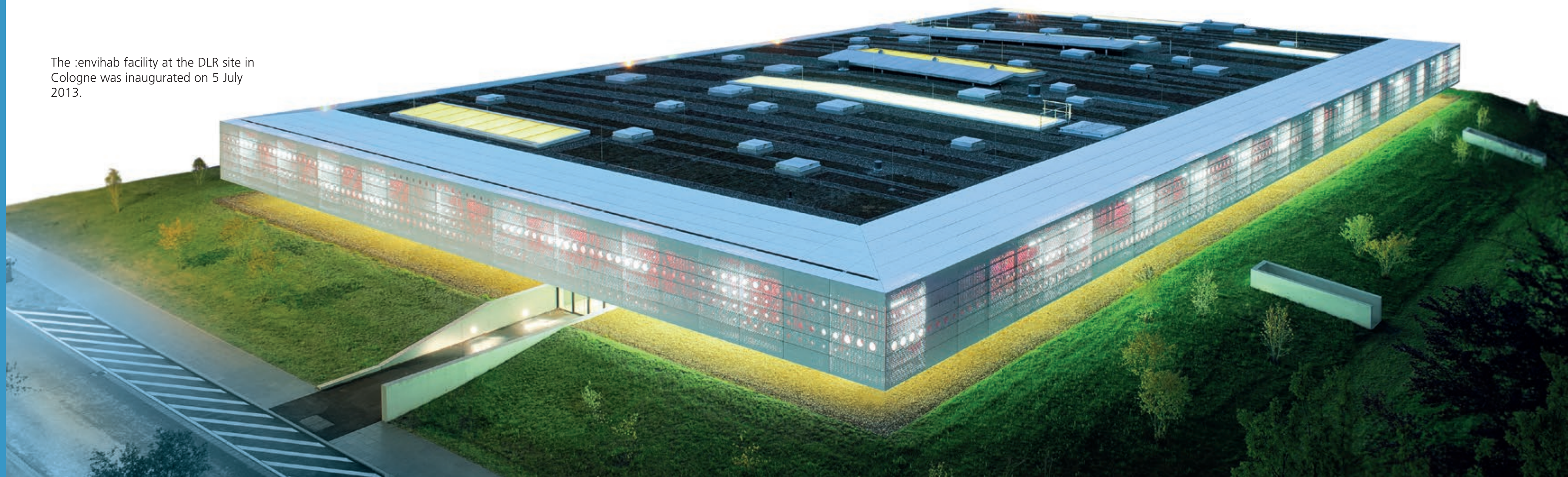
Bed-rest studies require large teams of researchers and related support staff. Melanie von der Wiesche, Head of the Study Team at DLR elaborates: "We have a large team, as we need many people to conduct this kind of studies – project scientists for the ESA long-term bed-rest team, a project manager, medical doctors, nurses and vital technical staff. We also need people for paramedical care and to supervise the test subjects. Medical monitors are needed for some experiments, mainly in the baseline data collection phase and the recovery phase – before the subjects begin bed-rest and during the immediate stage afterwards. And of course, we have nutritionists and a large kitchen staff that design and prepare the menus for all the test subjects."

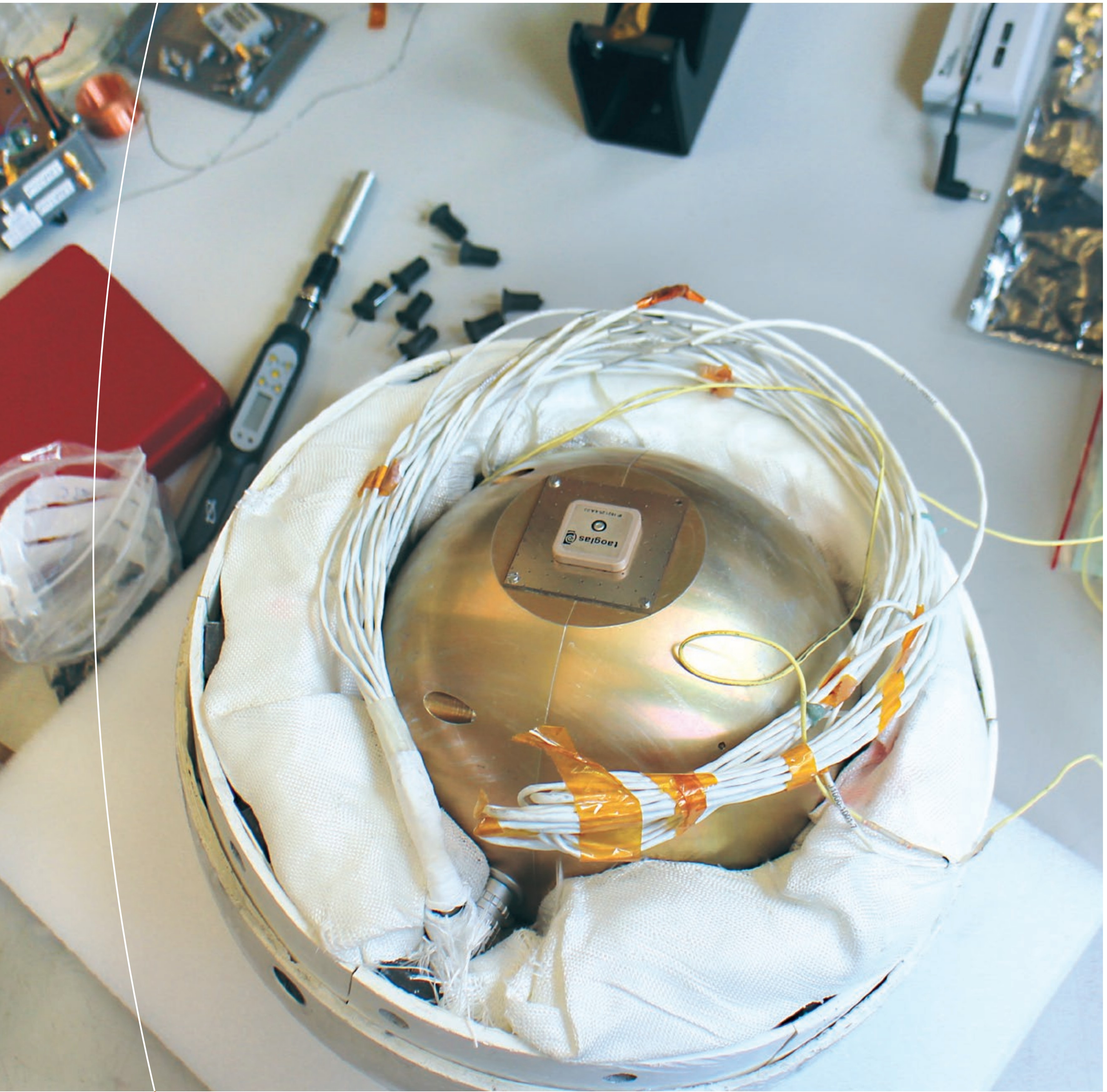
Taking all shifts into account, approximately 60 to 70 people are involved in a single bed-rest study at DLR. Mulder added: "This includes the students and the people that stay during the night to watch the subjects. For these reasons, bed-rest studies are very expensive – no single university, or even DLR, can undertake them on their own. These kinds of studies are normally funded by large space agencies – ESA, NASA and JAXA – which have their own facilities, but none as unique as DLR's :envihab." The DLR team is dedicated to developing studies based on international standardisation, so that both the work and results can be shared by everyone. "We work with fully standardised protocols," say Mulder and Frings-Meuthen. "Not only with regard to nutrition, but also atmosphere and all the other test conditions. We are contributing to an international standardisation plan and believe that this will be a tremendous achievement."

Nikita Marwaha is an editor for EJR-Quartz B.V. **Colin Brace** is an Amsterdam-based journalist who writes regularly on space-related topics.

DLR.de/envihab/en

The :envihab facility at the DLR site in Cologne was inaugurated on 5 July 2013.





The re-entry capsule with insulation and the electronics with the antenna, which were integrated into the subsystem by RUAG in Zurich.

THE 'GOLDEN SNITCH' OF RE-ENTRY

'Georges Lemaître' was the last of the five cargo spacecraft in the European Automated Transfer Vehicle (ATV) programme. In February 2015, ATV-5 undocked from the International Space Station (ISS) and entered Earth's atmosphere. A re-entry capsule developed by DLR was on board to observe this hot phase. What happened during the flight? What was the exact role of the capsule? The Institute of Structures and Design in Stuttgart reports.

Thermal protection system safeguards cool core of capsule storing pictures from ATV-5 re-entry

By Nicole Waibel

What exactly happens when a spacecraft enters Earth's atmosphere? This is precisely what DLR scientists working in the field of re-entry technologies are trying to find out. In the case of ATV-5 'Georges Lemaître', they investigated the moment at which the cargo spacecraft heated up so much that it began to break up into individual pieces. This knowledge will be important for example, when the ISS is 'retired' and attempts are made for it to re-enter Earth's atmosphere or for reentry strategies such as Design for Demise. The European Space Agency commissioned RUAG and its partners, ETH Zurich, ViaSat and DLR to develop a camera system that could observe the re-entry of ATV-5, and record the heating up and the start of the break-up phase, while storing and securing its data in a re-entry capsule. The DLR Institute of Structures and Design, together with the DLR Institute of Materials Research, based in Cologne, were responsible for the development, manufacturing, testing and assembly of the self-supporting capsule structure, as well as the insulation system, which is made from fibre-ceramic materials.

The 'break-up'

On Saturday, 14 February 2015, at 13:44 GMT, 'Georges Lemaître' undocked from the ISS, embarking on the final stage of its life. The Break-Up Camera (BUC) was first put to use on Sunday at around 17:47 GMT, shortly after the ATV-5's final deorbit manoeuvre. According to ESA, the cargo vehicle broke up into small pieces over the South Pacific at 18:08 GMT and the BUC began to send the recorded infrared images to the Iridium satellite network. The first status update from the BUC was received just four minutes later. DLR scientists received data on the vehicle's acceleration, magnetic field, processor temperature, spin rate and memory usage. For unknown reasons, the connection was lost and the infrared pictures were never received. This was disappointing because the camera had already taken approximately 6000 pictures, which were ready to be sent. "Nevertheless, we know that the camera system worked and that all images were transferred to the capsule," explains Christian Dittert of the Institute of Structures and Design, who was involved in the project from the outset. "Thanks to our thermal protection system, the temperature of the computer processor and the electronics within the capsule remained at 32 degrees Celsius – outside, temperatures during re-entry exceeded 2000 degrees Celsius." After a 'wild ride' through the atmosphere, the capsule finally sank in the Pacific.

The half-shells of WHIPOX™ during final machining at the DLR Institute of Structures and Design in Stuttgart

Small insulating pillows protected the electronics from the heat

The finished WHIPOX™ half-shell, lined with the insulating pillows.

Keeping it cool…

To maintain a cool core temperature at extremely high external temperatures, a capsule with a thermal protection and insulation system was developed at DLR in Stuttgart – one capable of withstanding the high temperatures as well as the mechanical stress during re-entry. The material also had to allow electromagnetic radio waves to pass through it, to enable a connection to be established with the satellites. From the experience obtained during the SHEFEX re-entry programme the scientists knew that WHIPOX™, a fibre-reinforced material based on aluminium oxide developed by DLR in Cologne, combined all the properties needed for the capsule. But, in addition to the material used, there was another key factor that would maintain the capsule's interior temperature as low as possible – its shape. "We decided to use a round capsule because, on the one hand, it was quick and easy to build, and on the other, it is easier to estimate the thermal stress on round shapes." Dittert went on to explain that "since a sphere-shaped capsule spins, the thermal stress is evenly distributed. The real challenge was the short amount of time that we had to complete the project." Between kick-off, on 15 July 2013, to the actual date of the flight, which took place on 29 July 2014, there was just one year. In the four months leading to the handover to RUAG – on 29 November 2014 – the components were designed, manufactured, simulated and tested.

Because of the short time frame, the design had to be simple, robust, quick to manufacture, and meet all the necessary thermal, mechanical and electrical requirements. The design was completed merely two months after the start of the project. The capsule was constructed and designed by the Institute of Structures and Design, and the basic structure of the fibre-reinforced ceramic capsule was manufactured at the Institute of Materials Research in Cologne. For the final touch, the capsule was sent back to DLR in Stuttgart, where it was prepped for the installation of the electronics by RUAG in Zurich. "It was quite difficult to attach the external connectors, which were to be used as temperature switches and for transmitting the data of the images acquired by the camera. As the connectors melt much more quickly than the ceramic, they had to be sealed from the inside to prevent the hot gases from entering the capsule. The insulation, which is like a very light felt or pressed candy floss, was sewn into 26 small handmade pillowcases for better handling," explained Dittert. Upon delivery of the flight hardware, a test capsule was built, which was tested at similar loads to those encountered during re-entry. These results were then used to improve the conceptual design and the simulations.

A hot topic

What will re-entry capsules look like in the future, and how can they be used? At any rate, the systems for investigating re-entry processes will become smaller. The difficulty herewith is that smaller surfaces and, therefore, smaller radii, increase thermal loads. A different approach would be to use a more aerodynamically stable shape – similar to that of a shuttlecock – in which the front becomes very hot and the rear remains cooler. In the field of re-entry technologies, therefore, investigations are ongoing to create and design smaller and lighter capsules using new types of ablative materials. "Small re-entry capsules will play a big role in the future," says Dittert confidently – as experimental platforms, black boxes for spacecraft or even as transport containers for samples returning from the ISS. "Their potential is huge."

Christian Dittert is a researcher of re-entry technologies at the DLR Institute of Structures and Design, and has been part of the project since the very beginning, right up to the re-entry. **Nicole Waibel** is responsible for Public Relations at the Institute of Structures and Design.

s.DLR.de/xwce

Christian Dittert, born in 1983 in Rüdersdorf near Berlin, studied aerospace engineering at the University of Stuttgart. He has been working in the 'Space System Integration' department of the DLR Institute of Structures and Design in Stuttgart since 2011. He is a member of the Helmholtz Young Investigator's Group 'High Temperature Management for Hypersonic Flight'. His PhD dissertation is on the topic 'Development and characterisation of a transpiration-cooled sharp leading edge for re-entry'.

GLOSSARY

ATV	Automated Transfer Vehicle
ESA	European Space Agency
ISS	International Space Station
RUAG	Swiss technology company with headquarters in Bern; the abbreviation originally stands for Rüstungsunternehmen-Aktien-Gesellschaft (Joint Stock Defence Company)
ETH Zurich	Swiss Federal Institute of Technology in Zurich
GMT	Greenwich Mean Time
BUC	Break-Up Camera
CPU	Central Processing Unit
SHEFEX	Sharp Edge Flight Experiment
WHIPOX™	Wound highly porous oxide composite

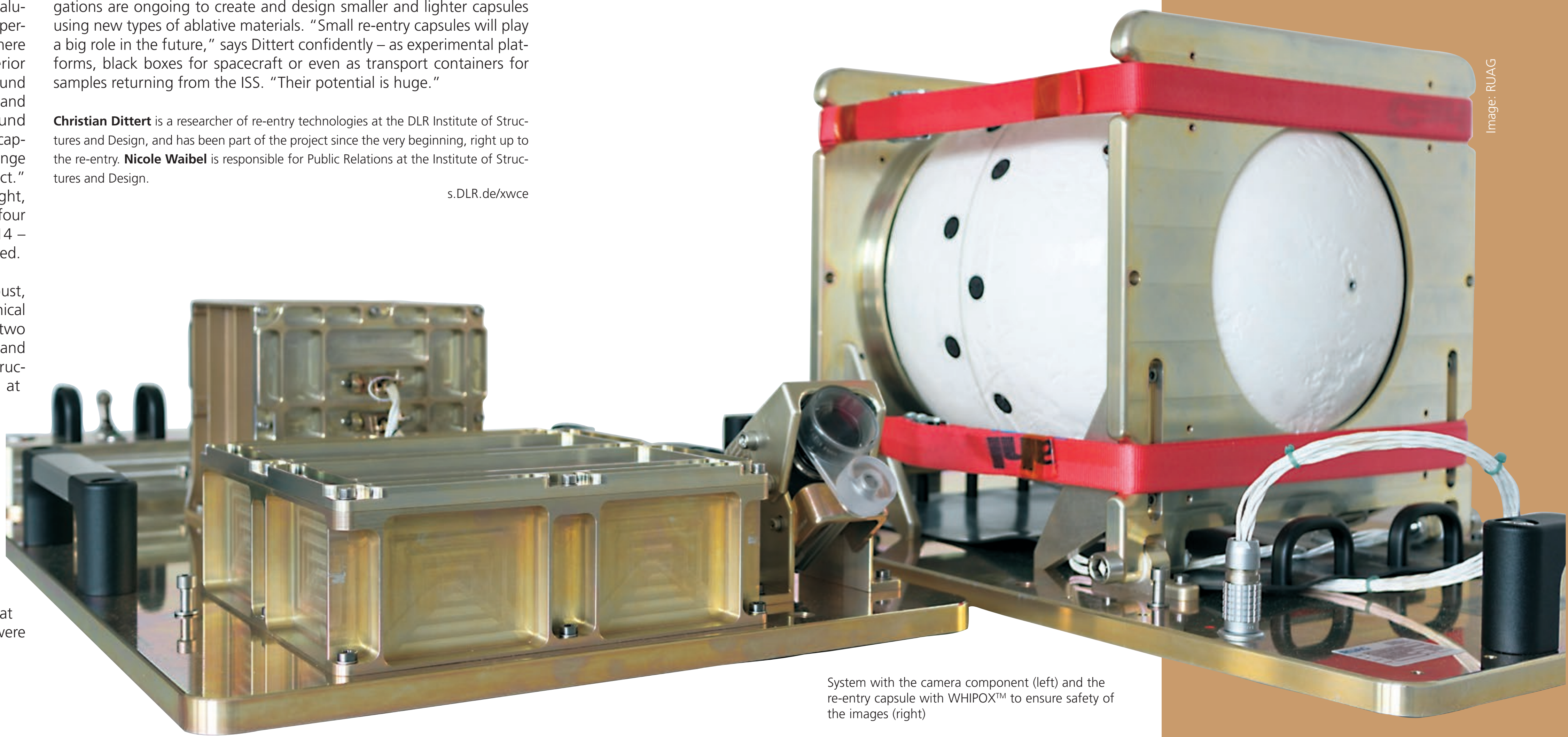


Image: RUAG

System with the camera component (left) and the re-entry capsule with WHIPOX™ to ensure safety of the images (right)

Artist impression of the InSight Mars lander with the DLR-developed 'Mole'

Image: NASA/JPL

A 'MOLE' TO TAKE MARS' TEMPERATURE

What lies beneath the surface of a terrestrial planet? Understanding the internal structure of a planet requires a technology capable of peering into its depths. The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport – InSight – is a forthcoming NASA robotic lander mission, which has the goal of landing a collection of scientific instruments on the Red Planet to gather geophysical data. DLR is participating with a type of self-hammering nail known as 'The Mole'. Its task: to measure the martian heat flow.

InSight – a NASA mission to learn more about terrestrial planets

By Matthias Grott

Mars might be the target of InSight, but this mission is about far more than just investigating and exploring the Red Planet. The researchers want to contribute to understanding the processes that shaped the terrestrial planets – those with a hard, solid surface that have a metal core, a rocky mantle and a crust that is chemically differentiated. In this regard, Mars is an ideal candidate, as it has experienced exactly the right amount of activity in the course of its history – on the one hand, the planet is large enough to have undergone geological processes such as volcanism and tectonics and, on the other, it is small enough to have retained traces of this activity over billions of years.

NASA is planning to launch InSight in spring 2016 as part of the Discovery Program. This is the first mission since the Apollo era to focus on geophysical exploration of the Solar System. Its instrumentation is unusual for planetary research; it consists of a seismometer and a heat flow probe. The Seismic Experiment for Interior Structure (SEIS) will determine the inner structure of the planet and the size of its core. The Heat Flow and Physical Properties Package (HP^3), will directly measure the heat flow under the surface, enabling planetary scientists to determine the heat produced inside Mars, as well as its bulk chemical composition and potential for geological activity. These instruments will make possible the first direct measurements of its fundamental planetary parameters – until now only estimated indirectly on the basis of gravitational field measurements.

In order to determine the heat flow of a planet, it is necessary to measure the temperature gradient underground. To accomplish this, the Apollo astronauts used an electric drill to drive bore holes up to three metres under the surface of the Moon. But the thermal conduction caused by the martian atmosphere makes this depth insufficient for InSight. HP^3 is faced with a major challenge – to place temperature sensors at depths of up to five metres. It will do this with a mechanical 'Mole', whose internal hammering mechanism will drive the sensors into the ground – millimetre by millimetre. As part of the heat flow measurements, HP^3 will be equipped with a radiometer to determine and monitor the surface temperature at the landing site. The DLR researchers will then be able to derive the planetary heat flow from the acquired surface and underground temperature data.

Preparations for the mission launch are in full swing – integration of the robotic lander, which was built by Lockheed Martin under contract to NASA's Jet Propulsion Laboratory, is almost complete. The final components are currently being installed and undergoing testing. Between late 2015 and early 2016, InSight will arrive at Vandenberg Air Force Base in California, from where it will be launched on board an Atlas V rocket on 4 March 2016 – it will become the first interplanetary mission to launch from the United States West Coast. Until then, however, there is still plenty of work for the DLR engineers and scientists as activities are gradually relocated to the DLR Microgravity User Support Center, MUSC, in Cologne, from where HP^3 operations will be coordinated upon the much-awaited landing on Mars, expected on 20 September 2016.

Matthias Grott is a researcher at the DLR Institute of Planetary Research and Science Manager of HP^3.

INSIGHT INSTRUMENTS

The Seismic Experiment for Interior Structure (SEIS), provided by the Centre national d'études spatiales (CNES), was built by the Institut de Physique du Globe de Paris (IPGP), in collaboration with Imperial College London, Swiss Federal Institute of Technology (ETH Zürich) and the Max Planck Institute for Solar System Research (MPS).

The Heat Flow and Physical Properties Package (HP^3), was built under the guidance of the DLR Institute of Planetary Research in Berlin, together with the DLR Institute of Space Systems in Bremen, the DLR Institute of Optical Sensor Systems in Berlin, the DLR Institute of Space Operations and Astronaut Training in Cologne, the DLR Institute of Composite Structures and Adaptive Systems in Braunschweig, the DLR Robotics and Mechatronics Center and the DLR Institute of System Dynamics and Control in Oberpfaffenhofen, as well as the Institute of Space Research in Warsaw.

The Rotation and Interior Structure Experiment (RISE), led by JPL, will use the spacecraft communication system to provide precise measurements of planetary rotation.


Mountain ranges in eastern Greenland at 69 degrees north in the light of the low-lying Midnight Sun

SUMMIT FLIGHT IN THE MIDNIGHT SUN

The Falcon, a DLR research aircraft that has proven its worth for decades, was on mission in Iceland for several weeks in May 2015. Together with NASA's DC-8 research aircraft, it conducted flights over the Arctic Ocean and the Greenland ice sheet. The objective: high-precision wind measurements. A new laser measuring device, a wind lidar (LIght Detection And Ranging), was calibrated and tested during these flights. The new technology is set to make its début on board the ESA satellite Atmospheric Dynamics Mission Aeolus (ADM-Aelous), expected to be launched into Earth orbit in 2017, from where it will acquire detailed information about the wind, which should significantly improve current weather forecasts.

The Falcon flies over Iceland and Greenland

By Falk Dambowsky, Oliver Reitebuch and Philipp Weber

On 11 May 2015, the Falcon took off, full to the brim – flying from Oberpfaffenhofen in southern Germany, to Iceland. Only two seats remain in the Falcon cabin, behind the measuring instruments that completely occupy what would normally be the aisle. The instrument cabinets with displays, numerous computers and a myriad of cables also take up a great deal of space. The rest of the aircraft is filled with luggage and survival equipment, such as life jackets and two inflatable life rafts – mandatory for flights over water. The flight path of the Falcon D-CMET passes over Prestwick in Scotland, all the way to Iceland's Keflavik International Airport, located approximately 50 kilometres from the capital city, Reykjavik. An 18-day mission of around 50 flight hours lies ahead for the 13-member crew of engineers, scientists, pilots and technicians. These 18 days will be filled with the joy that comes from research, but also packed with excitement.

NASA's DC-8, which also carries two wind lidars on board, has already arrived in Keflavik and is waiting. At this moment, the world's leading specialists in this type of wind measurement using lidar are gathered together in Iceland. Most of the NASA and DLR crew already know each other from joint research flights carried out in California in 2014, when the Falcon flew in close formation behind the DC-8 to investigate biofuel emissions. In this new collaboration, the teams will conduct parallel measurement flights around the coasts of Scotland and Greenland. The researchers are particularly interested in measuring the wind in the so-called North Atlantic Jet Stream, but they must take care not to get in the way of intercontinental flights between North America and Europe – when these aircraft fly from west to east, they take advantage of the strong tailwinds produced by this jet stream.

Highs and lows

After two intense weeks of research flights, a long-awaited 'weather window' opens up for a very special part of the mission – Falcon's solo flight to the 'summit' of Greenland. This is no mountain in the conventional sense of the word, but at its 3200 metres above sea level, it is the highest point of Greenland's gigantic ice sheet. A US research station based there will provide reliable comparative data for the wind measurements with ascending probes.


Image: NASA

Greenland's coast – its summits and, still in May, frozen fjords and sea ice.

Inside the cabin of the DLR Falcon. Here, DLR scientist Oliver Reitebuch of the Institute of Atmospheric Physics with the two wind lidar instruments. The optical receiver of the satellite prototype ALADIN is well insulated for thermal stabilisation (grey box, image centre).

ADM RESEARCH FLIGHT CAMPAIGN

The ADM (Atmospheric Dynamics Mission) research flight campaign over Iceland and Greenland is a DLR contribution to the ESA ADM-Aeolus mission. Involved in this mission are the DLR Institute of Atmospheric Physics, DLR Flight Experiments, ESA and the University of Leeds, which has installed a wind lidar at the summit station in Greenland for the mission to perform comparison measurements from the ground. This mission is being carried out in cooperation with NASA. For the first time, four wind lidar instruments on two aircraft are being used at the same time.

At present, wind fields are being monitored and recorded by following the movements of clouds with optical weather satellites or by using radar satellites that scan the air movements close to the surface of the oceans. There is a complete lack of wind information for a large part of the atmosphere. The wind lidar measurements will enable us to directly detect the wind speeds from the ground level to an altitude of 20 kilometres with much greater accuracy. This technique is using laser light with a specific wavelength emitted into the atmosphere. Depending on the movement of the wind field, the light is reflected back with a small change in its wavelength. The difference in wavelength is used to calculate the corresponding wind speed. This technique enables minute wavelength changes to be measured accurately.

Two days before the actual flight campaign, the expedition begins with a detailed weather briefing. On the screen, the video projection shows what seemed unlikely during the first two weeks of the mission: on the night of 21 to 22 May, the skies above the summit station – located in the middle of Greenland – will be cloud-free! Cheer inundates the room. Clear skies are necessary to test the wind lidar under optimal conditions, as was the case for the test flights conducted to the south of Greenland, north of Scotland and over the Arctic Ocean in the previous days.

The preparations for the perfect research flight intensify. Together, scientists and pilots decide on the exact flight plan – it will start at Keflavik, continue in a north-westerly direction towards the east coast of Greenland, then northbound and inland, all the way to the highest point of Greenland's ice sheet, where the research station is based. The pilots estimate that the quantity of fuel loaded on the Falcon will be enough to perform two overflights and to circle behind and over the station. They will then turn around and make their way back along the same route. This is also a special occasion for the crew stationed in the secluded Arctic outpost in Greenland, as a research aircraft flying over their station is not an everyday occurrence.

Night of the summit flight

At 19:00 on the evening of 21 May 2015, the on-board technician switches on the Falcon's external power supply to heat the measuring instruments to their operating temperature of 25 degrees Celsius. Now, whilst still on the ground, the scientists on board must begin to calibrate their detectors, transmitters and analysing instruments. The lasers on the wind lidar have to emit light at a very specific frequency to record the wind fields accurately. The spectrometer, which analyses the light that is backscattered from the air molecules, has to be stabilised to one-hundredth of a degree Celsius. This is an intense time, comparable to the hubbub in a base camp before climbing to the summit. A voice from the cabin says: "It's going to be one heck of a sunset cruise!"

At 19:30 the team is taken by surprise due to a system failure – there is a problem with one of the lidar instruments. More precisely, one of the cameras needed to adjust the sensitive lasers is not functioning optimally. Can the problem be fixed quickly? Tonight is the only night during the Iceland mission with skies clear enough to conduct a flight over Greenland. Several attempts are made to fix the camera and the tension rises. Pressed for time, the team is stuck in an emotional roller coaster: shut down all systems, wait, reboot, test all functions – and hope for everything to be operational once again. One hour later, the lidar lasers are back up and running and ready for the flight.

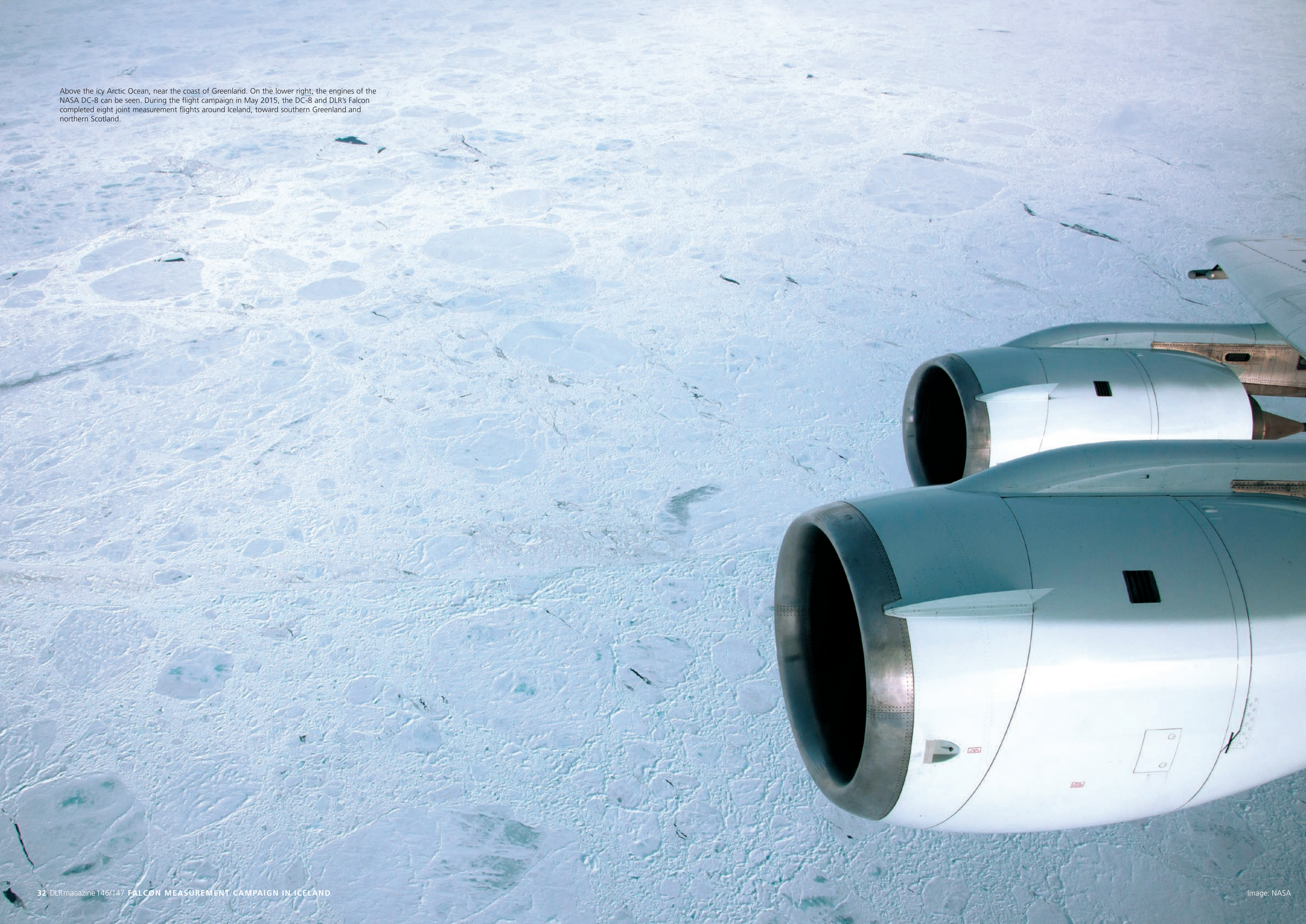
At 21:00 the hangar door begins to open – but after just two metres, it suddenly grinds to a halt. The fuel truck is ready and waiting, but the Falcon is trapped. There is another door at the back of the hangar, but there is no getting out there either – just a few hours earlier, an A320 passenger jet from the Icelandic airline, WOW-Air, was parked behind the Falcon and is now waiting to be serviced. The team is worried. Will they be able to reach the summit before the clouds close in?

The team moves the hangar door back and forth in an attempt to open it. But there is no quick fix here – the hangar door will not budge. Then comes an idea: "we could try to contact the Icelandic airline and ask them to move their airliner out of the hangar for us!" The airline is contacted and is luckily happy to help, despite it being late in the day. But to do so, a large pushback tug is required, which is being used in the passenger terminal area at the other end of Keflavik International Airport. In parallel to the efforts of finding a solution to the problem, a call is also made to an off-duty electrician to see if the hangar door can be fixed. And so the race begins – who will make it to the hangar first: the pushback tug or the electrician?

At 21:20 the pushback tug arrives at the hangar. The A320 is pushed out, making way for the Falcon to be let out via the back door. But the team is not out of the woods just yet. The Falcon has to be turned around in a very tight space, while making sure that the wings do not touch the front hangar door, which is still closed. Four gentle pushes with a tow bar and the Falcon is finally free. The driver of the fuelling truck has been waiting patiently for the Falcon so that things can get underway very quickly from here on.

At 22:30 the Falcon rolls onto the runway in the sunset, taking off half an hour behind schedule due to the commotion. On board are two pilots, an on-board technician and two scientists. Once above the clouds, they switch on the measuring instruments – one by one. The Falcon heads towards a handover point called HEKLA, which is out at sea, to the north west of Reykjavik. It is there that Icelandic air traffic control hands over the aircraft to their colleagues in the next control sectors. HEKLA is the only established waypoint that the pilots will fly over during this research flight – all other navigation will rely on coordinates. A stretch of Arctic Ocean lies before the five-man crew before reaching the world's largest permanent ice sheet. This far north, there is no radar coverage for air traffic control. The pilots have to contact air traffic control at pre-agreed waypoints to inform on their position.

At 23:30 the Falcon reaches the east coast of Greenland. From here, the mountains tower above the permanent ice – an impressive view in the sunlight stretching out over the horizon. The most exciting part of the flight is about to start for the scientists on board. Once above the ice, they can start to calibrate their apparatus. They check the frequency spectrum of the outgoing laser pulses and find that it still deviates slightly from the optimal operating conditions. In their words, "we are going to slightly readjust the frequency of the lasers." After this, the



Above the icy Arctic Ocean, near the coast of Greenland. On the lower right, the engines of the NASA DC-8 can be seen. During the flight campaign in May 2015, the DC-8 and DLR's Falcon completed eight joint measurement flights around Iceland, toward southern Greenland and northern Scotland.

Image: NASA

values displayed are correct. Then, the gauges displaying the atmospheric backscattering of the laser lights are checked. On average, just a fraction of the photons emitted by the laser pulse find their way back to the detectors on board. The information they carry about the wind speed beneath the Falcon is very important because, during the process of backscattering, the wind speed causes a slight shift in the wavelength of the light. Further inland, the mountains seem to sink into the mighty Greenland ice shelf, which reaches heights of 3000 metres, until they disappear completely behind a white horizon. From the cockpit window, the whiteness stretches out in all directions. Orienting oneself merely by sight is not possible. All that remains are the positional reports sent from the cockpit to the relevant air traffic controller over the radio: "Delta Charly Mike Echo Tango checked position 7230 North 03645 West, Flight level 360, Mach .72 at time 00:06, estimating 7236 North 04019 West at time 00:16, 7230 North 03645 West next."

At 00:10 they have made it. The Falcon has arrived at Greenland's 3200-metre high summit. The clock shows a delay of just 10 minutes despite the challenges faced earlier. The summit camp – 7500 metres beneath the D-CMET – is visible in the faint light of the Midnight Sun. Barely discernable bumps on the vast white surface of Greenland's ice sheet are the only traces of the research station. After the first flyby, the pilots prepare to circle the summit camp as planned and air traffic control is contacted by radio: "Request to circle overhead summit camp for 15 minutes at flight level 360." The air traffic controller confirms: "Cleared to circle, next report when finished."

The atmosphere in the cabin is laden with silent concentration. The scientists watch the panels while the Falcon performs a so-called 'procedure turn' in preparation for a full circle over the summit camp at a bank angle of 20 degrees. The lasers are pointed straight down through a large window in the Falcon's fuselage. It is now time to meticulously record the all-important and long-awaited data with the new lidar systems.

On the ground, the US scientists have just launched their radiosonde, which will provide exceptionally accurate comparative values. In addition, a ground-based lidar is also used, which projects its laser beam towards the sky above the summit, thus providing even more comparative figures. This ground-based lidar from the University of Leeds was flown to the summit at the end of April, especially for this mission. This is one of the most perfect locations during the research mission to validate the new system for its future use in space. The test lidar on board the Falcon is only half the size of the device that will be on board ESA's ADM-Aeolus Earth observation mission in 2017, but has exactly the same functionality. From the air, the scientists are able to measure all kinds of wind patterns, as well as aerosol and cloud profiles, which can be checked at a later date by the lidar from space. Meanwhile on board, the scientists are keeping a careful eye on the quality of the data being collected, as it will be used to test the algorithms of the future satellite lidar.

At 00:30 the crew is happy and relieved. The pilots have completed another circle – this time slightly further away from the station. The most important measurements are 'in the bag'. There is some time left to spare to enjoy the exhilarating mood in the Midnight Sun. Someone says: " We are flying over one of the few scientific outposts of humanity – how fantastic!"

At 02:00 the Falcon approaches the Icelandic coast again, and banks to land at Keflavik International Airport. The Midnight Sun has guided the crew throughout the flight. Now, in the middle of the night as they head south, and shortly before landing, the Sun disappears just beyond the horizon, but only for a little while. It is the icing on the cake of an incredibly beautiful – albeit stressful – research expedition. The Falcon touches down and taxis to the hangar, where the previously faulty door is now open. The problem was a fuse, which the electrician that had been called in found and replaced. It would have been risky for the sensitive apparatus on board if the D-CMET had had to spend the night in the open air at Icelandic temperatures of below zero. In this case "someone would have had to spend the rest of the night on board with a heater," is said by a relieved person. Luckily, the flight was successful and this was not necessary. This stage of the mission concludes normally – valuable data has been acquired.

More flights with NASA

In the days that follow, more flights are carried out, this time together with NASA's DC-8. Here, data gathered by weather satellites already in orbit will be used for comparison. At the end of this mission, eight joint research flights were conducted by the two teams.

The flight campaign with the DLR Falcon was carried out in cooperation with ESA in preparation for ADM-Aeolus, a satellite mission scheduled for launch in 2017. A Vega launcher will transport the new meteorological satellite to an altitude of 410 kilometres, where it will enter a polar orbit. The Falcon aircraft will continue to test new prototype satellite measurement techniques in the air before they are launched to space – as it has done many times before in its 40-year history.

Falk Dambowsky is editor for aeronautics at DLR. **Oliver Reitebuch** is a senior scientist at the DLR Institute of Atmospheric Physics and directed the ADM flight campaign. **Philipp Weber** is a test pilot at DLR Flight Experiments.

s.DLR.de/nt4h

The DLR Falcon and NASA DC-8 at Iceland's Keflavik International Airport during the ADM campaign in May 2015

Dave Emmitt is a meteorologist and has been working with airborne wind lidar systems for more than 30 years. He is one of the leading US scientists in this field.

WHAT THE JOINT MISSION WAS ALL ABOUT

Short interview with Dave Emmitt, Principal Investigator on the NASA mission PolarWinds

What is NASA's role in the joint mission in Iceland?
: Our mission in Iceland has two objectives. Number one is to support ESA in its preparation for the launch of Aeolus – a laser-based wind measuring instrument. More specifically, we are practicing manoeuvres specific to the use of airborne wind lidars to provide calibration of a space-based wind sensor. In some cases, we fly in formation with the DLR Falcon, which hosts the ALADIN demonstrator – the engineering version of the Aeolus instrument. The second objective is the NASA PolarWinds science mission, with a focus on validating numerical weather models with most of our attention on the winds near the surface, especially just above the ice of Greenland. There is a general consensus that we need to better understand how energy and mass are being transported above the Arctic Circle. This is a region where we have very few direct measurements, especially near the surface.

How long have you been collaborating with DLR for this mission?
: I have been a tropical meteorologist for over 30 years, and have been working with airborne wind lidar since the early 1980s. However, for the last three years I have redirected some of my energy to the polar regions. My connection to atmospheric research in Germany dates back to the 1970s when I was doing my postdoc in Hamburg. In the 1990s, DLR lidar researchers began attending the NASA/NOAA Space-based Doppler Wind Lidar working group meetings in the United States. Since then, there has been a strong interest at NASA to collaborate with ESA on lidar missions in general. Given that DLR has significant expertise in wind lidars, it was natural that we would work together on an ADM calibration project. We have our own set of wind lidars on the DC-8, including a direct detection lidar similar to the ALADIN demonstrator on the Falcon. It is noteworthy that this is the first mission ever where four Doppler wind lidars (DWL) have flown together in formation. In the USA, we have five DWLs flying on several aircraft. Much of this activity is related to the goal of launching a space-based lidar in the future.

What is the reason for flying two airplanes together, each with two wind lidar systems on board?
: We are practising for the post-launch calibration of ESA's Aeolus wind lidar system. One manoeuvre that the DLR Falcon needs to execute as part of the pre-launch calibration requires the Falcon to fly in tight circles (20 degree banks) to keep the Aeolus simulator pointing straight down. In this configuration, the lidar is not measuring the full wind vector, since we need multiple perspectives to get the wind profile. While the Falcon flies in circles, the DC-8 provides the complete, multiple perspective samples from which the full wind profile can be derived. In addition to the complete wind profiles from the DC-8 lidars, the ALADIN demonstrator needs temperature profiles to make corrections to the Aeolus raw observations. Since the DLR Falcon could not carry the hardware for making these temperature soundings, the DC-8 was equipped with a dropsonde system, making more than 50 soundings to support the ADM mission.

Tell me about the flight formation
: In the beginning, formation flying was rather tight. The DC-8 was flying just about 350 metres below the Falcon, just a few hundred metres behind. Air traffic control was not comfortable with this tight formation and thus the distances were increased to several kilometres of separation.

Is there more collaboration planned for the future?
: Yes, especially when the ESA satellite is launched. Certainly, after launch we will have the opportunity to work again with DLR to calibrate the space system under a variety of atmospheric conditions. As long as it remains in orbit, we will have many opportunities to under fly the satellite, steadily increasing our understanding of the technology performance and the utility of the data it provides to the science community.

About Alexander Sohr
Alexander Sohr is a qualified computer engineering scientist who has been working in the Traffic Management department at the DLR site in Berlin since 2005, focusing on traffic problems in (mega) cities.

Sustainable Mobility for Mega Cities
The project METRASYS is one of 10 projects funded by the German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung; BMBF) as part of the scientific programme 'Research for Sustainable Development of the Mega Cities of Tomorrow – Energy and Climate Efficient Structures in Urban Growth Centres'. With the topic of mobility and transportation in its focus, the project deals with one of the most pressing issues of current and future megacities and metropolitan regions.

The city of Hefei
Hefei is the capital of Anhui province in China and is located approximately 450 kilometres west of Shanghai. As such, it forms the interface between central China and the booming coastal region. The metropolitan area covers 7266 square kilometres – 640 square kilometres of which have already been urbanised. The Hefei region has a population of approximately seven million inhabitants.

AT THE CROSSROADS – MEGACITIES

Mobility and transport of Chinese metropoles – Interview with traffic engineer Alexander Sohr

By Melanie-Konstanze Wiese

Masses of vehicles, congested intersections and sluggish traffic are a part of daily life on the roads of Earth's major cities. Since 2007 – with the rise of rural exodus – more than half of the world's population has been living in urban areas. Seventeen of the world's 29 megacities are in Asia; of these, five are in China – and the number is expected to rise. Approximately 300 cities are home to between one and one-and-a-half million people. New transport concepts are required to meet the mobility requirements of the inhabitants. The DLR Institute of Vehicle Systems Technology has been collaborating with China for more than 10 years advising the national authorities on ways to cope with the immense volume of traffic, as well as providing support with sustainable traffic management concepts. In this interview by DLR Berlin Communications Officer Melanie-Konstanze Wiese, Alexander Sohr illustrates the involvement of German transport researchers, the challenges faced and the achievements.

Mr. Sohr, you have been involved with transport in Chinese cities – specifically in Hefei – for several years now. Why this city in particular?
: The Sustainable Mobility for Mega Cities, METRASYS, project focuses on the topics of mobility and transportation in future megacities. Hefei, the capital of Anhui province, is not yet a megacity – a city with more than 10 million inhabitants – but it is well on the way there. When the project began in 2009, Hefei had approximately five million inhabitants. In 2013, upon completion of the METRASYS project, the population had reached approximately seven million. Official figures show an increase of between 200,000 and 300,000 inhabitants per year, so it is evident that the city will eventually become a megacity. This makes Hefei an excellent model city for us.

Why is this collaboration so interesting for China? And why does China appeal to DLR traffic systems engineers?
: In China, there is a great demand for technology, knowledge and experience. How do you deal with a transport system that is becoming increasingly dependent on cars? What technologies are available for optimising the traffic system? For us, the collaboration is appealing because the sizes of Chinese cities offer unique research opportunities. Dealing with such volumes of traffic is a major challenge. European cities do not offer the possibility to work with data volumes of this order of magnitude. Germany's largest city is Berlin – with almost 3.5 million inhabitants. Although German cities are not growing as quickly, there is still much that we can compare with our own conurbations.

What was your project exactly about?
: METRASYS focused on the sustainable development of a rapidly growing transport system in a city like Hefei. Besides the current traffic situation, which was already very tense at the time, future problems needed to be detected. In this regard, we worked closely with the local authorities and implemented sustainable solutions in the Hefei police traffic management centre. In addition, we supported the traffic planning office. We developed scenarios for the traffic system in 2020 and 2030, to demonstrate to the authorities the consequences of such rapidly growing traffic. Where will following the suggested urban development plan take you? Using these scenarios, we were able to identify alternatives and possibilities for making the city a little more environmentally friendly.

The project began in 2009 – was the route to success a long one?
: Yes, indeed. Before a traffic management solution can be developed, it is necessary to grasp and understand the situation. First, we looked at the pattern of city growth and the prevailing conditions. It was necessary to start by comprehensively recording the city's traffic situation. We needed to accurately illustrate the focal points of the traffic problems for the authorities. We used the Floating Car Data System as a basis for this information – this involves acquiring data from flowing traffic, as we have been doing successfully in Europe for several years – in Berlin, for example. This system relies on GPS data transferred from the vehicles – in Berlin we used taxis – to a traffic control centre, where it is then used to generate traffic congestion reports. In the second stage, we installed a camera-supported Intersection Monitoring System at various intersections. This gave us a detailed view of the traffic behaviour in the vicinity of this intersection. You can see how traffic regulations are being observed and how infrastructure is being used. This is important for us because traffic in China is different to traffic in Germany.

What is different in China? Do the Chinese drive differently than Europeans?
: Quite clearly, yes. It begins with how the car is perceived – it is representative of social status, which is why there are so many vehicles. In 2013, 1.4 million vehicles were registered in Hefei; in 2010, this figure reached just over half a million. The city of Shanghai is currently trying to control this by charging 10,000-20,000 euro solely for registering a vehicle. The driving style is also very different. For example, road markings are rarely followed, but traffic lights are carefully observed, as failure to do so results in more severe disciplinary consequences. Other traffic regulations are 'individually-tailored' – self-organisation is more predominant in China's traffic. To us Europeans, it looks rather like a seething mass, and one wonders how it all works. For example, anticipatory driving in China only works within a short radius – the next five metres. Thus, the flow of traffic is somewhat slower than in Europe, as one cannot be sure that the right of way will actually be respected.

What were the cultural considerations of the project work when collaborating with Chinese partners?
: Hierarchy plays a major role in Chinese culture. Good networking is essential. At the start of the project, it was very important for us to pay a visit to the chief of police, as his impressions of the project were critical to its progress. We managed to convince him of the practical benefits of the project. After that, cooperation at lower levels was very good.

Was DLR able to make a difference with the work conducted in Hefei?
: Absolutely. We are very proud of the fact that our project was actually set in motion in the city of Hefei. The traffic data is now available to the police in the centre for traffic management, where it is being used. Our results have also been included in the district planning manual of the urban planning authority and are forming the basis of new planning processes.

Is METRASYS transferable to other Chinese cities?
: One focus of the project was that the concepts should be exactly that: transferable to other cities across the globe. We are very well established in Shanghai now as well. We have already conducted a follow-up project in Zhengzhou, the capital of Henan province, which is adjacent to Anhuit. In addition, the Floating Car Data System is being used in numerous Chinese cities as an information basis for traffic management.

Are the concepts that were developed working everywhere?
: The concepts cannot of course be transferred 'exactly as they are'. Universal solutions are based on the European model and are not easily applied to Chinese cities. The reasons for this include the volume and speed of the traffic, which are quite different. Nevertheless, some proposals are quite practical, such as the creation of traffic-calmed zones in the city centre. Elevated motorways and ring roads can give rise to new space for pedestrians in a city cross-cut by roads – but this is not a panacea for all traffic congestion and capacity problems.

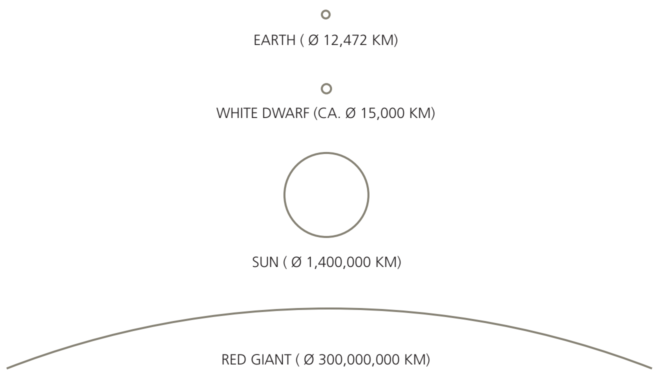
Sustainability and climate protection – were they addressed?
: At present, cities in China are legally obliged to measure, record and report air pollutants, so that the data can be compared. This is also done as an incentive to contribute to climate protection. When METRASYS began, almost no pollutant monitoring was being conducted so modelling emissions was relatively difficult for us. At the time, we only had a few days of measurement data. Now, we have access to comprehensive measurements of pollutants.

How can traffic management contribute to reducing emissions?
: This primarily involves developing new strategies for avoiding or relocating traffic. The optimisation of traffic leads to less congestion, and hence fewer emissions. The measures for this must be pooled together – they will only have the desired effect on global climate if applied in combination.

The project has now come to an end, but is DLR still conducting work in Hefei?
: Yes, we are still there. Together with our cooperation partners in Hefei, we have set up a joint research laboratory here at DLR, financed by the Chinese Ministry of Science and Technology (MOST). Together, we are developing methods and embarking on new projects. MOST is financing a project for the continued development of intersection monitoring. Furthermore, discussions are currently taking place concerning a traffic management project in a smaller city near Hefei. This is one of 49 cities in China with more than one million inhabitants. It could develop into a pilot project from which many other research projects could benefit. In addition, we have embarked on a joint study with the Institute of Optics and Precision Mechanics at the Chinese Academy of Science (CAS), which concerns the measurement of traffic-related pollutants in the vicinity of an intersection. The aim here is to minimise the emission of pollutants by optimising traffic flow.

www.metrasys.de

ABOUT STARS AND AIRPORTS



Astronomers and aviation researchers – united by more than just the sky

By Johannes Reichmuth

What we know today about the evolution of stars is thanks to observations of the night sky. The same holds true for the luminosity and colours of stars – if we were to chart these in a diagram, it would be clear that their values are not a mere coincidence – in some places, a lot of stars can be found, whereas in other places there are hardly any. Mathematical models that classify stars based on their characteristics, such as their mass and chemical composition, can be used to predict complete stellar evolution processes. Thanks to these models, we can outline the evolution of our own star: when all of its hydrogen is depleted, the Sun will start to expand, its luminosity will increase, and it will radiate more red-coloured light, eventually becoming a Red Giant. And it does not stop there – the Sun, as it continues to evolve, will become a White Dwarf towards the end of its development.

Ever since the beginning of humanity, stars have been a source of great fascination. It goes without saying that this is particularly the case for astronomers, but the same is also true for scientists from completely different disciplines – aviation researchers, for instance. Stars and airports do indeed have a few things in common.

A very busy airport can become a 'Red Giant'

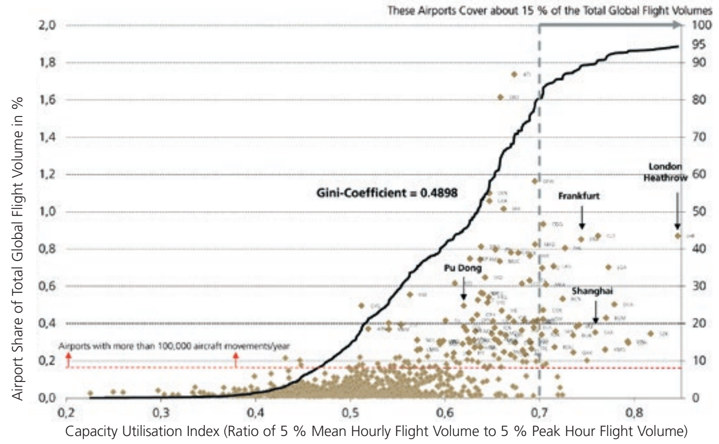
If one were to chart the currently observable stars, the different developmental stages of stellar evolution would be visible. Together with mathematical models, this data can be used to recount the history of stars and make predictions of their evolution over the course of billions of years. The DLR Institute of Air Transport and Airport Research is applying these mathematical calculations to airports. To do so, all airports across the world with regular scheduled flights are taken into consideration, and the flight plans for each individual airport are analysed year after year. In the case of stars, the luminosity is measured – for airports, what is recorded is the amount of planned movements each year. Rather than colour, which is used to analyse stars, airports are defined by their capacity utilisation. The question being addressed here is how close an airport is working to its maximum capacity.

To define an airport's capacity utilisation, it is important to determine its degree of hourly movement. The maximum capacity of an airport will be determined by the safety intervals between flights, which are dependent on weather conditions, type of traffic, its infrastructure and equipment, as well as its available runways. The resulting fluctuation of hourly capacity at airports complicates the task of calculating an airport's capacity throughout the year.

If too many flights are scheduled within any given hour, then the risk of failing to adhere to the flight schedule increases. It is therefore in the interest of both airlines and airports to strike a balance between the risk of a temporary congestion and providing reliability for the passengers.

In the case of busy airports, one way of measuring their capacity (per hour) is to look at all scheduled flights per hour throughout one whole year and filtering out the peak hours from this data. To do this, every hour is analysed and sorted by the number of aircraft movements. Typically, an hour can be designated as rush hour if it lies within the five percent of the hours at this airport where this amount of flights is reached or surpassed – this is a good indication of the capacity of that particular airport.

Busy airports worldwide versus capacity utilisation. Airports are classified by their traffic volume and capacity utilisation. There are a significantly small number of airports with a large number of movements; these are shown on the right hand side and generally portray airports with large or very large capacity utilisation. There is only a small amount of busy airports with moderate capacity utilisation and busy airports with low capacity utilisation are scarce.



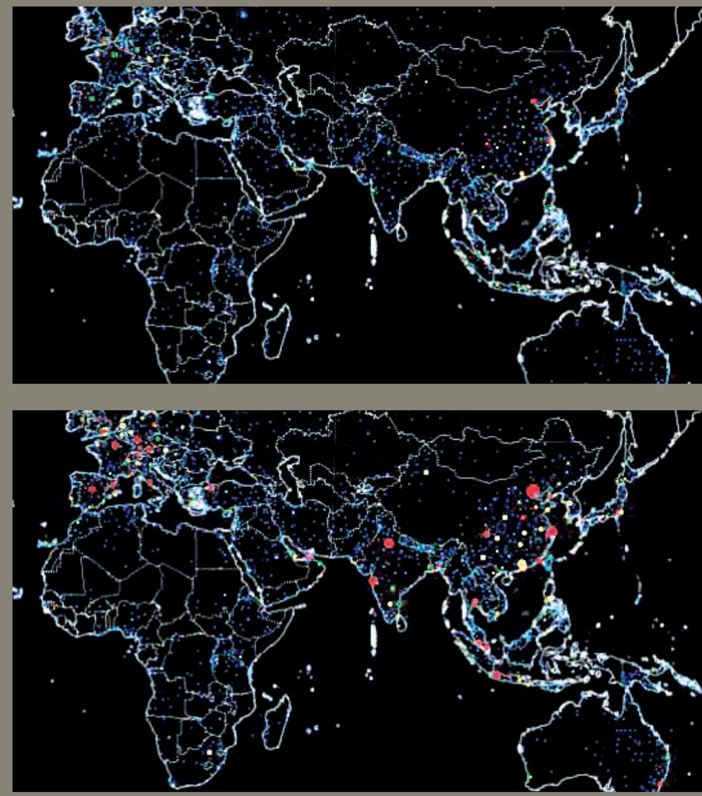
Determining whether an airport is more or less busy can be achieved by comparing the moderate hours with the typical peak hours throughout the year. Airports with less traffic show a greater gap between peak hours and average hours when compared to airports that have a higher capacity utilisation and are in 'the red zone'. In these cases, there are already a greater number of hours in which the number of movements typically only seen during peak hours has (almost) been reached.

Using this capacity rating system, we can determine the 'colour' of an airport – just like in the star diagram – and monitor it. The evolutionary path for an airport with high volumes of traffic would therefore be as follows: the airport starts with just one runway and, with increasing demand, its capacity utilisation increases. Over time, the airport requires a second runway in order to cope with the overload. If the expansion is carried out early enough, then the capacity utilisation is reduced to an intermediate level. If the capacity utilisation increases again over time, the airport will need another runway to avoid congestion. Many large airports have seen this kind of evolution. Airports such as Munich Airport, which are built to relieve another airport of its excessive flight volume, are generally conceived with two runways.

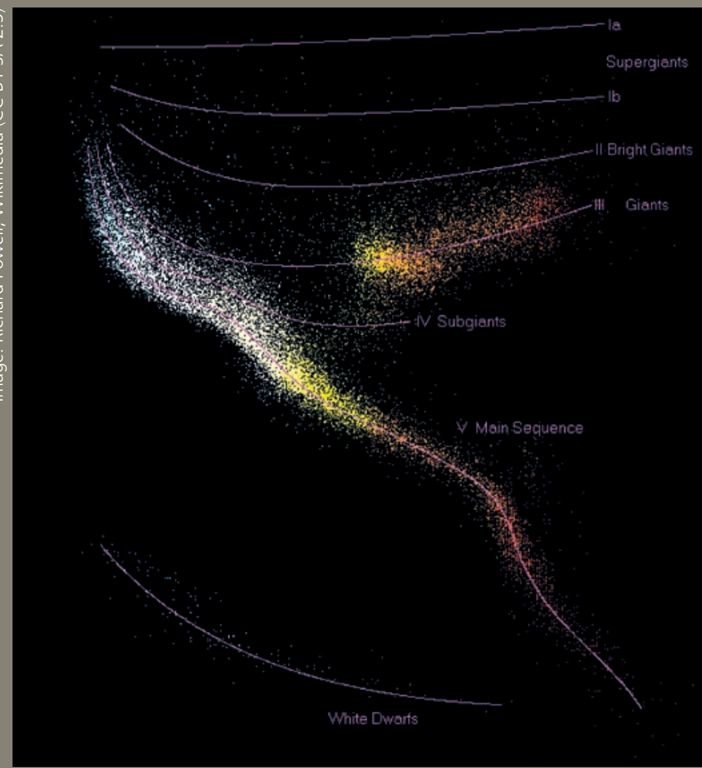
If the need for expansion is not addressed – as is the case for London Heathrow – which has been running above capacity for years, then flight movements can hardly be increased and the airport becomes stagnant. By the same token, if, for example, one airline dominates the operations of an airport and ceases its activity, it will lead to a sharp decline in the number of movements – the airport becomes a 'white dwarf'. By bringing the analysis of global flight volume together with growth forecasts, the future capacity utilisation of airports across the world can be estimated. In this way, airports that require urgent attention can be identified and their infrastructure expanded to increase capacity.

Johannes Reichmuth is Director of the Institute of Air Transport and Airport Research.

DLR.de/FW/en



Capacity utilisation of airports in 2010 (above) versus 2030 (below)
Many airports across the world that are located in areas with a high population density will be above capacity in the future, based on their current infrastructure (big red circles). Many more airports, however, will have less traffic, will no longer be used as often, and will face economic difficulties (small blue circles).



Stars' development in the Hertzsprung-Russel diagram: On the vertical axis is the absolute magnitude (upward rising) and on the horizontal axis (upper left, more bluish, lower right, more reddish) is the temperature.

SMALL PARTICLES THAT CAN WREAK HAVOC

How does volcanic ash affect aircraft turbines?

By Ravisankar Naraparaju

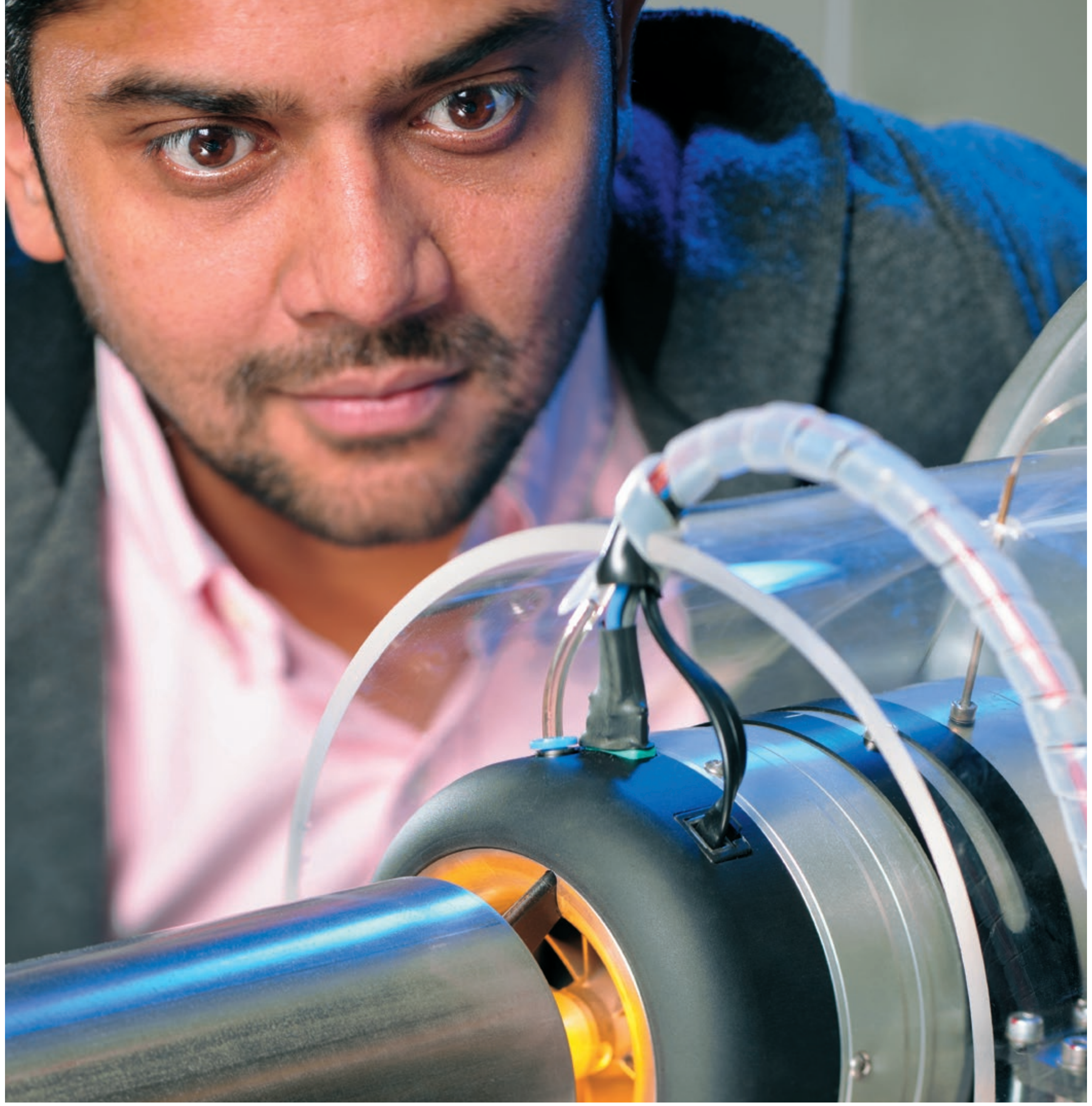
In 2010, the volcano Eyjafjallajökull erupted in Iceland – the resulting ash cloud severely affected European airspace. Since then, the threat of volcanic ash to aviation has been widely recognised, and it has become clear that extensive in-depth research is required to gain a precise understanding of the mechanisms at play when ash enters an aircraft engine – as realistically as possible. No laboratory experiments have been conducted on a real turbine to attain a deep insight to this problem – until now. A test rig was developed and built by DLR, the Laboratory for Environmental Monitoring of the University of Dusseldorf and the company Hammer Engines GmbH in a joint research project.

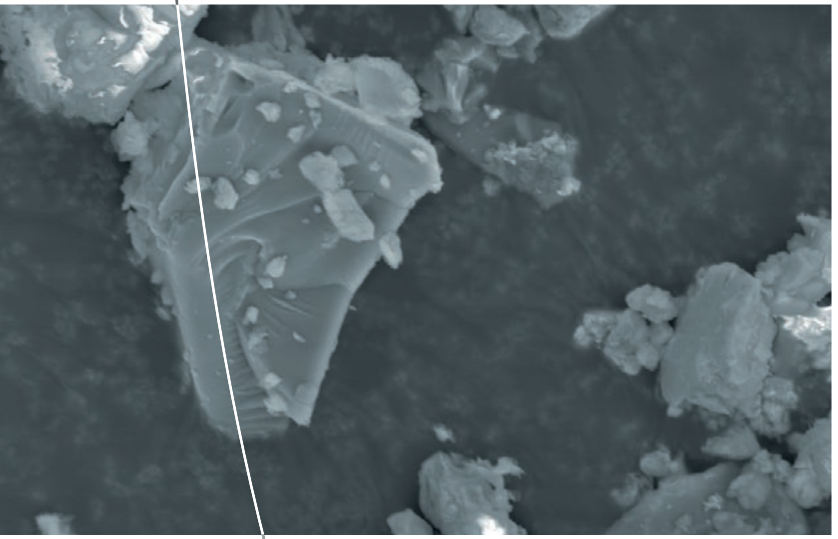
Volcanic ash in the air can be ingested by jet engines. At high temperatures, the particles adhere to the internal components of the engine causing substantial damage. In addition to volcanic ash, sand on airport runways and in the atmosphere is also another potential threat to aircraft engines. Aircraft flying in the Middle East and Asia, for example, very often encounter sand cyclones and industrial dust in the atmosphere. The air is ingested by the turbines and in cooler regions, such as a low pressure compressor or fan, can cause erosion of the materials, block sensors and cause a great deal of damage.

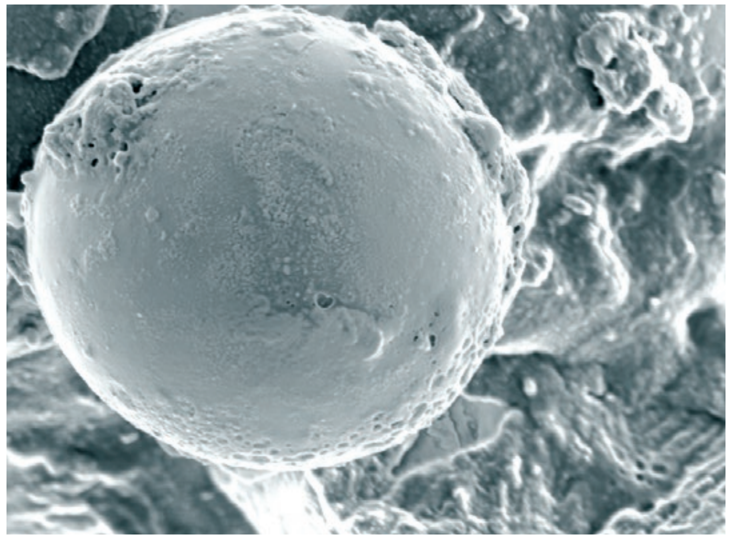
The temperature inside an engine ranges from 100 to 1600 degrees Celsius, depending on the area. The 'hot zone' – where temperatures exceed 1000 degrees Celsius – contains metallic parts covered with functional ceramic coatings, known as Thermal Barrier Coatings (TBCs). These TBCs are highly porous and have a very low thermal conductivity, hence causing the temperature to drop through them, and allowing the metallic parts to operate at lower temperatures. In addition to the internal cooling mechanism installed within the metallic parts, these TBCs act as thermal insulators.

When air contaminated with volcanic ash enters an aircraft engine, the particles melt as a result of the increasing temperature, infiltrating the TBC. The reaction will cause the TBCs to lose their characteristic ability, and will sometimes peel off, exposing the underlying metallic parts to high temperatures, which may cause damage during a flight, shortening the operational life of the engine or aircraft and increasing the frequency of servicing.

Although the interaction between volcanic ash and TBCs is understood, the scientists at the DLR Institute of Materials Research and their partners at University of Düsseldorf and Hammer Engines GmbH want to investigate and understand precisely how the damaging mechanisms on the turbine blades occur and develop, and what part exactly is played by molten volcanic ash. Do the ash particles soften and melt within the combustor and deposit on the turbine blade as a droplet, or will they first adhere to the turbine blade and then melt as a result of the heat on the blade?







The two Scanning Electron Microscope micrographs show original volcanic ash particles (left) and those collected in the exhaust (right). The initially splinter-shaped ash particles turn into molten spheres. If these accumulate on the turbine blades, they can cause its ceramic coating to crack or spall.

To get to the bottom of this, a test rig has been constructed and erected at DLR Institute of Materials Research in Cologne. The uniqueness of this experiment is based on the idea of sending real volcanic ash particles through a mini turbine coupled with a particle analyser. The mini turbine has a small compressor section, a combustor in which temperatures exceed 1500 degrees Celsius and a bladed disc. To achieve the most accurate results, these blades are coated with the conventional TBC (7wt. percent yttria stabilised zirconia).

The first test run was conducted in March 2015 – here, researchers used actual Eyjafjallajökull volcanic ash particles. It was a success! The presence of molten volcanic ash particles in the exhaust demonstrated that the test rig is capable of simulating the reaction between the components and the volcanic ash in flight conditions. Now, DLR scientists can precisely study the relation of particle size to its flying behaviour through the turbine and to the melting and adherence behaviour. The knowledge acquired will allow the scientists to better determine when the volcanic ash concentrations in the air become critical for air traffic, how much damage the aircraft engines can suffer, and the extent to which their service life is shortened.

THE VOLCATS PROJECT

The research conducted at the DLR Institute of Materials Research is connected to the VolcATS project (Volcanic Ash Impact on the Air Transportation System). Six DLR institutes are involved in investigating the effect of volcanic ash on air traffic, which covers detecting the ash cloud as it disperses, through to measuring the density distribution of ash particles in the airspace and the efficient reconfiguration of air traffic. The engine damage described here is an important aspect of this.

Ravisankar Naraparaju works at the DLR Institute of Materials Research in Cologne, focusing on the development of volcanic ash-resistant Thermal Coating Barriers (TBCs). He is also responsible for Project iVar (Increased Volcanic Ash Resistance).

A MATTER OF PERSPECTIVE

Innovative materials are just as much in demand in the aerospace industry as they are in the fields of energy and transport. This is one of DLR's many research areas. To know that a material achieves what can be overall expected of it, one has to investigate it into the smallest detail and, as such, find out how it behaves under certain circumstances. Klemens Kelm digs in. Even in his spare time, the scientist at the DLR Institute of Materials Research likes to picture details, albeit in an entirely different way …

Interview with Klemens Kelm on prepared specimens and wild beauty

By Frank Seidler

Mr. Kelm, what are pictures to you?
: When we develop and investigate materials in my line of work, a lot of information becomes available, which has to be gathered and documented. Images, in the scientific meaning of the word, are two-dimensional data sets, which visualise the properties of materials in a spatially resolved manner. In addition to the documentation, they are mainly used to obtain information. Our everyday experience allows us to intuitively grasp the spatial information contained in the images. The brightness and colour of each individual area represents a specific characteristic, which is displayed two-dimensionally. We choose the imaging technology depending on the characteristics we are looking for – some techniques enable the image information to be captured directly as it is being recorded by a signal in a detector. Other techniques require the image information to be extracted from an X-ray spectrum or another data set before the actual image is obtained.

To develop innovative materials, you must determine their characteristics. How is this done?
: The properties and behaviour of a material are first determined by looking at component-type test specimens, where you look for changes that explain the observed properties. As these variations are generally local, we tend to use different microscopic procedures. For example, to investigate a protective coating system, images of the specimen's cross-section are taken using a light or electron microscope. In this case, you look for manufacturing-related abnormalities, especially to see if there have been any changes – these could be due to spalling, corrosion, reactive layers, as well as the smallest of segregations in the layers. Once these have been identified, the chemical elements in, or near, the observed anomalies are generally determined. Using this information, we can create modified layer systems that have minimal undesired effects, such as spalling, whereas desired effects, such as the development of an advantageous contact layer, can be accelerated or reinforced. Further specimens are then tested to check whether this was successful. By analysing parts of these new specimens, we can conclude how the material improvements achieved are related to the adaptations made in the layer system.

Flower head of the native orchid 'Common Twayblade' (Listera ovata) at the DLR site in Cologne

"MY PICTURES, OR PHOTOS, ARE BASED ON VISIBLE LIGHT AND RELY ON THE ARRANGEMENT, WHEREAS THE SCIENTIFIC IMAGES SHOW MATERIAL PROPERTIES THAT CANNOT BE SEEN WITH THE NAKED EYE."

It is not possible to see it all with the naked eye. Which techniques do you work with?
: We use a variety of different microscopic techniques. For instance, we can use reflected light optical microscopy, which enables us to create an enlarged optical image. Using specially adapted preparation and lighting techniques, such as etching or contrasting with interference, we are able to view, for example, grains in metal or illustrate topological differences.

However, in scanning electron microscopy, an electron beam is focused on the specimen surface to create the image. Depending on the shape of the surface, this produces different amounts of secondary electrons. In addition, parts of the focused beam are backscattered, or they produce X-radiation characteristic for the composing elements. Registering these signals with appropriate detectors allows us to gather information on the morphology and composition of the surfaces under investigation. This information can then be used to produce images.

A newer technique is FIB (Focused Ion Beam) – rather than using a focused electron beam for imaging, this technique uses a gallium ion beam. This not only enables the specimen's surface to be imaged, but it also enables ablation, which allows hidden details to be exposed or nanometre-sized structures to be sputtered into the specimen's surface.

In transmission electron microscopes, an electron beam is transmitted through an ultra-thin specimen in the same way as visible light in common light microscopes. Conventional transmission electron microscopy uses a parallel electron beam, in contrast to the scanning electron microscope, which uses a point-focused beam. The image in a transmission electron microscope is thus obtained after going through the sample – contrary to the techniques mentioned earlier. By adjusting the equipment and using specialised detectors, it is then possible to obtain information about the composition, lattice structure and even lattice defects. It is also possible to image the boundaries inside a specimen – in some cases, even at atomic resolution.

You also enjoy capturing details in your spare time…
: Yes, I like taking photos of native plants in my free time, particularly orchids. They are characterised by a wide range of colours and – most of all – by unusual, sometimes even bizarre, forms. Macrophotography allows me to emphasise the variety of shapes by viewing them in an unusually magnified manner compared to the normal size. And by choosing the perspective and exposure parameters, I can accentuate the details and characteristic features of each flower.

How do these photos differ from the images that you work with?
: My pictures, or photos, are based on visible light and rely on the arrangement, whereas the scientific images show material properties that cannot be seen with the naked eye. The arrangement of an image does not really play a role in my professional work. Another difference is, of course, the magnification. When I am taking photos of orchids, I capture a couple of millimetres up to a couple of centimetres of the petals. The structures that are important to us in the materials that I image at work range in size from a couple of microns all the way down to less than one nanometre, which makes them around 1000-1,000,000 times smaller.

Are there any similarities between capturing meaningful images of materials and orchids?
: Yes, the processes that lead to the production of an image are surprisingly similar. Before taking the picture, I have to know exactly what the aim of the picture is in terms of essential characteristics. For example, when investigating a material, it could be the grain structure, the spatial variation of the composition or even the distribution of segregations or defects. For orchids, the characteristics that typically interest me are the shape of each petal, or even the whole flower head, a colour gradient within the flower, or a deviation of colour in the flower head. When photographing orchids, I have the choice of perspective, the section to look at, the focus range, and I can choose whether or not the photo should be in colour or black and white. Putting all this together, any person that looks at the photo can see what I wanted them to see.

When photographing materials, the selection starts by determining the appropriate magnification and, in turn, the most suitable microscope. Once that has been done, the relevant procedure is chosen for the specimen and that particular microscope, which corresponds to the choice between colour or black and white in photography. A major difference is that for microscopic investigations the specimen needs to be prepared first. As orchids are a protected species it is prohibited to carry out any kind of 'preparation' on them.

The choice of where to look, which level of sharpness to use, the orientation of the specimen with respect to the direction of the lighting, as well as the viewing angle are all part of the process carried out for microscopic investigations. These steps determine which characteristics or details will, in the end, dominate the image, even if the effects they have on the physical processes of the image formation are completely different than in photography. In my line of work, the times that are particularly pleasing are always when a specimen produces a meaningful image that at the same time is also visually appealing – purely by chance.

Frank Seidler conducted the interview for the DLR Magazine. Within the scope of his responsibilities, he is in charge of Public Relations at the Institute of Materials Research.

DLR.de/WF/en

Scanning Transmission Microscopy bright-field image of a titanium aluminide alloy for use in turbine engines. The striped areas consist of lamellar structures composed of γ-TiAl and α_2-Ti_3Al. The large γ-TiAl grain in the centre of the image is riddled with lattice defects, so-called dislocations, which indicate the strength and deformation behaviour of the material. Image width 7.8 microns.

Klemens Kelm operating a Philips Tecnai F30 transmission electron microscope. This instrument is used at the DLR Institute for Materials Research to investigate new materials, such as titanium aluminide alloys, which are used in turbine engines.

MAKING A DIFFERENCE

Image: CollectiveProject

The vision of The Collective Project – no child should have to pay for an arm.

Image: CollectiveProject

Albert Manero, sitting to the right of Alex, started the project. With the support of Robert Downey Jr (left), it gained momentum.

Albert Manero – a materials researcher with a touching project

By Michel Winand

Polite, modest and down to earth – this is the first impression you get when talking to Albert Manero. But the more he talks about his work, the clearer the passion with which he dedicates himself to it becomes. His job is to investigate non-destructive test methods for ceramic thermal barrier coatings for the aerospace sector. A PhD student at the University of Central Florida, the 25-year-old worked at the DLR Institute of Materials Research in Cologne for one year. In addition to his doctoral thesis, he pursues another exciting project 'on the side'. But more on that later.

Albert Manero conducts research into non-destructive methods for testing of materials used in aeronautics – specifically synchrotron X-ray measurements of ceramic barrier coatings for high-temperature applications. These coatings are used for turbine blades, jet engines and combustion chambers in aviation and for re-entry vehicles in spaceflight. Using X-rays, he is able to look deep into the individual material layers without damaging the object. This methodology enables both the development of new coatings and determining the criteria for the industrial market launching of new products. These can thus be evaluated and damage analyses can be carried out to industry standards. The laboratory equipment is tailored to examine a wide range of materials subjected to extreme temperatures and high mechanical loads. "There are numerous applications in the aerospace sector, for instance, coatings that enable a more efficient burning of the fuel," says Manero. "In this case the ceramic protective layers allow for higher temperatures inside the engine." A one percent improvement in efficiency can result in annual cost savings of billions for airlines. In addition, there are the positive aspects in terms of safety, reliability and environmental friendliness.

Albert Manero during his time at the DLR Institute of Materials Research in Cologne. As a Fulbright Scholar, he conducted research into thermal barrier coatings.

In 2012, a research visit as part of a collaboration with the DLR Institute of Materials Research landed the US student at the site in Cologne. In 2014, he returned to DLR as a Fulbright Scholar to work on his doctoral thesis.

He has aroused great public interest in the US with a project that helps to provide affordable prosthetics to children with physical impairments. What started out as a small side project has gained momentum since Microsoft and actor Robert Downey Jr showed support for the project in the media. "That our idea of using 3D printing to manufacture prostheses would prove so popular exceeded even our wildest dreams. We have founded a non-profit organisation in the United States, through which we are trying to help children all over the world."

"THAT OUR IDEA OF USING 3D PRINTING TO MANUFACTURE PROSTHESES WOULD PROVE SO POPULAR EXCEEDED EVEN OUR WILDEST DREAMS."

Manero became involved in a very special project while he was on a semester break. "The mother of a six-year-old boy called Alex Pring found me on the Internet via a network of people that design 3D printed prostheses. Alex's case was very specific and required a very unusual solution, so my team and I worked with him and his parents to develop a very special prosthesis." The project took off when Microsoft became aware of it and selected their engineering team as a partner in The Collective Project. "They provided us with a good multimedia platform and produced a video so we could tell our story. When Robert (Downey Junior) saw the video, he wanted to be part of the project. As our 'bionics expert', he presented Alex with a bionic arm made in the style of his film character Iron Man." This has opened up a lot of doors and made more than 15 million people aware of the project. Manero recalls: "This led to a lot of donations and additional supporters, which has helped us greatly with developing better prostheses. It was simply terrific for our team."

The engineer and his team could have made millions with the 3D printing of prostheses, but decided against it. "Our team firmly believes that no child should have to pay for an arm, and that no family should have to pay for an arm for their child." To make this dream come true for as many people as possible, he has been collaborating with sponsors and large companies. "Our blueprints are uploaded to an open source database for 3D printing templates. We are about to provide more data." As every arm must be 'tailor-made' for each individual, Manero and his team are working on a new design that expands the bandwidth and ensures that their system can be adapted worldwide.

Manero is convinced that scientists and engineers are responsible for sharing their knowledge and using it for the benefit of all: "I have always wanted to use my knowledge for something more than just working in a laboratory. And I think that the purpose of education is to use one's capabilities effectively for solving problems." His hope is that a new generation of engineers, encouraged by projects like this, will think of their abilities as a tool with which they can change the world for the better. "I was brought up this way, and this was my parents' philosophy. They always said: "It is your duty and responsibility to use what you have learnt to make a difference." And after a moment he adds: "And to allow others to have the opportunities that you have had..."

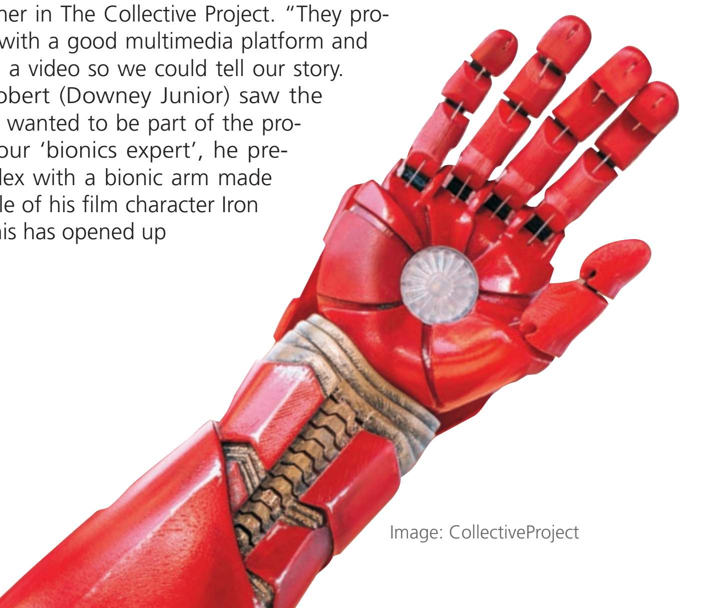


Image: CollectiveProject

A COMET LANDING – THE STORY CONTINUES …

By Cinzia Fantinati and Koen Geurts

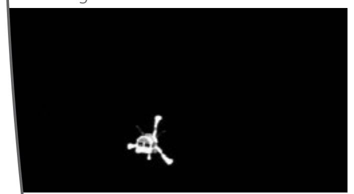
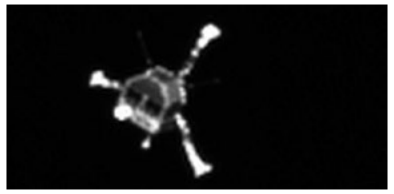
On 12 November 2014, the Philae lander became the first spacecraft to land on a comet – touching down at the Agilkia landing site on the head of 67P/Churyumov-Gerasimenko at 15:34 GMT, and confirmation arriving back to Earth 28 minutes later. The harpoons did not deploy as intended, and the ice screws alone proved insufficient to secure the lander on the surface upon landing. The lander bounced, embarking on an additional two-hour flight before finally coming to rest at a site now known as Abydos – albeit on its side in the shadow of a cliff.

Philae's 10 instruments sprung into action, sniffing the surroundings, drilling and hammering the comet – one covered with coarse material and a surprisingly hard surface, which complicated life for MUPUS (MUlti-PUrpose Sensors for Surface and Sub-Surface Science). SESAME (Surface Electrical, Seismic and Acoustic Monitoring Experiment) found the strength of the ice to be extremely high. Organic molecules were detected by COSAC (Cometary Sampling and Composition). Close-up images of the comet's surface were taken by ROLIS (ROsetta Lander Imaging System). Philae and Rosetta analysed the comet's nucleus using CONSERT (COmet Nucleus Sounding Experiment by Radio wave Transmission). After 60 hours of work, its primary battery became exhausted and Philae entered hibernation – completing its science sequence and delivering the first data from the surface of a comet. Was this the end?

Touching base with the lander

To communicate with Philae, the Electrical Support System (ESS) unit on board Rosetta, responsible for the interface between Philae and Rosetta, must be switched on and configured to 'Research Mode'. Then, the orbiter sends signals to the lander and, upon receipt, the lander switches on its transmitter to reply. This 'handshake' will result in a two-way communication link. Then, Philae immediately starts sending the acquired science and housekeeping data. Rosetta can also send commands to Philae – for example, to upload and execute scientific measurements.

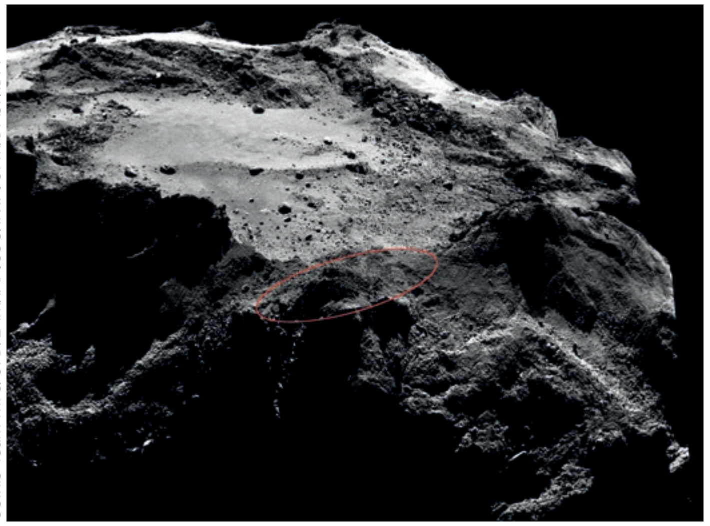
Image: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

Left: Philae upon separation from Rosetta on 12 November 2014, as seen with OSIRIS. Below: The first image from the surface of Comet 67P, by the CIVA camera. One of the lander's three feet can be seen in the foreground. The image is a two-image mosaic.

Image: ESA/Rosetta/Philae/CIVA

Image: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA



The red ellipse in this image from Rosetta's OSIRIS camera marks the area where Philae most likely ended up after its 'triple landing'.

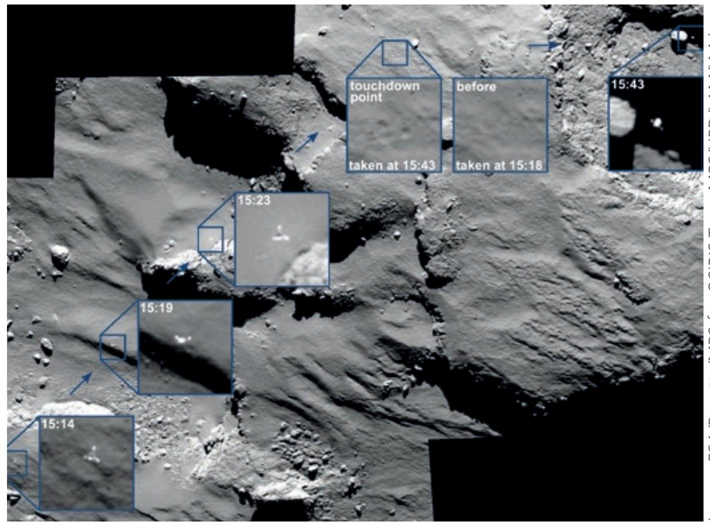


Image: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

OSIRIS image of the Philae lander, as it descended toward, and then bounced off, the surface of Comet 67P during touchdown on 12 November 2014.

Seven months later, on 13 June 2015, the lander contacted Rosetta. A two-way link was established for 78 seconds. Philae sent back 343 encouraging housekeeping packets with information from the thermal, power and on-board computer subsystems – alive and well, the lander was warm and its solar panels were receiving sunlight.

Since that day, the teams at the DLR Lander Control Center (LCC), the Science Operations and Navigation Center (SONC, CNES), Rosetta Mission Operations Center (RMOC, ESOC) and Rosetta Science Ground Segment (RSGS – ESAC), together with the mission scientists, have been working non-stop to establish regular and predictable contacts and resume scientific measurements with Philae.

Changing Rosetta's trajectory

The first signal triggered numerous teleconferences, discussions and immediate decision-making. It was clear that the orbiter's trajectory had to be compatible with Philae communication – this was a priority. The favourable latitude range was defined between 0 and +55 degrees North and processed for implementation by the RMOC Flight Dynamics and Flight Control teams.

The second 'conversation' with Philae, on 14 June, lasted 04:04 minutes – albeit with frequent link interruptions. The third contact occurred on 19 June: 18:53 minutes, again with frequent interruptions. The fourth contact, on 20 June lasted 31:01 minutes, with many interruptions. The fifth contact occurred on 21 June and lasted 11:25 minutes, with a 10:37 minute interruption. The sixth and last contact took place on 24 June and lasted 17:11 minutes with continuous link interruptions. All in all, the sparse stored and real-time data showed that temperatures had increased from -55 degrees Celsius in May to -5 degrees Celsius on 13 June, that the battery was charging and the comet days were getting longer.

Clearly, the team had hoped for more, and their focus was to improve this situation. At the time, Rosetta was at a distance of about 200 kilometres – at the very edge of the operational range. Communication was not established every comet day, so a dependency on certain latitude ranges was suspected. The scientists and engineers are still unsure of why the contacts suffered so many interruptions. Comet 67P has a 12.4-hour rotation period, so Philae's location is not always visible to the Rosetta spacecraft. Contact opportunities should be possible approximately two times per Earth day during an overflight by the orbiter, and orbiter and lander antennas must be aligned. The performance of Philae's antennas is partially affected by objects in the nearby environment and the orbiter must align its antenna as closely as possible towards the comet.

Hardware issues and CONSERT switch-on

The sparse contacts provided the team with enough data to puzzle the engineers further. The telemetry received during the contact on 19 June showed that only one of the two receivers was switched on, although the configuration was set to use two. Further inspection shed light on the situation: one of the receivers (RX1) suffered from a short circuit and was switched off by the hardware (HW) overcurrent protection. This was worrying, but is precisely why redundant units are provided.

After two weeks of silence, there were concerns that the second receiver could also be compromised. To reject this hypothesis, it was decided to use the CONSERT instrument on Rosetta and Philae with independent antennas. By sending commands to Philae 'in the blind', instructing it to switch on CONSERT, the unit on Rosetta should be able to tell if the unit on Philae is switched on. This would prove that the receiver is still working. The first attempt failed as no CONSERT signal from Philae was detected. But the second attempt was a big surprise, as contact was re-established on 9 July for 22 minutes, of which approximately 12 were completely uninterrupted – the best so far! Paradoxically, no signal from Philae's CONSERT unit was obtained.

What the future holds

Since that day, the comet-chasing duo have continued to travel with the comet. Rosetta is now 400 kilometres away from 67P, due to the increased cometary activity around perihelion on 13 August. Although communication with Philae at this distance is unlikely, Rosetta is trying nonetheless. On 22 September, Rosetta will begin a comet tail exploration, increasing the distance up to 1500 kilometres. Towards the end of October, Rosetta will come closer and attempts to communicate will resume. Thermal and power predictions suggest Philae should be operational until late 2015, so attempts to connect will continue.

If you, too, are wondering: Will we hear from Philae again? Guess you will just have to wait and see.

Cinzia Fantinati is Operations Manager for the Rosetta Lander. **Koen Geurts** is Technical Project Manager for Philae. They work at the DLR Lander Control Center (LCC).

DLR.de/en/Rosetta

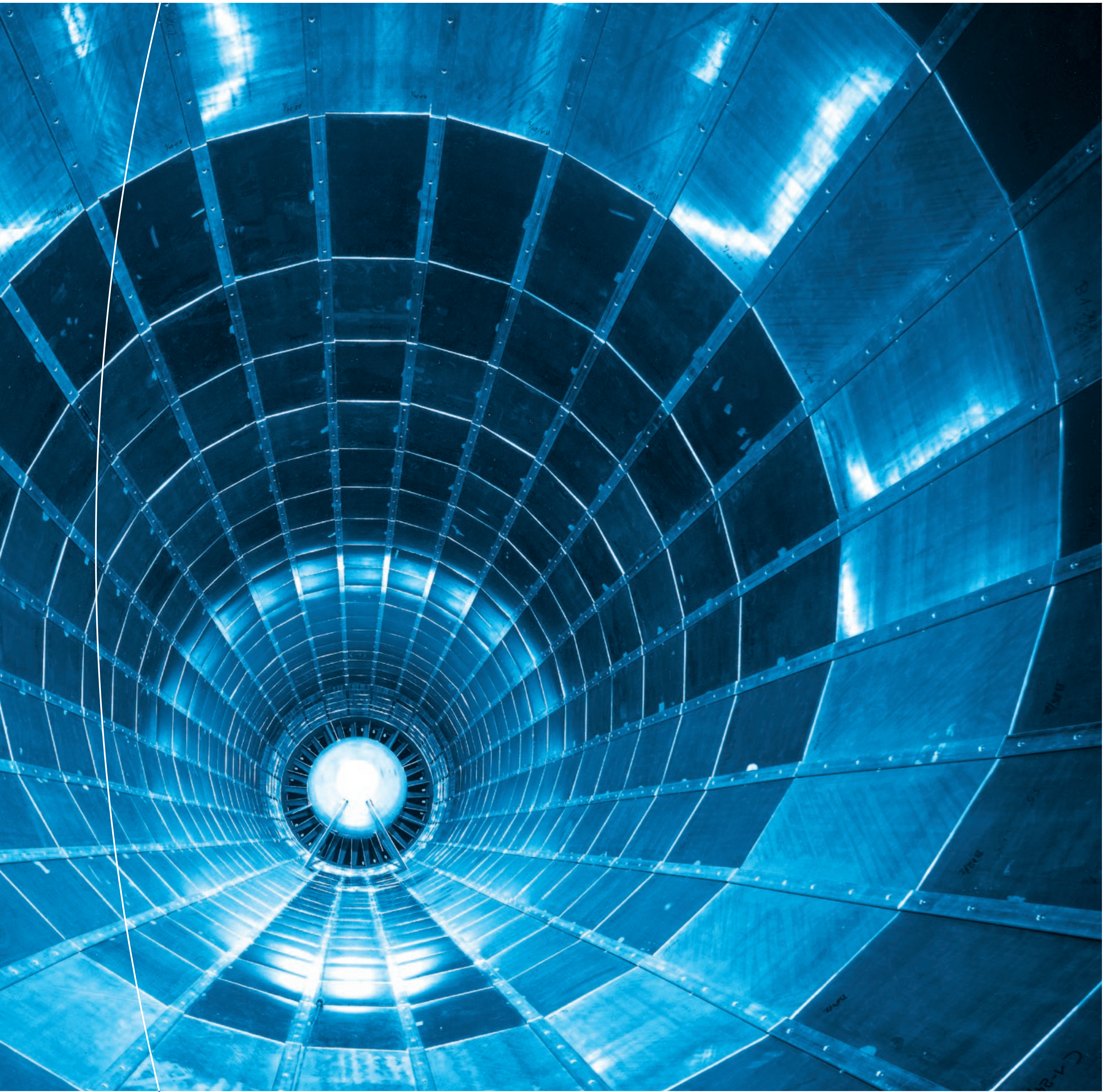


Image: ETW

Compressor of the European Transonic Windtunnel

EUROPE'S FLAGSHIP WIND TUNNEL IS IN COLOGNE

Part 4 of the series 'The Wind Machines'

By Jens Wucherpfennig

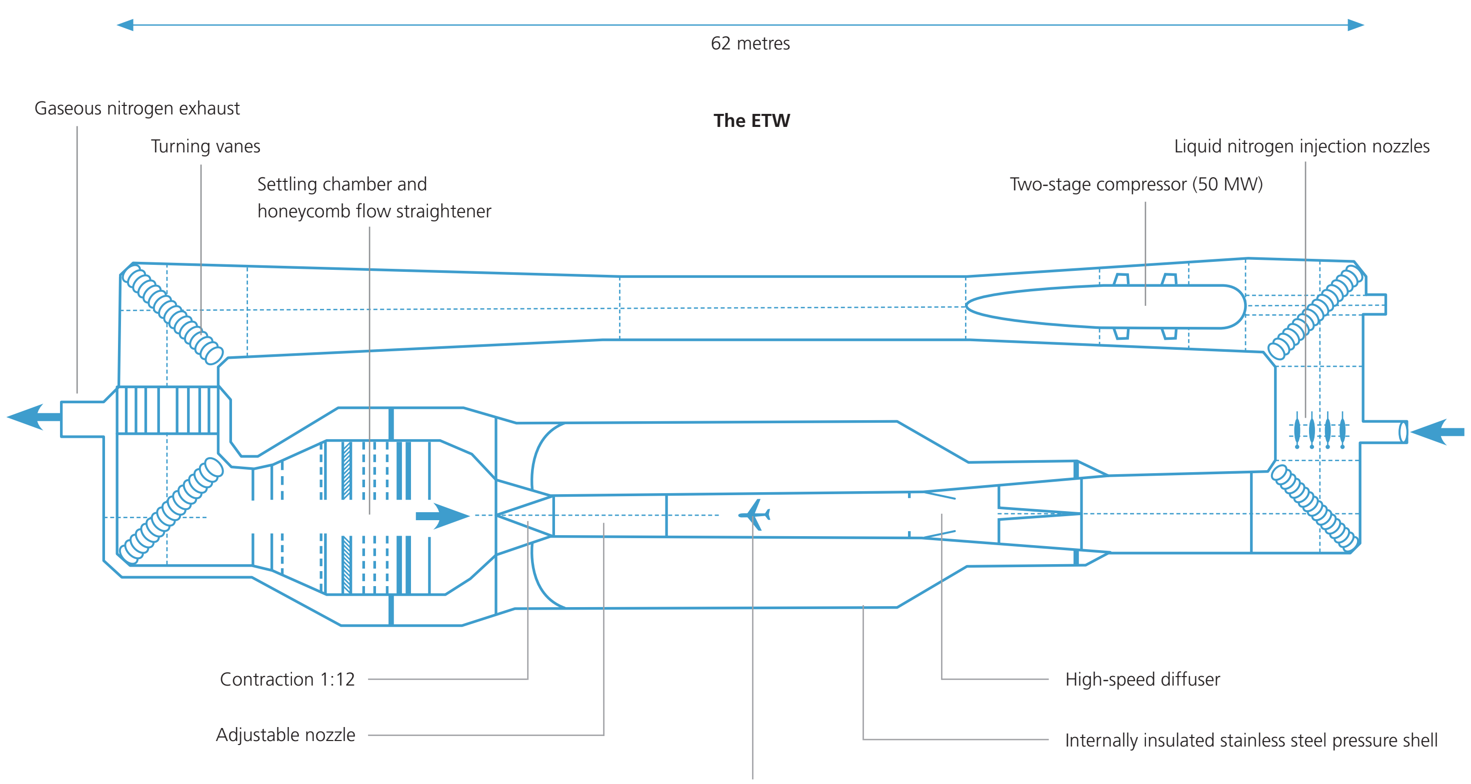
The largest and most powerful wind tunnels are often major national projects because of their enormous costs. Considering this, it is no surprise that four countries teamed up to construct the most modern aeronautical wind tunnel in the world – the European Transonic Windtunnel.

In 1977, France, Germany, the Netherlands and the United Kingdom decided to jointly design and construct the European Transonic Windtunnel (ETW). Construction began in 1989, and mechanical completion was achieved in 1993. The development of this wind tunnel was based on a prerequisite of NATO's Advisory Group for Aerospace Research and Development (AGARD) in the 1970s to be able to duplicate actual flight conditions on the ground under controlled laboratory settings, and thus acquire new scientific knowledge. The wind tunnel is operated by ETW GmbH, which was established as an independent non-profit company in 1988.

The ETW is the world's leading wind tunnel for testing aircraft under realistic flight conditions. Long before the first prototype of a new aircraft is available for actual flight tests, its capabilities and flight boundaries can already be precisely determined to an outstanding quality using the ETW. This significantly reduces the technical and economic risks associated with developing new aircraft. Manufacturers around the world make use of the exceptional capabilities of this hi-tech facility to improve the performance, viability and environment friendliness of their future products.

A cryogenic atmosphere guarantees realistic simulations

At ETW, aircraft models are tested under rather unique conditions – at minus 160 degrees Celsius and a pressure 4.5 times that of the Earth's atmosphere. This is necessary because at room temperature air molecules are too big in relation to the 'mini-aircraft' under investigation, which gives rise to too much friction. Consequently, to obtain correct aerodynamic predictions, it is necessary to artificially calm the air molecules and reduce the distance between them. One may say that the air is 'shrunk' – in the ETW, 'air' consists of pure nitrogen, the main component of natural air. This nitrogen is injected into the wind tunnel in liquid form, vaporised and the resulting gas then accelerated towards the model, following the principle of a Göttingen-type wind tunnel. To counteract the friction inside the tunnel circuit, the wind tunnel is equipped with a 50-megawatt compressor – equivalent to the power of about 500 mid-size cars. Enormous quantities of nitrogen are needed to compensate for the generated friction heat and to be able to cool down and maintain stable cryogenic conditions – up to 1500 tons may be required for one day of testing. At this rate, the nitrogen available on site is quickly exhausted, which is why four trucks are always on stand-by to transport up to 600 tons of the liquid gas daily from a nearby plant located 20 kilometres away from the Cologne-Porz / Wahn site.



At these extremely low temperatures and the high pressure, everything is on the right scale again, and the values determined here – together with computer simulations and other procedures – help to develop the aircraft of the future. The ETW allows measurements to be made at low temperatures (minus 163 degrees Celsius to 40 degrees Celsius), under high pressure (1.15 to 4.5 bar) and at high wind speeds, such as those during take-off / landing and cruise conditions (0.15 to 1.35 Mach). Up to three test configurations can be investigated per day.

Separate control of temperature, pressure and speed

An important parameter that characterises a flow is called the Reynolds number. This dimensionless parameter is determined by the relation of inertial forces to friction in the flow. The value of the Reynolds number for the aircraft and the model must be the same to achieve a similar flow in real and in model scale – this is also the case for the model shape and Mach number. The ETW achieves Reynolds numbers of up to 50 million for full-span models and 85 million for semi-span models. The test section has a rectangular cross section 2.4 metres wide and 2.0 metres high, accommodating models with a wingspan – and respectively half a wingspan – of around 1.5 metres. By adjusting the pressure, temperature and speed separately, the Mach number, Reynolds number and dynamic pressure can be controlled individually. This makes it possible to isolate the effects of model deformation from those related to the scaling. There is only one other wind tunnel aside from the ETW with comparable properties – NASA's NTF (National Transonic Facility) at the Langley Research Center in the United States.

The investment that went into constructing the ETW in 1994 amounted to approximately 330 million euro. The 10 million euro per year that it costs to operate the ETW shall be covered by the wind tunnel users. Depending on the exact requirements, one day of testing costs between 90,000 and 120,000 euro. At present, the ETW employs 34 people.

The current shareholders in the operating company European Transonic Windtunnel GmbH are DLR, representing Germany with 45 percent, BIS with 45 percent representing the United Kingdom, and the NLR with 10 percent representing the Netherlands. France left the shareholders' consortium in 2012 to focus on its national facilities.

.

ETW.de

Image: ETW

COLD AND UNDER PRESSURE

Interview with Dieter Schimanski, Manager Tests & Operations at the ETW

The ETW is the only wind tunnel in the world involving more than two countries. Is there a particular reason for this?
: In the 1970s, several NATO countries wanted to test aircraft under unprecedented realistic conditions. A wind tunnel that meets these expectations would be very complex – and very expensive to construct. For this reason, at that time four important NATO countries – Germany, France, the Netherlands and the United Kingdom – teamed up. The United States was also involved at the outset.

What role did military research play?
: Naturally, the military was very interested in the project – as was the civil aviation industry. But the ETW was not built until 1993, which was after the end of the Cold War. In Europe, there were – and are – far less military projects than expected. Today, the ETW is mainly used for civil purposes.

Can you give me an example of a major project conducted in the ETW?
: We have made valuable contributions to the development of the Airbus A380 and A350XWB aircraft. With the A350, we assisted Airbus in the development of a significantly lighter wing. We also contributed to the success of various Dassault Falcon business aircraft models.

What can the ETW do that other wind tunnels cannot?
: The ETW is the only wind tunnel able to conduct tests at flight conditions of future aircraft under realistic laboratory conditions. Conventional wind tunnels generally do not take into consideration the fact that the air molecules need to be scaled down in relation to the size of the aircraft model. This is achieved in the ETW by cooling down and pressurising the tunnel.

Why was the wind tunnel built in Cologne?
: It was clear that it needed to be built close to an existing national aeronautics research site, such as that of DLR. The site in Cologne had several advantages over those of the partner facilities. Firstly, it had a powerful energy infrastructure capable of supplying the 50 megawatts required to operate the wind tunnel at all times. Furthermore, there needed to be a nitrogen plant in the vicinity – the ETW needs up to 1500 tons of this coolant every day. There is such a facility right on the other side of the Rhine, and the close proximity has paid off for both.

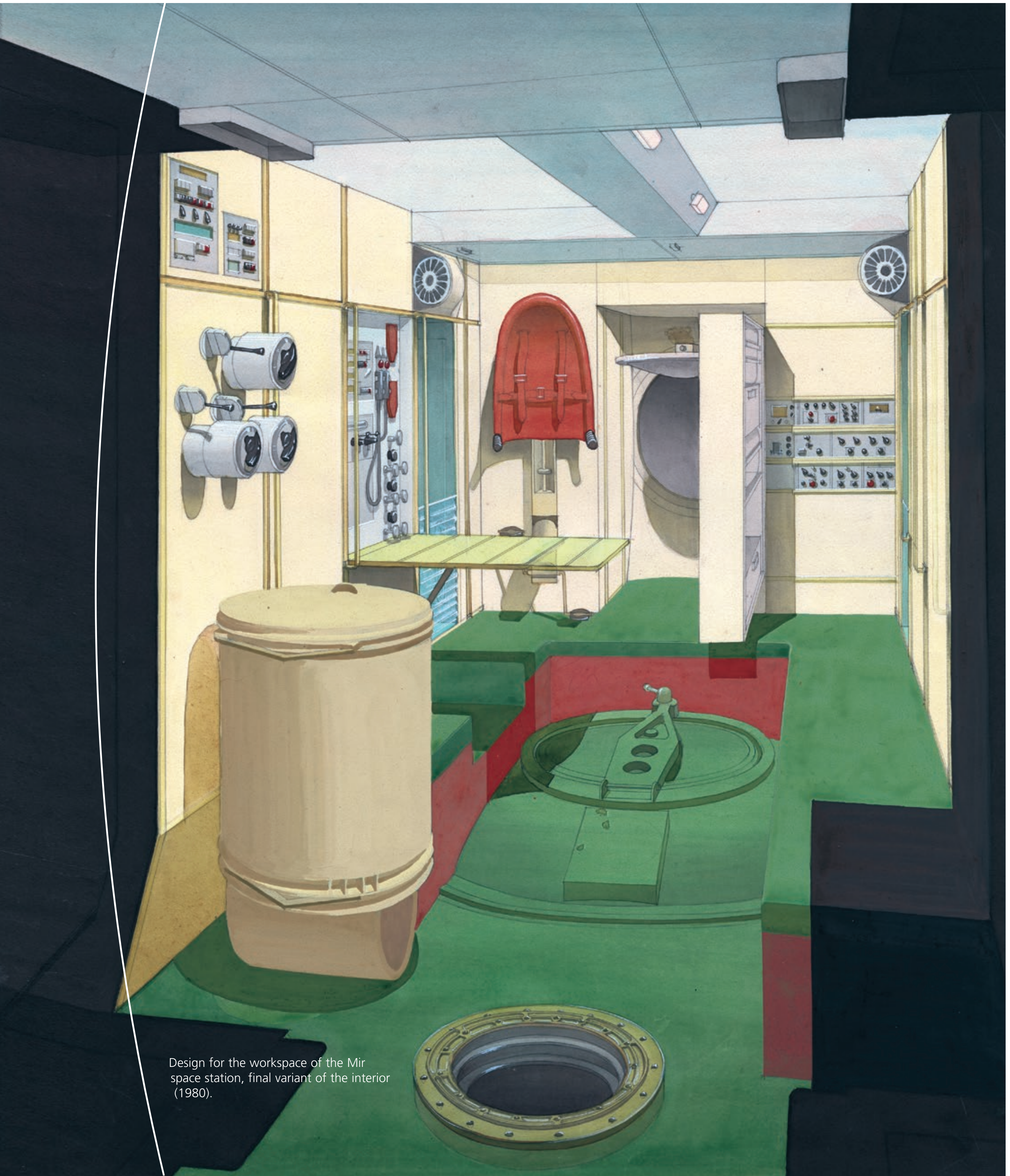
How intensively is the ETW used by researchers?
: The majority of tests – about 70 percent – are conducted for the development of new products, and about 30 percent of wind tunnel experiments in ETW involve research. To date, this research is strongly influenced by industry. We would like for the ETW to be used by scientists from universities and research institutes on a more regular basis. However, this has not been the case up until now because the respective funding was irregular.

How do civilian aircraft manufacturers use the ETW?
: The ETW was initially designed mainly to predict aircraft performance during flight. In the meantime, this task can also be performed by computer simulations as long as the flow is attached. Therefore, the capabilities of our facility are, nowadays, especially used for the regions of the flight envelope in which flow separation occurs and where computer simulations are not able to provide reliable results – for example, during take-off and landing, as well as at the border of the flight envelope at very high airspeeds. Our shareholders are currently investing in the facility to adjust the ETW to suit these varying customer needs.

How does the ongoing development of computer simulations affect the ETW?
: Both tools have their own strengths, complement each other and are an integral part of the process of aircraft development. A computer simulation, for example, can quickly determine whether a change in shape will be better or worse for the aircraft performance. Alongside verification and reliable mitigation of development risks, experimentation at ETW also provides a significant advantage regarding productivity compared with numerical simulations.

The ETW at a glance

The European Transonic Windtunnel (ETW) is the world's leading aeronautical wind tunnel. It is the only wind tunnel constructed by more than two countries. Erection was finished in 1993 by France, Germany, the Netherlands and the United Kingdom. France left the operating consortium in 2012. By blowing nitrogen at cryogenic temperatures under high pressures at the aircraft models, the wind tunnel can achieve realistic representations of flight conditions. Up to 1500 tons of nitrogen are needed for one day of operations.



Design for the workspace of the Mir space station, final variant of the interior (1980).

Image: Galina Balaschowa Archive

THERE'S NO SPACE LIKE HOME

Image: Uwe Dettmar

Curator Philipp Meuser with Galina Balaschowa

Image: Uwe Dettmar

The exhibition at Frankfurt's Deutsches Museum für Architektur

Image: Uwe Dettmar

Sketches and watercolors made by the space architect

Space architect Galina Balashova's work exhibited at Frankfurt's German Architecture Museum

"She is utterly down to Earth," enthuses Berlin architect Philipp Meuser, barely finding the words to describe just how much of a treasure she truly is. After years of conducting research on prefabricated buildings and serial housing in Russia, he fortuitously stumbled across the unique work of his now 83-year-old colleague Galina Balashova. For almost three decades, she was the architect for microgravity.

1963: The United States and the Soviet Union are in the midst of the Cold War. Everything related to space is top secret. The coexistent Space Race could also have been denominated Wernher von Braun versus Sergei Korolev. Here, the Soviet rocket scientist is leading the race: Yuri Gagarin is the first man to travel to space. It is now time to perfect the Soyuz spacecraft. Engineers from the OKB-1 design bureau show Korolev the wooden model they have designed – alas, without success. Korolev will not present it to the Soviet leaders. He meets Galina Balashova in the stairwell. At the time, she was responsible for company housing for the project staff. Over the weekend, she drafts an architectural drawing of the Soyuz habitation module. Period. Korolev wants more detail. The sofa to the right of the hatch is equipped with Velcro straps, so the cosmonauts can sit – or more precisely, be strapped – comfortably. Three books are stuck inside the cabinet. A calendar and an artwork of the local countryside decorate the room, screwed to rods on the wall. The architect chooses a grass green colour for the floor and a light shade of yellow for the walls. In this space, the cosmonauts should be able to move around with ease, but also be comfortable.

These drawings and watercolours are just the beginning – orders for the Salyut and Mir space stations follow, introducing folding work-tables and beds strapped to the wall. Even a shower is included. One design shows the cosmonauts playing cards at the table. Many ideas are discarded. After each space flight, Balashova wants to hear whether her ideas are useful in microgravity – directly from the cosmonauts. The artist and architect is also asked to work on the Luna and Buran programmes. She is allowed to take the architectural plans home with her – only engineering work will be archived in the project office.

Philipp Meuser visited the pensioner in her two-room apartment near Moscow (in his words, it is "as broad as the inside of the Mir"). She also keeps some autographed drawings in her country residence – among them, the designs for the 1975 US-Soviet Apollo-Soyuz Test Project. Balashova designed the logo for the joint mission – used for souvenirs, pins and stamps in 35 countries.

The exhibition includes a glimpse into the architect's living room. At Frankfurt's Deutsches Museum für Architektur (DAM), visitors can appreciate the dimensions of Mir and watch the artist on film. Wall drawings compare the height of the Soyuz rocket to that of the Römer, Frankfurt's city hall, and the height of the Buran space shuttle to St. Paul's Church.

The museum visitors cannot help but ask: why is this woman not world-famous? One reason is, without a doubt, the extreme secrecy maintained throughout the Cold War. In addition, a great deal of her artwork decorated the walls of the space capsule, which burned up during re-entry into Earth's atmosphere. Architect and exhibition curator Meuser, however, attributes Balashova's inconspicuousness to her unwavering modesty – never seeking the limelight, unaware that she could be proud of her work. And exploring space did not interest her that much: "The Universe never excited me in the way that architecture does."

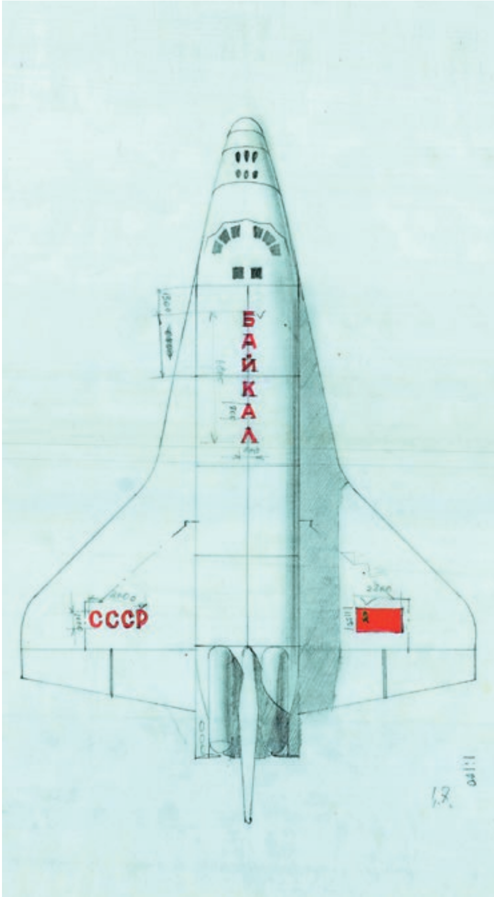
This wonderful exhibition is a must-see for space and architecture enthusiasts!

Sylvia Kuck is the editor of Hessischer Rundfunk.

Image: Galina Balaschowa Archive

Design for the interior of the Soyuz T landing capsule

Image: Galina Balaschowa Archive



Design for the typography on a space shuttle from the Buran program, Baikal variant (1978).

Image: Galina Balaschowa Archive

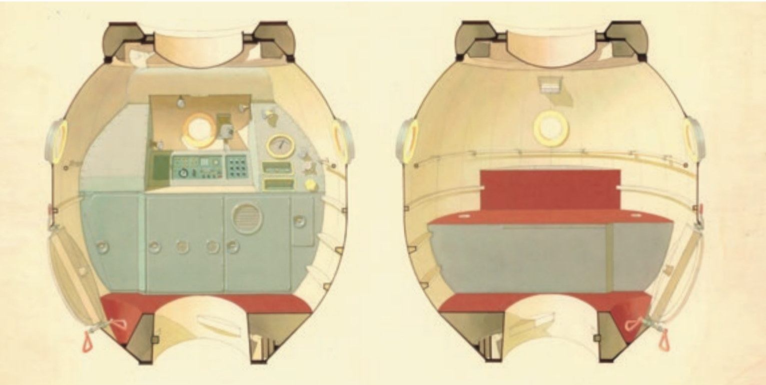


Illustration study of the Soyuz-M living area (1970–1974, design not implemented).

Image: Galina Balaschowa Archive

Design outlining the location of the name Mir on the space station's outer surface (1980)

DESIGN FOR THE SOVIET SPACE PROGRAMME – GALINA BALASHOVA, ARCHITECT

from 27 June to 15 November 2015 at the German Architecture Museum in Frankfurt

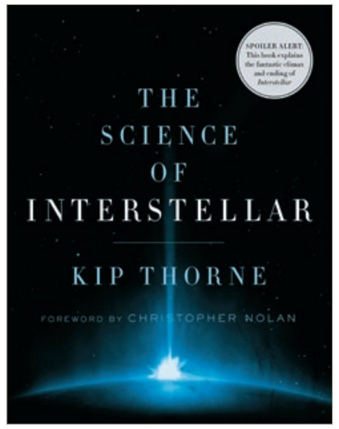
Guided tours are available on Saturdays and Sundays at 16:00

Opening hours: Tuesday, Thursday-Sunday 11:00-18:00, Wed 11:00-20:00

Admission: Adults 9 euro, reduced 4.50 euro

Catalogue: 19.90 euro. For the accompanying programme, see www.dam-online.de

SCIENCE VS FICTION



In **The Science of Interstellar**, Kip Thorne, Feynman Professor of Theoretical Physics Emeritus at Caltech, explained and elaborated on the science seen in Christopher Nolan's critically acclaimed film 'Interstellar', for which he served as executive producer and science advisor. Thorne set out to accomplish two tasks – to explain the parts in the film that are firmly grounded in the well-established astrophysics and planetary science, and to elaborate the parts that are speculations in gravitational and quantum physics.

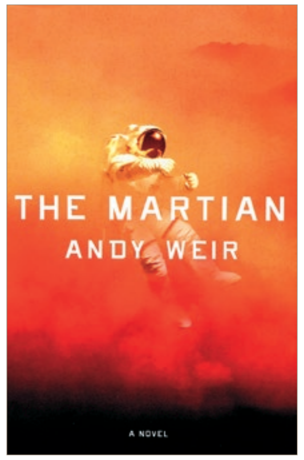
Topics covered include the biology and geophysics behind the oxygen/food shortage on Earth (which is the premise of the film), the physical laws of the Universe, interstellar travel, wormholes and black holes, quantum gravity, time dilation and much more. Thorne used illustrations, images, figures and diagrams to illustrate the more complicated concepts, making science accessible and comprehensible.

The film's complicated plot and dazzling visuals are best complemented by Thorne's science explanations. Interstellar's simulation of the black hole is, according to Thorne, one of the most detailed and accurate film portrayals ever made. As an expert in astrophysics and cosmology, he explained the science behind the gravitational lensing of light around a black hole. This behind-the-scenes look at the making of the film comes, however, with spoilers, so it is best that you watch the film first.

The Science of Interstellar is a well-written book that targets the average reader. It successfully introduces real scientific topics featured in the film. It is perfect for those who, after watching the film, are curious to learn more about the science behind the sci-fi blockbuster. A light, and yet most stimulating and satisfying read.

Reese Lee

WHEN YOU ARE STRANDED ON MARS …



At 10 hours and 53 minutes long, the tension in **The Martian** grows with each passing minute in the audiobook version of the bestselling novel. The narrator, R.C. Bray perfectly captures the intensity of protagonist Mark Watney's situation. Stranded on Mars, his fate is told in a gripping manner that draws the listeners in and takes them along for the ride.

The Martian is a thriller, adventure and science fiction novel all in one. Accidentally left for dead in the Acidalia region of Mars by his crew mates when a dangerous martian dust storm forces them to abort their mission, Watney spends the next 550 days on what was supposed to be two month's food rations for six people. With just his survival skills and intelligence to get by, he records each day in a logbook so, someday, a passing future traveller may learn of his story.

The audiobook fully immerses the listener in the world created by the author, Andy Weir. He delivers the harrowing experience of being alone on Mars in a way that is extremely well written and entertaining, whilst allowing the listener to empathise with Watney during his trials and tribulations on the Red Planet. Scientific descriptions add to the intense plotline. Listening to these complex scientific terms being read aloud as opposed to reading them from a paperback copy, softens the blow a bit – allowing the technical concepts to decorate the storyline instead of becoming the focus.

Bray does what every first person narrator should, he becomes Mark Watney – channeling him and bringing him to life through sarcastic wit, engaging thought processes and impeccable timing. With the release of the movie version of The Martian set for October 2015, there has never been a better time to listen to this wonderful piece of space fiction on audiobook, or read it.

Nikita Marwaha

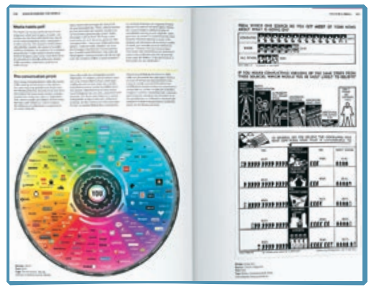
SEEING IS UNDERSTANDING

A picture is worth a thousand words – infographics play a big role when it comes to understanding complex issues or conveying a large amount of information in a short and snappy way. Many things can be explained clearly in pictures. Sandra Rendgen and Nigel Holmes address the role of visual information in the 20th and 21st centuries in **Understanding the World – The Atlas of Infographics** (TASCHEN).

With its 3.79 kilograms in weight and impressive dimensions, the book is – to say the least – visually compelling. The use of shapes, colours and typography is truly an art. The infographics are always accompanied by a text in English, German and French, stating the source, the year they were created, and providing a short description. Its five chapters explore subjects including nature and the environment, science and technology, as well as the economy and development. Each chapter is colour-coded, which allows readers to quickly turn to a specific page.

Ideally, complex issues should quickly become intelligible when visualisation is used, and there should be no need for a lot of descriptive text. But you do not have to pull out all the stops in graphic design to achieve this. Plain and simple charts have sometimes been more than enough. A bar graph can help to visualise development over time, or a pie chart can show the relationship between different sizes: one look at the chart and the message is clear, even though, or perhaps because, it has been presented in a very simple way.

A simplified look, which places the information to the fore and immediately conveys a message is not, however, always immediately obvious in this colourful book. Nevertheless, it is evident that some topics lend themselves better to visualisation than others – population figures or the proportion of renewable energies in the balance of energy can be presented well using this technique. Data taken from other fields is, however, less successful. The chapter on science and technology, which also explores the topics of space and Earth observation, is too intense, featuring attractive charts alongside others images showing their objectives. This makes the core message hard to recognise. Many images must first be turned around or flipped over before they become clear. For example, an image is used that tries to show performance data for NASA's three Mars Exploration Rover Missions, and it does so by using three picture-perfect graphs that show the different parameters, such as measurements and top speed, but the information on each graph overlaps. There is a lot of information for which visualisation does not yield the desired outcome, in other words, clarity; but rather it leads to confusion. Sometimes, a simple table would be a better choice.



Visual features can sometimes also be playful. Many images are really fun, sometimes appearing on nice fold-out pages. However, they should not be there just for the sake of it. A book is designed to browse through it and discover possibilities, it is not just a means of exploring the boundaries of visually-conveyed information.

Philipp Burtscheidt

VIEW ROSETTA'S COMET

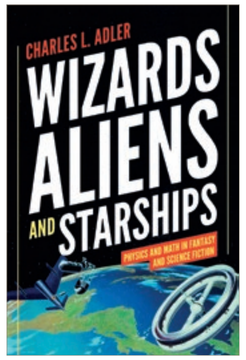
As the final destination of the Rosetta mission, Comet 67P/Churyumov-Gerasimenko is the first comet in history to be orbited and landed on by manmade spacecraft. **View Rosetta's Comet** is an interactive 3D visualisation tool developed using images acquired with Rosetta's navigation camera, NAVCAM. The use of 3D computer models allowed the shape of the comet to be digitally crafted and now explored using the site – it is possible to zoom in and out, rotate and pan across the comet. Colourful texture maps and labelled regions help to identify particular areas of the comet and better navigate its surface. Also, a trail of points trace Rosetta's footsteps, following the trajectory where images have been taken by NAVCAM. The tool highlights unique features of the comet in a vibrant and interactive way, both educating and entertaining the user.

The tool, developed by The Science Office and TECField for the ESA Directorate of Science and Robotic Exploration, was released to celebrate the one-year anniversary of Rosetta's arrival at 67P, coinciding with its passage through perihelion. This creative outreach tool brings space travel into the lives of the public with the click of a mouse.

The code of this beta version of the tool is available as open source, inviting the public to develop it further. It is a fascinating insight into the frontiers of space science and a great way to become more familiar with the comet.

Nikita Marwaha

WIZARDS, ALIENS AND SPACESHIPS



Have you ever wondered whether Mr. Weasley's car could actually fly to Harry Potter's bedroom window? Or if you could teleport to work or take the space elevator for an affordable holiday in a space hotel? Physicist Charles Adler did, and in his book **Wizards, Aliens, and Starships: Physics and Math in Fantasy and Science Fiction,** sets out to examine the scientific grounds for such ideas in popular novels.

The first section of the book discusses elements from fantasy books, mainly from J.K. Rowling's Harry Potter series and Jim Butcher's Dresden Novels. Fantasy fans will be disappointed to learn that it is unlikely dragons or hippogriffs could ever fly and that floating candles in Hogwarts' Great Hall did not provide enough light for reading – or even eating (only lots of hot wax dripping down). The laws of physics also make it unlikely that Odette ever transformed into a swan or Draco Malfoy into a ferret. Still, there is comfort in the fact that it is equally improbable that Medusa ever turned anybody to stone. And the good news does not end there – a large snowy owl like Potter's Hedwig can lift prey up to about one kilogram in weight, so Adler concludes that perhaps the owl post is not a crazy idea.

The bulk of the book discusses major themes from space-related science fiction, such as space stations, space colonies, interstellar travel, artificial gravity, and contacting aliens. Here, the author shows that, unfortunately, many of the ideas proposed by science fiction are unlikely to be realised soon because they work against the laws of physics. The scientific support for his arguments, although well explained, does require a basic knowledge of physics and mathematics from the reader.

Here also, not all the news is bad. Cars might very well fly, for instance, but it is an expensive hobby and rather more dangerous than ordinary driving when one runs out of gas or crashes into something. A space elevator might be risky and difficult, but not impossible from a technological point of view, though it would hardly be cost-efficient. Getting people to Mars is not so much the problem, it is keeping them alive long enough to come back.

Science and science fiction fans will certainly enjoy this look behind the scenes and might be inspired to invent something or even take the pen up themselves.

Merel Groentjes

RECOMMENDED LINKS

KNOWLEDGE FOR ALL
http://academicearth.org/
Interested in new topics? At Academic Earth you will find links to more than 8500 lectures and 750 online courses from prestigious universities. Academic knowledge is accessible free of charge. From design, biology, mathematics and business administration, through to psychology, a myriad of areas are represented and easily found – via a search box or a browse option.

ROUND THE WORLD ON SOLAR ENERGY
http://www.solarimpulse.com/
Solar Impulse began its flight around the globe in March 2015 and successfully broke records as the first ever oceanic crossing by a solar airplane. Follow this amazing mission, which started in Abu Dhabi. The Swiss explorers, Bertrand Piccard and André Borschberg, stopped over in places such as Oman, India, Myanmar and China.

FOLLOW PHILAE
http://twitter.com/Philae2014
How did you find out that Rosetta's Philae lander touched down on the comet? And that it woke up? More than 400,000 people follow Philae and its life on a comet. In first person, the lander engages with other spacecraft in the twitterverse and tells the latest news about its current status. So, if you are not yet a follower, sign up now and be the first to know what is happening on Comet 67P/Churyumov-Gerasimenko – directly from @Philae2014.

DISCOVER THE UNIVERSE
http://hubblesite.org/
Dedicated to all things Hubble space telescope, the Hubble site offers the latest images, breakthroughs and videos from the orbiting space telescope. Weekly Hubble hangouts are hosted here, inviting the public to submit questions. You can explore the Universe through a plethora of videos bringing space science to life, get involved through citizen science projects or look into the future of astronomical research with the James Webb telescope – set to succeed Hubble with its launch in 2018.

A NEW WAY OF PRESENTING
https://prezi.com/
Knowing how to present is a must – be it for work or for studying. If you are looking for a new way to prepare your presentations, take a look at Prezi. With this new system, your talks will be dynamic, interactive and well elaborated, guaranteeing an engaged audience. In them, you can incorporate images, videos, music and text, just like in the more traditional programs for preparing slides.

About DLR

DLR, the German Aerospace Center, is Germany's national research centre for aeronautics and space. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

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

Imprint

DLR Magazine – the magazine of the German Aerospace Center

Publisher: DLR German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)

Editorial staff: Sabine Hoffmann (Legally responsible for editorial content), Cordula Tegen, Elke Heinemann (Editorial management), Karin Ranero Celius, Linda Carrette and Nikita Marwaha (English-language Editors, EJR-Quartz BV). In this edition, contributions from: Manuela Braun, Philipp Burtscheidt, Falk Dambowsky, Merel Groentjes, Reese Lee, Melanie-Konstanze Wiese, Michel Winand and Jens Wucherpfennig.

DLR Corporate Communications
Linder Höhe, D 51147 Köln
Phone: 02203 601-2116
Fax: 02203 601-3249
Email: kommunikation@dlr.de

Printing: AZ Druck und Datentechnik GmbH, 87437 Kempten
Design: CD Werbeagentur GmbH, D 53842 Troisdorf, www.cdonline.de

ISSN 2190-0108

Online:
DLR.de/dlr-magazine

To order:
DLR.de/magazine-sub

FSC www.fsc.org MIX Paper from responsible sources FSC® C051149

Printed on environmentally friendly, chlorine-free paper.

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center