



Magazine of DLR, the German Aerospace Center · DLR.de/en · No. 140/141 · April 2014

magazine

Entering the home straight

Alexander Gerst in the run-up to the 'Blue Dot' mission



World atlas – 'made in space'
A new way of mapping Earth comes to life

The wind machines
A new series about wind tunnels

DLR magazine 140 · 141

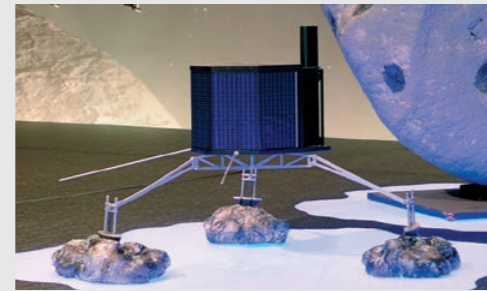


44

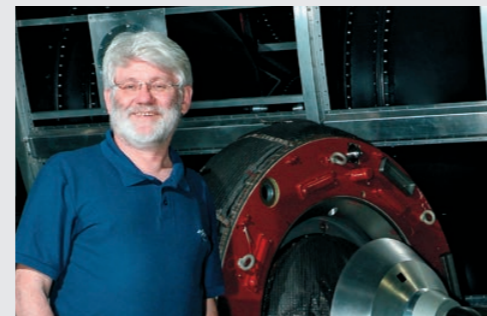
The wind machines

They are among the most impressive research facilities. Grandiose, closed, mysterious. Not many are seen from the inside. Wind tunnels. The low-speed wind tunnel Braunschweig is one of them. Why were they constructed, what makes them different from each other and what role do they play in research? All of this and more in a series of articles that begins in this issue of the DLR Magazine.

Editorial	3
Perspective	4
Commentary Research for the way ahead	6
In brief	8
Entering the home straight Alexander Gerst's 'Blue Dot' mission	12
Rise and shine! The day Rosetta awoke	16

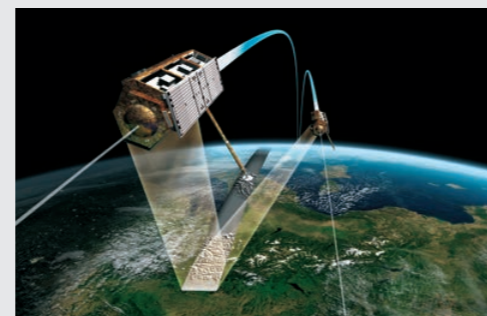


Portrait Raimund Lentzen – an extra pair of hands	20
---	----



Mapping the Reef from beyond the waters DLR spin-off EOMAP	24
--	----

World atlas – 'made in space' A new way of mapping Earth	26
--	----



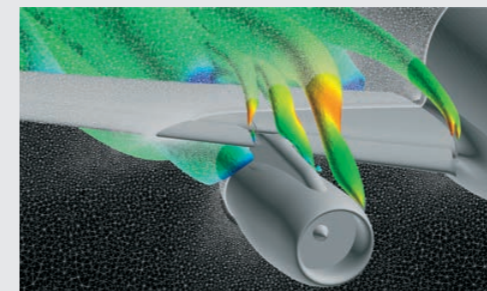
Aircraft news	32
----------------------	----

Forewarned is forearmed Caroline Forster studies thunderstorms	34
--	----

Outbound flight to the future AVES flight simulator	36
---	----



Through a wind gust at the click of a mouse C ² A ² S ² E	40
--	----



Wind tunnel series Part 1: The wind machines	44
--	----

Exploring the southern skies SOFIA, the airborne observatory	50
--	----

The globe in view and the landscape before your eyes 'Inside' satellite images	54
--	----

At the museum The Deutsches Museum in Munich	60
--	----



Reviews	66
----------------	----



Dear Readers,

The year 2014 is all about excellence. The Winter Olympics in Sochi marked the start. Athletes from all over the world pushed their bodies to the limit, seeking rewards for years of hard training and physical exertion, and hoping to mount the podium and have one of the coveted medals hung around their necks. Almost always, it comes down to one tense moment when everything must come together and one piece of the jigsaw fits into the next – for individual glory and the success of the team as a whole.

At DLR, too, 2014 will call for top performances.

Medals can be ruled out. But nevertheless, in May, the German ESA astronaut Alexander Gerst will reach for the stars following intense preparation and hard training. He is set to fly to the International Space Station, where he will live and work for six months. For the mission to run smoothly, everyone involved will have to deliver a top performance – on the ground as well as in space.

November will see a further result of top performance – as the culmination of a 10-year odyssey and having reached the inconceivable distance of 800 million kilometres from Earth, the European Rosetta spacecraft will deploy its lander, Philae, which will touch down on Comet 67P/Churyumov-Gerasimenko. DLR engineers have left nothing to chance in their quest to ensure a smooth landing on uncharted terrain, planning the mission down to the smallest detail. Now they are determined to claim victory, but for that to happen, everything must run according to plan.

It is not just the spectacular missions that deserve to be in the spotlight. Records are set just as frequently during the everyday work of major research facilities – in wind tunnels, for instance. A new series of magazine articles presents the most impressive complexes and the research conducted in them. Touching on the subject of 'high flyers', there is also an article about SOFIA, the airborne observatory, and its journey across the Equator to New Zealand, from where it observed the skies from altitudes of between 39,000 and 45,000 feet.

Becoming an Olympic Champion is a cherished dream at the start of a career. But this dream came true for the most tenacious, disciplined and creative athletes and their teams just a few weeks ago.

So with this sporting analogy, I hope that you find the experience of reading this magazine rewarding in many ways – even without a medal.

Sabine Hoffmann
Head of DLR Corporate Communications

Perspective

A sliver of space in the laboratory

Satellites cannot function reliably without absolutely precise attitude control. The DLR Institute of Space Systems in Bremen develops and tests exactly the modules required to achieve this. The attitude control systems are subjected to conditions similar to those in outer space in the Facility for Attitude Control Experiments or F.A.C.E., an air-bearing table that enables frictionless rotation around all three spatial axes. Magnetic coils generate an artificial magnetic field, simulating the conditions in Earth orbit, and a studio spotlight acts as a synthetic Sun. Positioned on the platform, the nearly self-sustaining satellite can be put through a variety of tests.

DLR.de/IRS/en

Image: DLR / Thomas Ernsting

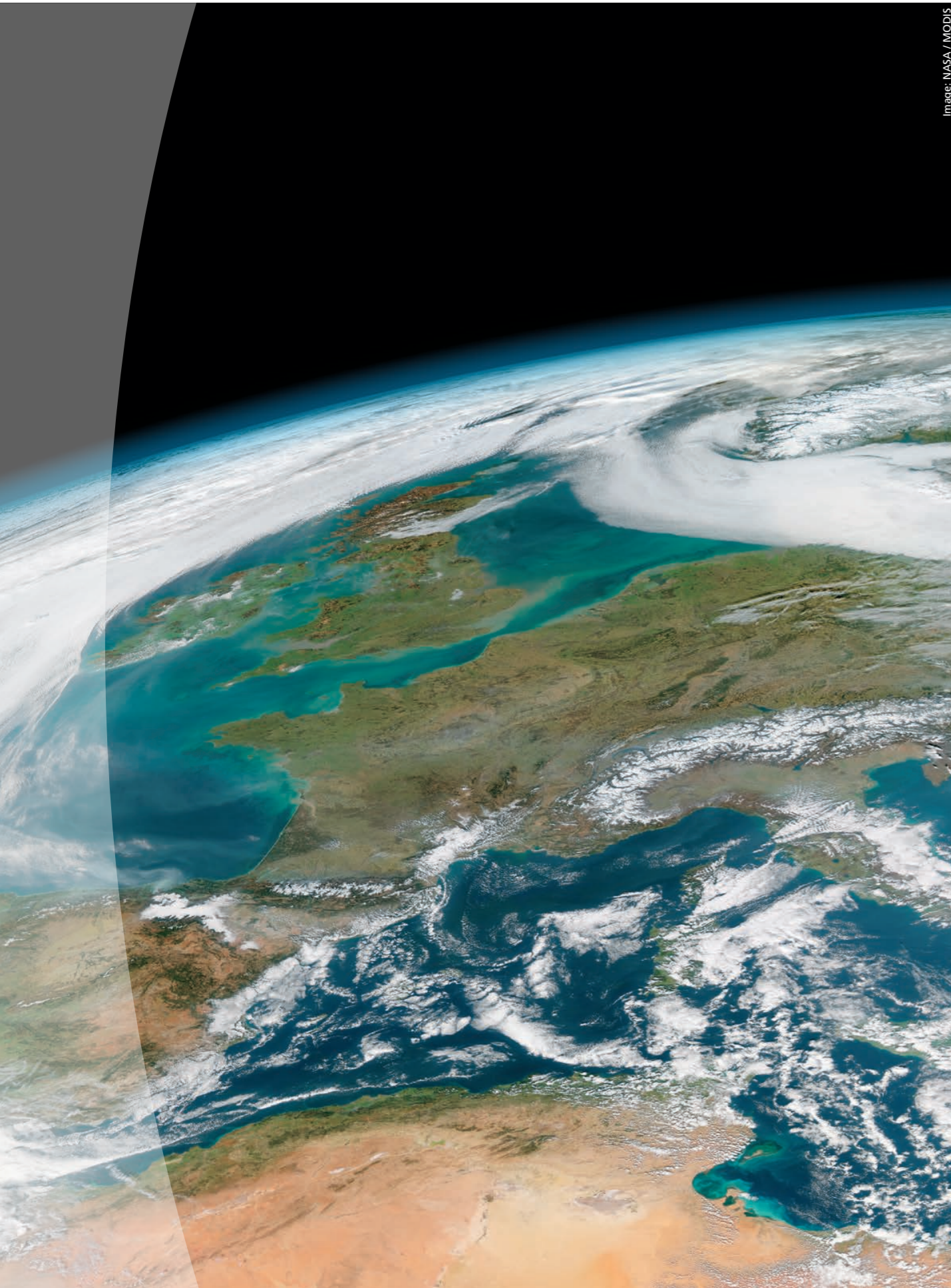


Image: NASA / MODIS

Research for the way ahead

By Brigitte Zypries

The new Federal Government has set out to advance the status of Germany as a location for science and business. Research, technical expertise and constant readiness for innovation are the best recipe for this. The key technologies of aeronautics and spaceflight, which lie at the heart of DLR's research activities, will make a substantial contribution to this. However, this applies equally to DLR's other research areas: transport, energy and security. The DLR Project Management Agency is an important contact for project funding. They must ensure that the projects are conducted with a high level of professionalism and that the legal conditions for project funding are being observed.

Translating excellent research results into practical applications is the only way we can retain research, development and manufacturing skills, as well as systems capabilities in Germany for the long term. In this regard, DLR plays a unique role, acting as a bridge between application-oriented basic research and innovative applications and precursors to marketable products. The German economy has been benefiting from collaboration with DLR for many years, as have both industrial heavyweights and medium-sized supply and manufacturing companies.

Once again in 2014, DLR is facing major challenges. With its aviation strategy, the Federal Government is pursuing the goal of making Germany a forerunner in high-performance, yet environment-friendly air transport systems. The Federal Government's Aeronautical Research Programme (LuFo), which consistently aligns its focus with this aviation strategy, represents an effective promotional tool. With its technical committee on aircraft noise, DLR is showing that it has recognised a sign of the times; reducing noise emissions will increase public acceptance of air transport.

In terms of spaceflight, a decision on launcher development is expected to be reached at the European Space Agency, ESA, Ministerial Council Meeting. A highlight this year is certainly the imminent flight of German ESA astronaut Alexander Gerst to the International Space Station, ISS. There has been plenty of coverage in the press and new media about the successful European Rosetta mission with its Philae lander. Philae was developed by an international consortium under German leadership and is controlled by DLR in Cologne. I hope to see much more good press coverage and public reaction to the work conducted by DLR.

Boosting the economy requires high-performance, innovative infrastructure, above all in the transport sector. DLR has the correct priorities in transport research: next-generation road and rail vehicles, combined with a novel transport management system; overall monitoring of the entire transport system; and electromobility. DLR is making substantial contributions to implementing the Energy Transition through energy research, in the energy storage sector for example, through high-efficiency, low-pollutant combustion technologies and materials development for cutting-edge technologies in the energy sector – for example, solar energy. In addition, Germany's economy is benefiting from state-of-the-art energy technologies 'Made in Germany', which provide access to important markets all over the world. With the 'Maritime Security' project, DLR and its partners are contributing to greater safety for shipping routes and ports.

The fact that DLR is well-positioned for the next few years was made evident in the evaluation of the aviation, spaceflight and transport programmes carried out by the Helmholtz Association in 2013. A further major challenge facing all research institutions lies in using the exceptional research results even more intensively, to strengthen the role of Germany as a business location; this principally means implementing them more quickly and turning them into innovative products. The high standard already achieved by DLR could be increased even more, in particular through additional industrial collaborations and greater joint financing from the private sector. ●



Brigitte Zypries, Parliamentary State Secretary at the German Federal Ministry for Economic Affairs and Energy.

www.bmwi.de/EN

In brief

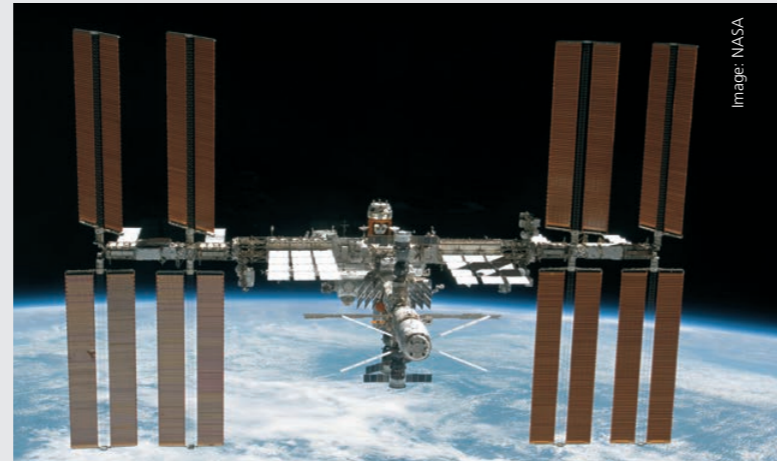
Fifteen years of the International Space Station

Earth's outpost in space – at present the size of a football pitch – started out small; once, it was just the 12.6-metre long and 4.1-metre-diameter Zarya module. With time, the Space Station has grown from a single module to a complex research laboratory.

With the decision to have an International Space Station, Zarya was designated as the first component of the ISS, which would be set up jointly by the United States, Russia, Japan, Canada and the European Space Agency. A short time later Zarya was followed by the Unity connecting module, and the ISS had two components, and the first residents of the ISS 'moved in' on 2 November 2000.

Germany was involved from the beginning. Sixty German experiments with various durations have been performed – including biological experiments on radiation exposure, experiments on the origin of life, from medicine to the cardiovascular system, but also physics and the physics of materials.

The ISS has become a complex research laboratory. About 90 Russian space vehicles and 37 US Space Shuttles have docked with the ISS, and space transportation vehicles such as the European Automated Transfer Vehicle (ATV) supply ISS residents with food, equipment, oxygen and fuel.



Earth's outpost in space – the International Space Station.

Image: NASA

s.DLR.de/9j67



Wind turbines and solar power plants

DLR has released a free version of the simulation program FreeGreenius, which brings together technical and commercial aspects and is able to calculate the yield that a renewable power plant project will bring at a certain location. DLR developed FreeGreenius in an ongoing exchange with period after constructors. It also determines how a system must be designed and constructed to ensure it can feed the targeted quantity of power into the grid.

The program considers the economic framework in order to estimate a system's efficiency – what price is paid per kilowatt-hour fed into the grid? Funding programmes for the construction of renewable systems in certain regions and the interest rates for loans and equity also play an important role.

A specialist tool, the program determines the ideal power plant size and technology for the individual units. System planners can also analyse whether a power station exclusively using wind turbines or solar power is a sensible choice, or whether a hybrid plant would be a better option. Simulation of power plant operation over the course of one year delivers hourly readings. FreeGreenius is continuously being adapted to keep up with technical progress.



The simulation program FreeGreenius calculates profitability and the optimal design of a power plant. This image shows a parabolic trough collector at the Plataforma Solar de Almería (PSA) in southern Spain.

Image: DLR/Ernsting

s.DLR.de/o1ps



Reaching for the stars

From now until 2018, Gaia, the new European Space Agency, ESA, space observatory, will measure the positions, distances and motion of over one billion stars and, for the first time, create a 3D map of the Milky Way. In addition to its contributions to ESA, Germany is supporting the science operations and data analysis for Gaia with around 15 million euros, which is about 10 percent of the total. DLR is implementing the German share of the project as part of the national space programme.

This is the second ESA astrometric observatory; its enhanced measurement accuracy will give us a much clearer picture of the dynamics and evolution of the Milky Way. Gaia is not only capable of studying stars, but also other celestial objects above a certain minimum brightness. It will study millions of asteroids and comets, as well as thousands of extrasolar planetary systems; it is also expected to discover brown and white dwarfs, supernovae and quasars, and look for clues regarding the distribution of mysterious dark matter.

s.DLR.de/283s

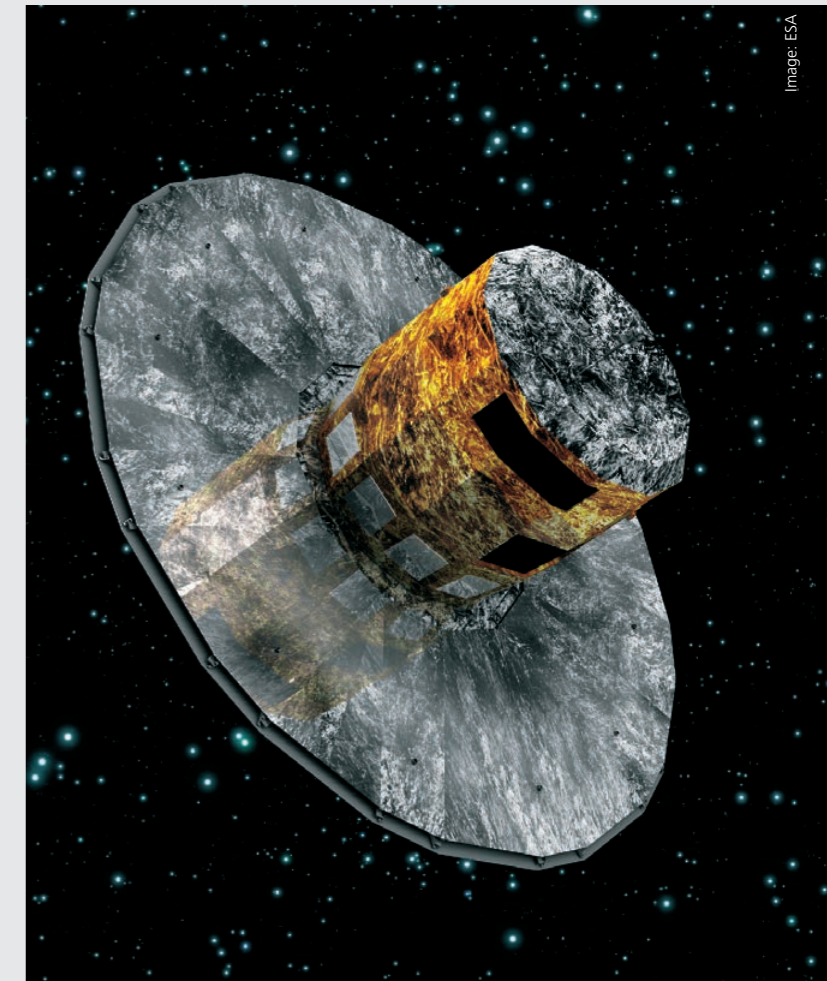


Image: ESA

The Gaia mission will generate the largest, most precise three-dimensional map of our galaxy by surveying one percent of its population of 100 billion stars.

To the rescue of the Akademik Shokalskiy

Things got complicated for the Russian Akademik Shokalskiy research vessel, as their progress was blocked by ice floes driven into the bay by strong winds. For 10 days, 74 scientists and tourists were trapped in the Antarctic on board the ship. High-resolution satellite data provided by DLR helped to assess the ice conditions.

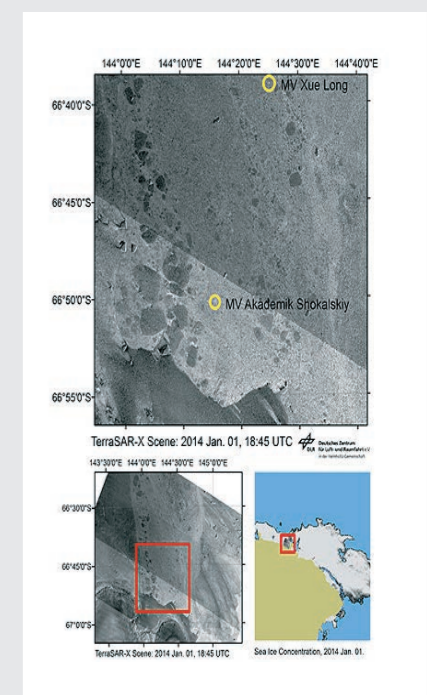
In pack ice, the situation can change quickly when the wind shifts. This is why researchers from the DLR Earth Observation Center, EOC, used up-to-date, high-resolution images from the Earth observation satellite TerraSAR-X to provide the crew of the Akademik Shokalskiy with information regarding the surrounding ice conditions.

The DLR ground station processed the satellite images in near-real-time and transmitted them to the rescue centre in Australia just one hour after acquisition of the Antarctic scenes. On 1 January 2014, Researchers from the DLR Microwaves and Radar Institute used TerraSAR-X images of the trapped research ship. Software at the DLR Research Centre for Maritime Safety in Bremen was used to track the ships by utilising the contrast and differing textures of the vessel and sea ice to detect the vessels amongst the frozen masses.

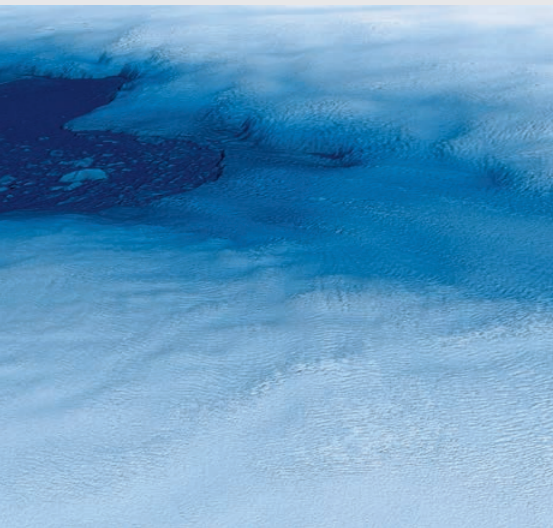
s.DLR.de/499p



In the west of the satellite images we see one-year-old ice (darker expanses), revealing distinct deformations around the Akademik Shokalskiy (light area); we also see larger floes with less pronounced deformations west of the ship. Open water is found to the northeast.



Fastest glacier in Greenland



Jakobshavn Isbræ – since the 1990s, it has been considered the fastest moving glacier in Greenland. Its speed is now increasing dramatically, according to studies carried out by researchers from the University of Washington and DLR. High spatial and temporal resolution data acquired by the German radar satellites TerraSAR-X and TanDEM-X were crucial to accurately determine the velocity of the glacier. DLR's Earth Observation Center, EOC, provided the satellite data and prepared it specially for this purpose.

Analysis of the data shows that the annual average of the flow rates for Jakobshavn Isbræ in 2012 and 2013 is almost three times greater than 20 years ago. During the summer period, the flow rates are over four times higher. The maximum speed measured by the scientists in the summer of 2012 was 17 kilometres per year; this is more than 46 metres per day – a record for outflow glaciers not only in Greenland, but also in Antarctica. The glacier's rising speed also indicates an increasing loss of thickness. The volume of Jakobshavn Isbræ entering the ocean is already so considerable that it is affecting sea levels, causing a rise of about one millimetre between 2000 and 2010. In future, the glacier will cause sea levels to rise even further.

s.DLR.de/qgyb



DLR creates country energy scenarios

Even today, thanks to abundant hydroelectric power, almost 57 percent of the energy supplied by Switzerland is produced using renewable energy sources. By the year 2050, this proportion could be at 98 percent, according to the Energy Transition scenario in the DLR system analysis. The corresponding figure for Poland reaches nearly 90 percent. A sustainable energy supply is possible in both countries in the long term. These figures are shown by energy scenarios that DLR researchers prepared on behalf of Greenpeace.

In the report, researchers calculate the necessary investments for a successful transition to renewable energy and the corresponding costs and savings for the economy. In addition, the studies show the potential for increasing energy efficiency in the target countries. DLR is preparing further country studies that show how a sustainable energy supply at a national level is possible while carbon dioxide emissions are reduced. In addition to DLR, Greenpeace is working together with national experts on renewable energy sources in the various countries.

s.DLR.de/12rq

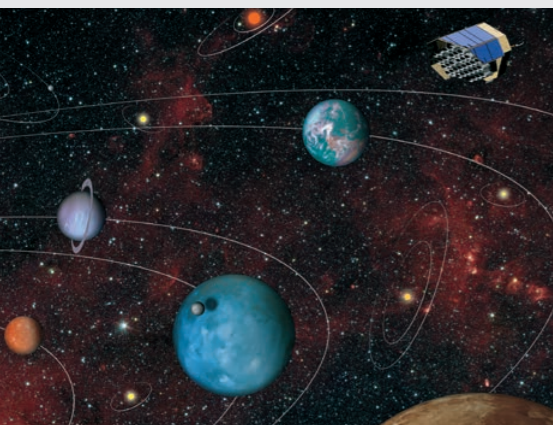


PLATO 2.0: the search for a 'second Earth'

Finding a 'second Earth' – a planet situated at a favourable, stable distance from its star and having liquid water on its surface – is one of its objectives. Scheduled to launch in 2024, the European Space Agency ESA Planetary Transits and Oscillations of Stars (PLATO) mission will continue the search for a 'second Earth' outside of our Solar System. From the second Lagrange point of the Earth-Sun system, it is estimated to discover and characterise thousands of new planets around other stars. Thirty-four telescopes mounted on the observation platform will survey approximately half of the sky for at least six years, examining around one million stars. An international consortium of planetary scientists, under the leadership of DLR, will analyse the data to gain insights into the development of planetary systems.

The scientists will use an indirect method to discover distant planets circling their host stars. PLATO will also measure the stars' seismic activity, and coupled with ground-based radial velocity measurements, planetary researchers will be able to identify the existence of planets outside of the Solar System as well as to determine the mass, radius and age of the host stars.

s.DLR.de/m51i



Alert4All – civil warning system for emergencies

When natural catastrophes and other disasters occur, emergency services must be organised across borders. DLR researchers have developed 'Alert4All', a unique civil warning system emerging from a cooperation between 11 European partners and 'Euralarm', a network within Europe's security industry. In this system, a variety of communication channels connect government agencies and institutions with their citizens, whether on the road, in the office or at home, providing standardised alerts.

In the event of a crisis, government agencies, security officers and relief services can access the latest information on the alert status wherever they are in Europe, and use this data to streamline responses. For the first time, the civilian population can be alerted on emerging situations within an internationally coordinated structure. The user platform creates common interfaces for decision makers throughout Europe. But communication is not just one-way; the new system also provides a feedback channel, giving public agencies a real-time appreciation of the public mood and allowing for targeted responses in the event that those affected have incorrect or inadequate information.

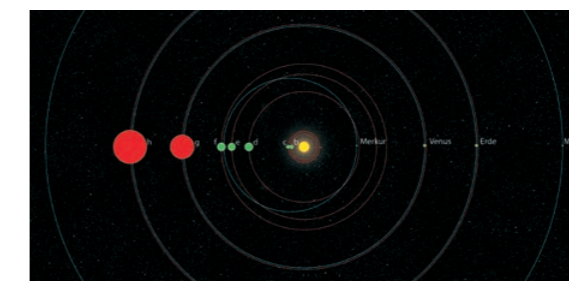
s.DLR.de/n717



A second Solar System

A team of astrophysicists at DLR, together with other European colleagues, has discovered the most extensive planetary system to date. Seven planets circle the star KOI-351 – more than in other known planetary systems. They are arranged in a similar fashion to the eight planets in the Solar System, with small rocky planets close to the parent star and gas giant planets at greater distance, providing an interesting comparison to our cosmic home.

The development of a special computer algorithm enabled the team to detect the four new planets. They were able to filter out the light curves that reveal the 'transit' of a planet across its parent star from the Kepler measurements. This technological development is likely to be crucial in the search for similar multiple systems using large data sets from future space telescopes.



PALE BLUE DOT



bit.ly/1ePXfsU

A wonderful 5:35 minutes! A video based on an excerpt of 'A Pale Blue Dot', in turn inspired by the memorable image of Earth sent back by the NASA Voyager spacecraft as it left the Solar System. It will definitely be worth your while.

CONNECT WITH ALEXANDER GERST



twitter.com/Astro_Alex

Nowadays, it is possible to connect with astronauts via twitter. The German ESA astronaut Alexander Gerst tells us all about his life and training as an astronaut through his personal twitter account. Join him during the run-up to his mission and while he is in space.

SEARCH ANONYMOUSLY



duckduckgo.com

Do you want to search the Internet without leaving a trace? It is now possible with DuckDuckGo. This search engine protects users' privacy through the network. It does not profile its searchers, showing the same results for everyone, because the IP address of the user is not saved.

REAL SCIENCE FICTION!



s.DLR.de/gwp5

The protagonist of this short DLR film 'Chasing a Comet' is the ESA Rosetta comet chaser, which has been flying through space for 10 years. In November 2014, the lander 'Philae', on board the spacecraft will land on a comet, take samples and give scientists an insight to the origin of life.

CAREERS IN SPACE AND MORE



DLR.de/jobs/en

Interested in science? Looking to work as a scientist, engineer, student or in an administrative position in one of the world's most prestigious research institutions? Check out the DLR jobs page. Offering insights into the various career possibilities, it is constantly being updated with exciting and varied, new opportunities.

LIVE SCIENCE



bit.ly/1fEtyY3

Science can be beautiful! Here, you will find a selection of stunning images from various scientific areas – colourful volcanoes, voyages to space, planetary neighbours, and creatures, large and small.



The simulated landing has proceeded as planned. In Star City near Moscow, Alexander Gerst completes a training session in the Soyuz capsule; one of the last before the trip into space becomes reality.

Entering the home straight

On 28 May 2014, Alexander Gerst will embark on his journey to the International Space Station, ISS, where he will live and work for six months. The final training stages have begun, the launch date is drawing closer, and saying goodbye to Earth is imminent.

Alexander Gerst on the run-up to the 'Blue Dot' mission

By Manuela Braun

"In six months it will be me sitting on top of this thing." This thought struck Alexander Gerst as he stood on the rocket launch pad in Baikonur last autumn. His mission to space had never seemed more real. For months he had been simulating landings in the Soyuz capsule, training underwater for extravehicular activities, enduring survival practice at minus 20 degrees Celsius – and yet this realisation only dawned on him on 7 November 2013, when Koichi Wakata, Mikhail Tyurin and Richard Mastracchio were launched to the ISS and, as the backup, he was left on the ground. It is not long until his journey to space begins. "Had there been an extra seat, I would not have thought twice – I would have climbed on board and gone with them."

Two weeks is the time spent with the crew in Baikonur – training, eating together, in quarantine prior to the launch, and helping them into their spacesuits shortly before take-off. As a member of the backup crew, Gerst was ready to step in and take off at any moment in the event that one of the

astronauts had to pull out. "You help the crew take their equipment to the rocket, see them climb into the rocket and stay with them until the end." There is a strong hint of longing in these words – for space, for living and working in weightlessness, for the training on Earth to finally be over, and for the reality of life aboard the Space Station.

A real landing

Alexander Gerst is currently preparing for the 'Blue Dot' mission in Star City, near Moscow, at the Russian Cosmonaut Training Center. Next on the list are Houston, Cologne and Japan. He is back to the carefully planned training routine. "At the moment, my mission seems to be a long way away again – even though I can now count the days to the launch." Today, Gerst and his crewmates Reid Wiseman and Maksim Surayev came back to Earth in the Soyuz capsule, landing in the Kazakh steppe – virtually, at least. He has done this 30 or 40 times in recent months. Although it has not always gone

Alexander Gerst – geophysicist, astronaut, flight engineer

In May 2009, Alexander Gerst was invited to join the ESA European astronaut corps, and on 22 November 2010 he completed basic astronaut training. In August 2011, the astronaut was assigned to fly to the ISS as a member of Crew 40/41. He will serve as a flight engineer in a six-man team.

Since he was selected, the qualified geophysicist has been training for his mission in Russia, Germany, Canada, Japan and the United States. On 28 May 2014, he will embark on his journey to the International Space Station, ISS, from the Baikonur Cosmodrome in Kazakhstan. Gerst will live and work on the ISS until November. During this time, he will participate in around 100 experiments from all ISS partners. Of the roughly 40 ESA experiments, 25 are under the guidance of German project scientists or have been sponsored in part by German industry.



Image: NASA



Training amid cutting-edge technology and potted plants: in the Gagarin Cosmonaut Training Center the astronauts practise their work in a true-to-life version of the Russian Space Station module.



Underwater training for the extra-vehicular activity: as soon as the modules are lowered into the water, the astronauts can start training almost as if in the weightlessness of space.

well, this time everything went to plan in spite of the trainers' attempts to put the crew under a certain amount of stress by including various hitches in the multiple-hour simulation.

"We had to react to eight problems," says Gerst. The engine shut down too early and there were pressure losses in various areas. The German astronaut was responsible for monitoring the life-support systems, which included carefully observing and regulating oxygen levels, for example. The number of training hours they have shared has brought the team even closer, and working with Wiseman and Surayev requires few words. In this last simulation, the trainers have spared them of a life-threatening fire. "They were a bit easier on us this time."

Living and training on different continents

A red carpet worn out by a multitude of astronauts' shoes covers the steps that lead to the Soyuz capsule. Various potted plants bring a cosy atmosphere to the training hall, where a number of Soyuz capsules have been installed. The Soviet Union and spaceflight idol, Yuri Gagarin, looks down onto the consoles of the trainers' control room. The first man to orbit Earth in a spacecraft is ubiquitous in Star City. Gagarin's sports gear still hangs in his locker, and Gerst uses the swimming pool in which the space pioneer used to swim his lengths. In the sauna, the 37-year-old meets Russian cosmonauts who have already orbited Earth in MIR or completed their first spacewalk.

Alexander Gerst practises for the extra-vehicular activity, this time in Houston.

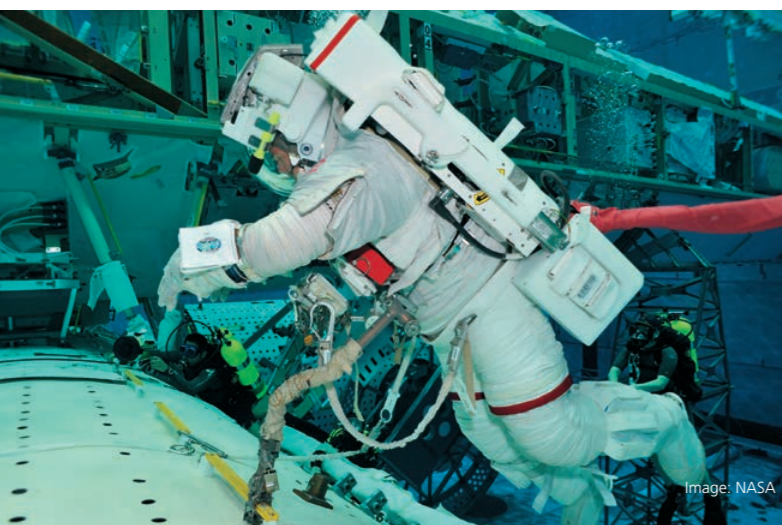


Image: NASA

Ready for the centrifuge session at several times the force of gravity



Image: GCTC

Gerst lives on site in Star City when he has to do training routines in the Russian modules. He has been given an apartment in Houston, and he owns a flat in Cologne. "Every three or four weeks, I am off to the next training site." He thinks for a moment. "And wherever I land, it feels like I am coming home." He has a great circle of friends across the globe – dinners in the United States, barbecues with the Russian trainers, jogging with crewmate Reid Wiseman. Gerst has made a home for himself in the different continents – three pairs of jogging shoes, three sets of clothes... And he is slowly starting to bring the first things back to Cologne. As the mission draws closer, the hours of training in Moscow and Houston are coming to an end. There are two things the astronaut cannot yet picture: the six months on the ISS, 400 kilometres above Earth, and what follows when the global commuting between the training sites is over.

On responsibility and the consequences of major errors

Hundreds of people across the globe are currently working on the preparations for the final training routines, to ensure that Alexander Gerst is as ready as possible for his mission. Several teams organise the launch from the Baikonur Cosmodrome. During his time on board the ISS, numerous people will be monitoring and guiding him from the consoles of the NASA Control Center in Houston and at the DLR sites in Oberpfaffenhofen and Cologne. "As an astronaut, I am just the executing arm of a huge team," says Gerst. "And I am willing to trust each and every member of this team." Space travel would not be possible without trust in the engineers,

technicians and trainers. The tables will turn during Expeditions 40 and 41 on the Space Station when, for six months, a large team of scientists will be relying on him to conscientiously and successfully carry out their experiments in space. "That is a big responsibility. If I make a mistake, years of work by a large research group could come to nothing."

Gerst is a scientist himself, which is important to him, and he wants to put his knowledge to use. "I am most looking forward to the electromagnetic levitator furnace." It will be delivered to the ISS by the European Automated Transfer Vehicle, ATV. Then, the geophysicist will unload the furnace and take it into the Columbus research module, where he will assemble it and use it for the first time. Scientists at the DLR Institute of Material Physics in Space want to use the furnace to test new alloys in space, among other things. This is stimulating for Gerst, as scientists on Earth may be able to develop new materials using the data acquired. "This might lead to new, lighter aircraft engines that consume less fuel. I would be delighted to be able to contribute to a better world through my work."

Looking back at Earth

'Blue Dot' is the name of his mission. The logo shows hands cupping the globe protectively. And the moment Gerst is most looking forward to is glancing back at Earth. This will hardly be possible from the Soyuz capsule during launch, but there will be plenty of opportunities from the Space Station. "Once the hatch opens and I have greeted my colleagues on board the Space Station, the moment will come when I will look back at Earth," says Gerst. He already had a similar feeling when he went to Antarctica as a geophysicist and looked at the deserted landscape for the first time; he tried to hold on to this view and would have liked to share it with everyone. On the ISS, he says, his five colleagues and him will be among the few people to enjoy this view of the Earth. Photos of friends and family and mementoes from his daily life on Earth should act as a kind of anchor, even in the weightlessness of space.

"With spaceflight we are entering a completely new, unintuitive environment that is hostile to life – to discover what is there." Gerst does not easily indulge in daydreaming – only when it comes to space and the spirit of exploration. "We are still part of the first wave of explorers who are venturing into an environment where no man has gone before." Being in the same training centre as Yuri Gagarin, having an office almost next to that of Neil Armstrong in Houston, or finding himself in Baikonur, by the tree that Sigmund Jähn planted before his flight – for Gerst, it is a huge privilege to be following in the tracks of these spaceflight pioneers. He will soon join them when he embarks on his own mission to space.

Respect vs. fear

The astronaut has respect for the launch and landing procedures, as well as for living in the ISS, which circles Earth at 28,000 kilometres per hour. "Let's be honest, human spaceflight is not without its dangers. We are working at the boundaries of technology." During the launch he will be sitting on top of 300 tons of fuel. "There will be 26 million horsepower underneath." He understands the risks, but what about fear? "Nobody can really say they are free of fear." But

One for the family album: Alexander Gerst, Maksim Surayev and Reid Wiseman pose for the traditional photo in front of the Lenin Memorial in Star City.

real fear only occurs if you are afraid of losing control, and that is something we can protect ourselves against. "We try to prevent the loss of control by getting to know our spacecraft inside out." Every training session, every emergency practice contributes to this. "Everyone is afraid when their own life is in danger, but the training teaches you to be able to set that aside, so you can continue to do your work." So although he does not feel fear, he has all the more respect for his mission.

Gerst has not once doubted about his career, not even for a minute, which surprised him a little, just thinking about the strenuous crash course in Russian or the many hours spent in the classroom learning schematics. But it has all been worth his while, he says. Gerst will be keeping a journal when he is in space, where he will note down his impressions – because one easily forgets and things start to fade quickly in your memory. Being in space will not leave him unmoved or unchanged, Gerst is certain about this even though he has not been up there before. "I will be seeing Earth from a completely new perspective – as a ball of rock, with a delicately thin atmosphere, vulnerable and unique." If the research trips to Antarctica have changed him, space will do so even more. "A trip to space simply is mind-blowing!" ●



More information:
s.DLR.de/y255





Happiness in the control centre: Andrea Accomazzo raises his arm, excited, upon reception of the signal from Rosetta.

Rise and shine!

The European Rosetta spacecraft has been drifting through space for nearly a decade – 31 months in hibernation and isolated from contact with Earth. It is an ambitious mission – a long flight through the Solar System, a rendezvous with the ‘unknown’ Comet 67P/Churyumov-Gerasimenko, followed by a landing on its surface, which could be covered in powder snow, craggy ice or dust. The moment of truth came on 20 January 2014: Rosetta’s alarm clock went off, and around the globe engineers and scientists waited for a signal from the orbiter, indicating it was alive and well.

The day that the Rosetta spacecraft awoke from hibernation

By Manuela Braun



As close as possible to the action – DLR scientist Stephan Ulamec, Project Manager for the Philae lander, gathers information about the current situation in the control room.

The time: minutes before 11:00 in Darmstadt, Germany. The digital display in the control room of the European Space Operations Centre, ESOC, of the European Space Agency, ESA, counts down the final seconds to the moment. The most important alarm clock in the Solar System goes off in space, more than 800 million kilometres away from Earth. Today, after 957 days of hibernation, the Rosetta orbiter is awoken from its slumber. The spacecraft has been flying blind for two and a half years – a mostly deactivated central computer, dormant instruments, a bare minimum of available heat, a radio receiver and a ‘ticking’ on-board clock. Rosetta was set up to spin slowly to prevent it from tumbling and has been unreachable for the engineers on the ground since 8 June 2011. The few sunrays that managed to reach Rosetta had become insufficient to supply the orbiter, the lander and all their instruments with power – the output of the 64-square-metre area of solar power cells attached to the spacecraft was not strong enough along the darkest stretch of the route. “By then, Rosetta was reaching distances of up to 795 million kilometres from the Sun,” says DLR researcher Stephan Ulamec, Project Manager for the Philae landing craft.

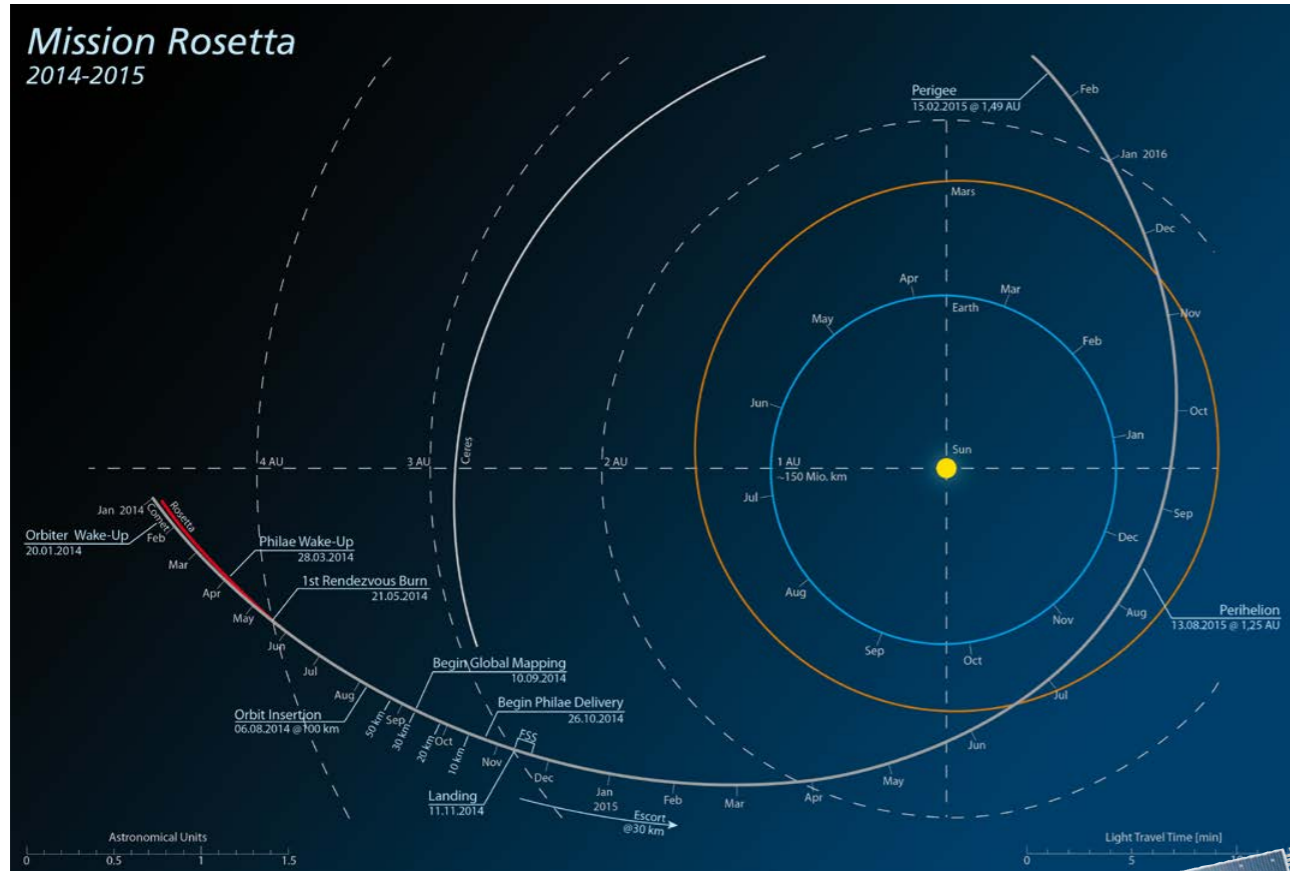
Holding one’s breath while listening to space



On 20 January 2014 at the European Space Operations Centre, ESOC, journalists, scientists and mission staff follow events in the control room.

For the scientists and engineers involved in the European Rosetta mission, 20 January 2014 is a day of waiting and hoping; anticipating that the spacecraft will wake up and send its signal as planned; that everything will run like clockwork; that orbiter and lander will continue their mission to Comet 67P/Churyumov-Gerasimenko without hiccups during the final nine million kilometres. The team gathered in the control room at ESOC, however, knows very well that many hours will pass before Rosetta wakes from its sleep. Across the world, fingers are crossed – here in Darmstadt, at the DLR Microgravity User Support Center, MUSC, in Cologne, at the French Space Agency CNES in Toulouse, and even at the NASA Jet Propulsion Laboratory, JPL.

Many of the people waiting so excitedly for this alarm signal to reach its destination in space have been involved in the mission since its inception more than 20 years ago – pretty much half of their professional lives. ESA designated the demanding Rosetta mission back in 1993 as one of four Cornerstone Missions, which also included the Herschel Telescope, for example. The original destination, involving two landing craft, was the comet 46P/Wirtanen – but things do not always go as planned. So instead, RoLand and Champollion – the two landers – became the single lander Philae, designed and built by an



The journey to the Sun by Rosetta and its lander, Philae (red line), and Comet 67P/Churyumov-Gerasimenko (grey line) begins.

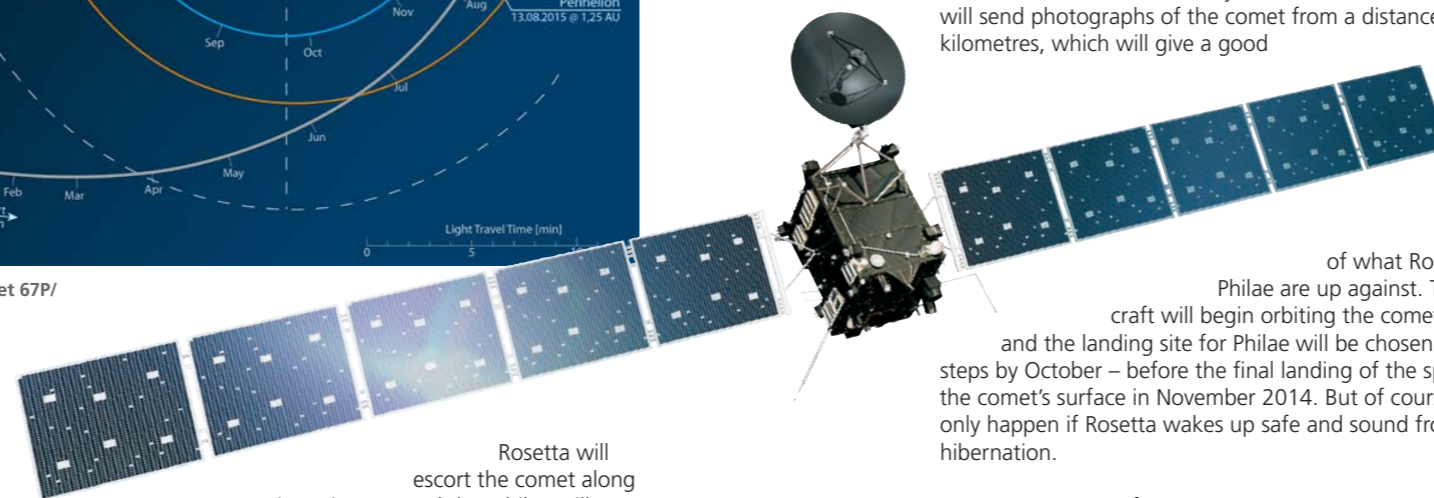
international consortium under the supervision of DLR. Upon an unsuccessful launch of the Ariane rocket, the mission had to be postponed, so the destination had to be changed as well, as 46P/Wirtanen had passed and was out of reach. The new target became Comet 67P/Churyumov-Gerasimenko.

A journey to the guardians of the past

This celestial body has only crossed paths with the Sun on a few occasions, which implies a minimal loss of its volatile material. Such a comet, in a nearly embryonic state, unchanged since the birth of the Solar System 4.6 billion years ago, is of course of inestimable value to scientists as an exciting testimony of the past. Philae was designed to land on a comet with a diameter of merely 700 metres. The nucleus of its new target is roughly three by five kilometres – bringing with it a significantly stronger gravity. “This meant we had to strengthen the landing gear as much as possible, meanwhile reconfiguring the on-board software to adapt to the new situation,” explains Ulamec. Rosetta and Philae finally embarked on their 10-year journey to space in March 2004. After such a prolonged period of meticulous preparation, planning and a trip through space one tends to be reluctant to lose contact with one’s orbiter for 31 long months. Now, though, only nine million kilometres separate the orbiter from its target – just a stone’s throw by celestial standards.

A watched pot never boils

It is two in the afternoon. The long-awaited signal from space is not expected until the evening. Most of the workstations in the ESOC control room are empty... Speech follows speech on the stage in the large auditorium... Those involved explain once again what makes it so special, unique, that



Rosetta will escort the comet along its trajectory, and that Philae will touch down on its surface. Nerves should not be jangling just yet. Everybody is convinced that the alarm call will be successful. Expectation fills the room. The end of hibernation is an important milestone in the mission. If the orbiter fails to wake up, there is a great chance that something has gone horribly wrong.

In the depths of space, Rosetta should be getting ready, activating its systems. First of all, the orbiter has to heat up the Star Tracker, sensors used for attitude control, to its operating temperature. Without it, Rosetta would not be able to orient itself. And the smooth rotation with which the engineers stabilised Rosetta for its long, somnolent flight should be slowly stopped. After all this, the spacecraft has to align its 2.2-metre parabolic antenna towards Earth to give its first sign of life after hibernation. This signal then has to travel 800 million kilometres, which should take about 45 minutes to reach Earth, making the control room erupt in celebration and relief. At 14:00 nobody can be sure that everything will go as planned. The NASA Goldstone Deep Space Communications Complex will be the first to listen for Rosetta’s attempt to communicate. That moment could be anywhere between 18:30 and 19:30. Until then, the team of scientists has no choice but to leave Rosetta to its business. All they can do is wait, wait, hope and wait a bit more.

Along for the ride

Eleven measuring instruments accompany Rosetta on its journey, and 10 more are along for the ride on Philae. Comets stick to the cold reaches of the outer Solar System and travel

through space in their frozen state until they draw closer to the Sun. At that point, gas and dust are shed off the comet at speeds of up to 100 metres per second as it sublimates. The planetary researchers involved in the project intend to use these instruments to find out whether organic material such as amino acids can be found on Churyumov-Gerasimenko. This would confirm that comets that have impacted with our planet may have transferred these molecules, thus contributing to the emergence of life on Earth. Thus far, the research conducted on these relics from the nascent phase of the Solar System falls a long way short of what scientists would like. “There is a lot we still do not understand,” says Ekkehard Kührt from the DLR Institute of Planetary Research. That is why the Rosetta mission features one first after the other: the first time an orbiter accompanies a comet as it awakens on its way to the Sun; the first time that a landing craft carrying instruments touches down on a comet; the first scientific examinations carried out in situ on the nucleus.

DLR’s MUSC will reactivate the lander in April and Philae’s experiments will be commissioned. Rosetta will be ready to rendezvous with Comet Churyumov-Gerasimenko in May, and will send photographs of the comet from a distance of 200,000 kilometres, which will give a good

impression of what Rosetta and Philae are up against. The spacecraft will begin orbiting the comet in August, and the landing site for Philae will be chosen in several steps by October – before the final landing of the spacecraft on the comet’s surface in November 2014. But of course – this can only happen if Rosetta wakes up safe and sound from its hibernation.

A momentous peak

18:30. All eyes gaze upwards in the control room. There, a green jagged line indicates whether the signal has arrived. Rosetta could ‘call back’ any minute now, saying that it has ticked all the boxes on its checklist out in space and is ready to receive commands from Earth. 18:43. Silence takes over the workstations. An engineer swivels silently from left to right on his chair, and back again. A neighbouring colleague stands up. The monitor still shows no change in the ‘white noise’ signal. 18:53. Still no news from Rosetta. Plenty of things could happen to cause a delay in the signal, all of which were considered in Plan B. At this time, few people remain in their seats in the control room. Legs are tingling with excitement; sitting and waiting is off the cards. At around 19:30, the window of opportunity during which the Californian satellite dish can receive the signal will close; and another ground station would have to be used.

19:17. The steadily jagged green line suddenly grows a peak. Almost everyone holds their breath. In the control room, nobody is celebrating just yet. Is it a malfunction, or another orbiter calling from outer space? No one wants to jump the gun. The peak gets bigger... ESA’s Rosetta spacecraft Operations Manager Andrea Accomazzo and Paolo Ferri throw their arms in the air in the control room. Rosetta is back! The time is 19:18, and the orbiter has made everyone wait. Hugs and embraces fill the room. Celebrations break out in the large auditorium in which scientists, team members and journalists have been following the events. A glass is tipped off the table; photographers make their shutters whirr. Joy and relief come together at

The Rosetta spacecraft will not only have a long journey behind it when it arrives at Comet 67P/Churyumov-Gerasimenko in August 2014, deploying the Philae lander the following November – it also has an extensive development history. Stephan Ulamec and Diederich Möhlmann of DLR were involved from the beginning. In their 256-page book (Raumsonde Rosetta: Die spektakuläre Landung auf einem Kometen), at present only available in German, they report on Rosetta and the spectacular landing on a comet – from the initial idea for the ambitious mission up to the year 2014. The two authors explain in detail why comets are so interesting for planetary scientists and describe famous examples from Comet Hale-Bopp to Halley’s Comet, along with previous cometary missions.

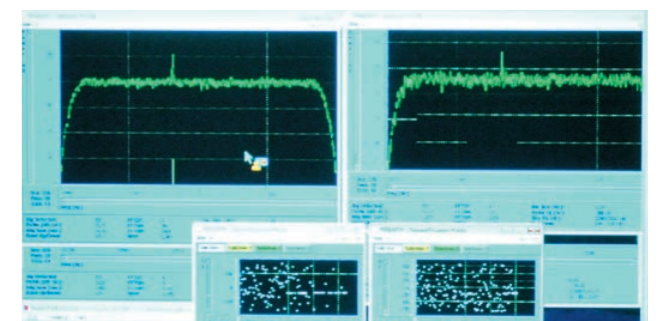
The flight to the comet by the Rosetta mission means breaking new ground in several ways; the orbiter will accompany the comet on its journey towards the Sun and the Philae lander will conduct experiments directly on the surface of a comet for the first time. Easy to understand, yet filled with current scientific knowledge, the book describes, among other things, what planetary scientists hope to learn from the 21 experiments and how the spectacular landing on the comet will take place. Numerous photographs, drawings and tables show exactly what experiments the spacecraft and lander will perform.

this once-in-a-lifetime moment. “This has been the most strenuous hour of my life, and also the most gratifying,” calls out Andrea Accomazzo.

New commands can now be sent to the spacecraft. But stress begets stress and the Rosetta team members’ nerves will be put to the test once again in November, when the time comes for Philae to descend onto the comet’s surface ... ●



More information:
DLR.de/en/Rosetta



The decisive moment arrives when the green line rising above the noise indicates reception of the signal

A safe pair of hands for a space odyssey

When an astronaut travels into space, all eyes are on him. But the success of a mission depends on hundreds of people working behind the scenes – they train the astronauts for their stay in space, sit in the control centres, make sure that the International Space Station, ISS, remains a safe home in space, and monitor the health of the astronauts. Raimund Lentzen is one of them. He is Head of the crew support team that assists the astronauts with their work, organises everything for them and is with them from the very beginning, to the launch and landing.

Raimund Lentzen – monitoring and assisting astronauts for three decades

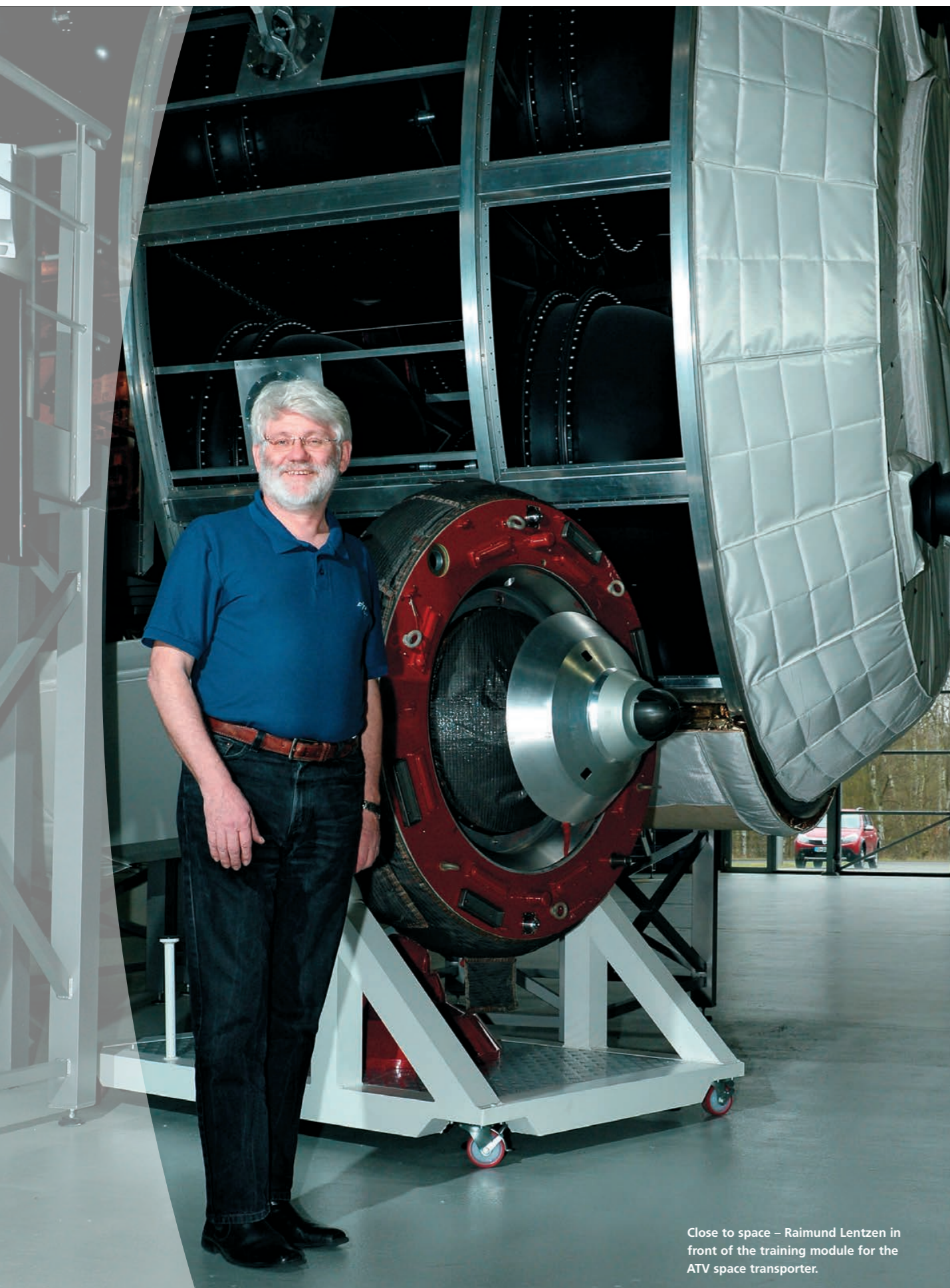
By Manuela Braun

It could be 15 or 16 missions, perhaps even 17 – Raimund Lentzen is not sure anymore. “For us, this is everyday work, so you tend to forget,” he says, shrugging his shoulders almost a little apologetically. Lentzen is the Head of the DLR Astronaut Training division and is leading the ESA crew support team. He supervised Hans Schlegel and Ulrich Walter during the D2 mission; he was there when Reinhold Ewald returned from his mission to MIR; he supervised Luca Parmitano on his launch from Baikonur; and he will be supporting Alexander Gerst during his flight in May 2014.

When European astronauts go into their fortnight’s quarantine before a launch, Lentzen is usually there. If they request specific equipment for their stay on the ISS, the DLR employee takes care of getting authorisation for it and transporting it to space. And when the Soyuz capsule lands in the steppes of

Kazakhstan, the 63-year-old is usually one of the first people the astronauts see following their mission in space.

When that moment comes, Lentzen is prepared – he holds a bag containing everything needed upon returning to Earth: a passport, visa, driver’s licence, wallet, mobile phone, shower gel and clothes, naturally. “Inside the Soyuz capsule, all that the astronauts have with them is their Sokol suit.” Every gram counts in the small, cramped capsule – there is no room for personal everyday items. So before the launch, he ensures that the astronauts’ families carefully pack a bag to keep them going, at least for the time in between landing in the steppe and arriving in Houston for the three-week rehabilitation following their stay in space. “In crew support, we take care of everything the astronauts need to work effectively,” says Lentzen. “An astronaut’s time is valuable and should be used for the mission – not for organising things.”



Close to space – Raimund Lentzen in front of the training module for the ATV space transporter.



The antenna from the Soyuz capsule in the Kazakh steppe, once held by the participants of the MIR 97 mission as a trophy, now has a fixed place in Raimund Lentzen's office.

From university to astronaut support

Raimund Lentzen studied foundry science before starting to work as a research assistant at RWTH Aachen. Had a former coworker not made him an offer he could not refuse, he might still be conducting research in that field. At that time, his colleague was working in science project management at DLR for the D1 Spacelab mission, and a position became available as Crew Interface Coordinator – the person responsible for communicating with the payload specialists. At the time, Lentzen was getting a pilot licence. “The application process was not lengthy,” he recalls, “which was handy.” He took a one-year sabbatical leave from the university in 1985, and after his excursion in aerospace, went back to RWTH Aachen – but he could not let go of space travel. One year later, he was back at DLR, and he wound up staying. After four years as a Crew Training Engineer, he was appointed Deputy Head of the DLR Astronaut Office, and ultimately Head of this Office. In 1998, the DLR Astronaut Office was integrated into the European Space Agency, ESA, and Lentzen was employed as a DLR representative at the European Astronaut Center, EAC.

From video equipment to a chocolate bar

These days, his work begins as soon as a European astronaut is selected for a mission. You could say that he is kind of a butler to the astronauts – his job encompasses many different things. “Most of my time is spent on launch and landing campaigns and the subsequent post-flight phase,” says Lentzen. Organising the astronauts’ stay in Star City in Russia, the subsequent flight to Baikonur, accommodation, local procedures, the quarantine prior to launch – all strands come together in Lentzen, who must also negotiate with over 30 international partners in a telephone conference. “These things cannot be acquired on the open market – you require the cooperation of NASA and the Russian space agency Roskosmos.”

First, he must ensure that the necessary equipment for the weekly videoconferences with the Space Station is installed in the home of the astronaut’s partner. “For Italian astronauts,

we also include equipment in the parents’ home – after all, family comes first.” Once the astronaut is living and working on the ISS, the members of the Crew Support Team plan the times at which the videoconferences can take place. Raimund Lentzen is also responsible for the crew care package, a surprise parcel in which the family can put small birthday presents, films, pictures or sweets to be sent to the astronaut in space. “A transport opportunity must be found and arranged for each of these packages.” The ‘bonus food’ parcel, extra food that the astronauts may choose for lunch is also arranged and sent to the ISS by Lentzen. There is hardly a mission for which the DLR employee has not ensured that the astronaut has gone to space as relaxed as possible.

Boxes and boxes of patches, slides and photos

Over time, his office has become a real treasure trove. Lentzen opens his desk drawer and takes out a thick stack of photos. “This is the official photo of the D2 crew,” he explains. Seven men in orange astronaut suits look seriously and optimistically at the camera. “This is the unofficial one...” Seven men in orange astronaut suits look seriously at the camera, each wearing a different hat. And then there was the time that he assisted Reinhold Ewald on his mission. In the photo, Lentzen is standing in the second row, with sunglasses and a beard. Among those sitting in front are Sigmund Jähn and Ewald in green astronaut jumpsuits. Boxes of slides occupy the cupboard. “I should really sort this out some time,” murmurs Lentzen. There are plenty more treasures to be found in the cellar of his house.

Some of the badges and patches from the various missions have made it into a glass display cabinet in his office – the historic souvenirs are tightly packed on the shelves. Whose is that signature on an official card? “For the life of me, I cannot remember who signed that...” Lentzen looks pensively at the somewhat pompous document. Over several decades of spaceflight history, there have been a number of occasions that have slipped into oblivion faster than expected – but also plenty of moments that will never be forgotten, such as the one involving

an at-first-sight unremarkable souvenir in his office: a metal rod with a small piece of cloth at the end. “That is an antenna from a Soyuz capsule that landed from space in the Kazakh steppe.” Lentzen grins. After the landing, he was standing in the steppe, holding the antenna – almost his height – in his hand. Behind him was the Soyuz capsule in which Reinhold Ewald had returned from the MIR 97 mission. Bringing the spaceflight relic back to Germany in his hand luggage was not easy, but he managed. Now the antenna stands between the glass cabinet and the cupboard – a truly special yet inconspicuous exhibit.

Behind the scenes

Raimund Lentzen knows that, even though much of it has become commonplace for him now, his work with and for the astronauts is far from ordinary. At Baikonur, for example: “I have access to things that are still completely off-limits to the general public.” Lentzen can join the astronauts’ families at just an arm’s length from the Soyuz rocket prepared for its launch into space. He is present when the astronauts sign the doors to their rooms as part of the pre-launch ritual. And he is there during the planting of a tree in Cosmonaut Alley in Baikonur before the flight to space. “In crew support, we do not just see things up close, we also help to make them happen – and that is something unique.” As a result, Lentzen is acquainted with the Kazakh beauty queen and the mayor of Star City, who come to see the astronauts for a flag-raising ceremony in the well-known city. Tea ceremonies upon the astronauts’ return, dozens of visits to the slightly dusty spaceflight museum in Baikonur, quarantine at minus 30 degrees Celsius, or barbecues with Kazakhs, Russians and United States citizens on the steppe – in the last 30 years, Raimund Lentzen has had countless opportunities to look behind the scenes as part of his work.

One thing matters above everything else: “You have to be a trustworthy person,” says Lentzen. “As a result of the closeness to the astronauts and their families, you get to know quite a lot, but of course you do not disclose this

information.” Privacy is highly regarded. You will not hear any anecdotes about the lives of astronauts from Raimund Lentzen. He was friends with three or four astronauts to varying degrees, he says cautiously. With some, the chemistry is good, with others less so. “The astronauts have very different characters – and getting to know their personality is key.” Of course, one must also contend with the cultural differences between astronauts from across Europe. “You have to be aware of that and act accordingly.” So at the beginning of the mission, a joint meeting is held to determine the framework within which the Crew Support Team can do its work to solve critical issues. “It stands to reason that the astronauts do not have *carte blanche* for their requirements either.” Lentzen’s goal is to realise as many requests as possible so that the astronauts can work under optimal conditions. ●



More information:
DLR.de/RB/en

The launchers at the Baikonur Cosmodrome, which are an almost everyday sight for the Head of the Astronaut Training Division at DLR.

The collection of now historic photos and patches has continued to grow with every mission

Lentzen is also there during the astronauts’ pre-launch rituals – here, Luca Parmitano and his crewmates are planting the traditional trees in Cosmonaut Alley in Baikonur.

Lentzen (fourth from left) is the man behind the astronauts – not just in his everyday work but also in this group photo from 1997. Among those in the front row are Sigmund Jähn (fourth from left) and Reinhold Ewald (far right).



Mapping the Reef from beyond the waters

Just off the coast of Australia is the Great Barrier Reef. As it stretches across more than 350,000 square kilometres in the Coral Sea, mapping it was considered an impossible feat – until now. Using conventional methods, it would take decades. Shallow reefs are often inaccessible to boats used for echo sounding and, more often than not, this method of mapping leads to accidents. The German company EOMAP – Earth Observation and Mapping – has successfully created the first ever, high spatial resolution map of the entire Great Barrier Reef.

DLR spin-off EOMAP maps the Great Barrier Reef for the first time

By Miriam Kamin

In August 2006, Thomas Heege founded the company EOMAP GmbH & Co.KG. The researcher worked at the DLR Remote Sensing Technology Institute for over 10 years, during which, together with colleagues and external partners, he investigated technologies that then formed the basis of the spin-off company. It specialised in generating and marketing sophisticated mapping products for coastal and inland waters using remote sensing data. In terms of industrial services, this includes the daily observation of sediment distribution in offshore building operations, such as the construction and installation of pipelines. Using various satellite sensors in places such as Australia, Mexico, the Arabian Peninsula and Germany, EOMAP provides services for the oil and offshore industries, environmental authorities, the European Space Agency, ESA, and the World Bank.

In 2013, EOMAP began to map large coastal zones in their entirety all over the world. In doing so, they were able to provide customers with standardised bathymetric products. Bathymetry is also known as submarine topography, through which it is possible to produce depth profiles of the ocean.

The principal advantage of using satellite-based remote sensing data is the risk-free and rapid mapping of large and shallow areas, as well as regions that are difficult and dangerous to reach. Furthermore, no costs are incurred for the despatch of boats or aircraft. Service users include the oil&gas sector, environmental agencies, navigation service providers, as well as hydrographic offices. Further examples of remote sensing based mapping that are currently paving way for official maps include the Ningaloo Reef – the world's largest fringing coral reef – the Yucatan Coast in Mexico, and the entire Abu Dhabi coastal zone. In November 2013, EOMAP

was awarded the Copernicus Masters for its entrepreneurial and technological ideas, an award acknowledging projects that make the best and most innovative use of Earth observation data for industry and society.

EOMAP and DLR collaborate in several projects. During the first German optical Earth observation mission in orbit, EnMAP, or Environmental Mapping and Analysis Program, EOMAP developed the atmospheric processor for water surfaces. In the German-Vietnamese project, WISDOM, coordinated by the DLR German Remote Sensing Data Center, DFD, an information system was developed for the Mekong Delta, to provide fundamental information on flooding and land usage. EOMAP was responsible for monitoring water quality throughout this project. At present, EOMAP and DLR are working together on the Apps4GMES project, the aim of which is to develop suitable infrastructure for operational satellite-based services using the Sentinel satellites.

At present, 19 members of staff are based at the company's headquarters at the research airport in Oberpfaffenhofen, near Munich. EOMAP is now planning to further develop this interesting sector on a commercial level with its offices in Singapore and colleagues in the United States and Australia. ●



More information:
www.eomap.de/great-barrier-reef

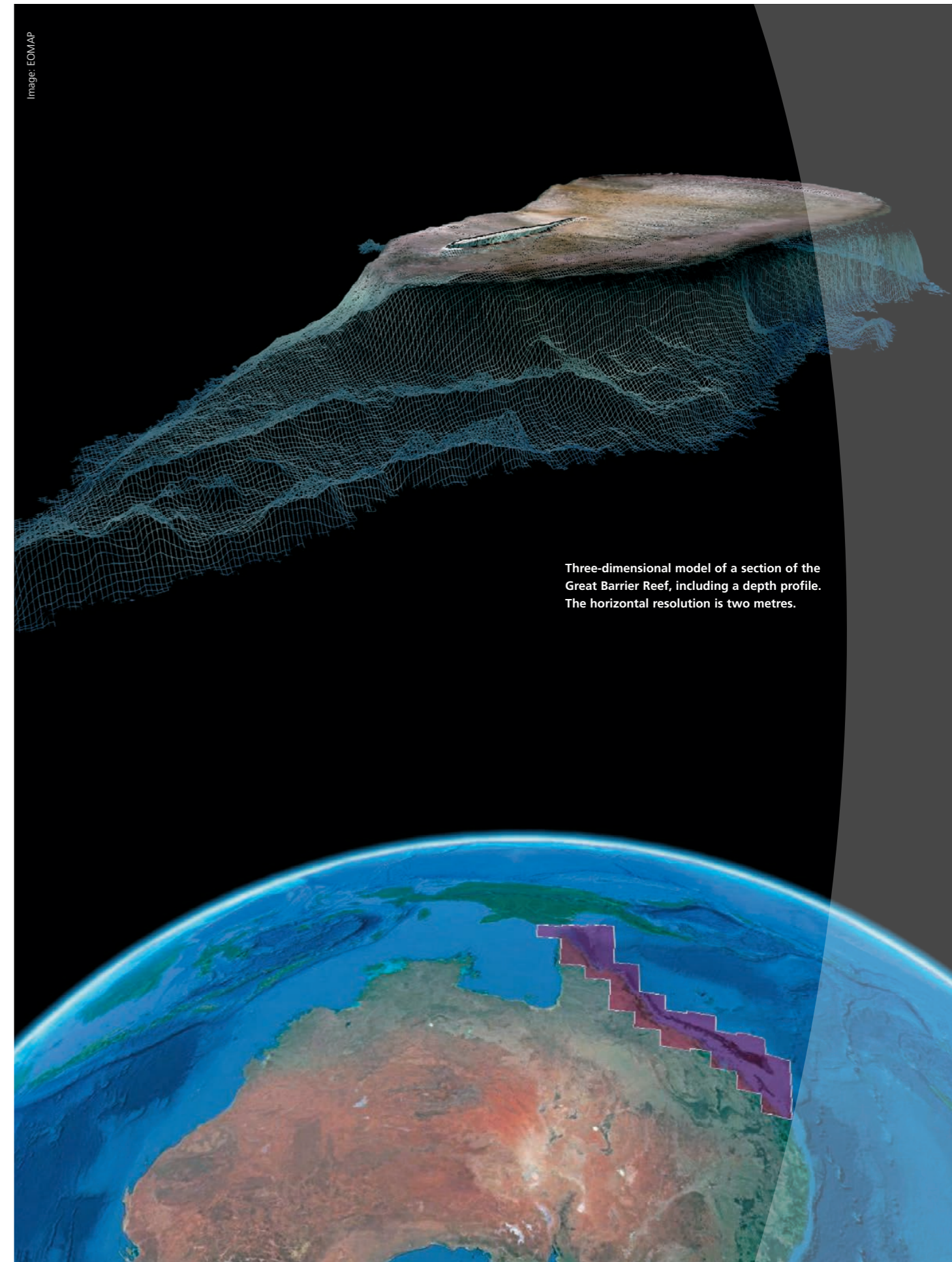


Image: EOMAP

Three-dimensional model of a section of the Great Barrier Reef, including a depth profile. The horizontal resolution is two metres.

World atlas – 'made in space'

In June 2007, the TerraSAR-X radar satellite was launched. It entered Earth orbit, where it flew 'solo' for three years until June 2010, when its twin, TanDEM-X, followed it into space. With their radar antennas pointed at Earth, they are on a mission to generate a three-dimensional elevation model of our planet. Now that the first elevation models are available for users, a true milestone has been reached on the journey towards a highly precise, three-dimensional world atlas 'made in space'.

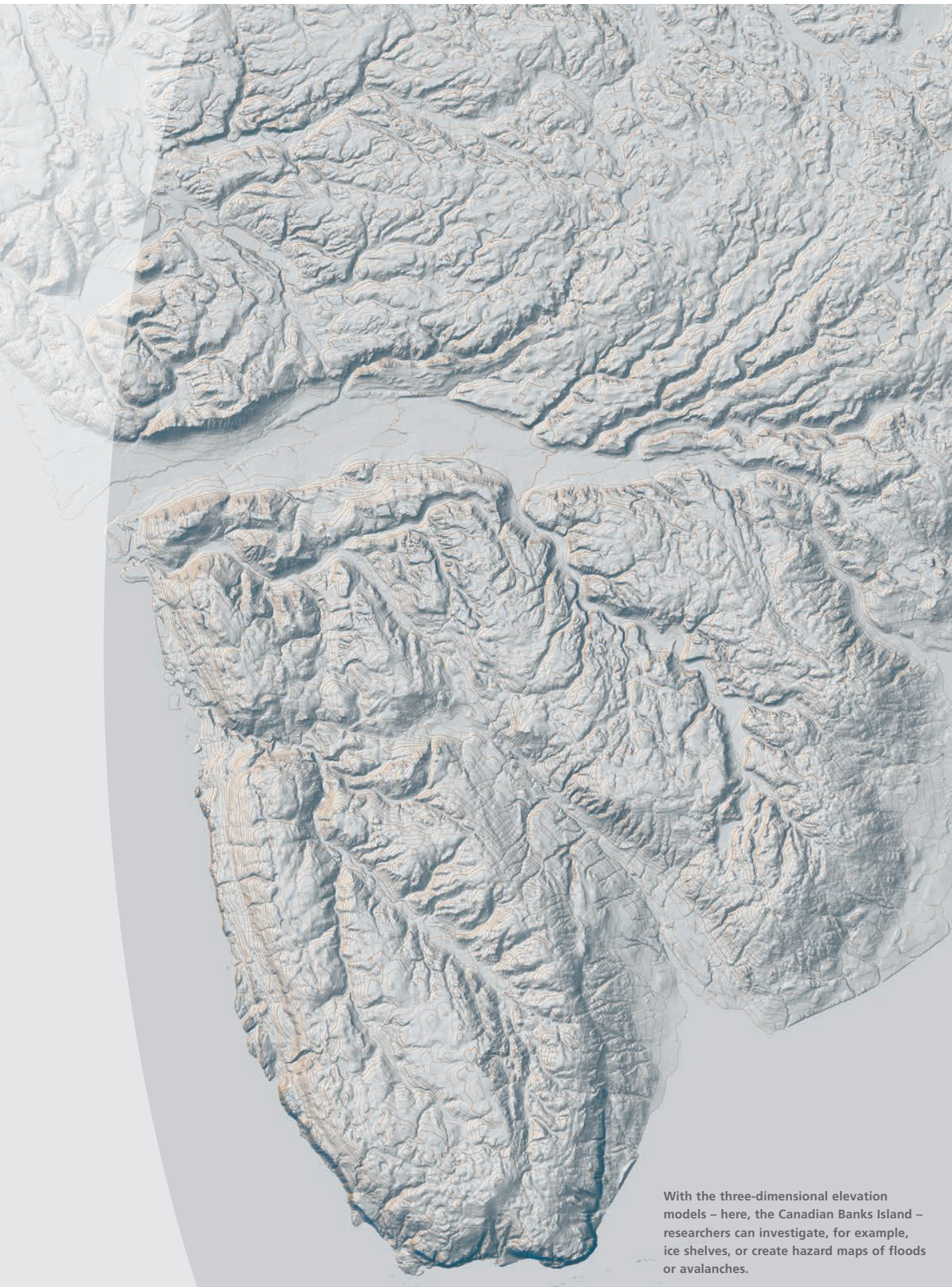
The TanDEM-X mission produces its first three-dimensional elevation models – a new way of mapping Earth comes to life

By Manuela Braun

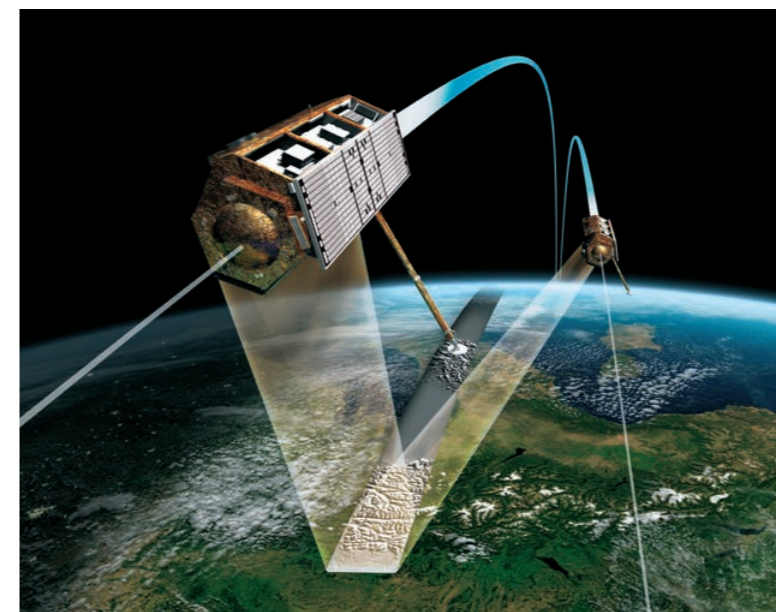
One cannot really blame Christopher Columbus for thinking he had found the western sea route to Asia in 1492, not knowing he had actually discovered America. After all, he had relied on Ptolemy, or rather on what the Greek scholar, mathematician, astronomer and librarian from Alexandria left to posterity in the second century A.D. – one of the first world maps. Although Ptolemy was a pioneer in assigning circles of latitude and longitude to our planet and thus managed to locate thousands of known cities, the distances were regrettably and frequently off the mark. Had Columbus been equipped with a world map generated with data from

the radar satellite TanDEM-X, he would not only have known exactly where he was, but he would have seen the third dimension – namely elevation. Can you imagine? The whole of America – from Alaska to Florida – in three dimensions. Columbus would have been amazed!

TanDEM-X has been circling Earth in formation with its identical twin TerraSAR-X since its launch on 21 June 2010. If TanDEM-X were a car driving around Earth, it would have clocked over 800 million kilometres on its odometer. Together, at an altitude of 514 kilometres, the duo have swept Earth's

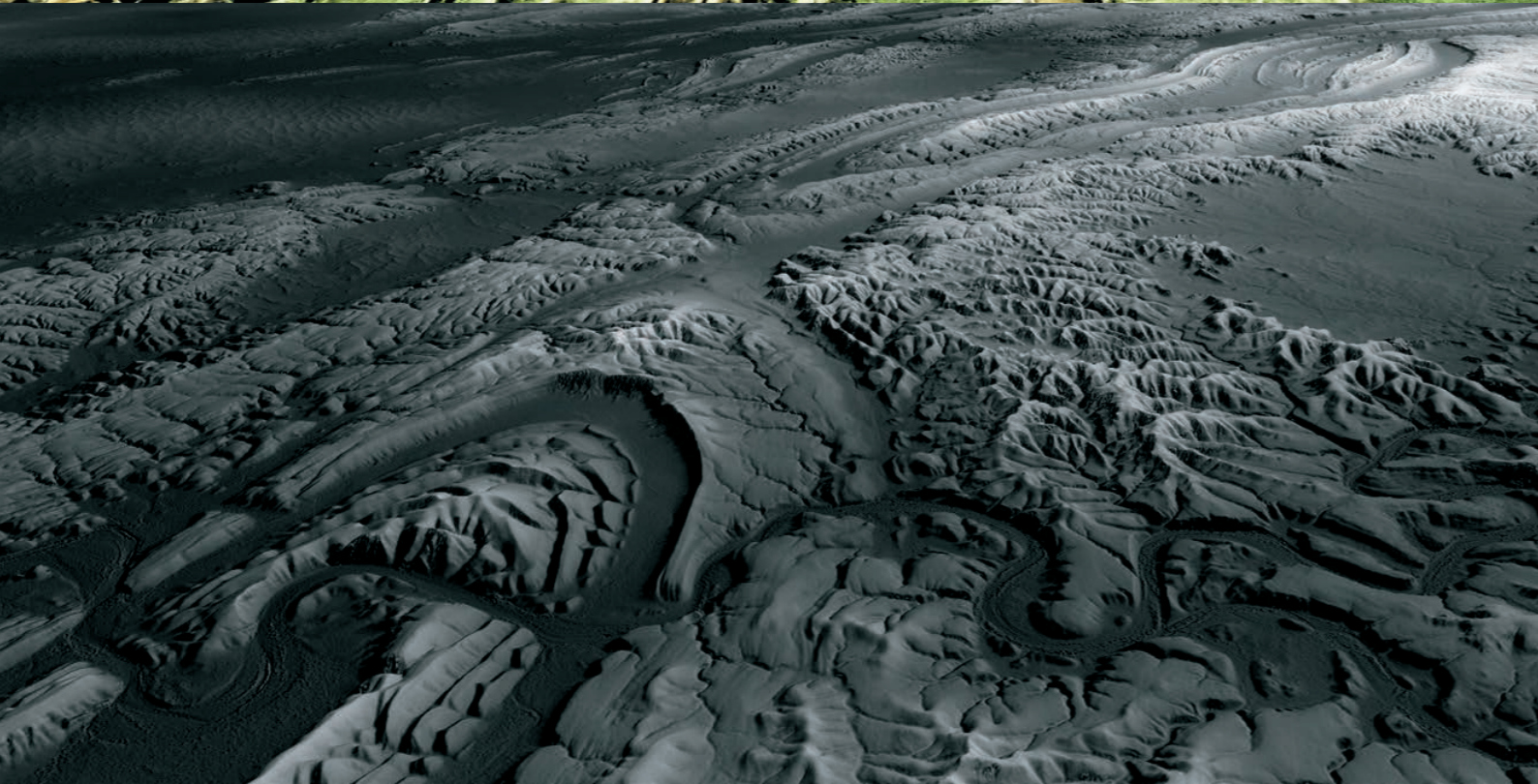


With the three-dimensional elevation models – here, the Canadian Banks Island – researchers can investigate, for example, ice shelves, or create hazard maps of floods or avalanches.



About TanDEM-X

TanDEM-X is operated by DLR with funds from the German Ministry of Economics and Technology in the form of a public-private partnership with Airbus Defence and Space (formerly Astrium). DLR has developed the ground segment and is responsible for the scientific use of TanDEM-X data, planning and implementation of the mission as well as controlling the two satellites and generating the digital elevation model. The scientific lead is with the DLR Microwaves and Radar Institute. Airbus Defence and Space built the satellite and shares the costs for the development and use and is in charge of the commercial marketing of TanDEM-X data.



entire landmass with their radar systems two and a half times: images of 380 million square kilometres have been processed into a vast quantity of data – over 2000 terabytes – around 250,000 DVDs. This pool of data will continue to grow in the coming months and years. “What we are delivering is a new global topography,” says Alberto Moreira. Even if highly accurate surveys of Earth have been available to us long since the days of Ptolemy and other famous cartographers, the precision of TanDEM-X is really the icing on the cake. “More precise, but how much? Certainly 30 times better than the current available topographic data sets,” says Moreira. TanDEM-X is generating topographical maps with a 12-metre-resolution and a vertical accuracy better than two metres for Earth’s entire landmass.

A mosaic of hundreds of thousands of individual elevation models

The meticulous task of creating the world’s most precise topography ever from this abundance of information falls to the scientists. Smaller elevation models were created from the images acquired by the two satellites using a fully automated process from the beginning – over 350,000 individual 3D models, each covering an area of 30 by 50 kilometres. “These images are already very accurate, but now we can get down to the fine tuning, correcting a metre here and there,” says Manfred Zink, Project Manager for the TanDEM-X ground segment. “We are really getting down to the nitty-gritty to optimise the automatically created models.” The ‘Raw-DEM’ – the first generated digital elevation models – are continuously being analysed, corrected and the processing system adjusted. Even the smallest inaccuracies, caused for instance by small differences in the path that the radar beams from TanDEM-X and TerraSAR-X follow as they travel through the atmosphere, are diligently corrected to prevent any such interference from being incorporated into the elevation model. In the final processing step, all the ‘Raw-DEM’ are mosaicked into the new 3D model of Earth.

The first highly precise elevation models derived from TanDEM-X data are on their way to roughly 800 scientists from 31 countries to help them progress their own research. More than 20 percent of Earth’s surface is already available – nearly all of Australia, for instance. “As Australia is mainly flat, it took only two sweeps of the radar satellites to get an optimal image.” The eastern half of the North American continent – from the Arctic to Florida – is also mainly flat, as is Siberia. South Africa is next on the list with its wide expanses and sparse foliage. All these models show very exciting topography – such as Flinders Range, a mountain chain in the south of Australia.

A new perspective for problematic areas

Then come those regions on Earth that make satellite mapping from space a true challenge: the Alps, the Rocky Mountains, the Himalayas... It takes more than just two passes to capture the topography accurately. In August 2013, the engineers at DLR performed an unusual manoeuvre, changing the direction of the helical formation in which TanDEM-X had been circling TerraSAR-X from counter clockwise to clockwise. For roughly one year, TanDEM-X will maintain its clockwise direction around its twin satellite. This new perspective of Earth allows to image difficult terrain such as high mountains or

canyons from a different angle. “We will need three or even four overflights to obtain all the data necessary for the new elevation model. That way we can make sure we cover any spots missed during the first and second fly-overs. It is tedious work, but work that must be done. After all, one of the mission’s principle objectives is to map Earth’s entire surface,” says Zink.

So what does this mean for the TanDEM-X team? While the elevation models are being generated and sent out to the researchers, they need to simultaneously plan and implement the upcoming satellite sweeps. Four DLR facilities and institutes are working hand-in-hand to accomplish this task: the Microwaves and Radar Institute runs and plans the mission; the Remote Sensing Technology Institute has developed the fully automatic data processing system; the German Remote Sensing Data Center, DFD, is in charge of data reception as well as archiving and mosaicking of the global DEM; and the German Space Operations Center, GSOC, controls and monitors the satellites. The data is received by antennas located at the DLR ground stations of Inuvik, Canada, and O’Higgins in the Antarctic, alongside the Swedish partner station in Kiruna. The antennas in Weilheim and Neustrelitz command the satellites and monitor their ‘health’.

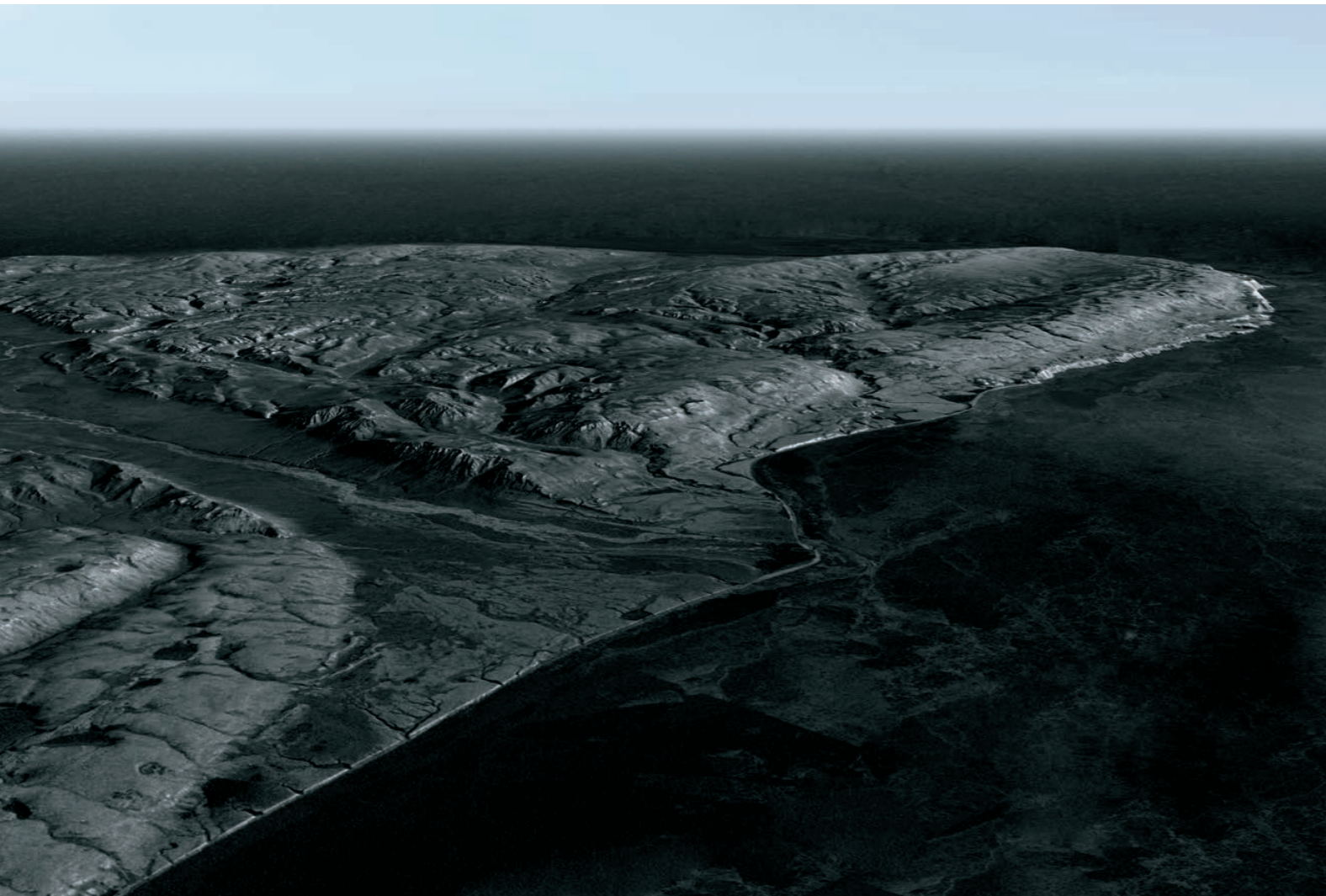
... Like clockwork

TanDEM-X has travelled around Earth more than 20,000 times at 27,000 kilometres per hour. At the start of the mission, TanDEM-X maintained a separation of roughly 15,000 kilometres from its twin, TerraSAR-X, whereas nowadays the two radar satellites are far more intimate and fly around the Earth sometimes just 120 metres from each other. “Having two satellites fly in formation like this for years on end is unparalleled,” emphasises Institute Director Alberto Moreira. “But it is necessary for us to accomplish our goal of creating a complete elevation model of Earth.” The engineers have calculated the distance between the two satellites down to the last millimetre. Without this, it would not be possible to accurately ascertain the elevation. The time it takes for the radar signals to travel to Earth and back is therefore clocked with absolute precision. “The radar electronics have been synchronised to an extremely accurate clockwork, which is about as precise as two watches that, after running simultaneously for about 100,000 years, tick by a mere second apart.”

The third dimension

A person’s view of the world changes in 3D. Glaciers, forests, farmlands, rivers – any changes to these systems are registered in the elevation models generated using the radar satellites. “Among the 800 scientists involved worldwide, many are glaciologists,” explains Moreira. How big are the ice masses? How large an area does this particular glacier cover? How fast do glaciers move? These analyses are interesting for oceanographers: the radar satellites can estimate the ocean currents with very high accuracy and hence provide clues about the ocean dynamics and associated climate change. Other changes, for instance in soil moisture content, can also be captured by the satellites. Agricultural researchers can examine and evaluate the harvest yield of any given field by comparing an entire sequence of TanDEM-X elevation models. “This of course demands that the elevation models that we create are extremely precise,” emphasises Moreira.

In the middle of nowhere – less than 180 kilometres from the nearest town of Alice Springs – is the Australian Finke Gorge National Park. The data of the TanDEM-X mission allows for high-precision topography of the landscape from a different angle. The Australian continent is one of the first regions in the world for which a complete three-dimensional elevation model has been completed and made available to the scientific community.



The Canadian Banks Island – here the southern tip – lay outside the coverage of the SRTM radar mission. The first digital elevation models of this region are now available thanks to the TanDEM-X mission.

The radar satellites also provide data that can be helpful in the event of a natural or man-made disaster. Maps produced by TerraSAR-X have already proven their worth; for example, when the river Elbe burst its banks in June 2013, flooding entire cities and regions. Staff at the THW technical relief organisation used satellite images from space to assess critical situations. “We were able to see the outcome in 3D, which helped us assess where potentially dangerous situations could still emerge,” stresses Moreira. This kind of risk assessment map helps relief services to predict where their deployment is needed. Three-dimensional models can also be used in the wake of an earthquake to analyse how many buildings have been affected, and to what extent. Hazard maps can be created for avalanche regions, and the elevation models help the scientists estimate the gradient of slopes.

In orbit in the name of science

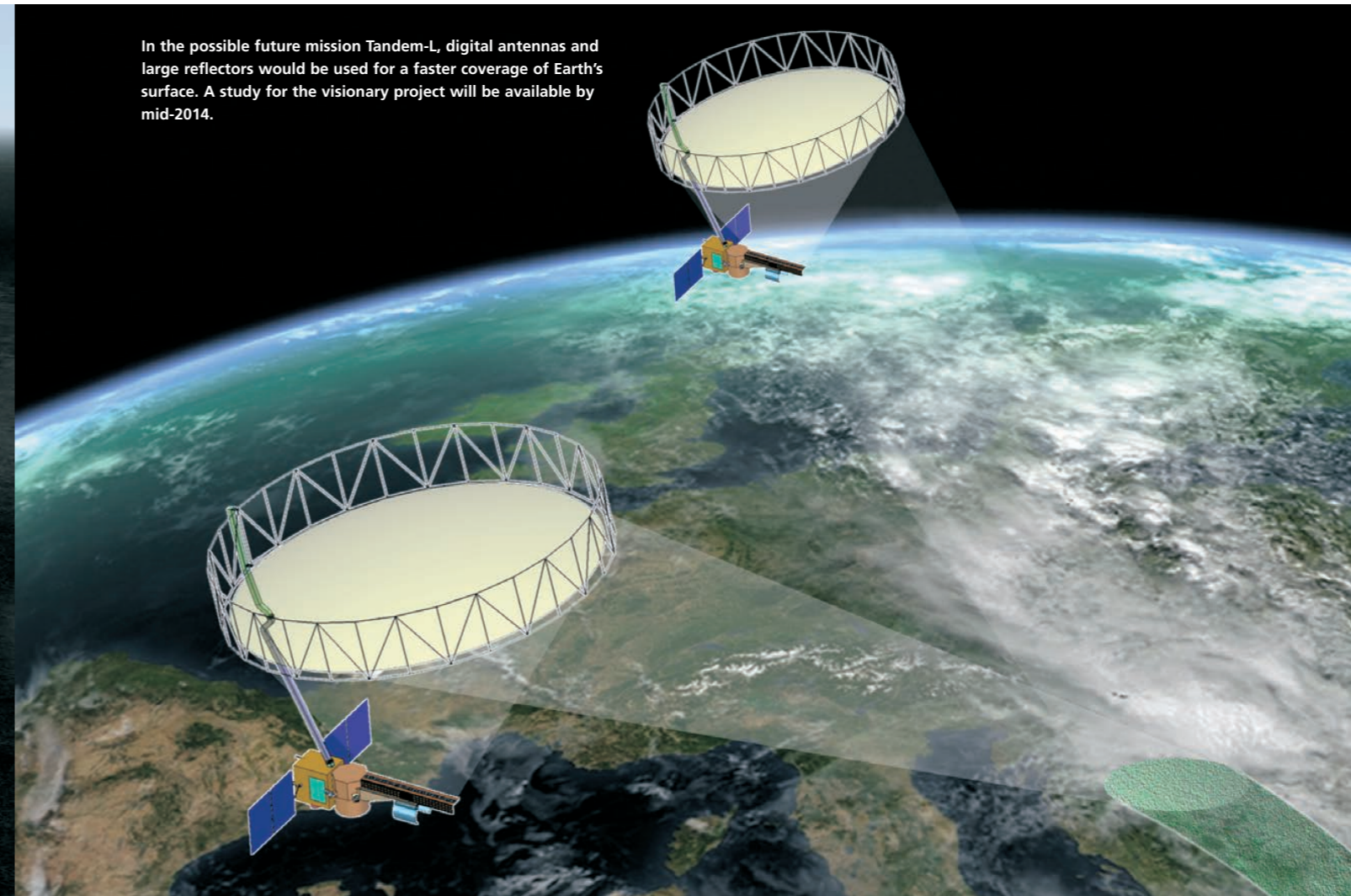
A complete image of Earth – uniform, absolutely precise and in 3D – should be completed by the end of 2015. “We are currently focused on the planning of the imaging to achieve this,” explains Manfred Zink. The next phase of the project will proceed as soon as Earth’s entire surface has been mapped: the engineers will focus more on specific requirements that the

scientists may propose. “What we plan to do is substantially change the satellites’ formation, which at the moment is stable at just a few hundred metres. We could, for instance, increase the distance between the satellites to several kilometres.” This will help to produce even more exact elevation models of specific regions.

“The tasks for TanDEM-X will continue to be expanded,” says Director Moreira. “Earth is so dynamic – we will continue to need round-the-clock images from the radar satellites to detect and analyse its perpetual changes.”



More information:
DLR.de/HR/en



In the possible future mission Tandem-L, digital antennas and large reflectors would be used for a faster coverage of Earth’s surface. A study for the visionary project will be available by mid-2014.

Tandem-L – because Earth is changing

Alberto Moreira – three questions

There is a long-standing tradition of radar technology in Germany, especially at DLR. What missions has DLR been involved in so far?

DLR’s involvement goes as far back as the first experiments on the Space Shuttle in 1983; we contributed to the first radar system to the Space Shuttle. Later on, we launched three further radar missions in collaboration with NASA: X-SAR (flown twice) and SRTM. Radar is the technique of choice to obtain a global view of Earth because it allows you to acquire high-resolution images of the planet’s surface regardless of weather conditions and availability of daylight. This is a unique characteristic of radar.

Tell us how TerraSAR-X and TanDEM-X broke new ground...

TerraSAR-X marked the dawn of a new era – the first German satellite and the most advanced at that time. With it, we were able to acquire images with a resolution of down to one metre. It was designed for scientific and commercial purposes, as well as being used by the DLR Centre for Satellite Based Crisis Communication, or ZKI. Although it was originally designed to have an operational life of five years, TerraSAR-X is performing so well that we expect to operate it for at least another five years. Together with TanDEM-X, we have accomplished something truly special – flying two satellites in formation,

which is a first in space, allows mapping of Earth’s topography in three dimensions.

A study is being carried out as a joint venture with the Japanese Aerospace Exploration Agency, JAXA, for the next possible mission involving Tandem-L. What additional benefits do you believe this radar mission may bring?

Tandem-L will be equipped with an entirely new technology, a digital antenna. Additionally, the satellite will have an enormous, deployable reflector. Our goal is to reach a new standard in image acquisition, moving beyond what TanDEM-X can offer by a factor of 100. This would enable us to image Earth’s entire landmass twice a week in high resolution. It will move us to a completely new dimension. This giant leap is necessary, though, as Earth is a dynamic place where things happen every minute of every hour. When disasters strike, for instance, we want images in near real-time, preferably in 3D. Thus far, they have not been available. Primarily, Tandem-L will make a unique contribution to monitoring Earth’s environment, be it to estimate the global forest biomass for an improved understanding of the carbon cycle or the melting of the polar caps. The data is urgently required to better understand our planet. Such a mission could be launched in 2020. ●

Aircraft news

Using voice recognition to quicken responses

A fast response time is vital for safety, especially in aviation. By evaluating radio messages between the control tower and pilots, DLR set out to investigate whether and how quickly an aviation assistance system can respond to the instructions of the air traffic controller.

Air traffic controllers are faced with ever more complex arrangements of aircraft taking off and landing. There are air traffic controller assistance systems that help the ATC officer by displaying the sequence in which aircraft waiting to land should be stacked up and released efficiently. Unfortunately, it takes the system 30 seconds to respond to instructions from the controller if he deviates from the original plan. During this response time, the system cannot provide optimal support to the controller. Using the radio communications between the controller and the cockpit could help with this. DLR joined the DFS Deutsche Flugsicherung GmbH and the University of Saarland in a project that analyses the reliability of this kind of voice-recognition system.

Air traffic controllers from Düsseldorf airport were among the guests visiting the DLR Institute of Flight Guidance in Braunschweig, invited to participate in the project Active Listening Assistant, AcListant®. The researchers, helped by the controllers, used typical air-traffic situations in the Düsseldorf airspace to put the combined system of voice recognition and assistance to the test. What makes this project special is that the assistance system and voice recognition use reciprocal learning to improve performance. Faced with an inbound aircraft waiting to land, for instance, the computer will mainly expect manoeuvres in which the machine loses altitude and slows down. So the voice recognition is set to recognise only corresponding keywords from a small group of possible terms used in these situations. A quicker grasp of the current traffic situation enables a faster display of additional recommended manoeuvres to help air traffic controllers in their work.

DLR researchers cooperate with the Chair of Spoken Language Systems, LSV, at the University of Saarland in the



It takes some time for a standard flight-assistance system to process inbound radar data and recognise when the controller deviates from the plan. Using the voice-recognition assistance system to process radio messages between the controller and the cockpit could prove to be beneficial.

project AcListant®. DLR is responsible for developing and validating the assistance system, while the university looks after the voice-recognition part. The concept of 'active listening' is not only interesting for aerospace applications; it could be just as beneficial in other areas in which human beings are called upon to communicate precise verbal information.

Alternative fuels – NASA and DLR plan joint research flights



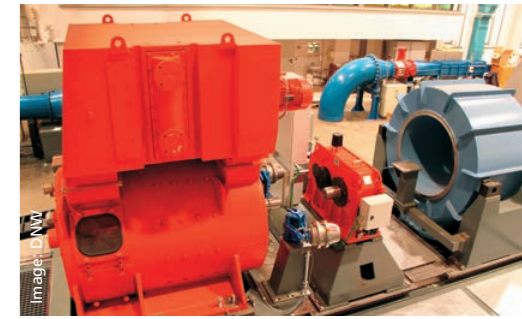
The DLR Falcon will be deployed in joint test flights with NASA during May 2014. The plan is to investigate how the use of alternative fuels in aircraft impacts their emissions and contrails during flight.

Green and sustainable fuels for aviation – DLR researchers at the Institutes of Combustion Technology, Atmospheric Physics and Propulsion Technology are working together on synthetic alternatives to the standard aviation fuel, kerosene. Within the framework of the International Forum of Aviation Research, IFAR, the US space agency NASA and DLR are planning their first joint research flights with alternative fuels. Taking off from Edwards Air Force Base in California, the scientists intend to test various biofuel compositions over the course of a two-week flight campaign in May 2014.

Renewable resources are suitable for producing alternative fuels, which helps to cut the emission of carbon dioxide into the atmosphere, and their combustion releases substantially fewer soot particles and less sulphur. DLR will contribute its Falcon research aircraft to the German-American project for in-situ investigation of changes in emission and contrail properties when alternative fuels are used in the test aircraft. NASA is modifying a DC-8 so that one of the four engines will be able to burn alternative, synthetic fuels during the test flights. Over the coming years, DLR plans further cooperation with NASA on alternative fuels as part of its new project ECLIF, Emissions and Climate Impact of Alternative Fuels.

Test stand for next-generation turbines

Top-class, high-performance test stands are needed to research and develop innovative engines; the aviation industry urgently requires suitable test facilities. At its Göttingen location, DLR is currently building a test rig for next-generation turbines: NG-Turb, Next Generation Turbine. Among other things, scientists will use this unrivalled system to analyse newly developed turbine blades, cooling systems and materials. The test stand will be able to examine full-scale aircraft turbines – from jet engines for small business aircraft to the turbines found in wide-body aircraft such as the A380 – under realistic aerodynamic conditions and Mach numbers. DLR has joined forces with industrial partners to analyse where turbine research is going and to create a suitable system design that meets customer demands.



New engine test stand at DLR Göttingen

What makes helicopters so noisy?

DLR pilots made the headlines at the beginning of 2014 by conducting flight experiments in a quarry located in the Harz region, Germany. Göttingen and Braunschweig-based researchers from DLR succeeded for the first time in visualising the main cause of what makes helicopters so loud. To do this they used the Background Oriented Schlieren method, in short BOS, developed by Markus Raffel. Fluctuations in the air density cause varying degrees of light refraction, which can be rendered visible against a suitable background, such as the cliff faces found in a quarry.

Helicopters generate noise as the tip vortex from one rotor blade collides with the following rotor blade. These vortices do not merely produce the typically low, pulsating sound, they are also behind the vibration inside the helicopter, making the ride less comfortable for the passengers. The BO 105 descended into a quarry in the Harz region during the most recent experiments, using the cliff faces as a background. Ten cameras installed in different positions produced images of such striking quality that, for the very first time, a significant portion of the rotor vortex of a flying helicopter could be visualised in 3D. With these insights, tomorrow's helicopters can be made substantially quieter and more comfortable.

s.DLR.de/774d

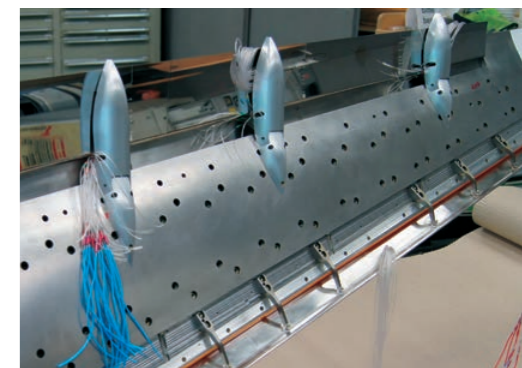


The vortices produced by the rotor blade tips can clearly be seen as distinct dark lines against a suitable backdrop. Understanding these vortices and how they create noise can contribute to making future helicopters quieter.

Innovative high-lift devices

Progress for laminar flow aerofoils: to ensure that air passes over the wing with as little turbulence as possible (laminar flow), the high-lift devices must fit snugly into the aerodynamic design of the wing when not deployed. The DLR-coordinated EU project DeSiReH, Design, Simulation and Flight Reynolds Number Testing for Advanced High Lift Solutions, has produced a concept for precisely this purpose.

To achieve this, the deflector that folds out from the underside of the wing, the leading-edge or Krüger flap, was given a modified form. The design process was also turned upside down and inside out to cut test times and costs; instead of developing a model, testing it in the wind tunnel and subsequently comparing the results with computer calculations, they simply built the new flap system on the basis of simulated computations and tested it in the wind tunnel under real aerodynamic conditions. The design was so good that the project participants are now convinced that laminar flow wings are achievable and that they may lead to fuel savings of between four and seven percent.



Revamping a familiar concept – the Krüger leading-edge flap, where a deflector folds out from the underside of the wing, has been given a modernised form, designed for a flight performance equivalent to that of modern-day slats.

Forewarned is forearmed

Thunderstorms can spell trouble for aircraft. The risk posed by factors such as hail, turbulence, ice formation and lightning make storms dangerous and the biggest challenge to pilots. This is a theme for DLR Atmospheric Research, with the WxFUSION project (Weather Fusion of User Specific Information for Operational Nowcasting). WxFUSION GmbH was founded to enable the commercialisation of the short-range thunderstorm forecasting systems developed by the DLR Institute of Atmospheric Physics. Since then, two of the three systems developed have been adopted and are currently being used in several locations, providing front-line help in the forecasting of thunderstorms. In this interview, Caroline Forster explains just what WxFUSION GmbH wants to achieve with its Cb-TRAM, Rad-TRAM and AutoAlert systems.



Caroline Forster

WxFUSION – improving flight safety with real-time thunderstorm information

By Alisa Wilken

Your forecasting technology makes flying safer – in what way?

Before boarding the aircraft, the pilot plans the route using maps produced with weather forecasting models. These maps show where thunderstorms can be expected. However, information regarding the exact location or time the thunderstorms will occur is not available. When heading towards a stormy region, all that can be relied on is the on-board radar. The pilot can 'see' what is occurring right in front of the aircraft, but not the actual scale of the storm system, so there is no way of knowing which alternative route is the most sensible to select. This is where our Cb-TRAM system can help, because it also shows the pilot the size and propagation of the storm and its imminent development.

If the information from Cb-TRAM, Rad-TRAM and AutoAlert is fed to all those involved – whether that be the pilots in flight or the air traffic control and airport operators on the ground – simultaneously, decisions can be made jointly and faster. When air traffic control becomes aware that an airport is inaccessible due to a storm, it can, for example, ensure that aircraft on long haul flights reduce speed or that short distance flights take off at a later time. The alternatives to such a warning system – the pilot would either have to fly a holding

pattern, burning approximately one ton of fuel every half hour, or the aircraft would have to land at a different airport. In the latter case, the crew, passengers, luggage and craft itself are not at the proper destination, bringing the need for a huge logistical effort. We cannot prevent storms from occurring, but what we can do is optimise the processes for dealing with them.

When WxFUSION GmbH was established, in late 2012, the main objective was to transfer the technology into a marketable product. Has this been the case?

The AutoAlert system was used operationally at Munich airport between June and September 2013. That was also the first order for WxFUSION as a company. The Rad-TRAM system has been used by Germany's National Meteorological Service, the Deutscher Wetterdienst, DWD, since July 2013. This service supplies the German Air Traffic Control (Deutsche Flugsicherung), and Munich airport with data. In addition, we have also licensed DWD to use the algorithms. In the case of AutoAlert, we supply the information directly to the airports. We are also in contact with clients in Singapore, Malaysia and Thailand, who have shown an interest in our products.

When will these systems be used throughout the whole air transport industry?

Aviation is a very sensitive industry. If you want to introduce a new product it must, of course, be tested and certified first. For example, Deutsche Flugsicherung values the fact that information is made available to them by the German Meteorological Service. Therefore, we have also licensed the German Meteorological Service to use Rad-TRAM. We also intend to do this for the Cb-TRAM system. However, many regulatory obstacles still lie ahead. We are already making good progress, but it will still be a while until these innovative sources of thunderstorm information become mainstream in aircraft and at airports. ●

Thunderstorm forecasting systems:

Cb-TRAM: (Cumulonimbus Tracking and Monitoring) – Detection of thunderstorm clouds in the upper atmosphere through the use of data provided by METEOSAT satellites

Rad-TRAM: (Radar Tracking and Monitoring) – Real-time detection of thunderstorms in the lower atmosphere, particularly in the vicinity of airports, using weather radar data

AutoAlert: (Automatic thunderstorm Alert) – Automatically sends warning e-mails to all airport decision-makers when a thunderstorm is approaching



More information:
www.wxfusion.com

Anvil-shaped clouds – the interest of Caroline Forster, because they promise thunderstorm. The DLR atmospheric researcher explored this weather phenomenon to make flying safer.

Outbound flight to the future

Behind a five-metre glass façade – two completely electronic, high-tech flight simulators; one with an aircraft cockpit and one with a helicopter cockpit. On 5 July 2013, the Air Vehicle Simulators, AVES, 'took to the skies' at DLR Braunschweig. There, researchers are investigating how pilots deal with new techniques during flight and how flight simulators could improve pilot training. Flight trials for the largest DLR research aircraft ATRA, as well as for the Flying Helicopter Simulator, FHS, are also being conducted at the modern research facilities. Hans-Leo Richter, long serving editor for aeronautics research at DLR, visited the facility and even had a go on the simulators himself...

AVES flight simulator – research on the ground

By Hans-Leo Richter



The eye-catching AVES full flight simulator in the hall at the simulator centre. The rounded structure, which is attached to a movable platform, can be used for both airliner and helicopter cockpits.

Altitude: 3500 feet; speed: 150 knots; course: 260 degrees. The Airbus A320 has started its final descent, approaching runway 26 of the research airport in Braunschweig. Visibility is excellent, and what little turbulence there is can effortlessly be compensated for thanks to the well-positioned sidestick. With the help of the magenta-coloured horizontal and vertical indicators, each of which is centred in its scale, the Instrument Landing System, ILS, shows on the 'Primary Flight Display' – located directly in front of me – that the Airbus is perfectly aligned with both the localiser and glidepath.

The copilot gradually extends the flaps and lowers the landing gear as we reach 2000 feet. With just a gentle touch of the sidestick, I manage to keep the Airbus on the centre line of the runway ahead. The synthetic voice of the radar altimeter has been informing me of my precise altitude during the final stages of my descent. When we reach 30 feet, I pull the thrust levers back, and by doing so I also activate the engines' thrust reversers. At the same time, the Auto Brake System brings the large, heavy airliner to a halt. Done! That was not so bad after all.

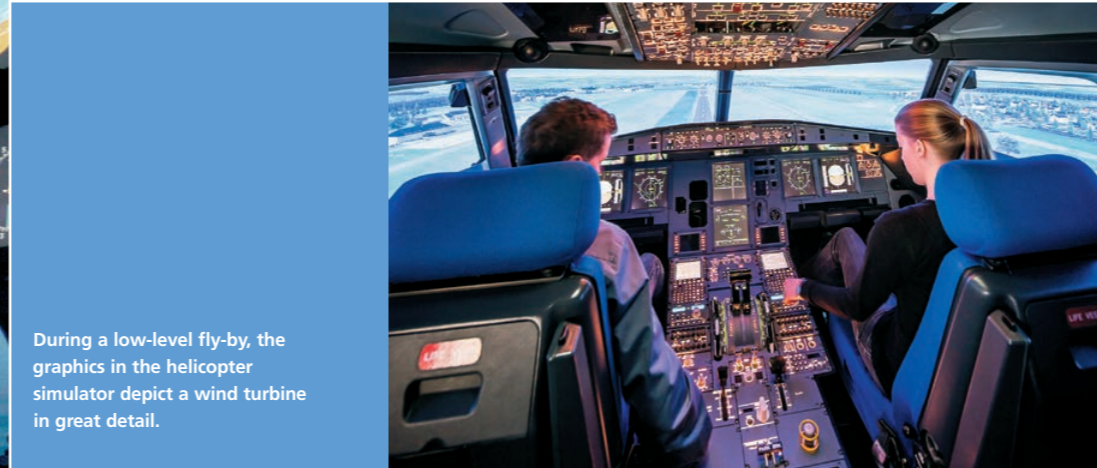
The end of a real flight? Hardly. I do not even hold a pilot's licence for an ultralight aircraft, never mind holding an Airline Transport Pilot Licence, ATPL, for 'big birds'. Even my co-pilot is not a licensed pilot. He is, however, Holger Duda, Doctor of Engineering and Head of Flight Dynamics and Simulation at the Institute of Flight Systems in Braunschweig. In addition to that, he is also the Head of the AVES project and DLR's new simulator centre. The test facility is the only one of its kind in Europe and provides the most realistic flight experience available. Duda showed me just how this flight simulator allows me, a layman in terms of aviation, to perform a fairly reasonable landing – under his expert supervision of course.

Two fully-fledged simulators

AVES can easily be spotted from the outside, in particular because of its white dome. On the inside, it can also be recognised thanks to the full flight simulator within the large glass simulator hall. It stands on a hexapod platform that can be moved in all directions with six degrees of freedom. Further down the hall is another high-tech test facility, which serves as a stationary flight simulator. The most unique aspect of this test facility is the way it has been built. Interestingly, the cockpits of both simulators can be interchanged between the cockpit of an

DLR pilot Insa Pruter at the controls of the AVES simulator for the EC 135 helicopter. All the controls and displays correspond to those in the FHS research helicopter.





Looking at the AVES facility from the outside, the rounded shape of the full flight simulator (on the left) stands out. On the lower left hand side, a picture of an Airbus A320 cockpit during a flight simulation.

Stefan Levedag acting as an instructor during the official opening of AVES. During an Airbus A320 flight simulation, he gave visiting politicians and research guests some tips for a safe landing.



During a low-level fly-by, the graphics in the helicopter simulator depict a wind turbine in great detail.

airliner, such as the Airbus A320, or a helicopter cockpit, such as that of the Eurocopter EC 135.

This clearly defines the role of the simulators. The aim is not to license future pilots; rather, the facilities are there for the sole purpose of conducting scientific research for DLR and the Braunschweig University of Technology, which is also involved in this project and further increases the demand on the simulators. Stefan Levedag, head of the Institute of Flight Systems, emphasises the unique aspects of this simulator centre and stresses the importance of the facility for German aeronautics research: "The new simulator centre provides us with a unique opportunity to investigate the dynamic interaction between the pilot, the aircraft and its systems within realistic scenarios. This allows us to address urgent questions regarding the future automation of aircraft and adapt the current approach to training, for example, as well as gain insight into the flyability of completely new configurations."

The moving dome is supported by a hexapod platform, which far exceeds commercial simulators in terms of elaborateness. But in contrast to those simulators, the DLR simulator is controlled electro-pneumatically, rather than using the more common hydraulic platforms, which require servicing on a much more regular basis.

Unique all-round visibility

Another significant difference from more conventional simulators is not noticeable at first glance. The DLR simulator offers test pilots and researchers a unique 240-degree display. In comparison, commercial simulators only have a horizontal field of view of at best 160 degrees, and a vertical field of view of 40 degrees, which is comparable to that of a standard aircraft. But helicopter pilots, in particular, are used to having a vertical field of vision of 90 degrees.

This near-realistic view is made possible thanks to 15 sophisticated LED projectors. Equally impressive is the computing

power required for this; a cluster of 60 computers supplies the projectors and control system with a vast amount of data. The software required was specifically developed for this highly specialised DLR project.

The range of tasks and applications for which AVES could be used in future fall into three main areas. Firstly, this simulator will be used for increasing the number of flight trials and experiments involving the Airbus A320, in parallel with the smaller DLR simulators that are already available, and the simulations will be tested extensively in the run-up to the actual flight trials. Secondly, this simulator offers a wide range of possibilities for testing software for the FHS, a highly modified Eurocopter EC 135. Finally, researchers hope to explore and determine the flight envelope of helicopters by implementation of an active sidestick, which is a completely new way of controlling helicopters. "With AVES, we can envision completely new steering mechanisms and even develop and test steering-wheel like controls," adds Duda.

Additionally, both simulators provide the opportunity to explore and scientifically evaluate new aircraft configurations for the future, and more importantly, they can do so long before real prototype flights are considered. For example, researchers today are very interested in the technical and aeronautical challenges that 'flying wing' transport aircraft would present to designers and pilots. Furthermore, the simulators may be used to evaluate and improve the flying characteristics of conventional aircraft.

Another task for AVES involves the investigation and evaluation of training standards for prospective pilots. Researchers want to work in close collaboration with the Hamburg-based Aviation and Space Psychology department of the DLR Institute of Aerospace Medicine to establish extensive and objective criteria for evaluating the performance of aspiring pilots. A short while ago, a joint venture with Airbus and Boeing was set up to focus on the continuous improvement of training using flight simulators.

In addition to the involvement of the Institute of Aerospace Medicine, there are also plans for collaboration with the Institute of Flight Guidance in Braunschweig. This would provide a link to the Control Tower Simulator, which would enable the simulation of a variety of special-case scenarios for air traffic control. To achieve this, plans have also been made to work alongside the Braunschweig University of Technology, which would enable students and university researchers alike to make use of the simulators. The company Rheinmetall, known for its expertise in the field of simulation technology, and whose know-how has contributed significantly to other facilities such as the helicopter simulator centre in Bückeburg, has also provided external support for the helicopter simulator.

Interchangeable cockpits

The most notable aspect of AVES is the ability to exchange the cockpit. Although for many flight simulations, researchers can do without 3D motion, quite a few experiments demand the use of dynamic simulation. All in all, it takes roughly three hours to change the cockpit on the simulator. Torsten Gerlach, Team Leader for Simulation Technology at the Institute of Flight Systems, stresses that: "Changing and checking each of the 16 system connectors takes up the least of that time. The most time-consuming operation is the disassembly and assembly of the many fasteners attaching the lifting device. After all, the cockpit unit weighs around four tons." Depending on the scope of the projects being conducted, cockpit changes take place a few times per year.

Such forward-looking research and testing facilities do, however, come at a cost. The investment totals 10 million euros, nine million of which came from contributions made by the Helmholtz Association, and one million of which was contributed by the Braunschweig University of Technology. Duda stresses proudly: "We are managing the project so rigorously that we have been able to stay within budget and keep to the three-year construction timetable."

Right-hand turn in a helicopter

A change of scenery – once again, I find myself in the pilot's seat. This time, however, I am in the cockpit of the stationary EC 135 helicopter simulator. We are flying over the runway of Braunschweig research airport at around 70 knots and at an altitude of about 1000 feet, when Gerlach hands the controls over to me. In contrast to flying the aircraft, I now have to handle and coordinate three control systems. Firstly, in front of me in the centre is the 'stick' for cyclic pitch control – in other words, for controlling the horizontal movements of the helicopter. In my left hand, I hold the collective pitch lever, which is the control used to initiate vertical movements of the helicopter. Finally, I use the 'rudder', or anti-torque, pedals to control the pitch of the tail rotor blades, counteracting the torque of the main rotor and providing yaw, or directional, control.

With a limited amount of control deflection, I try to turn the helicopter gently to the right but am taken aback by the sensitivity of the controls. Instead of turning gently to the right, we suddenly find ourselves in a steep descent. This whole affair is much more complicated than expected. On top of this, I have obviously forgotten to check my altitude, and we are unexpectedly heading towards the ground at a rather fast pace. I barely manage to level the helicopter out, when, to make things worse, the rear breaks away. "Pitch down," commands Gerlach, and as the memorable Loriot, the absolutely famous mastermind of sensitive humour would have put it, the exercise came to an end with a somewhat 'sporty' landing. Truth must be told – those who fall from the skies are rarely masters. ●



More information:
DLR.de/FT/en

Through a wind gust at the click of a mouse

At the beginning, a good deal of physics was involved; and mathematics; and of course a supercomputer, which can carry out millions of calculations for the aircraft designers. The outcome was an aircraft in a virtual world – a digital aircraft. Scientists plan to make it fly at the click of a mouse and make a wide range of aerodynamic phenomena calculable, long before the first real flight takes place. The path to this development was paved by a tool that has increasingly established itself in research over the past two decades – numerical simulation. With the C²A²S²E project, DLR has developed a globally acknowledged, multidisciplinary competence centre for digital flight simulations. Now that the project is complete, the prospect of its successor, Digital-X, gives hope for further major advances – towards realistic predictions and computerised aircraft certification.

C²A²S²E – laying the foundations for the future of aircraft design

By Yvonne Buchwald

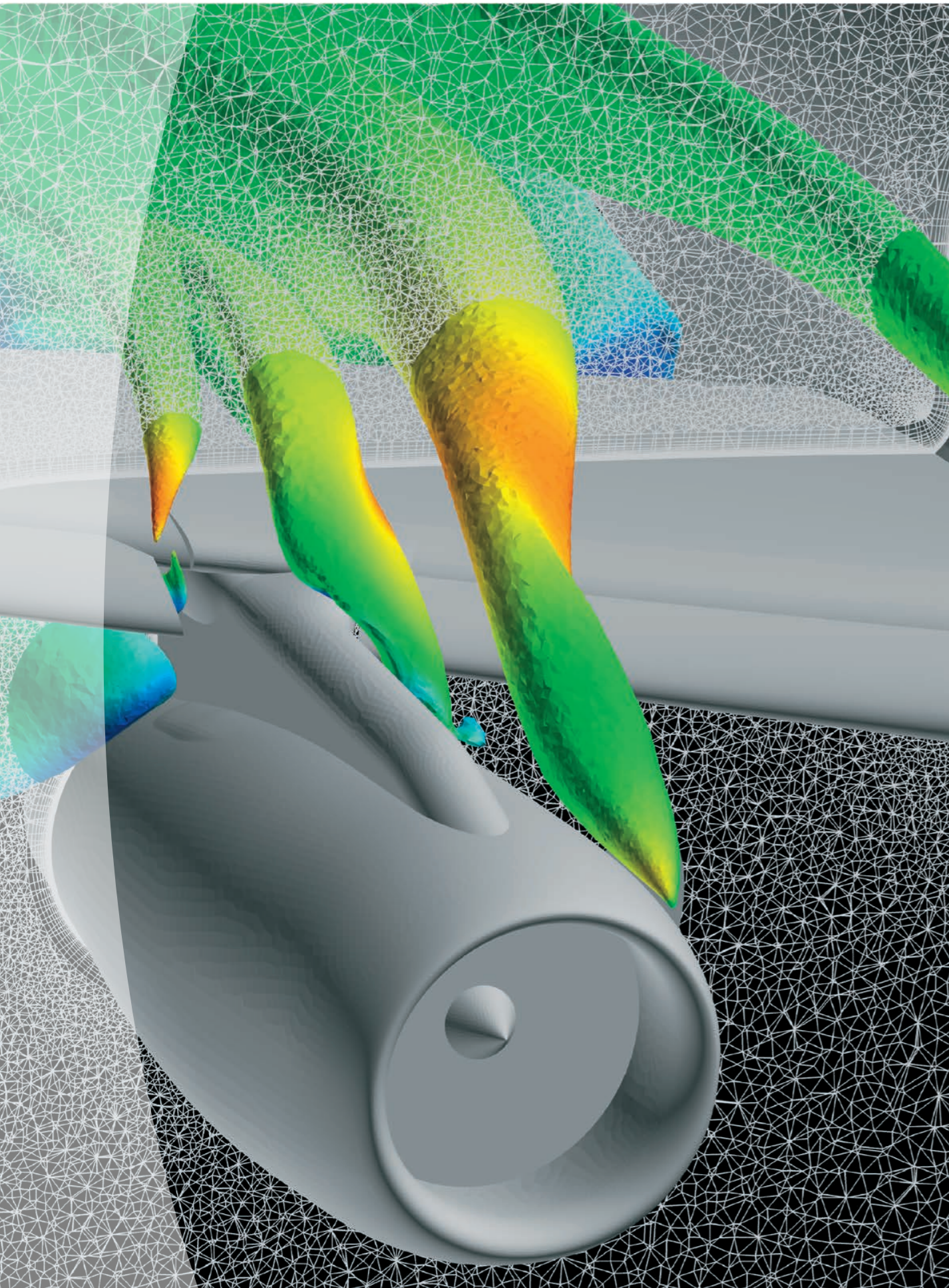
Modern aviation research must be capable of one fundamental thing – responding quickly and effectively to the ever-increasing demands for efficient and environment-friendly flight. “So it is no wonder that the work the researchers do would not be possible these days without numerical simulation,” says Norbert Kroll. Being an experienced mathematician, he knows that the huge progress in physical modelling, mathematical algorithms and modern computer technology make the reproduction of the complex relationships involved in aircraft flight behaviour on the computer possible.

Norbert Kroll is the Head of the Center for Computer Applications in AeroSpace Science and Engineering – C²A²S²E – a department of the Institute of Aerodynamics and Flow Technology at DLR Braunschweig. The department owes its name to the project – and to its principal aim; C²A²S²E also stands for a unique competence centre, a kind of research association for digital simulation. This group of experts originated from an agreement between Airbus and the State of Lower Saxony, which financed the whole project in tandem with DLR. C²A²S²E was established at the research airport in Braunschweig in 2007. Over the past six years, DLR has managed to establish critical prerequisites and gained important insights that will enable future numerical methods to accurately simulate an aircraft throughout the flight envelope.

The path to a campus of experts in numerical simulation

Thirty million euros have been invested in the C²A²S²E project. This sum has allowed the development of a programme for interaction between scientists and experts from all over the world. The result has been a research environment with new staff and the implementation of one of the fastest supercomputers in Europe – the C²A²S²E cluster – used for flight simulation research.

Some 60 scientists are now working at the C²A²S²E department in Braunschweig and Göttingen, where they are setting up a platform that will be used to simulate the complex flow conditions around the aircraft. The researchers have been



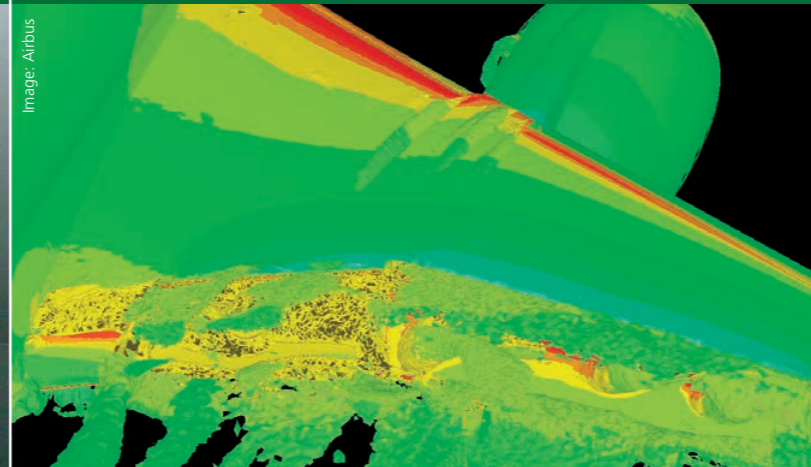
Today's advances in numerical simulation technology enable complex flow conditions to be visualised, such as this vortex system around an aircraft engine.



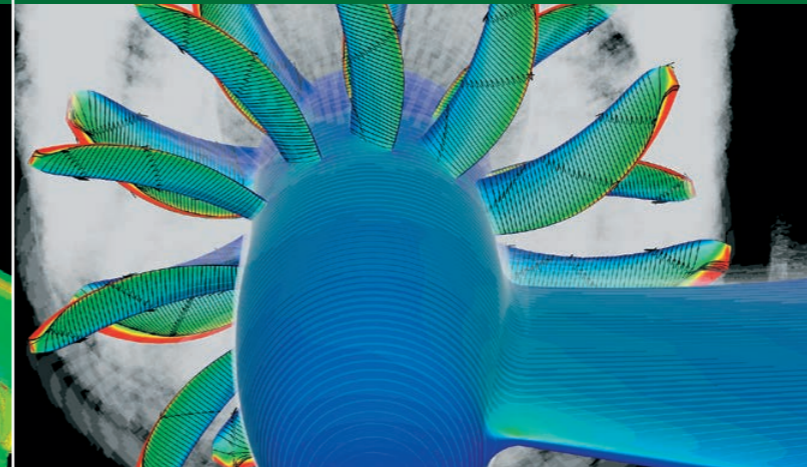
One of the fastest research computers in Europe – the C²A²S²E cluster – was put into operation in Braunschweig in 2007.



The high-performance computer, which was inaugurated in October 2013, is smaller than its predecessor, yet significantly faster; the new C²A²S²E cluster can perform up to 262,000,000,000,000 floating point operations per second.



In this aircraft configuration, the complex flow conditions that can occur on the wings during take-off and landing are visualised in colour.



The interaction between the propellers and the aircraft in a transport aircraft can be investigated. The colours show the strength of the vortices in the flow field.



Engineers Ralf Heinrich (left) and Stefan Görtz discuss the results of a computer simulation in which the behaviour of an aircraft in a gust of wind is simulated.

addressing physical problems and mathematical questions in various sub-projects. The objective is to simulate all the forces acting on the aircraft. "This will enable us to reproduce any situation," explains C²A²S²E engineer Ralf Heinrich. "We will know long before the first flight how the aircraft will behave when subjected to a gusty side wind during landing, for example. If it reacts in an unsatisfactory or even critical way, we can make specific changes to the virtual aircraft and re-run the flight simulation before the costly aircraft manufacturing process begins."

A maiden flight on a computer

The researchers agreed that a multidisciplinary tool needed to be developed because a simulation platform such as C²A²S²E is of enormous significance not only for aerodynamics, but for other disciplines as well, such as structural mechanics. The major advantage of computer simulation is that "it makes things much more visible than conventional experiments. In particular, changes in aircraft geometry that would have incurred major costs in real life can be carried out with ease," says Heinrich. Using the results of the simulations, experimental tests – in the wind tunnel for example – can be planned with much greater accuracy. Thus, computer simulation not only enables very detailed insights – it is also expected to yield significant savings in cost and time.

One example from Heinrich's work is that he was able to simulate an encounter between an Airbus A340 and a gust of wind. The aim was to precisely predict the stresses on the aircraft in such conditions. Using these simulations, the forces affecting the aircraft and the behaviour of the machine can be predicted with much greater accuracy than with the software tools currently used in aircraft design. "A key aspect of the C²A²S²E project was to develop this predictive capability and make it available to the aviation industry," says Heinrich, looking at the simulated gust of wind encountering the virtual aircraft in an animation on his monitor. Even so, they are still far from using a joystick to manoeuvre a digital aircraft in every possible situation, as in a flight simulator, while accurately calculating all the values at the same time. However, individual manoeuvres have already been simulated in detail. Ralf Heinrich hopes that, at some point, the digital simulation technology will enable the maiden flight of an aircraft to be simulated so it can be 'digitally certified'.

Time for a technological leap

Norbert Kroll succinctly summarises what drives researchers across the world to pursue this 'third path' in aviation research alongside wind tunnel and flight tests. "It is expected that the number of passengers will double over the next 15 years. At the same time, it is of paramount importance that the cost, environmental impact and risks are drastically reduced. Challenges of this magnitude simply require major technological leaps." He is aware that "progress towards more efficient aircraft and economically and ecologically improved air transportation can only be achieved through better and significantly more advanced numerical simulation technology."

This, above all, means faster computation and increased quality. The optimistic expectation when the project began in 2007 was that numerical simulations would become some 100,000 to one million times faster over the following 15 years. "That was a major motivation," says Stefan Görtz, a scientist in the C²A²S²E department. "The idea of seeing our software run one million times faster really inspired us."

Transformation in computer architecture

The individual units – the computing cores – are unfortunately no longer following the previous trend of becoming faster and faster. "Instead, there are just more and more of them," explains Görtz. This transformation in computer architecture is due, in no small part, to electricity costs. Instead of allowing immensely powerful processing cores to devour increasing amounts of energy, more efficient chips were installed in high performance computers – and in significantly greater numbers. These adaptations ultimately prevented the C²A²S²E researchers from generating higher costs in energy and computer use than the aircraft design using simulations would ultimately save. Because of this, they are still on the right track to developing cost-effective aircraft design methods.

"It meant that the software used in our simulations needed to be adapted or redeveloped for the new computer architecture," says Görtz, describing the additional scientific work required in the past few years. When today's aircraft engineers leave their calculations running overnight with up to 500 million variables, they no longer use a handful of processing

units, but several thousand computing cores working in tandem. This constitutes major progress, but it also entails high costs, largely because the trend is set towards the simulation of complex manoeuvres or even entire simulation campaigns. So the researchers are relying on another strategy – they are developing 'alternative models'. To avoid having to run all the computations down to the smallest detail every time, highly accurate computations are only run on a few variables in the parameter space.

The results of these less expensive computations are then fed into a mathematical model that can be assessed in just a few seconds. Hence 'approximate models' are created that are generated using only a few calculations, but that can be used as the basis for many millions of simulation scenarios. This is an exciting everyday task for Stefan Görtz and his colleagues, who are working in one of the biggest departments in the Institute. People here are no longer happy just simulating ideal flying conditions. "We are gradually moving from the ideal conditions for cruising to the limits of the flight envelope," says Görtz. Simulating the aerodynamic phenomena in these extreme areas and putting the entire digital aircraft to the test in the computer is the next big challenge upon completion of the C²A²S²E project. Following on from this project phase, which is supported by the State of Lower Saxony, the research work will definitely be continued in the coming years – through the Digital-X' project, funded by the Helmholtz Association.

As realistic as possible

A digital aircraft? "We are already thinking beyond that now. Our grand vision is the entire virtual product," says Stefan Görtz, looking toward the future. This road should be paved by the Digital-X project. "We are now collaborating with several institutes so we can optimise the aircraft from the perspective of separate disciplines." This involves not just aerodynamics – all of the specialist areas are expected to collaborate on the virtual aircraft in the new project.

"Flight tests and wind tunnel experiments can never be completely replaced," states Görtz. Numerical simulation should be seen as one of three tools in aviation research and development, he says – one capable of minimising risk, reducing costs and increasing reliability. Knowing as much as possible

beforehand is very important for businesses, explains Görtz, because the huge development costs of every new aircraft design can put a company at risk. The aim of project Digital-X is to recreate all aspects as realistically as possible. Initially, only simplified aircraft were considered, but now more and more details are being added. Even variations that can lead to a change in shape, such as icing, are taken into consideration in the development, to achieve the optimum product. Stefan Görtz knows: "The digital aircraft will only be on a par with test aircraft when it behaves in the computer as it does in reality." ●

Author:

Yvonne Buchwald works at the DLR Institute of Aerodynamics and Flow Technology in Braunschweig, where she is involved in public relations.



More information:

DLR.de/AS/en
s.DLR.de/4k57

The C²A²S²E cluster – a special kind of high-performance computer

The new C²A²S²E cluster was put into operation at DLR Braunschweig in September 2013. The footprint of the supercomputer is three metres by four. 262 TFlop/s – or 262,000,000,000,000 floating point operations per second – can be carried out on it. The new cluster has 1120 processors and 13,440 computing cores. (This corresponds to 3000 home PCs. Even home PCs now contain multiple-core processors.) This makes C²A²S²E the fastest computer for aviation research in Germany and also in Europe.

The wind machines

When it comes to questions of aerodynamic behaviour, wind tunnels come into play to find the answers – at DLR, across Europe and throughout the world. The DLR Magazine is dedicating a series of articles to these magnificent machines.

Part 1

Meaning and purpose. Overview. Importance.

By Jens Wucherpfennig

The wind tunnel – one of the world's largest research tools and a necessary stopover in the design of each and every aircraft. Using some of the most sophisticated technology, and working mainly with scale models, their purpose is to research how best to design tomorrow's aircraft, spacecraft or vehicles with optimum aerodynamic properties. Ships, houses, animals and even human beings have been studied in wind tunnels as well. Read about some of the most outstanding wind tunnels and their research applications.

Low-speed wind tunnel at Braunschweig

Anything that needs to fly must have a certain aerodynamic shape. Even the Wright brothers were aware of this before attempting the first flight of their motorised aircraft back in 1903. The US aviation pioneers initially tested their flying machines by attaching them to a bicycle and pedalling vigorously – which made for a very bumpy ride and was not reproducible. As early as 1872, researchers in England had come up with a different idea; instead of moving a model through air, they used a fan to stream air past a fixed model, the reverse of reality. The wind tunnel was born.

Today, wind tunnels are used to measure the aerodynamic drag and other properties not only of aircraft, but also of space planes, cars, trains and even high-rise buildings. Basically, there are two types of wind tunnels – Eiffel and Göttingen. In Eiffel-type wind tunnels, a flow of air is drawn from the environment in which the wind tunnel is situated, most commonly a large building. Eiffel wind tunnels, however, come with critical disadvantages in terms of airflow quality, power consumption and noise emission. The Göttingen-type wind tunnel, developed by the renowned German aerodynamicist Ludwig Prandtl, employs a closed airflow circuit, thereby improving flow quality and reducing noise emissions. The majority of wind tunnels use the Göttingen design.

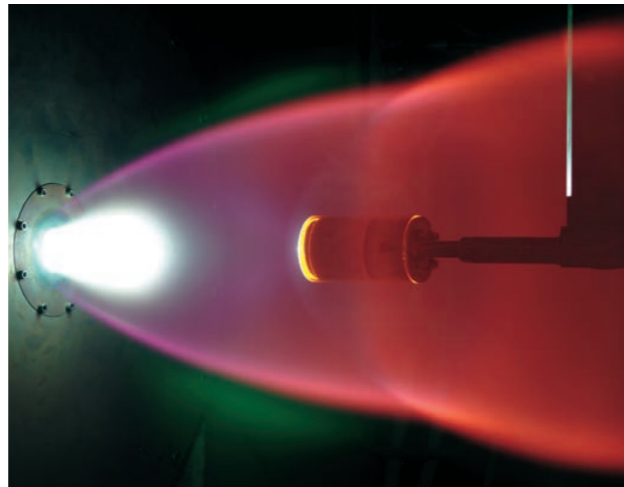
Today, most European aerospace projects could not do without DLR and its subsidiary, German-Dutch Wind Tunnels, or Deutsch-Niederländische Windkanäle, DNW; together, they operate over 20 wind tunnels of different sizes and designs. Determining the precise number of wind tunnels is not easy as, in addition to the large-scale wind tunnels that usually require and investment of millions of euros, there are many smaller and even tiny systems used, for example, by the DLR_School_Labs. This range of wind tunnels is necessary as each one can only accurately replicate reality over a limited range of conditions. Low-speed tunnels, for instance, only yield meaningful results up to a flow speed of around 500 kilometres per hour, whereas transonic wind tunnels are designed for airflows around or above the speed of sound. Hypersonic tunnels can reproduce air speeds of up to 30,000 kilometres per hour, which is relevant for spacecraft re-entering Earth's atmosphere.

The wind tunnels in Göttingen, Braunschweig and Cologne are usually selected for experimental research projects or when testing new simulation and measurement systems.

Stronger together

DLR set up the foundation Deutsch-Niederländische Windkanäle (DNW) together with its partner, the Dutch National Aerospace Laboratory – the Nationaal Lucht- en Ruimtevaartlaboratorium, or NLR – as a non-profit organisation, tasked with operating, maintaining and developing 10 wind tunnels in the two countries.

Göttingen is home to four of these wind tunnels. The focus here is on research, whereas large models are tested in the Netherlands. One of the projects at the NLR facilities analysed the entire form of the Eurofighter, whereas specific tests on the engine intakes took place in Göttingen. In addition to public sector contracts, DNW also works on industrial projects, for instance to improve the aerodynamic properties of trucks. The association is also regarded as a pan-European pioneer in wind tunnel technology across the entire range of aeronautics and aerospace research.

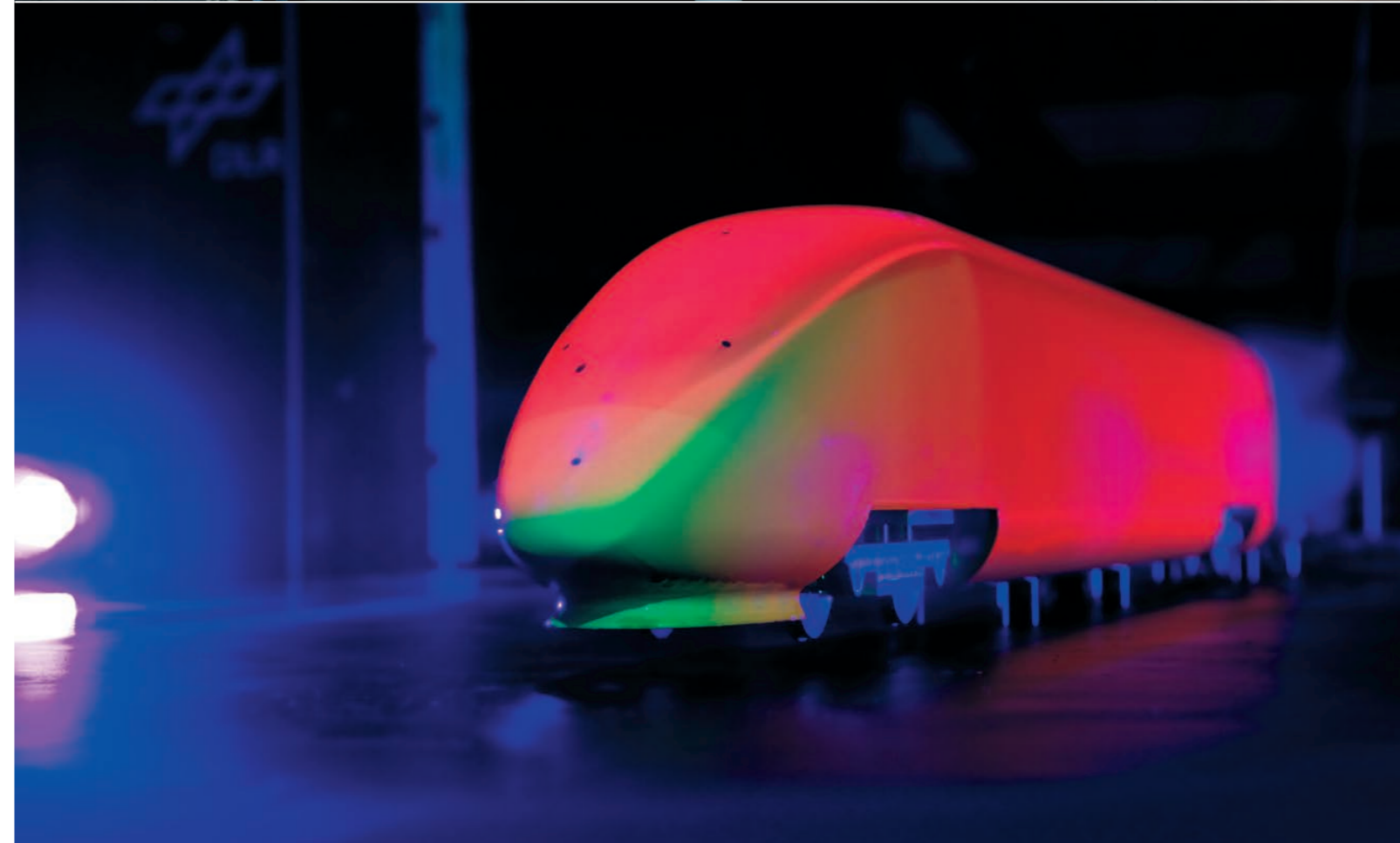
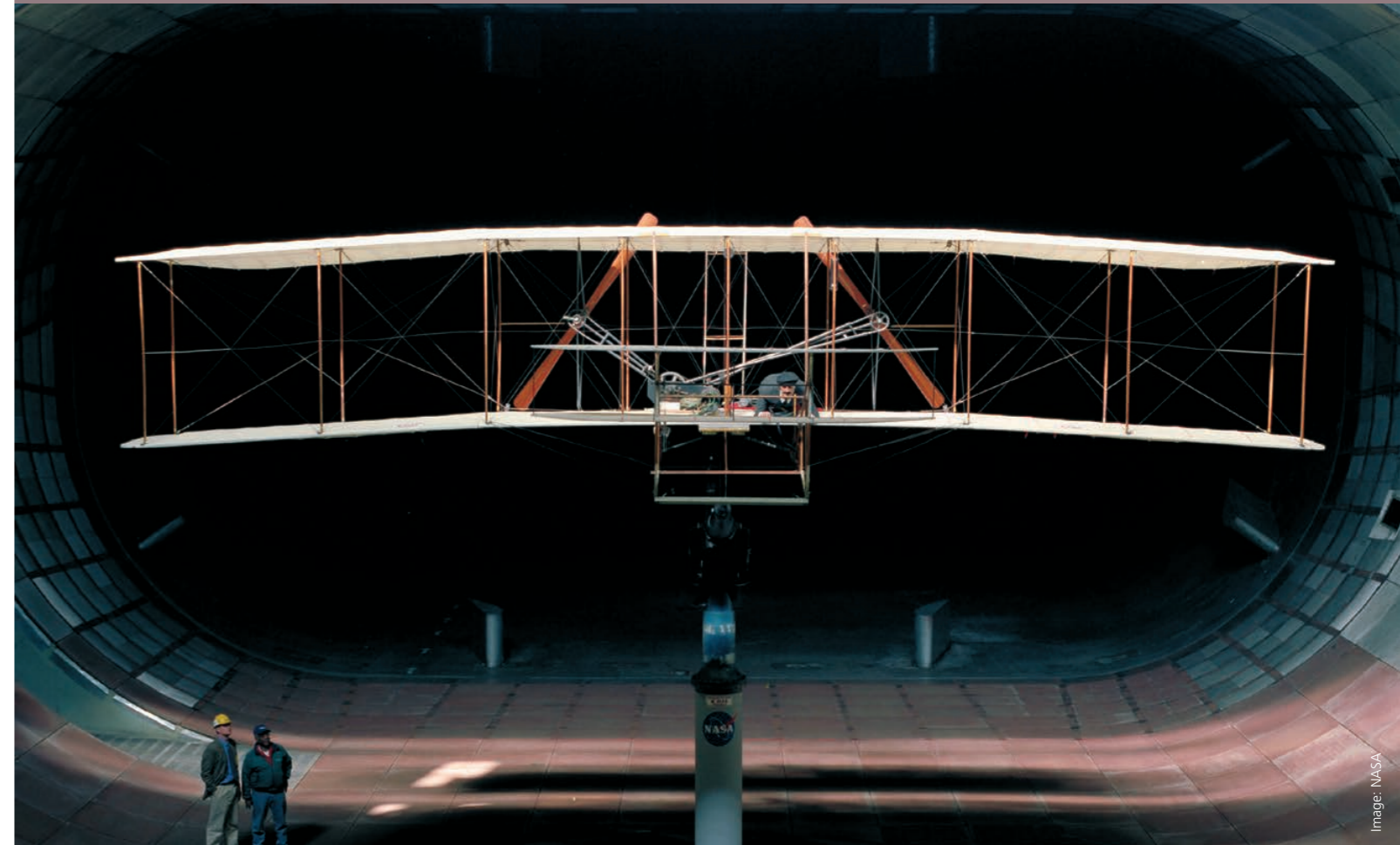


Re-entry of a spacecraft into Earth's atmosphere simulated in the arc-heated wind tunnel at DLR Cologne

Much bigger models, such as those of an entire aircraft in the advanced stages of its development, can be accommodated in the far bigger Large Low-speed Facility, or simply LLF, in the Netherlands. Whole aircraft, up to the size of a Boeing 737, can be put through their paces in the world's largest wind tunnels, such as the National Full-Scale Aerodynamics Complex, NFAC, at NASA's Ames Research Center. This immense facility has six fans, each driven by a motor that delivers 22,500 horsepower. It is hardly surprising that this involves extraordinary costs, which limit the amount of testing that can be performed. Smaller wind tunnels are used more frequently to conduct detailed examinations of aircraft and spacecraft to investigate, for example, the performance of their control surfaces. Experimental techniques and theories can be put to the test in these wind tunnels. The Aero-acoustic Wind Tunnel in Braunschweig is one of a kind – its performance is unrivalled anywhere in the world and it is used to detect sound sources and discover means for reducing noise. Every wind tunnel has its strengths in a particular field.

Most objects tested in wind tunnels are not full scale, with the exceptions of cars as their size is manageable and the air speeds needed for testing are relatively low. Analysing an aircraft or a building calls for the use of scale models. But scaling adds another problem, as the behaviour of air flowing around reduced-scale models is different from its interaction with the actual objects. To address this problem, wind tunnel experts use a variety of techniques – adjusting the properties of the air to suit the model by changing the pressure or temperature of the air in the tunnel. In the high-pressure wind tunnel in Göttingen, for example, the air is pressurised to 100 bar, which is equivalent to the pressure found at an ocean depth of 1000 metres. This enables testing of small train models at a scale of 1:100.

Because wind tunnel experiments are costly, they are often used in combination with numerical simulations involving computational fluid dynamics, or CFD. Together with experiments on 'the real thing', these three methods represent the basis for aircraft development. In the dawn of the computerised era in Europe, some developers believed that one day, wind tunnel experiments would be consigned to the annals of history. We now know that aerodynamics is far too complex a subject to be able to completely do away with wind tunnel experiments in the near future.



Top – one of the largest wind tunnels in the world is at the NASA Ames Research Center. In 1999, a replica of the aircraft with which the Wright brothers performed the first powered flight in 1903 was tested here. Bottom – in the side wind tunnel at Göttingen, pressure sensitive colours are tested on a model train.

Overview of the main wind tunnel types

Göttingen design

This type of tunnel has a recirculating airflow; an axial fan or fans propel the air within a closed circuit. This requires a relatively elaborate, rectangular tunnel and a return path with a substantial cross-sectional area. The complex construction, the large space occupied and the high construction costs are disadvantages compared to an open design without recirculation.

The fans produce an airflow that is constantly being recycled. The energy losses are therefore kept at a minimum, allowing high airspeeds to be maintained. Since the fans primarily have to compensate for losses in the airflow around the closed circuit, the power requirements are lower than those for a design without recirculation reducing the operating costs. One of the primary design drivers for this type of tunnel is the reduction in energy consumption and the resulting drop in the cost of the connection to the power grid, both of which account for a substantial proportion of the budget for large wind tunnels. Although the running costs for this type of wind tunnel are lower, the construction cost is much greater than for Eiffel, or open circuit, tunnels.

Another factor affecting cost is that wind tunnels must be cooled. The walls can reach temperatures of 100 degrees despite the cold, as a result of frictional heating. This is compensated for by a cooling system.

Because of the higher energy costs involved in running an air-conditioned wind tunnel, the only suitable type is a recirculatory system; hence, all air-conditioned wind tunnels are based on the Göttingen design. Unlike in open design wind tunnels, the actual test section of the Göttingen design can be constructed to any specifications, meaning that a pressure chamber is not necessary.

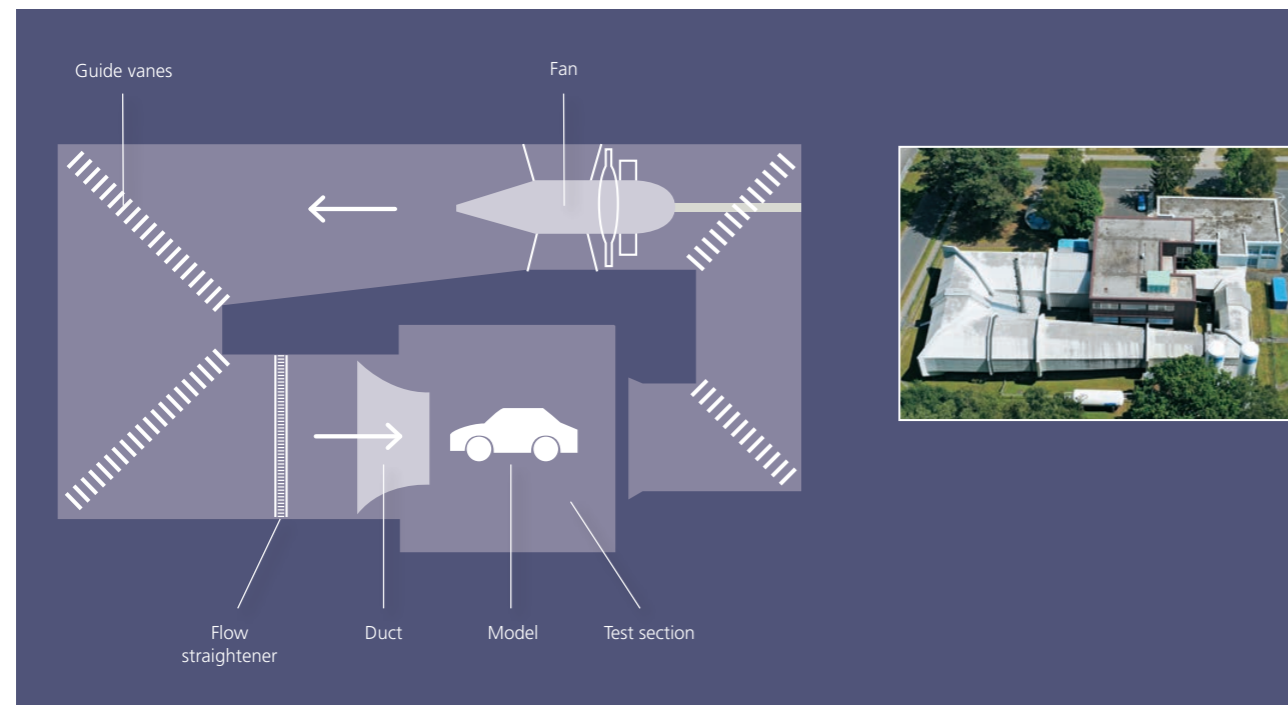
Eiffel type

The principal feature of an Eiffel-type tunnel is that the air used for the tests is drawn from the surrounding environment and then discharged from the system. There are two versions, which can be categorised by the location of the fans within the tunnel. In the blast type system, the fan is fitted downstream from the test section, whereas in the blow type tunnel the fan is installed upstream. The test section also comes in closed or open (free jet test section) versions. The easiest test section to construct is the closed design with slightly diverging walls that are sealed on all sides. Open designs have a higher construction cost, as they require a pressure-tight casing to accommodate the reduced pressure in the test section of an Eiffel tunnel.

Large Eiffel tunnels are often in the open air and do not have a recirculation system, which makes them very susceptible to the weather. This is the reason why their use is limited to countries with a temperate climate.



More information:
www.DNW.aero



How a wind tunnel of the Göttingen design works – a fan accelerates the air, which is directed in a closed loop around the model to be tested. Guide vanes and flow straighteners ensure a uniform flow through the test section. A shaped duct regulates the speed at which the air impinges on the model. The construction is clearly visible in the aerial view of the cryogenic wind tunnel in Cologne.

As important as ever

Interview with Georg Eitelberg, Director of German-Dutch Wind Tunnels, Deutsch-Niederländische Windkanäle

Running wind tunnels is a costly endeavour. Do we really need them?

Cost is always relative; using wind tunnels is less costly than using aircraft for research. Generally speaking, of course, experimental research requires a greater investment than theoretical research in isolation. It is always necessary to combine several disciplines within complex experiments, and this is what produces the visible costs. But they are incurred in every field that requires a technical-scientific infrastructure. We will need wind tunnels until computational methods are able to provide absolute certainty concerning the aerodynamics of future aircraft. This is not yet the case. Even the most advanced and complex numerical simulation methods use models that must be put to the test in experiments.

Why do we need so many different types of wind tunnels?

Because any wind tunnel offers an adequate experimental simulation for only a limited range of flight conditions. All progress made in this area comes from specialisation. We need this array of wind tunnels also to be able to vary the input and degree of detail required to provide adequate answers to scientific questions.

It was a common belief during the 70s and 80s that one day, supercomputers would entirely replace wind tunnel experiments. What has become of this idea?

That belief still has its followers. However, Andreas Dillmann, Head of the DLR Institute of Aerodynamics and Flow Technology, has estimated that it will take at least another two generations to even get close to this. It is, of course, undeniable that computers have already changed the way that wind tunnels are used.



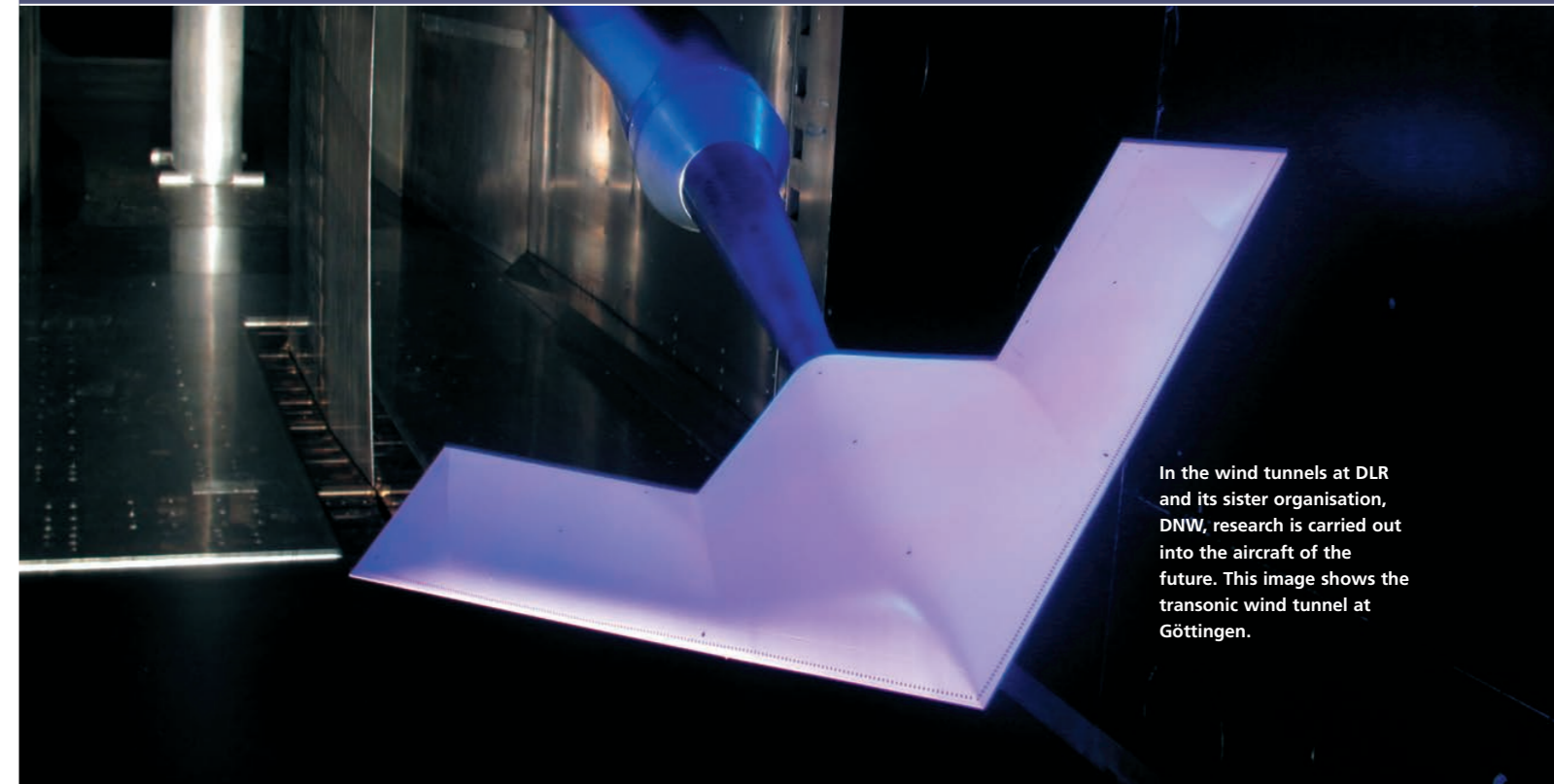
Georg Eitelberg

Some wind tunnels have been up and running for decades – is this not surprising in the fast-paced world of science?

Possibly. One should not forget that the requirements within aerospace research have steadily increased, which has contributed to the ongoing use of these tunnels. The continued use of wind tunnels has been made possible by developments in measurement technology and data acquisition. The one thing that has not changed is that in all wind tunnels, air continues to flow over aircraft models.

What role will wind tunnels play alongside supercomputers and experimental flights in the future?

It will remain the same as today – a combination of wind tunnels, supercomputers and experimental flights. Some wind tunnels will not be able to maintain this position. We will only need wind tunnels that attain sufficient quality in the verification of aerodynamic and aeroacoustic modelling or those that produce an adequate determination of how aircraft designs behave in flight. ●



In the wind tunnels at DLR and its sister organisation, DNW, research is carried out into the aircraft of the future. This image shows the transonic wind tunnel at Göttingen.

Exploring the southern skies

The engines are roaring. It is extremely cold. We are flying at about 43,000 feet above Antarctic waters. However, we are not sitting in the cosy environment of an airliner with cushioned seats and friendly flight attendants serving snacks and drinks, but in the austere conditions and tense environment one would find in a research laboratory. The majority of seats have been removed to make room for scientific equipment, electronics and the massive mechanism of a 2.5-metre telescope. We are in the midst of a science flight with SOFIA as she embarks on her first mission in the Southern Hemisphere.

A visit to the Southern Hemisphere with SOFIA, the airborne observatory

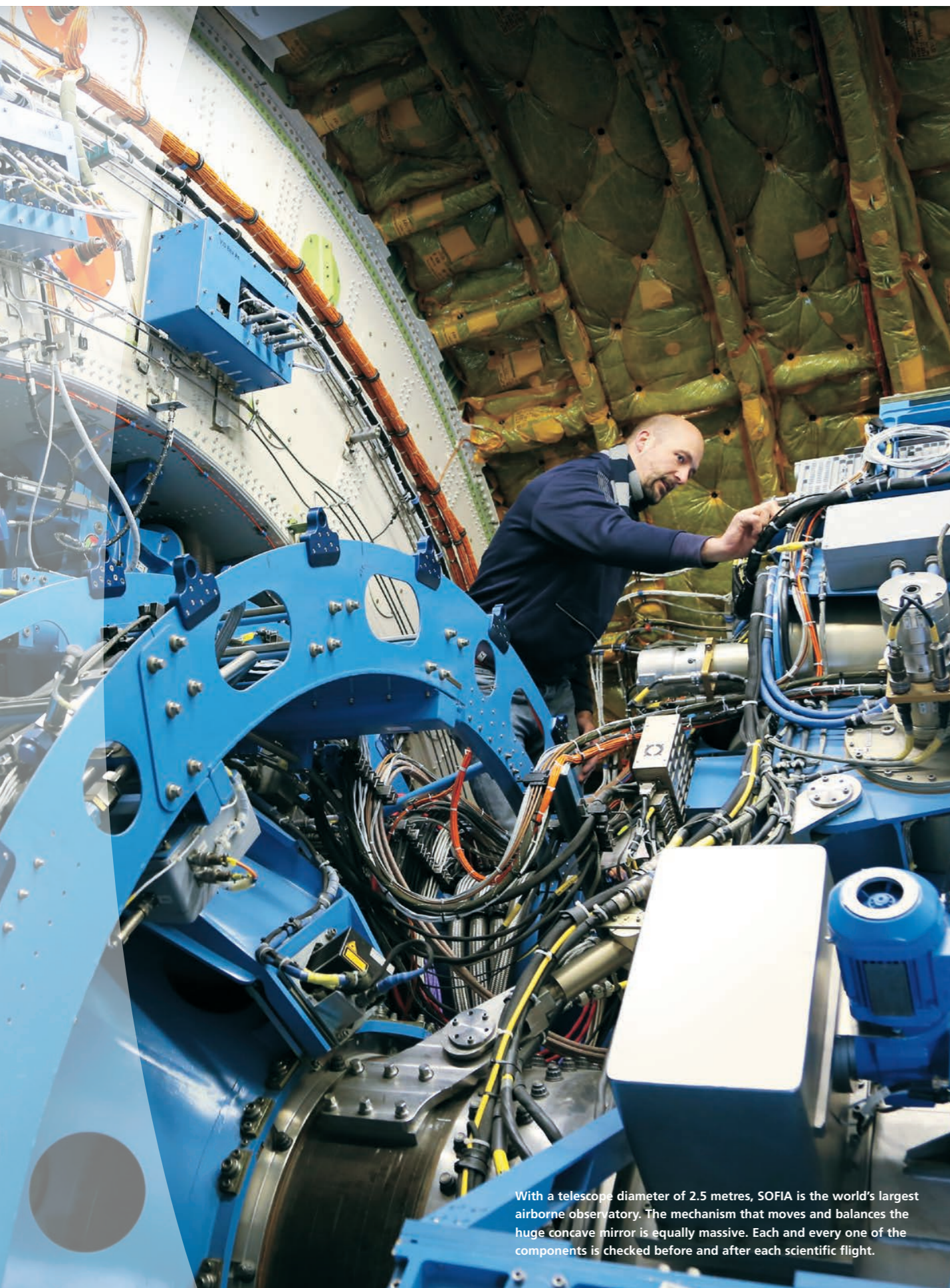
By Diana Gonzalez

Do not be fooled by the name, as SOFIA is not a person, but rather the one-of-a-kind Stratospheric Observatory For Infrared Astronomy. The airborne observatory, operated by the US National Aeronautics and Space Administration, NASA, and the German Aerospace Center, DLR, took off from Christchurch airport in New Zealand into the skies of the Southern Hemisphere. The converted Boeing 747SP, home to a 20-ton telescope, is expected to complete a total of nine observation flights using the facilities of the US Antarctic Program at the airport. Three series of three consecutive night flights each were scheduled between 14 July and 2 August 2013 – a programme never previously accomplished. The observatory must demonstrate that it can operate reliably far from its home base in Palmdale, California. The tension among the team, comprising around 60 scientists, engineers and the flight crew, is palpable.

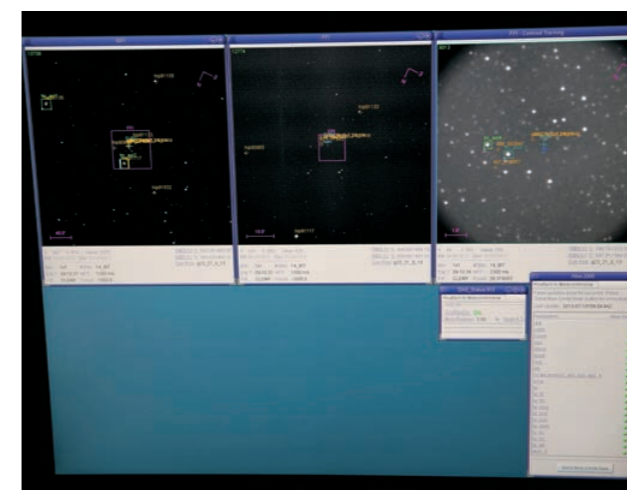
Will everything go as planned? Can SOFIA meet the high expectations during its first full scientific deployment overseas? Its fleeting visit to Cologne and Stuttgart in autumn 2011 only permitted brief test observations. Another passenger on this flight is the German Receiver for Astronomy at Terahertz Frequencies, or GREAT, which was developed by scientists and engineers at the Max Planck Institute for Radio Astronomy in Bonn and the University at Cologne. The spectrometer, which is installed on the telescope, finely divides and sorts the radiation from dust and gas clouds in interstellar space into its component frequencies for detailed analysis. The information acquired – chemical composition, density, temperature and flow rate in these molecular clouds – enables a detailed look into the formation and evolution of stars and planets, from birth to the final phase.

The benefit of long nights

While summer has arrived in Germany with temperatures of up to 30 degrees Celsius, winter is here in Christchurch, and temperatures are low. I had to make my way across the airfield through icy wind, rain and hail to capture the SOFIA landing in Christchurch on camera. "Why is this campaign being conducted in the middle of winter in the Southern Hemisphere?" I wondered. Heinz-Theo Hammes from the DLR SOFIA project team clarified: "The nights are longer, so correspondingly extended observation flights can be carried out. There is an additional advantage – during the winter, the air above the ocean is very dry, making research in the infrared range particularly productive." As infrared radiation is absorbed by moisture in the atmosphere, it is very hard to measure from the ground. This is why SOFIA flies at altitudes exceeding 40,000 feet. "In the Southern Hemisphere, scientists can investigate astronomical objects that are difficult or impossible to observe from north of the Equator," he added. "These include the centre of the Milky Way and its smaller companions, the Small and Large Magellanic Clouds. The Large Magellanic Cloud is home to the Tarantula Nebula, an extremely active stellar nursery and the main observational target for tonight. We are expecting to make exciting, new discoveries there."



With a telescope diameter of 2.5 metres, SOFIA is the world's largest airborne observatory. The mechanism that moves and balances the huge concave mirror is equally massive. Each and every one of the components is checked before and after each scientific flight.



The scientific target is located, pointed at and held steadily in the field of view via a very sophisticated software processing data from the telescope's three positioning cameras, called imagers, and with the help of three gyroscopes mounted perpendicular to each other.



A converted Boeing 747SP carries the infrared observatory to an altitude of around 42,000 feet. The avionics in the aircraft cockpit were modernised in 2012. Modern, digital displays were installed to replace the previous analogue instruments.



During the flight, the data from the telescope and the GREAT instrument is transmitted to the scientists' monitors. A fast pre-analysis enables the observation to be checked and corrected if necessary, to make the best possible use of the valuable research time.



Early in the morning of 18 July 2013, following a successful first research flight in New Zealand, the scientists and crew disembark from the airborne observatory. Because of the extremely low moisture content in the atmosphere, the infrared measurements were especially fruitful.

The SOFIA project

SOFIA, the 'Stratospheric Observatory for Infrared Astronomy' is a joint project of the German Aerospace Center (DLR) and the National Aeronautics and Space Administration (NASA). It is funded on behalf of DLR by the German Federal Ministry of Economics and Technology (BMWi) on the basis of legislation by the German Parliament of the state of Baden-Württemberg, and the University of Stuttgart. Scientific operations for Germany are coordinated by the German SOFIA Institute (DSI) at the University of Stuttgart; in the USA, operations are organised by the Universities Space Research Association (USRA). The development of the German instruments is financed by the Max Planck Society (MPG) and the German Research Foundation (DFG).

GREAT German contribution

GREAT, the German Receiver for Astronomy at Terahertz Frequencies is a receiver for spectroscopic observations in the far infrared spectral regime at frequencies between 1.25 and 5 Terahertz (60–220 microns), which are not accessible from the ground due to absorption by water vapour in the atmosphere. The receiver has been used as a first generation instrument on the SOFIA flying observatory since 2011. GREAT was developed and is operated by a consortium of German research institutes (Max Planck Institute for Radio Astronomy (MPIfR) in Bonn and the University at Cologne's KOSMA radio telescope, in collaboration with the MPI for Solar System Research and the DLR Institute of Planetary Research). Rolf Güsten (MPIfR) is the Principal Investigator for GREAT. The development of the instrument was financed by the participating institutes, the Max Planck Society, the German Research Association and the Federal Ministry of Economics and Technology (BMWi).

A slight shaking of the aircraft brings me back to where I am – aboard the research flight. Across from me, a group of scientists point excitedly at the monitors in front of them. I see them deep in discussion, but do not understand one word of what they are saying. In this case, it has nothing to do with the technical jargon researchers are so used to, but rather the incredible volume of noise inside the passenger cabin. Thankfully, passengers are given headsets to eliminate the background noise and to allow for dialogue between the passengers. I try some on as well. There are multiple channels I can dial into, so I can follow the conversations taking place between the scientists, as well as those between the crew and pilots. Dots, lines and curves flicker away on the computer monitors – visualisations of the data that the GREAT spectrometer has just recorded. As a non-scientist, these symbols do not make much sense to me. But as I look at the scientists, it would seem like they are watching a thriller. Four experts are sitting at a small table, carrying out a fast pre-analysis of the data, which will allow the scientists to assess whether it is worthwhile to continue observing here, or whether the telescope should be pointed elsewhere in the sky – because every second counts. Even in research, time is money.

The great tension in the passenger cabin contrasts with the calmness upstairs in the cockpit. As the pilots control the aircraft above the icy waters between New Zealand and Antarctica, the horizon is but a hazy blue glimmer. Standing out are the bright displays covering most of the digital instrument panel. These have replaced the analogue instruments following modernisation of the cockpit technology last year. This mission gives them the first opportunity to demonstrate their capabilities in practice.

An unbeatable instrument

As I head back to the passenger cabin, I catch sight of the huge telescope mechanism at work. Seeing it rotate on its axis is truly an impressive sight. In reality, the telescope with the instrument remains fixed, pointing towards the same position in the sky. It is us who move with the aircraft. I scrutinise the mechanism – hundreds of specially designed and carefully manufactured prototypes and individual parts – and marvel at the fact that this fascinating technology not only exists, but also works flawlessly. This was some undertaking!

A sudden commotion in the cabin startles me. I put the headset back on and learn the reason – the Southern Lights! Anyone with a moment to spare takes a quick look out of the window. The night sky is covered with a green glowing veil which varies in intensity each second. The bands of light shimmer and pulsate in ever changing patterns as they move across the sky. But as quickly as the enchanting scene starts, it is over again. A few minutes later, only a faint, diffuse light remains, then the black of night returns.

A typical research flight lasts a total of 10 hours, which means four still lie ahead. Amid all the excitement that keeps me alert, I cannot help but feel a certain tiredness washing over me. Some of the scientists who have completed their shift have moved from the work area to the 'first class cabin' – a couple of original first class seats from the 1970s installed towards the front of the cabin, and that 'clash' with the surrounding ultra-modern technology. The seats have clearly seen their best years and are well worn from use, but after being on your feet for hours, you would not turn your nose up at them. At this point, a coffee would be greatly appreciated to revive the spirits, but no food or drink service is available on these research flights yet – here, you must remember to bring your own.

During a break from observing, I am able to have a chat with a scientist from the Institute of Physics (I. Physikalisches Institut) of the University at Cologne. The Institute developed and manufactured the detectors for the GREAT instrument, among other subsystems. I ask him what fascinates him most about his work. He does not have to think about this for long. "When you are building such sensitive receivers, working at the limits of the available technology, things converge from different areas – like high frequency, cooling and vacuum technologies. First, you have to deal with the physical fundamentals, and then turn these into technology. Above all, it gives the students taking part in the project a truly comprehensive training. It is very exciting, very varied, and satisfying when the technology then works so well," explains Patrick Pütz.

Top-notch observations

As we near 04:00, SOFIA makes its way back to the airport in Christchurch. The landing could not have been smoother, even on a commercial airliner. The computers are

powered down and the headset cables rolled up. The tension of the past, long hours is noticeable on the faces of the scientists. But, having acquired data of such exceptional quality, it was well worth it. The moisture content of the air was so low that it was barely measurable by the GREAT instrument. GREAT itself was celebrating a small anniversary – tonight the spectrometer completed its 25th science flight exceptionally well.

The remaining observation flights proceeded to the complete satisfaction of the scientists. "The fantastically transparent atmosphere on these flights has enabled the capability of the GREAT receiver to be exploited to the full," says Rolf Güsten from the Max Planck Institute for Radio Astronomy, who is the Head of the German research group that developed the GREAT instrument. "The mission was extremely productive. These nine flights have enabled us to gather unique data for more than 30 very different research projects. The results will be published in the coming months."

After spending roughly three weeks in New Zealand, one thing is clear – during the mission, SOFIA has reached a number of milestones. "The outcome could not have been better," says a pleased Heinz-Theo Hammes. "SOFIA managed four 'firsts' during the mission. It is the first time that three research flights have been conducted back-to-back; the first time there have been three flight series in three weeks; and the first time that nine successful flights have been completed one right after the other. What is more, in doing so, the observatory has masterfully completed its first deployment far from its home base. The support received from the US Antarctic Program, whose equipment and services we were allowed to use, was of utmost importance in these achievements." The path is now clear and the aircraft is prepared for further measurement campaigns in the Southern Hemisphere. New Zealand will be waiting for SOFIA once again in 2015. ●



More information:
DLR.de/en/SOFIA

The globe in view and the landscape before your eyes

Up above, at the boundary between Earth and the expanse of space, satellites monitor the globe and provide important data on climate change, water levels, land usage, urban structures and biomass. Down below, staff at the DLR German Remote Sensing Data Center, DFD, must also operate across borders: remote Earth observation often implies having to be directly on site – on the Mekong Delta in Vietnam, close to penguin colonies in Antarctica, around the Mediterranean, or in the tsunami-affected region in Indonesia. Take a peek into the cross-border ventures of three members of staff at DFD – join Claudia Künzer as she explores the Yellow River Delta in China, Hennes Henniger while he adjusts a satellite dish at Inuvik, in the Canadian Northwest Territories, and accompany Ursula Geßner who, with her GPS device in hand, is on the move in Ghana or the broad savannah of Burkina Faso.

Remote sensing up close – DLR researchers go ‘inside’ their satellite images

By Manuela Braun

On the Yellow River Delta – a balancing act between the economy and the environment

Much can be said about Dongying – except that it is a tranquil, idyllic city. High-rises and shopping centres dominate the panorama in the vibrant city centre. In the suburbs, however, people live in small, simple, one-storey brick houses, with no car or luxuries. “A rich oil city,” says Claudia Künzer. Very close to Dongying we find Shengli, the second largest oil field in China. You could say it is a bit like Texas, with oil pumps tirelessly extracting raw material from the ground.

Inhabitants of Chinese metropolises consider the city in the province of Shandong – with a population of roughly two million – to be rather small. Shanghai has 20 (officially, 30 unofficially) million inhabitants, and over 18 million people now live in the capital city of Beijing. But Dongying is growing – and fast. Hundreds of factories have been built in the region in recent years. The Yellow River Delta is booming – unfortunately, at the expense of nature, as this is a breeding and stopover area for

millions of migratory birds. Nowadays, the Delta is one of the most important industrial centres in Northeast Asia. “When many families struggle to afford food on a daily basis, have a very meagre income, do not own a car, often cannot afford health insurance and sometimes work long hours seven days a week, environmental preservation is a luxury item, and therefore hard to deliver,” says the DLR scientist.

Künzer knows that achieving a balance between economic development and conservation of resources will not be easy. Nevertheless, as the project leader of the Delta Information System for Geo-Environmental and Human Habitat Transition, DELIGHT, she will be working with a number of German and Chinese colleagues to assist the local government in attaining a balance between the economy and environment over the coming years. The Delta is expected to become a model region in which the economy and ecology are in balance. The Chinese government has the will and the knowledge – but the challenge is its implementation.

It was for this reason that the German-Chinese project for a Delta Information System was launched in May 2013. Now, the project leader and her DFD colleagues, Malte Ahrens, Christina Eisfelder, Juliane Huth, Mattia Marconcini, Tobias Leichtle, Michel Wolters and Christian Wohlfart are on site, using satellite images to build up a picture of the items they need to focus on. The researchers travel by foot, on bicycles and in taxis through a city that has not stopped growing in the last 30 years, as industry has drawn people in. For some in the team, these are not new sights; others are now getting to know China for the first time. “It can be demanding at times – the unfamiliar language, the different culture, the many new things you see.” In the evenings, the team sits on foldaway wooden stools inside a small roadside bar – a break in the tight programme. The next day, it all starts again. The hinterland and valuable habitats along the coast are being inspected as well. This means piling crates and toolboxes in the front of the bus before setting off for the Yellow River Delta, along with colleagues from project partners such as the University of Bonn, the University of Hanover and the German Research Centre for Geosciences in Potsdam.



Field research under an African baobab tree – Ursula Geßner of the DFD captures land coverage in the savannah of northern Ghana.



Travelling down the Yellow River – DFD scientists and colleagues of the University of Hanover and the company HYDROMOD, on board a field campaign boat.



Leaving Beijing for Dongying – 30 German and Chinese scientists and their luggage and measurement equipment head for the river delta region.



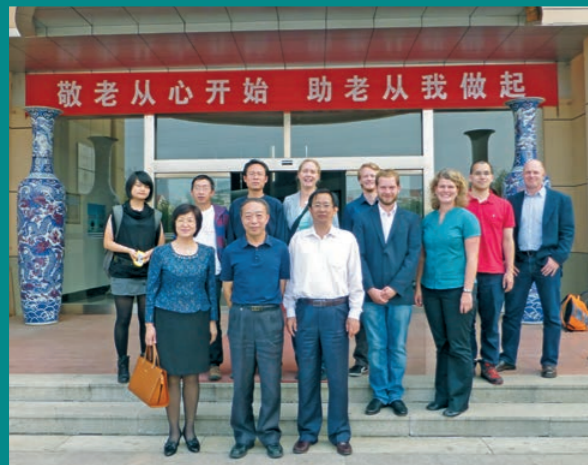
Workshop on the hydrology of the region – there is hardly ever a shortage of thermos flasks of green tea in China.



Using the working platform to get to the equipment room of the dish installation – working at a height of 15 metres in occasionally strong gusts of wind.



A dusty gravel road leads to the control huts between the dishes



The traditional group photo – mandatory in China – during a visit to the Yellow River Nature Reserve Headquarters in Dongying.



Travelling in the river delta region – Claudia Künzer (right) and PhD student Christian Wohlfahrt spread satellite maps out on the back of the field taxis. They communicate with the taxi driver using broken Chinese, hands and feet.



PhD student Tobias Leichte (left) and Mattia Marconcini of the DFD talk to a Chinese partner about urbanisation and city planning in Dongying.

The region extends over 18,000 square kilometres in which there is plenty going on – nature, aquaculture and agriculture for supplying the nearby large cities such as Tianjin, as well as oil and gas fields between the river branches in the Delta. Land and water resources are becoming scarce in the region, the natural wetlands are degrading, the coast is being eroded – and humans, in particular, are increasingly invading and transforming the natural landscape. Seeing as much as possible within a short time and developing an understanding of the local issues is no easy task. “For example, people here are tending to move towards the coast, but they are destroying the environment as they do so, while putting themselves at risk in a region affected by rising sea levels.” Why is the city developing increasingly eastwards, towards the coast? How do the locals react to the rising sea levels and the salinisation of soils and drinking water? Which valuable wetlands are making way for industrial food production? Claudia Künzer and her team want to understand the processes involved before proceeding to analyse them over the next three years.

The final result will be a Delta Information System – a data portal in which all the information products, such as thematic maps, statistics, all the publications and project documents, will be tailored for use by the local decision makers. Developed and implemented at the DFD, this portal is designed to have a long-term effect – it will be handed over to the local government at the end of the project. “For this, we must have a clear understanding of the Delta: What do the locals need?” Once this is known, the satellite images and their use on site will make a small contribution to answering some of the many questions. How vulnerable is the region as a result of the oil industry? What is happening in the upper reaches of the river, and is this having harmful effects on the Delta? How is land usage changing with time? “Research work only at the office in Oberpfaffenhofen is not adequate for this,” says Claudia Künzer. “It is equally important to talk to local environmental scientists and, above all, to the decision-makers in the Delta.”

Inuvik – at the end of every road in Canada

When Hennes Henniger travels to his remote place of work, crowds of people are not a problem. In fact, it is quite the contrary. Nothing much happens in the Canadian Northwest Territories. “The local radio station has shown interest in our work and are eager to report on it.” Germans going all the way there to perform maintenance on their satellite dish are a nice change for the radio station. Inuvik lies above the Canadian Arctic Circle. The famous Dempster Highway ends here – no road reaches deeper into the Canadian arctic. In winter, massive trucks supply areas even further north via the frozen Mackenzie River – known as the Ice Road. Here you can find a somewhat rustic bar – ‘not beautiful, but special’ – supermarkets, an airport and plenty of abandoned buildings.

“Inuvik does not have much to offer,” says Henniger. “People migrate to places where life is more comfortable, energy is less expensive and supplies are easier to come by.”

Once a year, Henniger travels to northern Canada with another DFD colleague. His destination is the 13-metre satellite dish that is mainly used for receiving data from the radar satellites TerraSAR-X and TanDEM-X. The dish, which tracks a satellite 15 times per day, is controlled and monitored from Oberpfaffenhofen, “but we cannot grease the mechanisms over the Internet.” That is why he dons a thick jacket and woollen hat and trudges through the Canadian cold, to shovel snow from the compound and examine the dish. Are the cables fraying? Is there unwanted dampness anywhere? “The work platform rises 15 metres – you can have fun being blown around by the wind up there.” In spring, temperatures remain between minus 10 and minus 15 degrees Celsius. And in this cold dry air, screws must be turned and adjustments made – without gloves. The humid cold comes at the change of season, turning everything to mud and creeping in through even the thickest jacket. In summer, dust clings tightly to people and shoes. In Inuvik only the main road is paved. The remaining streets are just gravel and earth, and there is no hope for grass in this barren landscape.

“Watch out for bears!” construction workers warn the DFD employee. He has not yet seen any, but a construction worker has shown him tracks. “I would never have noticed them, but the locals spot them straight away.” Henniger has already been to the dish three times since it was inaugurated and consecrated by the Inuit in August 2010 – sometimes in spring, when the temperatures drop significantly below minus 10 degrees Celsius, and sometimes in summer, when the Sun is in the sky around the clock, rising again after a brief twilight. On such an occasion, recalls Henniger, he and his colleagues constructed a grill directly next to the log cabin containing the computer equipment. Burger and chips every day – you can get fed up with it, he says. “Sometimes you end up looking for an alternative.” But the truck delivering fresh fruit and vegetables to Inuvik comes just once a week in summer.

Henniger is there for two weeks. Upon his arrival, he works seven days a week, and sometimes the working days are long. “We try to carry out all the maintenance and modifications quickly at the beginning so that, at the end, we can ensure that everything is running smoothly.” Nobody would make changes the day before departing. “If you notice that something is not right at the end, you are too far from the dish.” If everything runs the way it should, there is perhaps even time for a trip on a dog sled. Otherwise, everyday life at the other end of the world consists of hotel and work: “Well, you can look in vain for something to do up here in your spare time.”



In winter the route to the office has to be cleared of snow



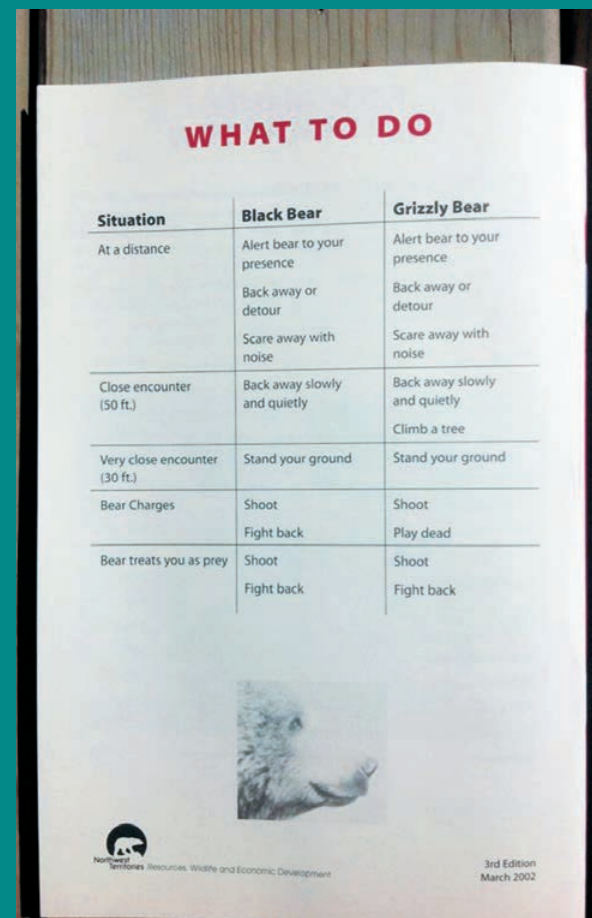
Part of the maintenance – replacing lamps on the antenna.



At the low temperatures in northern Canada the rivers are turned into roads – these ‘ice roads’ are used by lorries to transport supplies to remote locations.



Hennes Henniger checks the field of view of the antenna on the tower



You need to be prepared for an encounter with bears in northern Canada

West Africa in all four points of the compass

If nothing else, the driving conditions that Ursula Geßner encounters during her trips abroad are like the Canadian roads in summer. The roads through Burkina Faso, Ghana and Benin are dusty and difficult to drive on. “We would not be able to get to our research area without a Jeep.” Along with her colleagues Kim Knauer and Markus Niklaus, the geographer travels once a year to the countries being researched under project WASCAL, West African Science Service Center on Climate Change and Adapted Land Use. What Geßner and her colleagues do when they get there could at first seem a bit odd to the locals. “But the people we meet are always very friendly and curious,” she says. The scientist is looking for predetermined positions with her GPS device, then she stands on fields and takes photographs in four precise directions – north, south, east and west, turning four times, and pressing the shutter release button four times. Then she takes out her pen and takes notes carefully; what land cover can be seen within a 50-metre radius: scrubland, rainforest, wooded savannah or grassland? How is the land being used? Are there fields, plantations, and irrigated or non-irrigated soil?

Geßner meticulously notes down what she sees. In this way she and her colleagues collect data that is used to check DFD products – maps of land coverage and use, for example. “We need to know whether our analyses of the satellite images stand up to scrutiny on site.” With each trip and each view in all four directions, the scientists’ understanding of the local background grows, so that their assessment of the satellite data can be optimised. The children are especially fascinated by what the DFD workers are doing, but adults also ask questions about the significance of the unusual activity in their fields; likewise, they are happy to talk about their cultivation methods and how they cope with the variable rainfall so critical for successful harvests. With them in the Jeep are African colleagues who work with the staff at the DFD and other German partners, such as the University of Würzburg or the Center for Development Research at the University of Bonn. “We have to get used to their way of working, and they have to get used to ours.” The local scientists are hugely approachable and interested. The German visitors

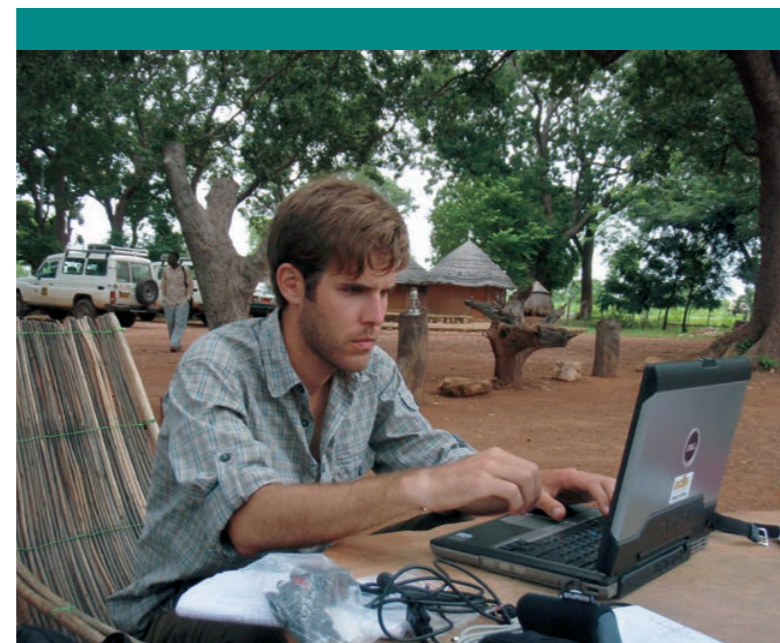
benefit from the cooperation as much as the local people. “It helps us understand and analyse the change processes to which the environment is exposed.” WASCAL is concerned with the effects of climate change in West Africa and is looking into adaptation options for sustainable land use. The German-African interdisciplinary team of researchers is primarily looking into the question of what kind of adapted usage will be appropriate for both food supplies and local income and for the protection of natural resources. The German scientists stay in Africa for two to four weeks, travelling through the principal research areas and holding workshops on various subjects.

The landscape becomes greener and greener as the Jeep travels from the arid, barren north to the lush south. Individual mud huts, lively towns, herds of cattle and trucks packed with goats and sacks pass by the dusty vehicle windows, until the next measurement point is reached. At midday, when the temperature reaches its peak – 38 degrees Celsius – dishes of fufu made from cassava and plantain, beans and chicken with a spicy sauce cover the tables of small roadside shops. West African countries have a good infrastructure in their cities. The roads connecting towns are empty and difficult to drive along in the rainy season, whereas the towns themselves offer everything a person could need for everyday life.

Back at the office in Germany, Ursula Geßner is once again looking at satellite images instead of at the savannah. “We want to use the images to understand how and why the landscape is changing, and what the consequences are for agricultural productivity, for example, or terrestrial carbon sequestration,” she says. Even though she is just sitting at her desk, in her head the satellite images are still triggering pictures – memories of the savannah, trees and arable land. ●



More information:
DLR.de/en/DFD



During the evening after fieldwork, DFD scientist Kim Knauer processes the data acquired.



The pictures of the site are located using a GPS device so they can be added to the satellite data later



Travel with obstacles – after rainfall the roads, as here in Benin, are sometimes very difficult to drive on.



The researchers use a special camera lens to photograph the treetops. This is how they measure the density and transluence of the leaf canopy.

Science and technology – hands-on

Since its establishment in 1903, the Deutsches Museum in Munich, Germany has devoted itself to making science and technology as accessible as possible to visitors of all ages and backgrounds. Having one of the largest collections of original exhibits in the world, it does not cease to captivate visitors. The first motorised aircraft built by the Wright brothers, the world's first diesel engine, the instrument with which Heinrich Hertz proved the existence of electromagnetic radiation, or the first Apple Macintosh 512K personal computer – the Museum has it all. And there is more: the Deutsches Museum combines traditional core elements with interactive displays in an effort to present the evolution of science and technology from its origins to the present day – always leaving room for futuristic ideas.

A stroll through the Deutsches Museum in Munich

By Miriam Kamin and Alexander Schwaiger

The Deutsches Museum – actually the Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik (German Museum of Masterpieces of Science and Technology) – has always enthused its visitors, not only because of the sheer volume of exhibits, but also with its unconventional approach. Visitors are allowed, even very much so encouraged, to handle the objects on display and try experiments themselves; taking pictures, laughing and being fascinated are all permitted. This is precisely what the Museum envisioned from the very beginning, and it has remained true to its form. The founder, Oskar von Miller, came up with a completely new museum concept, from an educational perspective. He wanted to combine education with entertainment. The museum was to offer something for everyone, taking technology and science into the public domain. Miller wanted a hands-on technology museum – one in which people had fun!

Cornucopia of exhibits

The excitement begins before you even reach the first exhibit. The 50,000 square-metre Deutsches Museum sits on more than 1500 posts driven up to seven metres into the ground of the Museumsinsel, or Museum island, in Munich. But it goes even deeper – 11 metres below the Museum is an underground tunnel network showcasing a 700-metre-long display on mining technology from the 16th century to the modern day. It is significantly cooler, narrower and, especially, dark down here. In this environment, you can really experience the hardship of those working in the ore, salt and coal mining industry.

Upstairs, 'invisible to the human eye' items are displayed in the Nano- and Biotechnology exhibition. Scanning tunnelling microscopy allows visitors to unlock the secrets of the nanoworld. With this technology it is possible to measure how



People and machines with a vision: Apple founder Steve Jobs (left) in May 1985, with the first functioning computer in the world, Konrad Zuse's Z3 – a crucial forerunner of the Personal Computer; next to him, Otto Mayer (then General Director of the Deutsches Museum), and on the far right Ralf Deja (CEO of Apple Computer GmbH Munich).

Oskar von Miller

Bavarian civil engineer Oskar von Miller (1855-1934) was known as a pioneer in hydropower and electrical engineering. In 1903 he fulfilled his dream of establishing a museum dedicated to science and technology. The Deutsches Museum was born.



The Astronautics section is by far one of the most impressive departments in the Deutsches Museum.



The Deutsches Museum in Munich



220,000 volts and very noisy – high voltage current test using the Faraday Cage.



Fascinating presentation – the Foucault Pendulum demonstrates the rotation of the Earth.

At the forefront...

DLR Magazine spoke to Matthias Knopp, Head of the principal department of Aerospace and Navigation at the Deutsches Museum

How has interest in the aerospace exhibitions at the Deutsches Museum developed in recent years?

Both our main museum in Munich and our sister site in Oberschleißheim are as popular as ever. We have had over 100,000 visitors yearly at the Flugwerft Schleißheim since it opened in September 1992. We know from surveys amongst our visitors to the Museum Island in Munich that, over the years, a steady 80 to 90 percent of them visit the Aerospace exhibitions. With its more than 16,000 square metres, this section is also the biggest in terms of surface area.

How long has the Deutsches Museum been working with DLR?

For decades. It would be a surprise if we did not. DLR, the main research institution in Germany in terms of aerospace, is our biggest partner, not only in technical and scientific matters but also in the history of technology. Apart from collaborating with various departments at the Deutsches Museum, such as the board of trustees, the scientific advisory board, and the friends and sponsors group, we also work directly with scientists at DLR. This ranges from training events at our Kerscheneiner College to regular support at our Fly-In event in Oberschleißheim, supported by DLR Flight Operations. We especially appreciate DLR as a donor of exhibits. DLR's ATTAS research aircraft, which was decommissioned last year, is the most recent example.

Are there joint events as well?

Yes, plenty. In 2012, we worked with DLR to bring about the exhibition 'Robots – our Pioneers in Space' in our sister museum in Bonn. In 2005 we had a special exhibition in Munich on the Mars Express spacecraft, with fantastic 3D images. DLR scientists are often invited to speak at our 'Science for everyone' lecture series. We also celebrated the second anniversary of the Columbus space laboratory with DLR and ESA, and we are discussing future projects, such as a special exhibition on the TanDEM-X satellite project.

What can visitors to the Astronautics exhibition area expect in the future?

The Astronautics section only covers about 1000 square metres. Unfortunately, there are no plans for an extension of our permanent exhibition space in the future. Large exhibits such as SPACELAB or the EUROPA rocket are therefore displayed in other areas of the Museum. But we will be carrying out a planned renovation of this area in order to remain at the forefront. Live demonstrations and hands-on experiments, especially in the area of satellite technology, are planned. And we would be delighted to do more on the exciting subject of robotic planetary research.

much a block of granite is compressed by the weight of a human being (the answer is 54 nanometres, or 0.000054 millimetres). Contrast and diversity, the Museum's most striking characteristics, are omnipresent: an entire fuselage section of an Airbus A300 jumbo jet, complete with wings and engines, makes itself known just halls away from delicate musical instruments belonging to different centuries and that bear witness to a different, nonetheless impressive craftsmanship. One curiosity in the musical instruments section is the Siemens Studio for Electronic Music: even before the age of Personal Computers, electronic sounds had to be created for telephones, shop tills and other everyday objects. So in 1960 the Siemens instrument, using punched paper tape, "produced sounds never heard before to create new aesthetic experiences" – according to the perception of the time at least.

Endless expanses and electrifying experiments

The wonders of space can be explored in the Museum's Planetarium, the first projection planetarium in the world. Constellations, galaxies and planets are displayed above the visitors' heads. Thanks to time-lapse photography, a full starry night can be experienced in just a minute and a half, giving you time to come back down to Earth. At the Foucault Pendulum, you will be 'shown' the rotation of Earth. Continue on to the Mathematical Cabinet, where your knowledge of algebra, analysis and such are put to the test. Anyone keen for a rest at this point is welcome to visit the Sundial Garden on the 6th floor and take a break. Want to catch a glimpse of the future? An Oracle answers questions – even the toughest ones – on futuristic subjects such as immortality, memory chips, perfect recycling, customised children, artificial life and an intelligent environment.

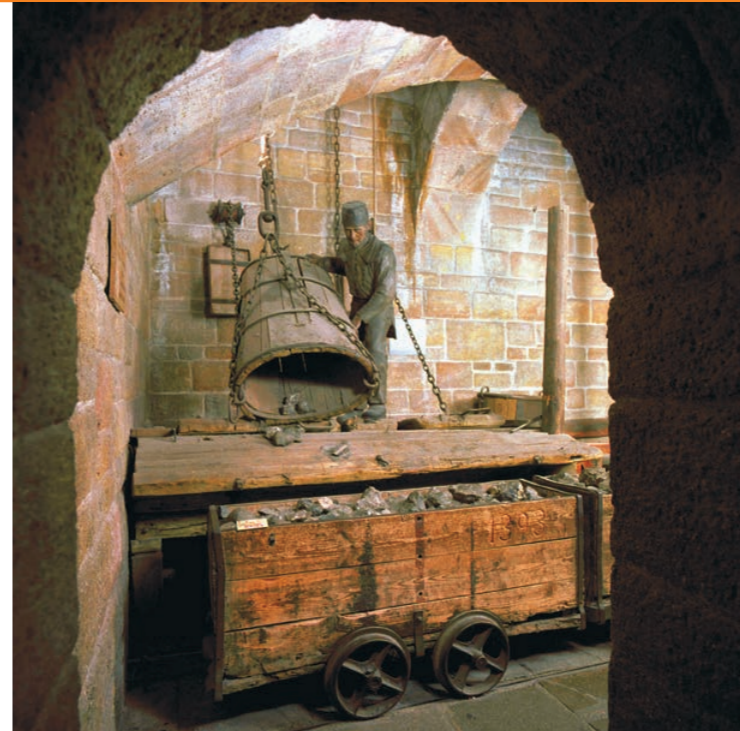
In the children's area, budding researchers are in good hands with selected tours, workshops, and experiment and culture clubs. Beware! It is not only children that should protect their ears from the tremendous roar emitted by the Faraday cage. To demonstrate its workings, a member of the museum's staff ventures into the wire mesh sphere. The interior is shielded from external electric fields and electromagnetic waves by the conducting, enclosing shell, so nothing happens to the person inside, even when a current of some 220,000 volts is applied to the wire mesh. For safety reasons, visitors are not permitted to participate in this experiment – even though the cage is probably one of the safest places you could be in.

Fabulous flights and visions of the future

Enthusiasm for flight is universal and the exhibits in the Aeronautics hall at the Deutsches Museum are among the most popular – a necessary stop for aeronautic enthusiasts. Few museums have a working Junkers Ju 52 in their collection, or an original V2 liquid propellant rocket from the Second World War. From a replica of Otto Lilienthal's Normal Gliding Apparatus to a cross-section of a jumbo jet, the hall provides a historical overview of the evolution of aircraft from which it is hard to draw yourself away. Visitors can reach even greater heights in the Astronautics display area. Numerous unique pieces are showcased here, such as the impressive collection of spacesuits. This area homes the most 'powerful' exhibit of all: dazzling everybody with its power output of three million kilowatts, the VULCAIN thrust chamber, acquired from the European Spaceport in French Guiana, once ensured that the European Space Agency's Ariane rockets would lift off.

A visit to the Deutsches Museum is highly recommended. Due to renovations, some of the departments may be closed, so if you have your heart set on a particular display hall, make sure to check the Museum's website before visiting. Furthermore, it is wise to carefully plan your visit beforehand, as you might need more than one day to explore this museum properly.

Our insider's tip: get a condensed view of the Deutsches Museum – in two hours. Anyone ready for a quick stroll through all the departments should book a guided tour with a former pilot, for example. And anyone booking a tour beforehand will avoid queues at the ticket desks.



Eleven metres underground: experiencing the trials and tribulations of mining.



Down to the smallest detail: the Nano- and Biotechnology exhibition.

Deutsches Museum Masterpieces of Science and Technology

Opening hours:

Open daily from 9:00 to 17:00 (Deutsches Museum, Flugwerft Schleißheim and Transport Centre)

Museumsinsel 1
80538 Munich
Tel: (089) 2179-1
Fax: (089) 2179-324

Tickets:

For visitors over 16 years: 8.50 Euro. Schoolchildren: 3 Euro.
Ticket for Museumsinsel, Flugwerft and Transport Centre: 15 Euro

'Musical chairs' at the museum – Flugwerft Schleißheim welcomes ATTAS

On 7 December 2012, it was time to 'Welcome ATTAS' to Schleißheim. DLR donated the ATTAS (Advanced Technologies Testing Aircraft System) research aircraft to the Deutsches Museum. Skilled restorers then prepared the aircraft for display in the new hall. On 15 October 2013, ATTAS was officially handed over to its new owners.

Interview with Gerhard Filchner, the head of Flugwerft Schleißheim – by Miriam Kamin

You have been the Head of Flugwerft Schleißheim since its establishment in 1992. What does a new addition mean to an aviation museum?

Work! It begins with the transportation. Most of the time the aircraft are disassembled, as they no longer have flight authorisation, or because our 800-metre runway is not long enough to land on. The separate parts are then delivered on heavy-duty transporters, which is a real adventure on the streets of our idyllic location. We then put the aircraft back together on site. ATTAS was still authorised to fly, so from that point of view it was no problem. The real challenge resided in the size of the aircraft: the tail unit of ATTAS is very tall – almost eight metres – and the hall door is seven metres tall, so we gently raised the nose with a hydraulic lift to lower the tail. At that point, everybody held their breath!

How did ATTAS find its current place?

It started back in 2007 – we thought about the best location for ATTAS in terms of subject matter within the museum. We planned its integration in the hall using real models and computer simulations. Like all the other exhibits, ATTAS is intended to be an educational tool that is integrated with the surrounding exhibits. That is when the aircraft 'musical chairs' began. Two aircraft were moved into another department, where two more aircraft had to make way in turn. It would have been easier with paintings in a gallery... ATTAS' new neighbours are the prototype of the Eurofighter and a Rockwell/MBB X-31, a US-German joint production project. These are both test and experimental aircraft, like ATTAS.

How do you make a museum exhibit out of an aircraft?

When it arrived, we began to adapt ATTAS for its new purpose, as we do with all exhibits. Visitors can watch the restorers from a gallery while the aircraft is being prepared in the workshop. First, the aircraft is meticulously cleaned of oil and dirt. A layer of protective polish is applied but none of its original appearance is changed. In the case of ATTAS, even the 'autographs' of the two DLR pilots, the test flight engineer and the on-board mechanic, are visible at the front of the aircraft. And all of the campaign logos and signs of operational wear and tear remain visible. All these aircraft were once used for flying, and one should get a feel for that when seeing the exhibit.

Will the ATTAS exhibit offer more than just a view of the aircraft's exterior?

Yes. The engines have been opened. Part of the wings have also been opened up and covered with see-through Plexiglas to make ATTAS' pioneering fly-by-wire controls and the landing gear visible. Exhibition panels on the walls describe in German and English how ATTAS was developed and used, and additional details are explained in a film.

When will visitors be able to go inside the aircraft, and what will they see?

ATTAS is having steps installed that will lead up to the front doors, where you can see into the cockpit, and then make your way through the aircraft and take another set of stairs back down on the other side. Glass panels in the interior offer protection against any damage, while still allowing views into the test systems. Some of the floor panelling has been removed as well, so visitors can see the technology, control lines and fuel tanks. From the end of this year, museum visitors will be able to view the inside of the research aircraft. ●



More information:

Deutsches Museum:
www.deutsches-museum.de/en



Flugwerft Schleißheim:
www.deutsches-museum.de/en/flugwerft/information/

DLR Braunschweig:
DLR.de/en/Braunschweig

DLR Oberpfaffenhofen:
DLR.de/en/Oberpfaffenhofen

Video of ATTAS in flight over
Oberschleißheim:
www.deutsches-museum.de/flugwerft/sammlungen/strahlflugzeuge/vfw-614-attas/film/



Flugwerft Schleißheim at night. In 1992 Flugwerft Schleißheim was opened on one of the oldest surviving airfields in Germany. On an area of 7800 square metres, around 60 aircraft and helicopters, numerous hang gliders, aircraft engines and flight simulators await visitors. A restoration workshop is also situated in the glass hall. Furthermore the airfield is used by six air sports clubs and the Federal Police Force flying squadron.



View of the historic hangar



ATTAS landing at Schleißheim



View from the ATTAS cockpit to the taxiway in front of the hangar

Aviation fans please note!

An 8000-square-metre exhibition area, some 1.5 million visitors a year, over 50 original aircraft alone – the Deutsches Museum in the centre of Munich has plenty to offer the aviation-loving public. But there are even more exhibits awaiting aviation fans in Schleißheim. The Deutsches Museum displays an important part of its aircraft collection at a historic site – Schleißheim airport. The airport and its historic buildings were built to the north of Munich between 1912 and 1919 for the Royal Bavarian Air Force (Königlich-Bayerische Fliegertruppen). In the early 1990s the historic hangar was restored and a modern exhibition hall and a restoration workshop were added.

Deutsches Museum

Flugwerft Schleißheim
Effnerstraße 18
85764 Oberschleißheim
Tel: (089) 315 714 10
Fax: (089) 315 714 50

Opening hours:

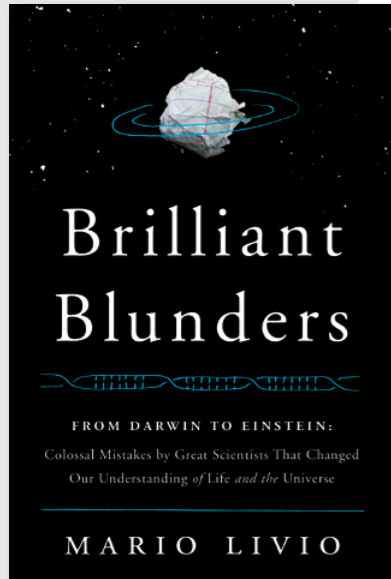
Daily from 9:00 to 17:00

Tickets:

Day pass for visitors 16 and above: 6 Euro

Ticket for Museumsinsel, Flugwerft and Transport Centre
(Visit also possible on different days): 15 Euro

Family ticket: 12 Euro



We all make mistakes

In science, success stories are often the result of numerous mistakes. In the words of the famous US inventor Thomas Edison: 'I have not failed. I've just found 10,000 ways that won't work.' And that is science; whether it is a straight success or a series of unfortunate errors, it is constantly moving us forward. **Brilliant Blunders**, written by Mario Livio, is an enlightening account of some of the biggest blunders made by five renowned scientists – Charles Darwin, Albert Einstein, Fred Hoyle, Lord Kelvin and Linus Pauling.

For many people, being a great scientist means getting it right all the time. This is what makes Livio's book special. Through the stories of how these scientists made astounding contributions to science, at times with flawed reasoning, the author gives us an insight to the process and course of science.

Livio delves through the scientists' correspondence, feedback and historical records to attempt to explain not only what went wrong, but where and when. In the attempt to describe the evolution of the Universe at large based on General Relativity, Einstein failed to see the importance of his cosmological constant. Fred Hoyle ridiculed the Big Bang theory. Kelvin miscalculated the age of the Earth. Darwin's development of the theory of Natural Selection is filled with blunders, and Pauling's model for the structure of the DNA molecule was far from perfect. But these mistakes are just as important as the discoveries themselves – they were a necessary part of the scientific process.

This book is a must-read for anyone wanting to know more about some of the greatest scientific discoveries of all times, and those who made them, as well as for those that find the sciences discouraging at times. So delve in, there is much to learn!

Karin Ranero Celius

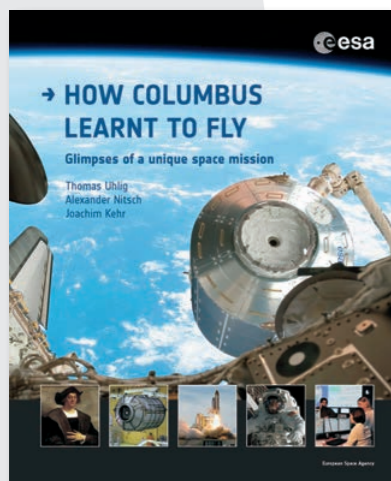


Spacecraft 3D

NASA has launched **Spacecraft 3D**, an exciting new Augmented Reality (AR) application offering a unique close-encounter with some of the spacecraft that explore Earth, the Solar System and beyond. Just focus the camera of the mobile device on the printed AR code provided by the app, and slowly move it back to reveal shockingly real 3D models of Cassini, Juno or Hubble. The model can be examined from all sides with a simple movement. The technical and mission specifications for each spacecraft are included as well.

The App contains a total of 16 spacecraft – from Voyager to Curiosity. Some satellites orbit Mars, others the Moon or Earth, and some are still en route. Easily the favourites, however, are Curiosity and the Mars Exploration Rover, with 3D models including animated parts. Updates will add to this wonderful collection that offers a close encounter with the spacecraft that contribute so much to our understanding of the Universe. Available for iPad® and Android™ tablets.

Merel Groentjes



Inside Columbus

This year, the European Columbus research module celebrates six years in space. With this in mind, why not delve into '**How Columbus learnt to fly**'? Find out what it is like to work on board the ISS, as well as the process for developing such a mission and the challenges involved in human spaceflight. The book takes the reader on a trip to the history and development of Columbus – a truly detailed account of the 14-day 1E Mission, in which the module was delivered to the ISS by the Space Shuttle Atlantis.

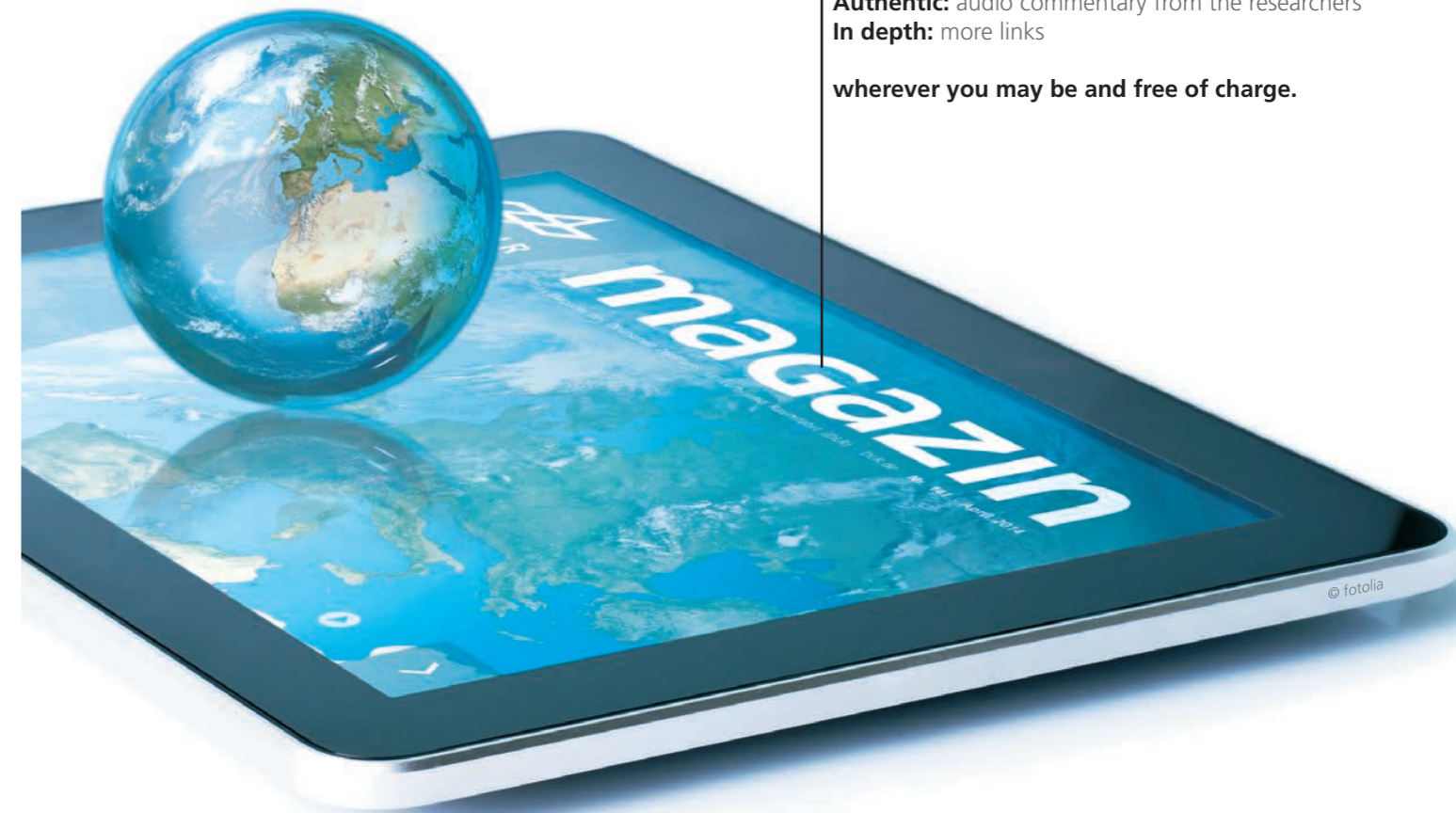
The authors, **Thomas Uhlig**, **Alexander Nitsch** and **Joachim Kehr**, were directly involved in the mission as flight directors and flight operations engineers, so one is truly getting a first-hand impression of the events that took place. They also make sure to include explanations of technical terms, so that you can easily follow the story through to the end.

Karin Ranero Celius



Earth is (not) a disc. Knowledge for tomorrow.

Experience DLR's research via multimedia with the free magazine app for iPad® and Android™ tablets.



Fascinating: science images
Moving: videos and animations
Authentic: audio commentary from the researchers
In depth: more links

wherever you may be and free of charge.

Knowledge for tomorrow.



iTunes store



Google play store

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 7400 employees at 16 locations in Germany: Cologne (Headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Jülich, Lampoldshausen, Neu-strelitz, 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, Marco Trovatiello (Editorial management), Karin Ranero Celius, Peter Clissold and Linda Carrette (English-language Editors, EJR-Quartz BV)

In this edition, contributions from:
Manuela Braun, Diana Gonzalez, Merel Groentjes, Miriam Kamin, Alisa Wilken and Jens Wucherpennig

DLR Corporate Communications
Linder Höhe
D 51147 Cologne
Phone: +49 (0) 2203 601 2116
Fax: +49 (0) 2203 601 3249
Email: kommunikation@dlr.de
DLR.de/dlr-magazine



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

ISSN 2190-0108

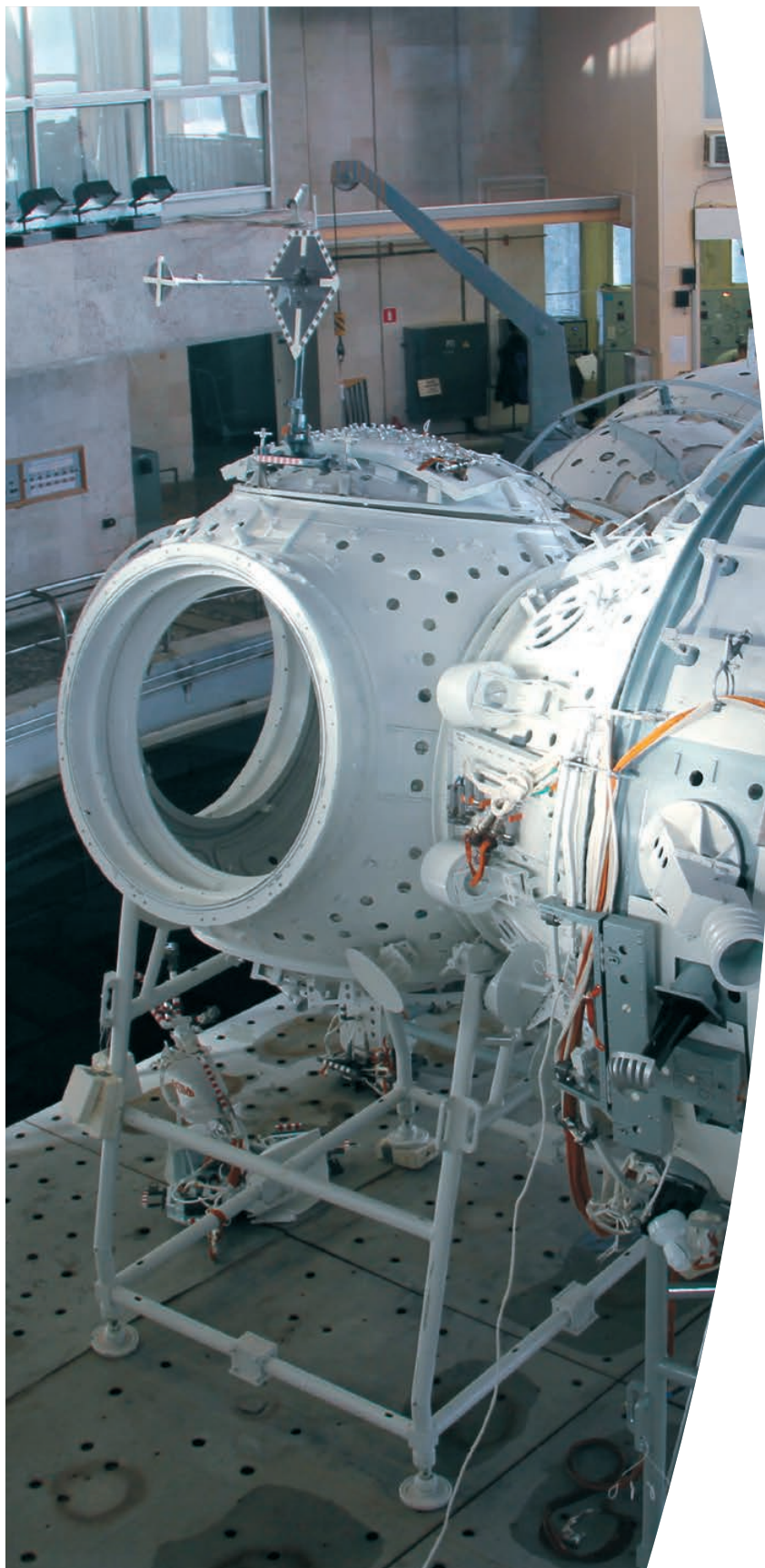


To order and read online:
DLR.de/magazine

The DLR Magazine is also available as an interactive app for iPad and Android tablets in the iTunes and Google Play Store, or as a PDF file.

Content reproduction allowed only with the prior permission of the publisher and must include a reference to the source. Some English-language material has been translated from the German original. The respective author(s) are responsible for technical accuracy of the articles. Printed on recycled, chlorine-free bleached paper.

All images are property of DLR and published under a CC-BY 3.0 unported license unless otherwise stated.



**Deutsches Zentrum
für Luft- und Raumfahrt**
German Aerospace Center