DLR

DLR magazine

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NO VOICE – NO MOUTH

REPORT: Caught in the net – landing without an undercarriage

ON THE RAILS: High-speed chase for signals in Italy

GLORIOUS GIANTS SERIES: Driving in a virtual world

DLRmagazine 151·152

Image: DLR/Gesine Born

Dear readers,

There is something special in the air during the last weeks of the year. We look forward to the holidays at the turn of the year, pleased with what we have achieved. But often in our everyday lives here in Germany, the gleaming lights illuminate the trials of November and 1000 accomplishments push their way to the fore before we can get a chance to relax with a warm cup of tea; the longed-for sleigh ride often comes only at the price of hours spent in traffic; and many a one do not even have enough money to buy a single string of lights. And if we look beyond our personal lives, environmental damage, hunger and economic and political crises cast long shadows over our, in principle, wonderful world. We Germans often forget how good we have it.

And this brings with it an obligation. We have the means to bring about change. In addition to will and strength, knowledge is crucial for this. Research and development can lead to solutions. Environmental monitoring 'made by DLR' ensures rural livelihoods in Vietnam and China. Flying without landing gear paves the way for increasingly lighter solar aircraft in our skies. Communication systems between trains save time for passengers and prevent collisions. Robots are designed and built to assist humans. Research into the mobility of the future is leading to safer and more efficient ways of driving.

There are ways and means to get out of problematic situations. These can often lead us down uncomfortable paths, making these problems that much more difficult to solve. But we cannot avoid taking on this endeavour – on a large or small scale.

In this spirit, let us take time to enjoy the good things, time to enjoy what we have and time to gather the strength to tackle all that needs our action. I wish you happy holidays and a prosperous 2017!

Sabine Hoffmann
Head, DLR Corporate Communications

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Image: private

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Image: DLR/Henrik Frensch

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UNLEASHING INNOVATION FOR A WORLD WITH ZERO HUNGER

Robert Opp is the Director of Innovation and Change Management at the UN World Food Programme (WFP)

Commentary by Robert Opp

Fifteen years ago, only one in seven people had a mobile phone and few people owned a laptop. Since then, new technologies have rapidly and radically transformed our world – drones are being used to deliver blood and plasma to remote communities in Rwanda; a team of social and computer scientists at Stanford University is researching how satellite images can gather crucial data to map poverty, from space.

Yet despite our advances in the world of technology, some of the most pressing global problems remain. Conflicts and climate change are threatening livelihoods, and 795 million people do not have enough food to lead a healthy life.

Without doubt we are making progress in tackling these issues. Ending hunger, for example, is not a pipe dream; 72 countries worldwide have already halved hunger. Thanks to these efforts, billions of people now have access to sufficient food.

The problem is that we are not getting there fast enough. If we continue with business as usual, eliminating hunger at the same rate as over the past 15 years, 550 million people will still be suffering from starvation in 2030. We need to unlock the power of innovation for sustainable development and use it to accelerate our efforts to eradicate poverty and hunger in the world.

At the World Food Programme (WFP), innovation is a cornerstone of our efforts to provide food assistance to over 80 million people worldwide, each year. In the past, WFP has delivered food by aircraft, train or lorry. Today, we distribute e-cards so that people can buy what they need, when and where they need it – and for the first time in the history of the retail industry, Syrian refugees in Jordan can use an iris scan as a payment method.

These are just some of the innovations that have transformed the way WFP serves the most vulnerable people worldwide. And we are pushing even further, for example by crunching big data to identify trends in food purchases and prices to ensure that the right assistance is available – where and when it is needed.

To create an environment that supports and nurtures innovative thinking and the development of novel approaches, WFP launched an Innovation Accelerator based in Munich, Germany, that uses best practices from the private sector and leading scientists. The Accelerator supports innovations along the entire value chain – it runs internal and external challenges to surface and brainstorm innovative ideas for Zero Hunger. It supports rapid testing and prototyping and also provides leadership on bold and cutting-edge ideas.

Projects supported to date include a 'Green Box', which enables staff in the field to measure energy consumption. In the desert-dry slums around Lima, the capital of Peru, WFP is working with partners to provide hydroponic growing technologies to marginalised families and empower local entrepreneurs. We believe that the importance of such technologies will only grow further.

We live in exceptional times, in which we have the opportunity to end poverty once and for all. If we work together with partners, such as DLR, and learn from their experience, introduce new technologies and crowdsource skills and contributions, we can eradicate hunger.

CLOUD HUNTING TO UNDERSTAND WEATHER AND CLIMATE

Atmospheric research helps to refine weather and climate models. That is why DLR scientists are travelling around the world in their research aircraft and analysing the atmosphere. Clouds and winds affect the European climate even though they may be thousands of kilometres away.


The atmospheric research aircraft HALO at Barbados Airport

The weather in Europe depends heavily on weather systems over the Atlantic. The fast-rising warm air currents there divert large wind movements, which then have an effect on the continent thousands of kilometres further away. Using the HALO (High Altitude and LOng-range research aircraft) and the Falcon research aircraft, scientists from DLR and the Ludwig-Maximilians-Universität München flew from Iceland into these weather systems. They penetrated regions from which there have been hardly any observations. During the flights, they gathered information about temperatures, wind conditions and cloud properties using novel measurement systems. This will help to better understand the weather patterns over the Atlantic. The measurement values were transmitted via live data transfer to global weather services.

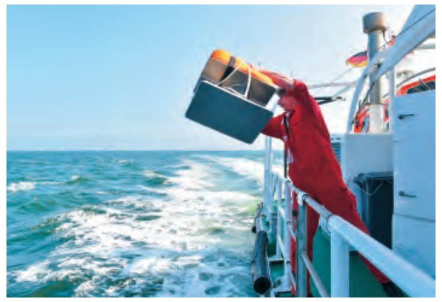
The scientists also used HALO to investigate – southeast of the Caribbean island of Barbados – the extent to which tropical clouds in the trade winds region can affect global warming. This should clarify the relationship between clouds, air circulation and climate over the tropical ocean. The clouds that form in the Caribbean region cover a large part of the world and consequently significantly determine how strongly a changed cloud formation can reduce global warming. To this end, atmospheric researchers are investigating which mechanisms on the ground, as well as in the atmosphere, affect air circulation. At the same time, they are looking into the type of clouds these processes lead to.

JOINTLY RESPONDING TO THREATS AT SEA

Hijacked ships, hazardous substances on the ocean surface, a ferry going astray and people overboard – researchers from DLR and the University of Rostock have developed scenarios for threatening situations such as these. In the EMSec (Echtzeitdienste für die Maritime Sicherheit - Security; Real-Time Services for Maritime Security) joint project, researchers combined multiple data sources such as satellite images, aerial photographs acquired by aircraft and ship reports, because having a quick and comprehensive overview of the hazardous situation is crucial in such crisis scenarios. In a large test programme at the end of the EMSec project in September 2016, they presented research results of the past three years.


DLR tested four scenarios to gain a quick overview of the dangers

With the combined information from satellite and aircraft photographs and ship signals, the researchers were able to simulate the location of a ferry and identify the situation. The 'Bayreuth' had deviated from its course when performing a simple evasive manoeuvre, and in the subsequent scenario switched off its automatic identification signal (AIS) due to a hijacking. In addition, scientists tracked several buoys that were previously thrown overboard as 'persons in distress' and, in the last scenario, analysed the drift behaviour of a 'hazardous substance blanket' – 50 cubic metres of popcorn.


One of the scenarios was: 'Man Overboard!'

The solution proposed by EMSec shows, for the first time, a closed system ranging from information acquisition to dealing with the situation. All the information converged in the situation centre, which was built for the campaign in Cuxhaven. For four days, DLR tested the four scenarios in real conditions together with ATLAS ELEKTRONIK GmbH, Airbus, the University of Rostock as well as the German Federal Maritime Police, the German Maritime Search and Rescue Service (DGzRS) and the Waterways Police.

QUIET LANDING

To help passenger aircraft pilots make quieter landing approaches, DLR researchers have developed the LNAS (Low Noise Augmentation System) pilot assistance system. A low-noise approach is an extremely complex task in which the aircraft must be consistently flown with the lowest possible level of thrust. LNAS shows the pilot the ideal vertical approach profile on a display. To do this, the optimal times for extending the flaps, reaching the intermediate flight altitude and lowering the landing gear are each highlighted in the approach profile. For test flights, DLR and Umwelt- und Nachbarschaftshaus in Kelsterbach tested the LNAS system with the Airbus A320 ATRA research aircraft at Frankfurt Airport.

RAILWAY CROSSING ALERTS

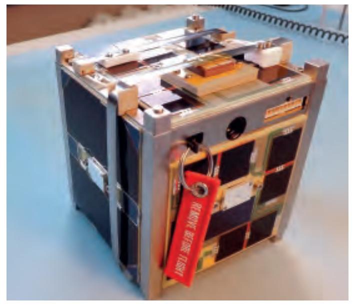
An advanced assistance system will increase the safety of railway crossings by communicating with railway infrastructure. As soon as a train approaches, drivers are warned that the crossing will close soon. At the same time, the train driver also receives the information that the drivers have been warned and that the railway crossing is secure. In this way, the so-called Rail2X system can provide increased alertness at critical locations. Initial field tests were successful. The Rail2X technology also offers additional potential: With a button on the platform or using their smartphone, passengers could in future tell train drivers in advance that they want the train to stop. If the train does not receive a message, it can pass the platform without stopping.

TRACKING ALTITUDE SICKNESS

DLR scientists studied the effects of altitude sickness at 4554 metres. To do this, 10 volunteers ascended to the Regina Margherita, the highest mountain hut in Europe, located in Italy. The results of the medical study are also of interest to human Mars missions, since astronauts on Mars would most likely live and work in an atmosphere with a pressure similar to that of the Alps. It is not yet possible to predict who will suffer from altitude sickness and which exact processes take place. In the alpine study, scientists investigated whether oxygen deficiency at high altitudes damages the vascular barrier, allowing fluid and proteins to seep into the connective tissue.

SMALL 'BEES' IN SPACE

The BIROS (Bi-spectral Infrared Optical System) fire detection satellite has released the pico-satellite BEESAT-4 in space. The cube-shaped satellite, with an edge length of 10 centimetres, was developed and built by employees and students at the Berlin Technical University. With a built-in GPS receiver, BEESAT-4 collects data for position and orbit determination. In addition, it photographs Earth's surface with a special camera. The precise knowledge of the pico-satellite's position is the basis for experiments on formation flights of satellites. Formation flights have the advantage that tasks and functions can be split between several satellites.



NEW WEATHER SATELLITE INSTRUMENT

With METimage, Germany is the first country to develop an instrument specifically for a European weather satellite. The multi-spectral, imaging radiometer will be used in 2021 on the Metop weather satellites. Metop is part of the EUMETSAT Polar System – Second Generation European weather satellite system. On board Metop, METimage will collect weather and climate data at an altitude of approximately 830 kilometres. The radiometer will acquire information on cloud coverage, sea and land surface temperatures, as well as determine the distribution of water vapour in Earth's atmosphere. It detects sunlight reflected from Earth's surface, atmosphere and clouds in 20 spectral channels – from the visible to the infrared.

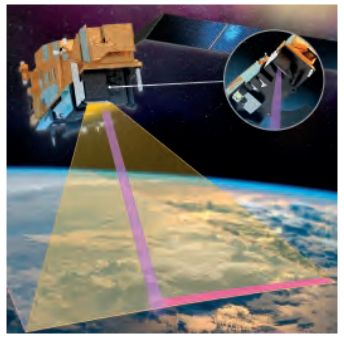
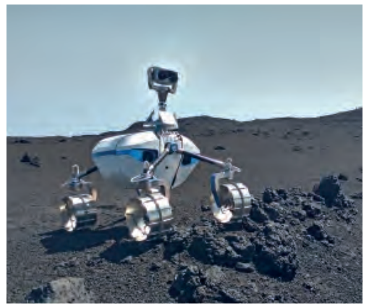


Image: Airbus Defence and Space

ROBOTS ON ETNA

The technologies used in future Solar System exploration missions will have to withstand extreme surfaces and conditions. In the Robotic Exploration under Extreme Conditions (ROBEX) mission, the interplay of different robotic systems is being demonstrated. New technologies will help to better explore hard-to-reach areas with extreme environmental conditions such as the deep sea, polar regions and other celestial bodies.
In order to prepare for ROBEX's final demonstration mission in 2017, 21 scientists tested wheeled and flying robots on the impassable terrain of the Italian volcano Etna. Flying robots surveyed the area while the wheeled robots autonomously placed the instrument boxes on the lava surface.



INFLUENCE OF PLANTS ON THE CLIMATE

Vegetation and soil can slow down global warming by absorbing more carbon through an increasing rate of photosynthesis. A study by researchers from DLR and the University of Exeter in the United Kingdom, which was published in the scientific journal Nature, shows exactly how this happens. Long-term measurements in Alaska and Hawaii showed that doubling of the carbon dioxide concentration in the atmosphere will cause global plant photosynthesis to increase by approximately one third. This means, however, that with future stabilisation of carbon dioxide concentration in the atmosphere, this now favourable effect will also diminish again. In total, vegetation and soil absorb about one quarter of man-made carbon dioxide emissions.

MASTERFUL CANSAT FLIGHT

The winners of the third German CanSat competition were announced at the end of September 2016. The 'Recognize' team from the Alexander von Humboldt Gymnasium in Bremen was the best of nine competitors. The students developed and built mini-satellites in drink-can format that were carried by a rocket to a height of 600 metres and ejected. The Recognize team's CanSat, like the other mini-satellites, recorded the temperature and air pressure during the flight to Earth and sent values to the ground station. In addition, it also photographed the ground with an infrared camera to draw comparisons to map material using image recognition techniques. The winning team will compete with international teams in 2017 in the European Space Agency (ESA) competition.

TECHNOLOGY TESTS WITH BALLOONS

The BEXUS 22 and 23 research balloons carried technology experiments from the Swedish Esrange Space Centre in Kiruna, Sweden, into the stratosphere at the start of October 2016. On board the two balloon gondolas were eight experiments from student teams from Poland, the Czech Republic, Belgium, Italy, Spain and Portugal as well as two from Germany (TU Dresden and TU Munich). The tests of the joint DLR and Swedish space agency SNSB mission involve the fields of astrophysics, satellite communication and navigation, as well as solar cell development, altitude and radiation measurements. With the BEXUS (Balloon Experiments for University Students) programme, students are able to acquire practical experience in spaceflight projects.

MEET DLR AT ...

WONDERS OF NATURE
Until 30 November 2017 • Oberhausen
The 'Wonders of nature' exhibit at the Gasometer in Oberhausen follows growth and development on our planet, and celebrates its intelligence and diversity. The highlight of the exhibit is Earth, which is brought to life, glowing in the immense interior of the Gasometer. It was so successful that it has been extended until the end of 2017.

COMETS – MISSION ROSETTA: JOURNEY TO THE ORIGINS OF THE SOLAR SYSTEM
9 August 2016 – 24 January 2017 • Berlin
This exhibition, developed by DLR in cooperation with the Berlin Museum of Natural History and the Max Planck Society, features the Rosetta mission and comets. They are dark bodies composed of dust and ice – as old as the Solar System itself. Will they reveal the key to the early history of Earth? Did the oceans' waters arrive as cometary ice? Were hydrocarbon molecules from comets the fundamental building blocks of life on Earth? Find out by visiting this one-of-a-kind exhibition at the Museum of Natural History in Berlin. There, you will also find models of Rosetta and Philae, as well as a scale model of Comet 67P/Churyumov-Gerasimenko.

7TH INTERNATIONAL CONFERENCE ON FUNDAMENTALS AND DEVELOPMENT OF FUEL CELLS
31 January – 2 February 2017 • Stuttgart
The conference, organised by the DLR Institute of Engineering Thermodynamics will take place in Stuttgart.
In addition to presenting scientific and technical advances, the conference is designed to instigate high-level scientific discussions and networking between scientists, laboratories, research institutes, fuel cells suppliers, component manufacturers and industrial end-users. A number of exhibitions will be held during the conference, giving an excellent opportunity for fuel cell materials and hardware suppliers as well as manufacturers to advertise their products and present them to future users.

WORLD ATM CONGRESS 2017
7 – 9 March 2017 • Madrid, Spain
CANSO, the Civil Air Navigation Services Organisation, and ATCA, the Air Traffic Control Association, are providing the innovation and education needed to meet ATM's future head-on. An international mix of Air Navigation Service Providers, Air Traffic Management experts as well as leading product developers and service providers will gather at the fifth annual World ATM Congress – the largest international exhibition and industry forum of its kind.

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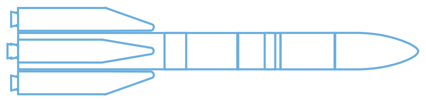
LAUNCH INTO SPACE WITH A DOWN-TO-EARTH ATTITUDE



Report on engine test for future space launch vehicle Ariane 6

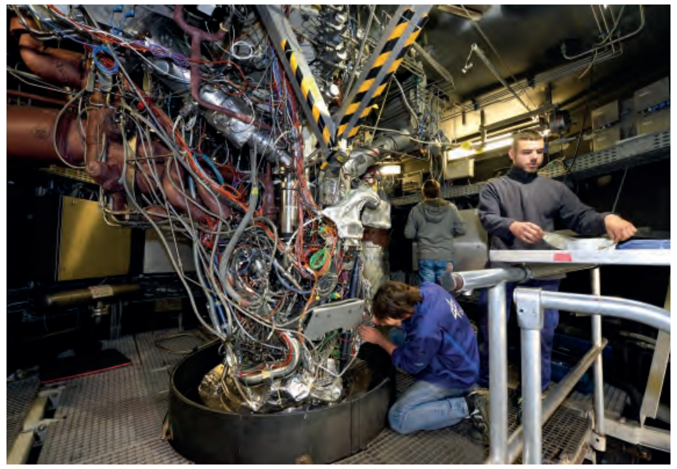
By Manuela Braun

The first barriers will be set up at 10:45. The Talstrasse, which passes directly below the test facilities at the DLR site in Lampoldshausen, is now closed to traffic at a distance of about 300 metres. And the traffic light is red at approximately 50 metres from the P4.1 test stand, built and operated by DLR on behalf of the European Space Agency (ESA). A warning sign dangling on the chain that stretches across the access road to the test stand reads 'Danger zone' in bright red uppercase letters. "When the chain is locked: Life-threatening danger! Major DLR test underway!" Today, liquid oxygen at a temperature of minus 183 degrees Celsius and liquid hydrogen at minus 253 degrees Celsius will flow through feed lines, a Vinci engine will be ignited twice in a vacuum, followed by a two-hour simulated propulsion-free flight. In doing so, the vibrations that occur in the feed line filled with liquid oxygen will be dampened as effectively as possible with a newly developed system. All this happens under the space conditions that the Ariane 6 launch vehicle would endure during a flight – yet it takes place close to the ground. The P4.1 test stand is the only one in Europe that can maintain a stable vacuum during a test in which the engine and nozzle can operate as if at an altitude above 70 kilometres.

Choreography of a test

"The test stand has been cleared." Bernhard Linseisen puts down the telephone receiver. He is responsible for ensuring that the strict safety barriers around the test stand are met during the engine test, and ensures contact between the test director and the safety centre. Only those who have permission from the test director and express clearance from the safety centre can remain in the restricted area. Manuel Müller nods and reaches for his ballpoint pen. One more item checked off the long list of around 1500 that must be completed during today's test. Müller is responsible for this chronology today and will therefore be test director Stefan Grunwald's right hand. This evening, at approximately 19:00, the last note will be added to the thick pile of paper and the last item checked off. An engine test follows an elaborate choreography with many participants who are each responsible for their respective fields. The chronology ensures that no detail is forgotten and everything falls into place.

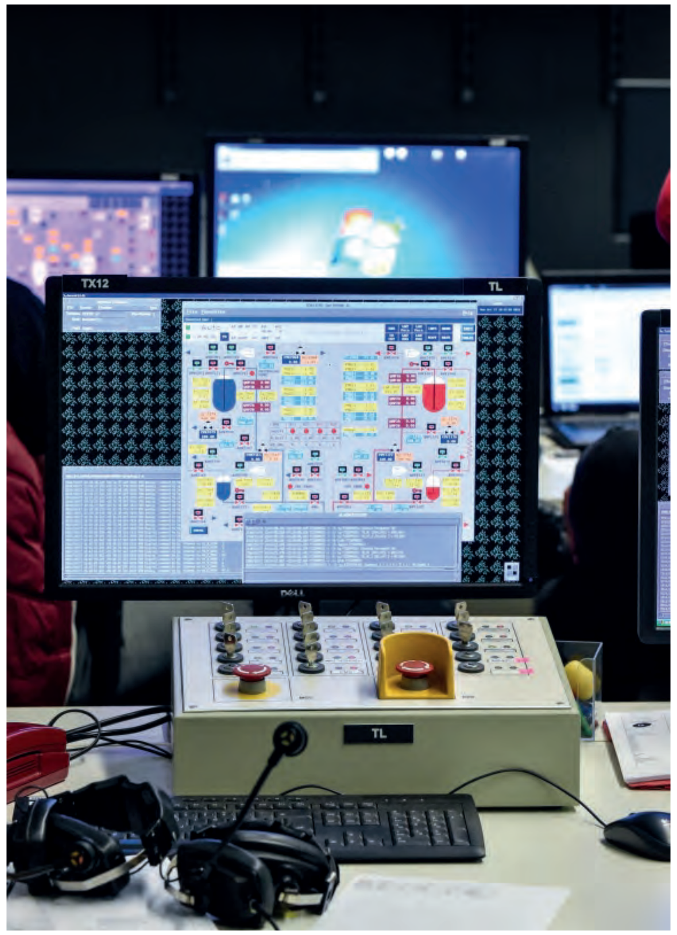
Caution: Ongoing test at P4.1 test stand. An engine is being ignited in a vacuum, that is, under near space conditions. This makes the large facility at the DLR location in Lampoldshausen unique in Europe.



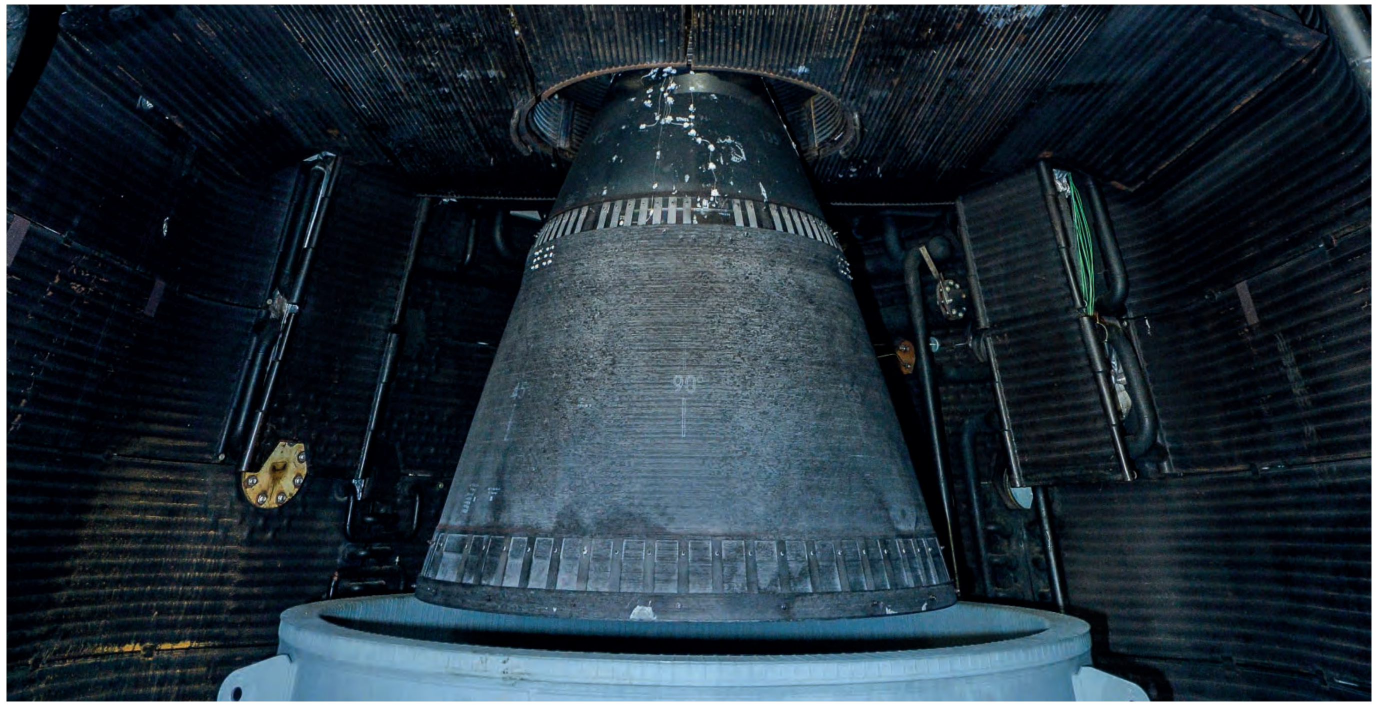
Around 900 sensors are installed in the test stand and the Vinci development engine. Each test and data evaluation is one step closer in the development of the future engine of the Ariane 6 launch vehicle.

NEW TEST STAND FOR ARIANE 6

A new facility is being developed and built at the DLR site in Lampoldshausen for testing the upper stage of the new Ariane 6 launcher. The upper stage of the Ariane 6 will be tested extensively on this new P5.2 test stand – the only place in Europe where this will be possible. These tests will include fuelling and defuelling tests as well as hot run tests for the upper stage. The commissioning of the new test stand is scheduled to start in 2018. The DLR Institute of Space Propulsion is technically responsible for the construction and subsequent operation of the test stand.



The test director's station: The test is followed through computer screens and can be interrupted in the event of an emergency.



Upon engine ignition, the grey-black nozzle in the vacuum chamber will begin to turn a bright red-orange.

Waiting for clearance

The atmosphere in the control room is still relaxed. Since 10:00 this morning, the engine has been covered with a special protective heat shield, all equipment and tools from the vacuum chamber in the test stand have been dismantled, and the heavy door of the vacuum chamber has been closed. One of the screens in the control room seems to show nothing – the camera is pointed at a black nozzle in a pitch-black chamber. Only during the hot run will this screen show something – the orange-coloured glow of the engine nozzle. While the last preparations are underway, Grunwald is sitting next door in the meeting room. Together with his team, he is discussing the last measured values and the deviations from these values during the final rehearsal with the client, the company Airbus Safran Launchers (ASL). Green light for the planned test run will only be given if both parties – DLR as the test stand operator and ASL as the contracting entity – agree on the framework conditions for today's test.

Increase from test run to test run

At 11:30, the time has come: Grunwald attaches the clearance document to the white board in the control room. "Green light for test M5R-12" and the signatures of the test director and client are on the paper. The twelfth test run since April 2016 – and number 108 in total with a Vinci engine – can begin. After the decision made at the ESA Council meeting at ministerial level in December 2014 to develop the Ariane 6 launcher, the previously tested Vinci engines and nozzles were also changed. Instead of an extendable nozzle, for example, a shorter, more compact one is now being developed and thoroughly tested. At the DLR site in Lampoldshausen, the tried and tested P4.1 high-altitude test stand was therefore modified and adapted to the new development targets. While a hot run without a nozzle was carried out in the first test in order to keep the risk low, the final configuration has meanwhile edged a bit closer with each test. Today, several newly developed components are in the test stand, such as the engine, the nozzle, liquid-oxygen feed line and valve, as well as a vibration damping system.

The 'Go' is given. Oxygen and hydrogen are now flowing through the test stand feed lines – it will take between two-and-a-half and three hours until the test stand and engine have cooled down enough for the test conditions to be reached. "LH2?" – "Tank pressure control is running." "What is the gas composition in the vacuum chamber?" There is less and less background noise in the control room. Only brief questions and answers are exchanged. Everyone is now sitting in position as a specialist for their area and looking at the graphics and measured values displayed on the screen. At the beginning of the test, many things are still set manually – important in this case are the boundary values, and the experience and instinct of the scientist. Later, the computer will increasingly take over. Approximately 150 sequences with countless lines of code will then ensure that the processes in the test stand are automatically and precisely executed – and that the test is stopped if the measured values require it.

Ignite, cool, fly

The engine will run for 600 seconds after the first ignition. Shortly before that, four steam generators will be ignited that – after a large, three-metre-diameter flap has connected the vacuum chamber and high-altitude system – will produce an air pressure of only a few millibars, almost like a vacuum, in the facility for the duration of the test. A short 120-second period follows in which the engine is purged and cooled again before re-igniting for 60 seconds. Then, there is a two-hour 'free flight', a so-called coast phase in which the upper stage of the Ariane 6 rocket 'flies' without propulsion. The test on P4.1 should then end with a final cooling of the engine. Approximately 900 sensors installed in the engine and test stand record pressure, temperature and acceleration levels throughout the test. On this test day, however, not everything will go as planned.

13:00. "Now it's getting cold." Today, Ralf Hupertz is the Supervisor of the test team. He looks at two screens crammed with data, measured values and graphics. "Now there is liquid in the lines." "13:30, then the next safety barrier," Grunwald says. Linseisen informs his colleagues in the safety centre. From this moment, the radius of the secured zone is drawn even wider than before. The control room is now cut off from the outside world – only voice communications with the safety centre and fire brigade remain. It gets even quieter in the control room. Hardly any words are exchanged across the room. Rather, everyone is wearing headphones with radio communication. Separated only by a thin wall, in the control room next door, sits the team responsible for the steam generator system, which will develop the necessary vacuum conditions just before engine ignition. The telephone between test director Stefan Grunwald and 'chronicler' Manuel Müller is off the hook. During the hot phase of the test, no telephone ringing should disturb people's concentration or the procedure.

System against damaging vibrations

Before the test run is initiated, the system that is used to induce a simulated vibration onto the oxygen column within the feed line is checked once more. In the worst case, such so-called Pogo oscillations could occur in the resonant frequency range of the rocket. "This could destroy the entire rocket," says supervisor Hupertz. Even the great Saturn V rocket, which later flew the Apollo astronauts to the Moon, had engine failures due to these vibrations during an unmanned test flight. The Pogo Suppression Device (PSD), which should dampen the artificially induced vibrations in the engine above the LOX turbopump, could later ensure that the Ariane 6 will not have problems with this.

Delayed start-up

It is just minutes after 14:00. The 20-minute warning is heard from loudspeakers across the entire site. But it will not be 20 minutes – the hot run will not start for 25 minutes. The cooling criteria are only reached after a few additional minutes. On the following day, in the team session with the client, these deviations will be discussed in order to set different, optimised conditions for the next test, if necessary. The cameras now only send images from an abandoned test stand to the screens. The only people in the immediate vicinity of the test stand, with the engine ready for ignition, are sitting in the protected control room. The exchange of questions and answers starts once again. "Pressure in the vacuum chamber?" "32 millibars" "Mass spectrometer, close valves for the hot run!" "Closed."

The steam generators are started. On the screen, the test stand is cloaked in more and more clouds. A muffled rumbling sound can be heard from outside. Just a few seconds until the large vacuum control valve is opened – and the engine can ignite. The countdown clock over the screens jumps to zero, the engine is running in the vacuum chamber, and the camera image changes colour – from black to bright red. "No alarms so far." The nozzle glows in the hot run for 10 minutes. "OK, engine cut-off," Grunwald calls. On the screen, the nozzle slowly darkens again.

During the test, cameras transmit what is happening in and around the test stand. The control room is a protected area, which must not be left.

Test director Stefan Grunwald (back) and chronicler Manuel Müller are under tension. All the information is gathered in these two positions.

Dealing with the unexpected

Just two minutes pass between the first and second ignitions. The atmosphere in the control room remains tense. "Now the second ignition ..." Grunwald's voice is hesitant. If it takes place at all. The planned second ignition does not happen. All eyes turn to the measured values. No one can intervene now. Two minutes pass – the hissing of the steam generators from outside fades and the white cloud around the test stand slowly dissipates. Even though the second ignition has failed, the test continues with the planned free-flight phase and a re-cooling of the engine. It will take about one and a half hours before the next phase starts again at the consoles. Meanwhile, in the next room a discussion about why the planned ignition did not take place is going on. "It could be, for example, that the parameters for the test sequence could not be realised for technical reasons," Grunwald says. "The analysis of the measured values will show this."

At 16:35, the next 20-minute warning echoes from the loudspeakers. Again, the test stand and engine will be cooled and the steam generators will generate a vacuum. Today's test will end as soon as the Vinci engine is ready for a third ignition. Shortly before the steam generators are supposed to start, a message from the neighbouring control room comes through the headphones: "We have a problem with the tank pressurisation." The options are clear: The steam generator team could leave the control room once again and fix the problem on site. But that would prolong the current coast phase. And it is not certain that the steam generators will run. The test director nods briefly and decides with the client: The free-flight phase will be simulated as planned – should the steam generator not run, this would not be decisive for the desired measurement data. Finally, the last warning – the one-minute warning – inundates the site. And the hissing of the steam generators starts again. "Well, it is working as planned after all," murmurs Ralf Hupertz.

Measurement data for the future

Felix Löhr, who is responsible for running of the automatic sequences, looks at his screen. "LH2 is already cold." In the chronology, Manuel Müller is almost on the last page, checking off items, one by one. "LOX has met two of three cooling criteria." When the liquid oxygen has also reached the prescribed temperature, Stefan Grunwald looks up. "OK, then the test ends here." The noise of the steam generators subsides. At 17:18, the main test run is complete. All that remains is the decommissioning of the individual test stand systems as well as the reconditioning of the engine, which will take another 1.5 hours.

Thousands of measurement values will be analysed and evaluated on the following day. 'After the test' is immediately 'before the test' because each result flows into the next test run. A new Vinci engine is expected to be installed in the test stand in December 2016 – one that will be very similar to the engine that the Ariane 6 will launch with in 2020. The changes that come from the tested development engine will be based mainly on one thing: today's results from the DLR P4.1 test stand.

EUROPEAN LAUNCH VEHICLE OF THE FUTURE

The Ariane 6 development programme was approved at the ESA Council meeting at ministerial level in December 2014 and signed by 12 participating states. Studies conducted in the run-up to the conference had shown that, on the basis of previous experience with the existing Ariane 5 and the development work on the Ariane 5ME, the prerequisites for implementing a viable launcher concept are fulfilled. By combining these existing building blocks and the development of further elements, it is possible to fully develop the Ariane 6 in just five years.

The carrier configuration of the new Ariane 6 uses the fuel combination of liquid hydrogen and liquid oxygen in both the lower and upper stages. The new lower stage is based on the 'old' lower stage of the Ariane 5, but has been improved technologically and has been cost-optimised. As a transitional step, a modification of the new upper stage already designed for the Ariane 5ME will be used with the re-ignitable Vinci engine. Depending on the configuration, the Ariane 6 can transport five or 11 tons of payload into Geostationary Transfer Orbit (GTO). It will be equipped with either two or four solid rocket boosters. The first launch of the 70-metre-long rocket is scheduled for 2020. The French-German company Airbus Safran Launchers (ASL) was commissioned by ESA to develop the Ariane 6.

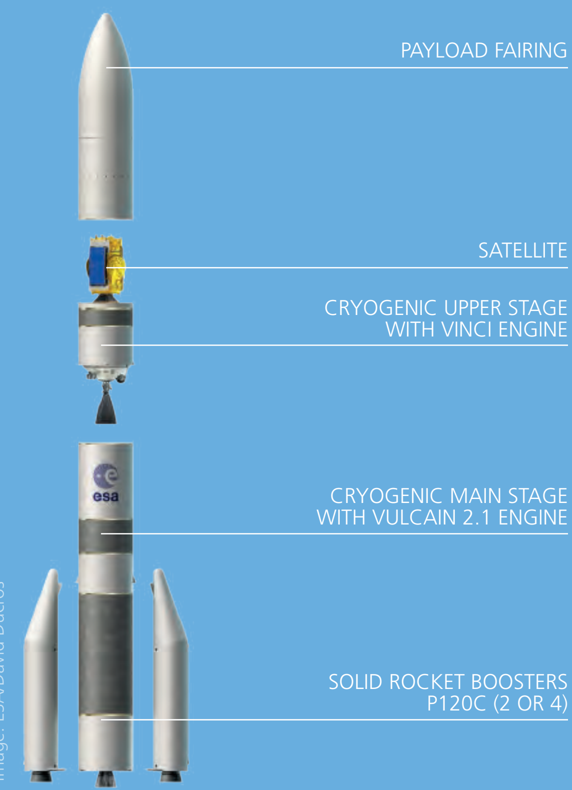


Image: ESA/David Ducros

CAUGHT IN THE NET

No landing gear for lighter solar aircraft

By Fabian Locher

The howling wind whips treetops into a frenzy at a small airfield in the midst of idyllic Bavaria. Clouds come together and part above a lush green meadow surrounded by pine-clad hills in the Lower Allgäu. Out of the blue, a car appears on the runway, driving at approximately 80 kilometres per hour – a four by five-metre net strapped to its roof. A humming drone flies just two metres above, slowly descending toward it. The end of the runway is fast approaching, while the wind batters the car and drone from the side. Now almost directly over the net, the drone stops briefly, seeming to stand still in the air as the car races further. Then it drops safely into the net. The car comes to a screeching halt. The concentrated faces of the team now show relief. But what does this experiment have to do with solar aircraft? More than you might think ...

When ultralight is still too heavy

Ultralight solar aircraft flying at altitudes of more than 20 kilometres for months is still a distant dream. This altitude is twice as high as that of normal airliners but significantly lower than that of satellites. As 'pseudo-satellites,' they could fulfil similar tasks – but at substantially lower cost. They provide, for example, live situation reports in the event of disasters, replace failed communications networks, or collect data on climate change. The wingspan of these so-called HALE-UAV platforms (High Altitude Long Endurance Unmanned Aerial Vehicle) can have the wingspan of a conventional passenger aircraft while weighing just a few hundred kilograms. The space on the wings is used, among other things, to place the numerous solar cells, from which the aircraft draw their energy and charge their batteries for the night flight. But the platforms are still too heavy, so they are still unable to stay in the air long enough or be loaded with ample hardware and are still too vulnerable to wind and weather. They are, therefore, still not commercially attractive enough to replace or complement satellites.

Inspection before departure: Final system check-up before the drone is ready for take-off.

Complex electronics: The drone's software autonomously combines GPS data with the data from a camera. That makes the positioning more reliable.

Depending on the type of aircraft, the landing gear constitutes up to 10 percent of the take-off weight. But if this is removed from the configuration, the situation changes significantly – because less weight means more payload and longer flight time. The prospect of reusability of the systems is also a major incentive for commercial users. Unlike most satellites, which fly their orbits at high altitude, the HALE-UAV platforms fly much lower – and data could be transferred substantially faster and with less of a delay.

But it is not just the speed of data transmission that is important. The systems also fill in the so-called resolution gap between conventional aircraft and satellites – they are far enough from Earth to cover large areas, yet close enough to allow high resolutions. Also important is the high degree of flexibility they offer – unlike satellite systems, they are not bound to place and time by orbits and speeds. This makes them quickly deployable – a decisive advantage, especially in the event of catastrophes. These alone are good enough reasons to test the necessary technology on a smaller scale.

A different kind of landing

"When you do not have any landing gear, you have to come up with a different concept for landing," explains Tin Muskardin from the DLR Institute of Robotics and Mechatronics. "And that is exactly where we come in." But how do you land an aircraft without wheels? Or, to be more precise: How do you land an autonomous aircraft on an autonomous vehicle? Theoretically, the scientists already have the answers to these questions, which were developed within the scope of the European EC-SAFEMOBIL project. To test this in practice, the place to go was an airfield near Tussenhausen in the Swabian district of Lower Allgäu.

The equipment: an electric drone, two cars, a net measuring five by four metres in size and a van converted into a control centre equipped with monitors and electronics to keep an eye on the complex algorithms. The net is quickly mounted on the roof, and the drone made ready and taken to the runway. Once manually started, it autonomously flies a previously programmed waypoint pattern at a height of 100 metres. It flies a circuit over the airfield, and arrives once again at the start of the runway. There, the vehicle-driven net is ready and waiting.

Under the net, inside the car is Konstantin Kondak. He leads the Flying Robots group at the Robotics and Mechatronics Center (RMC). A screen mounted above the car radio shows him a crosshair. Even before the drone catches up with the car, the crosshair rockets upwards from the rest position. The car uses a mathematical model to estimate the start time of the acceleration phase. The driver does not know the exact location of the drone – he is merely the executive organ of the algorithm. This shows him whether he should go faster, slower, more to the left or more to the right. When the drone reaches the car, the speeds of the two systems match. The drone's systems and the car's software communicate with each other and continuously exchange data. The current position, course and speed are transmitted. The roboticist's algorithm compensates for delays in the data exchange, so that car and drone move completely in sync – at 80 kilometres per hour.

Ready, set, go!

The drone is quickly approaching. The landing begins. This manoeuvre consists of a sequence of stages. First, the drone starts to descend independently of the car. Within a few seconds, it drops from 100 metres to 20 metres. It continues to fly at low altitude, approaching the runway start. The car driver steps on the gas pedal – the cooperative phase begins. The car accelerates and matches the speed of the drone. Things start to get exciting when the drone reaches five metres altitude: In the final phase of flight, the so-called Landing Flare, the drone pulls its nose up slowly and gradually descends. The vertical speed decreases steadily. The drone is now flying centred over the landing platform. Both vehicles are synchronously racing along the runway at 80 kilometres per hour.

Safety pilot: According to the German Federal Aviation Office, a safety pilot must be within visual range during experiments with autonomous drones. The pilot must be able to take over manual control of the aircraft at any time.

Drone in the net – experiment successfully accomplished.

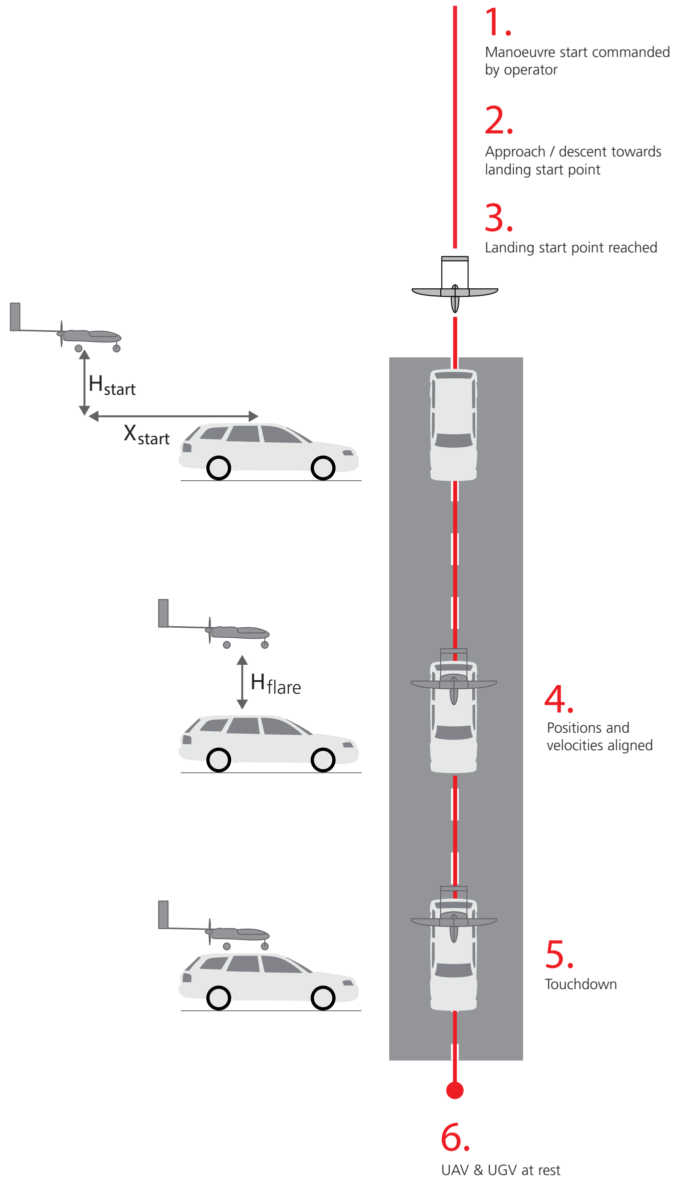
Finally, the last phase of the landing begins when the drone enters an assigned area in the airspace above the car. In addition to the GPS data, it scans the optical markers mounted on the roof of the car. By doing so, the drone increases its positioning reliability. If a gust of wind pushes the drone out of this 'landing cube' in the air, it will rise by a few metres automatically, correct its position and try to re-enter the critical area. The manoeuvre is repeated until it works and the drone is in the net – or the runway ends. If the car stops, the drone's system registers it and automatically aborts the manoeuvre. It climbs to 100 metres again, flies back to the beginning of the runway and reinitiates the manoeuvre.

Robotic cooperation

"The person in the car is simply an operating link between the machines," explains Muskardin, who led the flight tests. In a later application, this bridge will be completely eliminated. "In the future, an autonomous vehicle equipped with an intelligent landing platform could automatically pull out once it detects the approaching aircraft. Such equipment will also dynamically adjust to the height and orientation of the aircraft." Through the constant information exchange of the algorithms, the machines are able to 'align' themselves precisely. Thus, a landing with wind, rain and two very fast machines simply becomes an intelligent exchange of ones and zeros.

Landing without an undercarriage can also be applied to commercial aviation. The robotic technologies needed for this are being developed at the DLR Robotics and Mechatronics centre in Oberpfaffenhofen.

High-altitude platforms are still a dream in the distant future. The successful landing of an autonomous drone on a semi-autonomous car makes this dream a bit more real. "In five years, our communications could take place through ultralight solar platforms instead of via satellites," concludes Kondak. "We are working on having high-altitude platforms land safely back on Earth."



ALWAYS ALERT ON THE ETERNAL ICE

A nine-metre antenna and 35 containers partly hidden in ice and deep snow – that is GARS O'Higgins, the Antarctic station on the eternal ice.

The GARS O'Higgins Antarctic Station has been listening to satellite data for 25 years

By Manuela Braun

It happened on 24 September 1991. The German Antarctic Receiving station GARS O'Higgins received its first-ever satellite image; an image of the Coats Land region in Antarctica – with its structures, cracks and edges. And with this data from the ERS-1 Earth observation satellite, the Station began operating in the eternal ice 25 years ago. Since then, on the small Schmidt Peninsula, the 35 interconnected containers and the nine-metre antenna brave the temperatures and the squalls of Antarctica – and offer even the resident penguins welcome protection from the wind.

In the beginning, things were different – the Station was only occupied during the summer months when, at just minus one or two degrees Celsius, it was nice and warm – for Antarctic standards – and the Sun only made it completely below the horizon for a very short time at night. From October until well into March, small teams of four scientists, engineers and technicians lived and worked at the Station, where they cared for the operation of the satellite receivers. During the other months, O'Higgins was put into hibernation. The last person to leave turned off the lights and, once again, the Schmidt Peninsula became a bit more deserted.

365-day operation

"But mothballing the Station in March to then wake it up again six months later was tedious," recalls Station Director Erhard Diedrich, Head of the International Ground Segment at the DLR German Remote Sensing Data Center. In addition, more and more satellites began sending their data to the Antarctic station – not just the ERS-1 and ERS-2 radar satellites, but the German TerraSAR-X radar satellite, operated by DLR, also used the receiving antenna. When the TanDEM-X satellite was launched on 21 June 2010 to measure the Earth in formation flight with TerraSAR-X, the DLR Antarctic station began year-round operations.

Since then, a team in Antarctica ensures uninterrupted satellite reception every day of the year, sends commands to satellites, clears the snow from the container and antenna – from time to time – and has adapted to the seasons in the eternal ice. Whenever there is time, they read books, watch films or, in the summer, make an occasional visit to the scientists in the neighbouring Chilean station General Bernardo O'Higgins or eat together in the GARS station's small kitchen.

"We actually celebrate New Year's Eve twice," says Ruslan Artemenko, who completed the shift going into the New Year with three colleagues this year. "First at 20:00 with a small group." In Germany, at this time, the fireworks are firing and the champagne glasses are filled. Four hours later, the Antarctic team celebrates again. At exactly midnight, local time, they make a toast and have a meal with the team from the Chilean station. Fireworks are, however, forbidden in Antarctica – they could frighten the penguins breeding in their nests during the Antarctic summer. But New Year's greetings from Antarctica are possible: "Luckily, we are able to call home and speak with our family and friends."

Office amongst ice and penguins

Year-round operation is still a challenge: Positioning and control of the antenna had to be automated so that the small Station team could handle all of the tasks. New satellite communication links had to be established with Oberpfaffenhofen, and the Station was 'upgraded' so it could operate all year round. "The operational readiness of the team was strongly demanded, which was not always easy for the colleagues and their families," says Station Manager Robert Metzig, who has often worked in Antarctica for months at a time. "With the change of our team also during the winter, the logistical cooperation with our Chilean and Brazilian partners had to be expanded." But the switch to year-round operation has worked well. "We are noticing that more and more satellite missions are asking for the support of our ground station in Antarctica," he continues.

Thousands of data packets

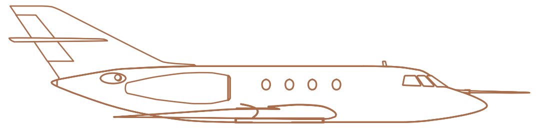
The German FireBIRD mission, with the TET-1 and BIROS satellites, transmits its data to the receiving station on the Schmidt Peninsula. And the German-US GRACE mission and the Canadian Cassiope and NEOSSat missions rely on O'Higgins to command their satellites and transmit their valuable data from space to Earth. More than a third of the data for the now-completed global 3D elevation model of Earth by the TanDEM-X mission was received at GARS O'Higgins. The team at the Antarctic station is, for example, in contact with the TerraSAR-X radar satellite up to 2700 times per year – and up to 2600 times with TanDEM-X.

The overall performance of the past 25 years is telling. For satellites in space, the GARS O'Higgins station is all but a secluded, unworldly place: The nine-metre antenna on the Schmidt Peninsula has already received data packets tens of thousands of times from space.

Work station of the DLR scientists in one of the 35 interconnected containers of the Antarctic station GARS O'Higgins

Image: DLR/Valerian Hahn

SOMETHING IN THE AIR… OVER TOGO



With the Falcon in West Africa – on the lookout for atmospheric pollution in a changing region

By Fabian Locher

Welcome to West Africa! Where the dusty Saharan wind from the north meets the wet monsoon from the ocean; where the air is filled with the aftermath of burnt waste, rattling motorcycles and countless small charcoal fires, mixed with the emissions from power plants, shipping and offshore oil platforms; where forest areas are converted into agricultural land without regulations, and where the megacities of the future are emerging as a result of a great growth in population and rapid urbanisation. But, what are the consequences of these changes for the air in this region? How do they affect the composition of the atmosphere? How does all this alter the weather and climate? How do these changes affect human health and nature?

To answer these questions, scientists from the DLR Institute of Atmospheric Physics are investigating how the emissions from pollution sources in the region are influencing the properties of clouds. On board the DLR Falcon research aircraft, they flew from the Togolese capital, Lomé – through stratus clouds and over major cities, tankers and oil rigs – to determine the chemical composition of the air and gain insight into the microphysics of the clouds in this polluted region. The data acquired is helping to improve climate models and weather forecasts and better assess the consequences of change in the region – the basis for a sustainable development policy.

THE DACCIWA PROJECT

Within the EU DACCIWA (Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa) project, coordinated by the Karlsruhe Institute of Technology (KIT), scientists are investigating the connection between the weather influences, climate change and air pollution on the West African coast. With coordinated ground and airborne measurements, the scientists are, for the first time, exploring the entire chain of effects of natural and anthropogenic emissions on the atmosphere. During June and July 2016, they were on site with three research aircraft. In addition, they constructed three instrumented ground stations inland. From there, the project partner researchers launched weather balloons and small, uncrewed aircraft several times a day to collect data and take measurements. In addition, colleagues from KIT have created a register of urban emissions and evaluated health data. The five-year project is thus creating the basis for more accurate climate, weather and air quality models that will enable a sustainable development policy. The European Union is funding the project with approximately 8.75 million euro as part of its 7th Framework Programme. Sixteen international research institutions from Germany, Switzerland, France, Great Britain, Ghana, Nigeria and other African partners from Benin and Ivory Coast are involved in the project.

A complex cocktail in multiple cloud layers

Looking at the weather map, the satellite image shows a thick layer of clouds above Ivory Coast, Ghana, Benin, Togo and Nigeria. Even more cloud cover lies below this top layer – hidden from the view of satellites from space. Thin stratus clouds regularly form just 200 to 600 metres above the West African coast. This cloud layer is well suited for investigating the influence of particles in the atmosphere – namely, aerosols – on the climate-relevant properties of clouds. The origin of these aerosols can be either natural – originating from sea salt or fine sand – or may be anthropogenic, generated by, for example charcoal fires or urban pollution gases.

One of the greatest challenges of atmospheric research is to find out how aerosols affect cloud formation and their radiative properties. One thing is certain – they are of relevance to the climate. They propagate in the atmosphere and influence clouds at different heights. Aviation and shipping produce aerosols. In particular, the influence of sulphur-containing aerosols – those that form from the sulphur present in fuels – is still poorly understood. According to numerical modelling, these sulphate aerosols exert a cooling effect on the atmosphere and thus counteract global warming. "With our measurement flights in West Africa, we are able to study the impact of aerosols on cloud properties. In this way, we can contribute to the understanding of this process and are able to develop resilient models," explains Hans Schlager, DLR Project Manager for the measurement campaign in the EU DACCIWA (Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa) project.

To track the highly complex interactions between aerosols and cloud properties, the scientists can take advantage of the conditions at the West African coastline, which has areas with varying degrees of aerosol pollution and areas with different levels of anthropogenic and natural aerosols. The properties of the stratus clouds that form along the entire coast of West Africa can be related to the different aerosols. Beforehand, the scientists used dispersion models to calculate the spread of emission gases from various sources, which extend like a plume up to 300 kilometres wide across the West African mainland. The pollution plumes from the major coastal cities of Accra, Abidjan, Lomé and Cotonou extend from the coast across the mainland, over forests and agricultural land, as far as the Sahel region.

On the hunt for clouds and pollution plumes

Scientists conducted numerous measurement flights between June and July 2016 on board the Falcon 20E research aircraft. To achieve this, pilots from the DLR Flight Experiments Facility in Oberpfaffenhofen flew the Falcon under, over and right through the cloud layers. The highly modified aircraft – a former business jet – is well equipped for this type of cloud hunting mission. Using laser technology, which

EMISSIONS COCKTAIL OVER TOGO

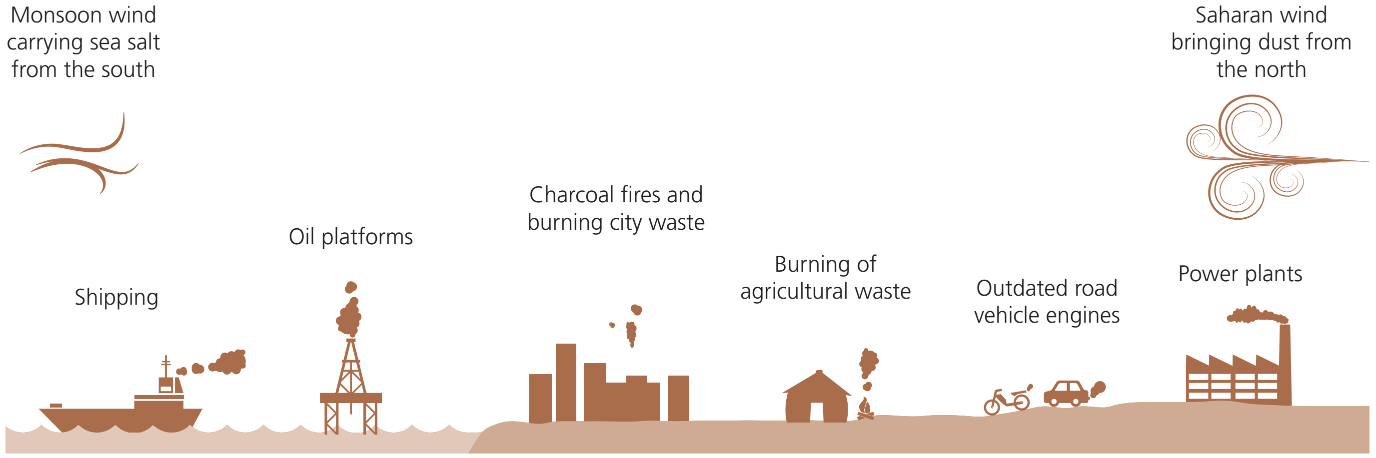
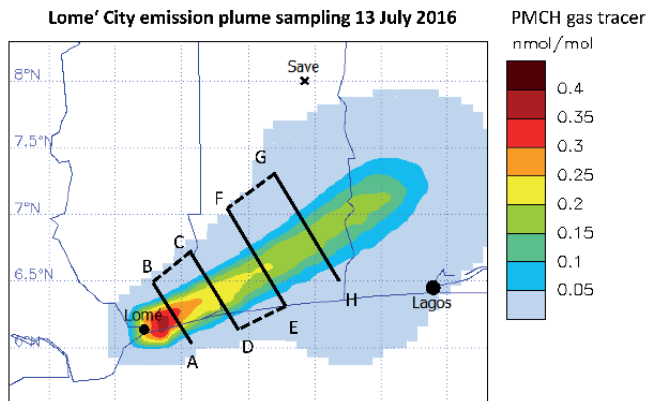


Image: DLR/Valerian Hahn

The measurement systems installed under the wings of the Falcon determine particle concentrations, liquid water and ice content, as well as the degree of attenuation of light in the clouds. Aerosol particles are also captured, enabling the scientists to, in combination with the data from other particle measurement instruments on board, derive the microphysical and optical properties of aerosols and clouds.

Image: DLR/Valerian Hahn

The Falcon can carry up to 1100 kilograms of scientific instruments. It was tightly packed for the measurement flights over West Africa.



Prediction of the emissions plume from Lomé for the measurement flight on 13 July 2016, together with the Falcon's measurement route. Shown in colour are the concentrations of non-atmospheric gases that were released in Lomé prior to the measurement flight, to enable tracking of the exhaust gas plume.

Image: DLR/Valerian Hahn

Cloud layers regularly form at low altitudes above the cities on the West African coast. Their influence on weather and climate is the subject of the EU DACCIWA research project.

is accommodated in external attachments under the wings, the scientists are able to measure the size and number of droplets in a cloud. Conclusions can be made about the microphysical properties of the clouds in the subsequent analysis.

Withstanding the 40 degrees Celsius inside the aircraft cabin, the DLR researchers and project partners from the Max Planck Institute for Chemistry in Mainz and the French National Centre for Scientific Research (Centre National de la Recherche Scientifique; CNRS) in Orléans monitored the data from the aerosol mass spectrometer and laser measuring devices installed on the Falcon. "With our instruments, we can characterise the number of particles in the atmosphere and their chemical composition. In this way, we are able to understand the influence of the measured air pollution on the cloud properties," explains Schlager, who heads the Atmospheric Trace Species Department at the DLR Institute of Atmospheric Physics in Oberpfaffenhofen. To obtain the most accurate data on the emissions, the pilots flew the Falcon close to the sources of the pollution plumes. Following the airflow, the scientists investigated how the plumes disperse and what kind of chemical and particle processes take place there. In doing so, it is possible to determine the effect of various aerosols on different types of clouds.

The DLR Falcon measurement flights through the tropical air were carried out with two other research aircraft from European project partners – a Twin Otter propeller aircraft from the British Antarctic Survey and the ATR 42 from the Service des Avions Français Instrumentés pour la Recherche en Environnement (French Airborne Environment Research Service; SAFIRE), an association of the French CNRS, Météo-France and CNES research institutions. While each aircraft played to its respective strength – whether altitude, range or endurance – all were equipped with similar instruments that allowed for a common set of data to be generated.

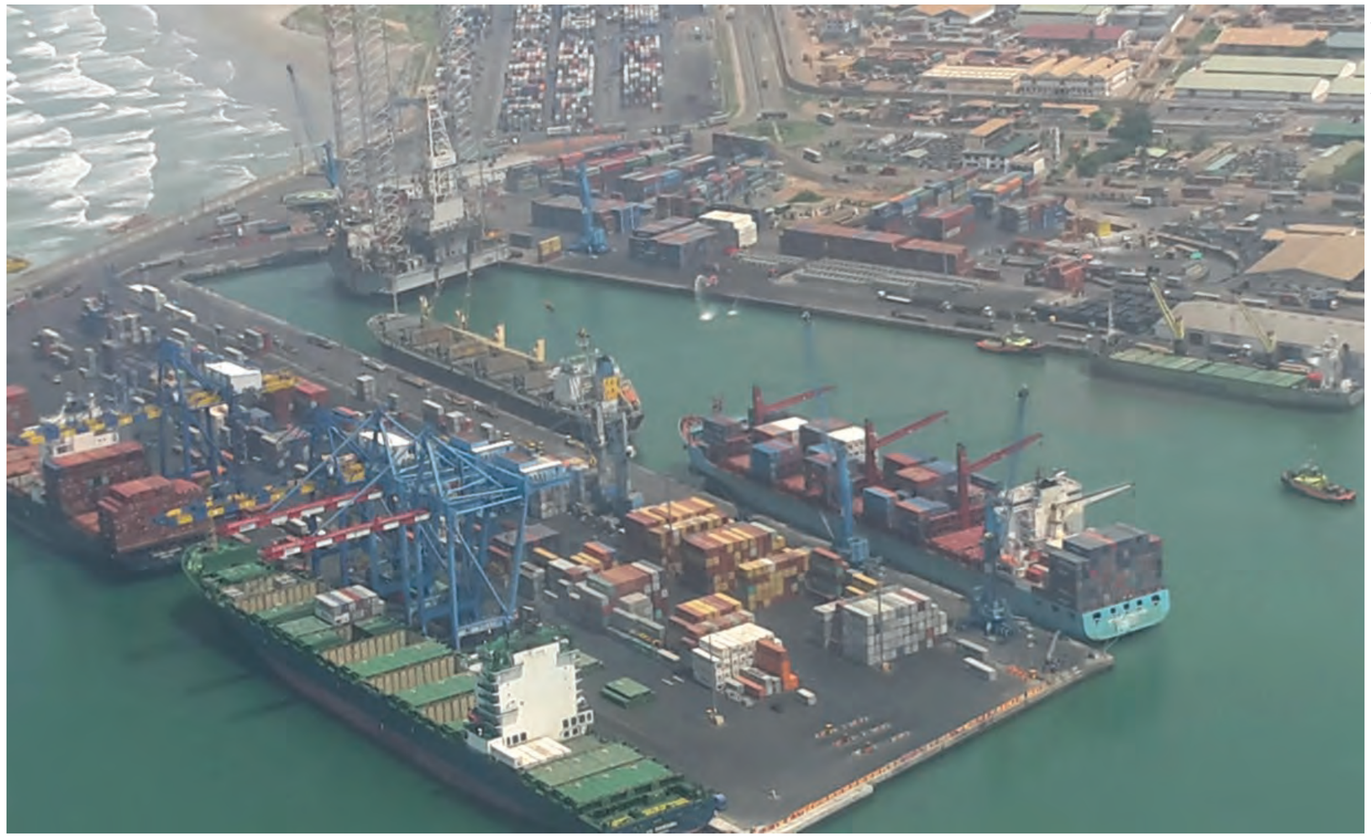


Image: DLR/Valerian Hahn

Air pollution is a growing problem for the West African coastal cities

Surprising first finds

Initial analyses of the data acquired suggest that, in addition to sulphate aerosols, a high fraction of other aerosols is also present: "Contrary to our expectations, the pollution plumes also contained a high fraction of organic particles," notes Schlager. These are produced as a result of the burning of refuse, agricultural waste and charcoal at low temperature and high humidity. "We still have to find out during the detailed data analysis how the various particles affect the chemistry, dynamics, clouds and radiation balance of the atmosphere."

Until 2018, the DACCIWA project will study the interactions between aerosols and clouds and the impact on the radiation balance of the atmosphere. "Once we have evaluated the data, our findings will be used to improve climate and weather models. Together with the project partners, we will then be able to make more reliable forecasts for West Africa – one of the regions that will be most affected by global climate change," Schlager says, taking a look into the future.

The three research aircraft participating in the measurement programme in Togo (from left to right): the Falcon 20E (DLR), the Twin Otter (BAS) from Great Britain and the ATR 42 (SAFIRE) from France.

Image: DLR/Valerian Hahn

A TYPICAL DAY OF FLIGHT PROGRAMME

Scheduled take-off: 08:30

04:00 Technicians start the Ground Power Unit (GPU) to supply the Falcon with power. Scientists prepare the instruments on board the Falcon.

06:00 The weather forecast from the previous day is compared with the present data; where needed, the flight plan is adjusted.

07:00 Two pilots, a mechanic, a flight operations manager and three scientists arrive at the airport.

07:00 – 07:30 The mechanic begins conducting the pre-flight inspection, checks oil levels and inspects the external attachments and modifications. The scientists check that the measuring equipment is functioning.

07:30 – 08:00 The pilots begin their pre-flight checks; they examine critical points, inspect the aircraft for visible defects and check the brake pads and tyre profiles. The flight operations manager informs the control tower about the flight schedule with details of the aircraft and the planned route. The scientists perform final preparation of the instruments.

08:00 The GPU is disconnected. The scientific instruments are powered down. The Falcon is towed out of the hangar onto the apron.

08:05 The Falcon is on the apron. The pilots enter the flight deck. The Auxiliary Power Unit (APU) is started. The APU supplies the aircraft, including the scientific equipment, with power and cool air.

08:10 The pilots start working through the pre-flight checklist. The scientists switch the instruments to flight mode. Those not taking part in the flight exit the Falcon.

08:15 The operations manager sends the latest information from the control tower to the pilots; this includes recent changes, information about active restricted areas and the latest weather forecast.

08:20 The pilots contact the control tower by radio and ask for permission to start the engines. They also carry out further checkss.

08:25 Taxi to the runway.

08:30 Take-off.

08:30 – 12:00 Measurement flights at various altitudes, depending on the daily objective and mission.

12:00 Landing.

12:10 Taxi for refuelling.

12:30 The Falcon is towed into the hangar.

12:40 The mechanic starts the post-flight checks and hands the Falcon over to the technician in charge of the measurement and sensor technology to reconnect the power supply.

12:45 – 17:00 The GPU is connected. The scientific data collected during the measurement flight is transferred, and the scientific equipment is recalibrated.

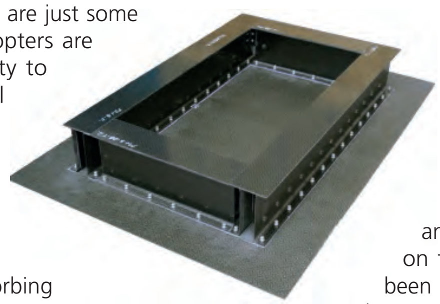
17:00 Power off – flight day is over.

'CRUMPLE ZONES' FOR HELICOPTERS

DLR researchers are developing structures that absorb as much energy as possible in the event of a crash

By Nicole Waibel

Mountain and sea rescue operations, medical emergency and police deployments, fighting forest fires, and load transport in high mountain regions: these are just some of the extreme situations in which helicopters are used. However, rugged terrain, proximity to ground, water or buildings, and critical wind and weather conditions make it difficult to operate in and out of the air and increase the risk of accidents. With active safety systems that assist pilots, such hazards can be avoided. In the event of a crash, passive safety systems, such as belts and energy-absorbing seats, minimise the consequences for the occupants. Improving the crashworthiness even further is the focus of researchers at the DLR Institute of Structures and Design in Stuttgart. "We are developing lightweight composite structures that, in the event of a crash, reduce the accelerations acting on the occupants. The term 'crumple zone' is familiar from the automotive sector – it deforms on impact, thus absorbing some of the energy," explains Marius Lützenburger, who is responsible for helicopter crash safety in the Department of Structural Integrity.



Experiments complement virtual testing

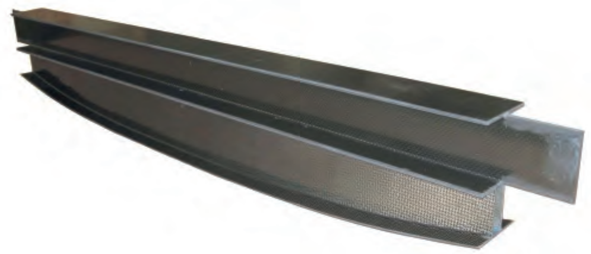
Simulations are a major element in the development of these energy-absorbing components. "Real crash tests are expensive and complex. On the computer, we are able to reconstruct accident scenarios and expose structures to loads as they occur in reality. Virtual tests demonstrate the crash behaviour even before the real test is conducted, which reduces costs and development times," Lützenburger says, summarising the advantages of the simulation. Nevertheless, real experiments are indispensable for creating a database as well as for verifying and refining computer simulation models. The simulation is then compared with the test results. "In our drop tower, we are able to test structural components up to a certain size." Very few crash tests have been carried out thus far worldwide using complete aircraft or helicopters due to high experimental and financial effort.

In October 2014, NASA conducted a crash test with the airframe of a former U.S. Marine transport helicopter. The test was conducted at NASA Langley Research Center, as part of the NASA Transport Rotorcraft Airframe Crash Testbed (TRACT) programme. "This is where Neil Armstrong once practised landing on the lunar surface," Lützenburger explains. "One test objective was to study how effective composite subfloors absorb the impact energy. For this purpose, three metallic subfloors were replaced with different composite subfloor structures, one of which was jointly developed by DLR and the Australian Cooperative Research Centre for Advanced Composite Structures (CRC-ACS). In this concept, a very rigid transverse beam was combined with a 'softer' structure underneath. This structural zone is intended to absorb the impact energy and thus reduce the vertical accelerations acting on the occupants. "The concept had previously been demonstrated in purely vertical tests," Lützenburger says. "In the NASA test, a high forward speed was also added." The 13-metre-long airframe of the CH-46E Sea Knight Helicopter was swung to the ground from a height of more than nine metres using steel cables. In order to simulate free flight conditions all the cables were pyrotechnically separated from the aircraft right before impact. At a speed of about 45 kilometres per hour, the fuselage weighing more than 4.7 tons impacted onto the soft ground (a mixture of sand and clay), coming to a standstill after just a little more than one metre. The abrupt stop generated very high longitudinal accelerations. The result – on the helicopter's underside, the fuselage skin ruptured and the transverse beams sheared longitudinally.

Image sequence: NASA

Scientists study the helicopter fuselage after the impact
Right: sequence from the TRACT2 crash test

With the help of high-speed cameras each of the more than 8000 black dots painted on the helicopter skin could be tracked and the deformation of the fuselage analysed



Composite structure installed in the subfloor of the helicopter (upper picture), replacing the original metallic subfloor.

The newly developed Multi-Terrain Crash Test Demonstrator (component on the left side) is designed to mitigate the impact on water as well as on hard and soft ground.

Protection in soft soil impacts

"Through windows that were cut into the floor panels and filled with polycarbonate, high-speed cameras filmed the behaviour of the subfloors during the impact," Lützenburger says, describing the experimental setup. Approximately 40 cameras recorded every move of the fuselage and its 15 occupant dummies. The evaluation of the test shows that the researchers must now focus even more on the more complex impact scenarios involving both soft impact surfaces and an additional forward speed. DLR scientists are currently working with partners from New Zealand and Australia on an energy-absorbing structure designed to provide the smoothest possible impact on water as well as on hard and soft ground. "Soft ground particularly presents us with difficulties here. Due to the soft nature of the soil, the 'crumple zones' provided in the structure are not always activated; 'ploughing' and higher accelerations are the result." This explains why motorways are occasionally used for small aircraft emergency landings. "They are simply better suited than a soft field."

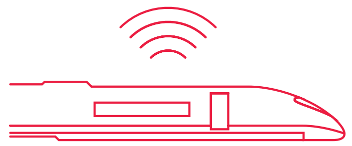
Nicole Waibel is responsible for public relations at the DLR Institute of Structures and Design.

Image: NASA (1969)

At NASA Langley Research Center, Neil Armstrong once practised landing on the Moon's surface.

Image: DLR/Henrik Frensch

HIGH-SPEED CHASE FOR SIGNALS



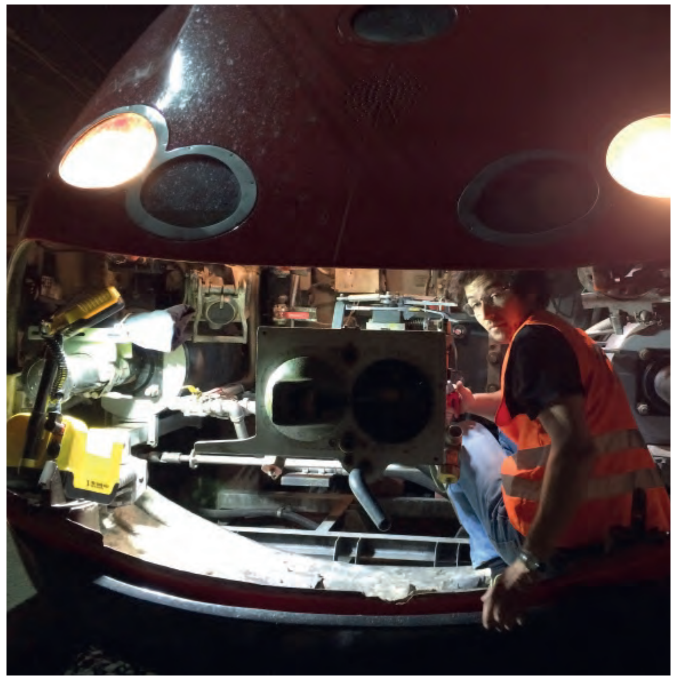
Report from a nocturnal measurement campaign in the Italian express train Frecciarossa

By Julia Heil

It is 23:00, and the train depot in Naples is bathed in yellow light. A deafening hissing sound fills the air as a train pulls into the depot and slowly comes to a halt. Two tracks ahead, a spotlight in the ballast of the track bed illuminates the open front of a railcar. It is an unusual sight: Paul Unterhuber, a researcher from the DLR Institute of Communications and Navigation, is sitting in the train's nose, mounting a measurement antenna and a distance radar. Highly concentrated, he connects the individual units: the red cable with the blue, the green with the brown – a meticulous job where caution is advised. Excessive bending of the cables could lead to problems during the measurement campaign that Unterhuber is leading. The rest of the train is a hive of activity: laptops are set up, cables are passed to and fro and the ceiling panels are removed to connect additional antennas. "I need some help here at the front again! We have to hurry a bit if we want to meet train 28 at the station on time," calls Unterhuber to the front car.

Image: RDLR/Henrik Frensch

The two Frecciarossa high-speed trains are 328 metres long and can travel at speeds of up to 360 kilometres per hour. In their noses, the scientists installed measurement antennas and a proximity radar to accurately determine the distance between the two trains and exchange information between them.



The work in the train nose demands dexterity and physical exertion from Paul Unterhuber.

Like number 7, in whose nose the antenna for the radio channel characterisation has just been mounted, number 28 is also an Italian high-speed train – a Frecciarossa (Red Arrow). Tonight, these two trains are neither occupied by passengers nor waiting to be cleaned in the depot, which would be more usual at this time of day – they are occupied by an 11-person team from the DLR Institute of Communications and Navigation. The scientists are using the two high-speed trains to study train-to-train communication during their journey. The high-speed line between Rome and Naples provides the team with 206 kilometres of track to conduct investigations during nocturnal test runs. The researchers want to find out how the exchange of information between two trains travelling at full speed can be made reliable enough for train control purposes. In preparation for the measurements, Unterhuber travelled to Naples and Vicenza beforehand and equipped the measurement trains: four antennas on the roof of train number 28, two antennas on train number 7 and no less than 150 metres of measuring cable straight through carriages and locomotives. Five more antennas have to be installed tonight.

Unterhuber is now working in the open train nose and is making a telephone call. At the other end is Stephan Sand, Leader of the Vehicular Applications Research Group at the Institute of Communications and Navigation and team leader of the research campaign. While Unterhuber has taken care of the last installations in train 7, Sand has been making sure that train 28 is ready as quickly as possible. “We are ready. See you in the station soon,” says Unterhuber into the phone. And minutes later, the train slowly begins to move.

Signal interference after midnight

With 50 million travellers per year, Naples Central Station is one of the most important railway stations in Italy. When the two trains arrive at around 01:00, the station is almost at a standstill – a few passengers are still travelling and a crew is dutifully cleaning the platforms. The scientists are in a hurry, as every minute in the station is one minute less of measurement time. And at the starting signal everyone must be sitting in the right train. Equipment is exchanged between trains – with a length of 328 metres each, this is a time-consuming affair. The transmitting and receiving units are being calibrated inside the passenger cars. Everyone sits concentrated by their instruments. Michael Walter, Wei Wang and Thomas Jost lean over a large box, the so-called Channel Sounder. Walter is suddenly concerned: “I hear a clicking noise – not a good sign!”

Using the Channel Sounder, the scientists want to accurately characterise the transmission channel between the two trains. A pulse with a bandwidth of 120 MHz is emitted by the transmitter unit at 5.2 GHz and reaches the receiver unit, which is located on the other train. Based on the signals, the scientists can make predictions about how a particular environment affects the transmission signal. A model for the radio channel is created using the results of the measurements. Based on this, communications systems with which trains can exchange information while moving will be developed in the future. Tunnels, bridges, forests – they should all be identifiable in the received signal. Yesterday, when the team carried out measurements in a single train, everything worked flawlessly. Today, however, there are problems with the calibration – the scientists are receiving signals that do not fit into the scheme.

Several colleagues have now gathered around the measuring equipment and are trying out various solutions – still, the scientists are receiving signals that they cannot explain. Meanwhile, the two trains are somewhere between Naples and Rome, and time is running out.

Finally, Unterhuber draws the line: “If we don’t succeed by three o’clock, then we will only measure with the other instruments. We have to get going and should not lose any more time.”

At 03:00, with persistent calibration issues, the train starts moving.

Michael Walter, Wei Wang and Thomas Jost begin packing up the equipment. Disappointment is spreading. Tonight has, at least for the measurements with the Channel Sounder, been a lost cause. But the tight schedule no longer allows further troubleshooting. Tomorrow, the scientists will spend several hours meticulously checking every connection and every cable to find the fault. The overhead line most likely caused the disturbances in the signal. Over the next two nights, the team will achieve good measurement results with the Channel Sounder and will be able to precisely characterise the radio channel between the two moving high-speed trains. Tonight, however, everybody is none the wiser. Therefore, the three scientists cannot but take a short break after everything has been stowed away – the night is still not over. Now, Paul Unterhuber finally has a little time to eat a slice of his pizza, which sadly went cold a long time ago.

Collision avoidance at high speed

A different picture presents itself when you look back: In the driver’s cab at the back of the train, Thomas Strang’s gaze is directed towards a small laptop monitor, with a telephone in one hand and a radio within reach. “220 kilometres per hour – maintain speed,” he speaks into the handset. He is talking to the driver at the front while maintaining contact with his colleague Andreas Lehner in the train that is following them. Strang looks out the window – the lights at the edge of the track seem to fly past. There is no sign of train number 28. But it is not far away. Strang points to his laptop, which displays the data from the Railway Collision Avoidance System (RCAS): “I can see the other train here. At the moment, we are about 10 kilometres apart. But it is steadily catching up and we should be able to see it soon.” Indeed, a short time later, lights appear from around a curve announcing the approach of the moving train.

The RCAS system installed in the two high-speed measurement trains is continuously recording relevant parameters such as position, route, speed and braking power. This information is transmitted to all trains in the vicinity. While travelling, the system compares its own parameters with those of the other trains. The exact knowledge and comparison of parameters make it possible to quickly identify potential conflict situations. Another advantage of the system is with regard to line occupancy – currently, the track sections between two trains are always calculated using the maximum braking distance required. If there is a train in a particular section of the track, the train that follows must keep a distance of up to 10 kilometres. With the RCAS system, tracks could be used more efficiently in future because the braking distance can be accurately determined at any time.

In a brightly lit tunnel, the two ‘red arrows’ have finally drawn level at a speed of approximately 250 kilometres per hour. When passing, Sand, who controls the measurements in train number 28, can be seen through the windows of the front carriage. Strang directs the overtaking manoeuvre: “Increase speed, yes, that is good. The others are travelling at 230 kilometres per hour, so we will keep our speed at 250 and move steadily past them.” His system is working flawlessly – even at high speed. His face glows with pride: “We are doing RCAS at 250

THE PROJECT

For four nights, the DLR researchers investigated wireless train-to-train communication in and between two high-speed trains in Italy. The Italian partner Trenitalia made two Frecciarossa high-speed trains available to them. The measurements were carried out as part of the EU Roll2Rail project on the high-speed line between Rome and Naples. The measurements in Italy were carried out as part of the European Union (EU) Roll2Rail project. Roll2Rail is one of the lighthouse projects of Shift2Rail within the Horizon 2020 programme. Thirty-one European partners are working on the development of key technologies, increasing reliability in the railway sector and reducing costs. The Roll2Rail project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 636032. The project is closely connected to the DLR Next Generation Train project.

Image: DLR/Henrik Frensch

The Channel Sounder consists of a transmitter and a receiver unit. The receiver reveals how the radio signal is reflected by the environment.

kilometres per hour – this has never been done!" On the last night of measurements, the team will even exceed this record on an intersecting trip at a relative 560 kilometres per hour – and then, too, the system will work to perfection.

Radio link saves changing trains

In addition to the RCAS system, with the ITS-G5 (Intelligent Transportation System at 5 GHz), the DLR scientists have yet another system on board for exchanging information between trains. It is designed for the high-rate exchange of information, and was originally developed for road vehicles. It works like the RCAS system, without having to rely on cell towers or other components along the way – but so far only over short distances. While the RCAS system can still receive a signal at a distance of up to nearly 40 kilometres, the ITS-G5 tends to lose the connection after approximately 1.2 kilometres.

With the measurements from the ITS-G5, the researchers want to lay the foundations for the so-called dynamic coupling of high-speed trains. In this manoeuvre, which is also called virtual coupling, the trains will automatically connect while moving to form a longer train and can also separate into individual trains again. The trains travel one after the other, only connected over a wireless communication link. The closer the railway vehicles are, the more precisely they must exchange information about their position and speed. This is the only way to adapt to each other and behave as a single, long train. The advantage of this is that passengers can reach their destinations without changing trains. Time-consuming coupling and uncoupling manoeuvres in stations are also avoided. In addition, the capacity limits of the routes can be increased with the dynamic coupling.

Train 28 overtakes train 7 several more times and drops back again immediately. Dawn is breaking, but most of the nocturnal researchers are unaware. Their only focus is their measurement instruments. When the two Frecciarossas make it back to the depot in Naples, the Sun is rising. The instruments are carried out of the carriages and the cleaning crew boards the trains and gets to work.

After their night as a communication laboratory, it is time for the two Red Arrows to do what they always do: transport passengers. For the scientists, however, it is now time to go back to the hotel and sleep…

Just before the start of the campaign, Stephan Sand from DLR and Maurizio d'Atri from Trenitalia complete the last formalities.

Care must be taken when the sensitive Channel Sounder is pushed into the train carriage.

THE CHANNEL SOUNDER: 15 YEARS OF SIGNAL ANALYSIS

In the development of new communication systems, it is important to know and capture the radio channel between the transmitter and receiver as accurately as possible. The better a channel can be understood and defined, the more accurately the transmitter and receiver can be attuned to the environment. The so-called Channel Sounder is used to characterise the radio channels.

A signal that is broadcast from a transmitter undergoes reflections from the environment before it reaches the receiver. In the vicinity of a train travelling at high speed through a tunnel, the signal is reflected differently than that of a satellite radio link to a receiver in a wooded area. Such reflections and other effects such as diffraction cause signal distortions. Since the transmission signal from the Channel Sounder is known, the scientists can accurately measure the signal distortions that the transmitted signal experiences on its way through the radio channel.

The nature of the ground that reflects the signals from navigation satellites also plays a role in the behaviour of the signal. From 2014 to 2015, various measurements were carried out by a team of scientists, which mounted the Channel Sounder transmitter and receiver on two 40-metre high cranes. The properties of the asphalt of a runway, of water and of an ice-covered lake were measured.

All the same, whether it comes to future communication systems or whether new applications are being designed, without the Channel Sounder, communication would be a shot in the dark. With today's navigation systems, such as Galileo and GPS (Global Positioning System), it is currently not possible to make precision positioning inside buildings. The measurements with the Channel Sounder should change this. In 2008, the scientists succeeded in characterising the transmission channel of a simulated navigation satellite to an improvised pedestrian inside a building using the Sounder.

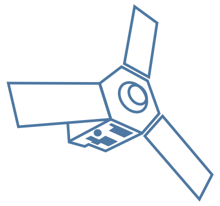
In addition to measurements for systems such as Galileo and GPS, the Channel Sounder is also used for the preparation of new communication systems. Scientists have investigated the communication channels from aircraft to aircraft (2009), from car to car (2013), and from ship to ship. While in 2014 measurements were carried out in the Baltic Sea in calm sea conditions, in 2016 DLR scientists investigated the reflections from the waves and the water around the island of Heligoland in the North Sea in gale force seven winds.

For 15 years, the Channel Sounder has been a proven measurement instrument for researchers at the DLR Institute of Communications and Navigation. In the Roll2Rail measurement programme in Italy in 2016 it proved its worth once again: scientists gathered valuable information about the characteristics of the radio channel in train-to-train communication.

In 2002, DLR researchers investigated the radio channel between a measurement bus and a Zeppelin using the Channel Sounder.

To measure the ground reflections of a radio signal emitted from an aircraft or a satellite, the scientists installed the Channel Sounder on a 40-metre-high crane during tests in 2014 and 2015.

COLOSSAL MOUNTAINS RIGHT BEFORE YOUR EYES



'Unseen Extremes' – 13 distinctive mountains in a new light

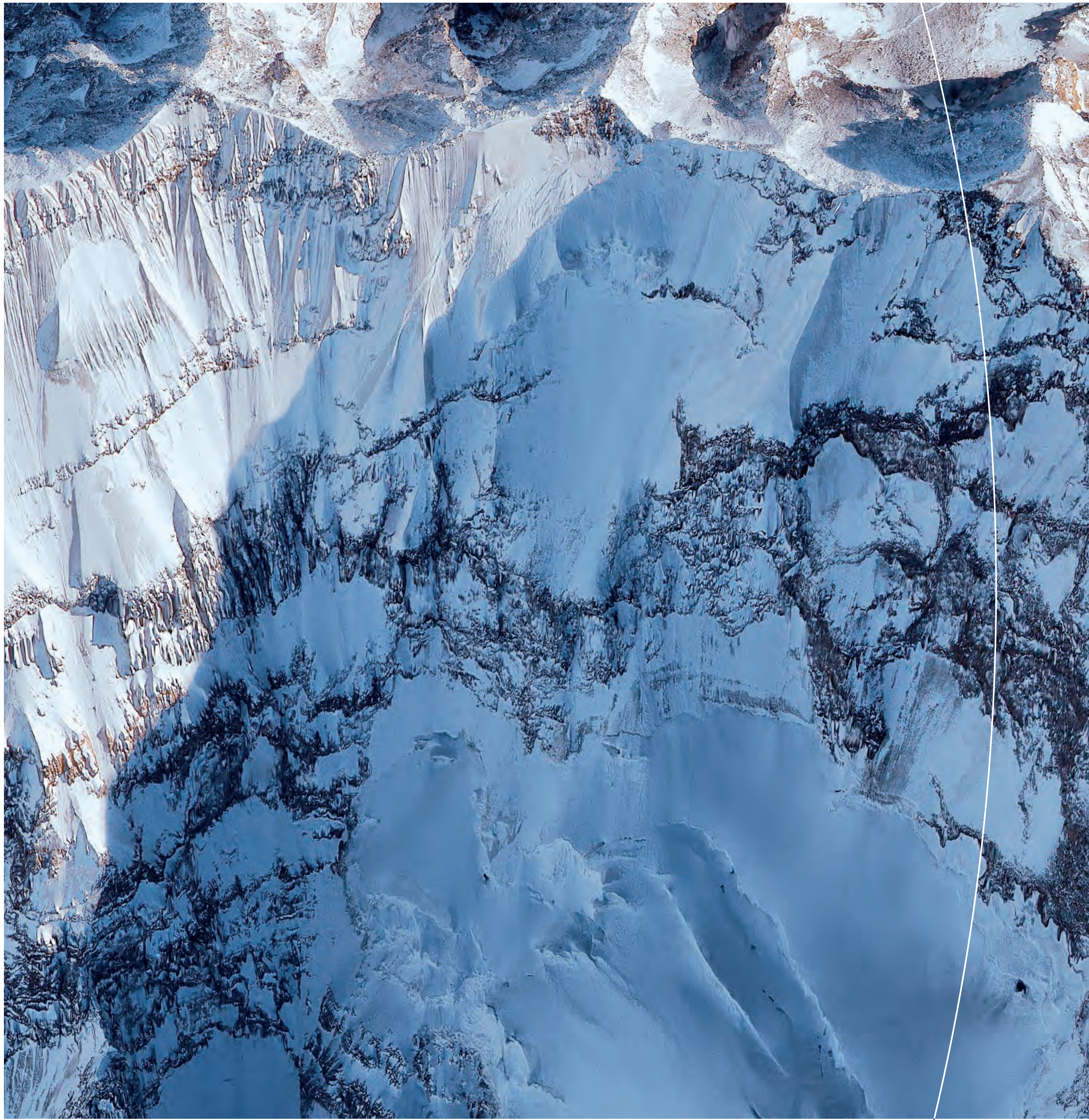
By Nils Sparwasser

Silently, the satellite soars through space. Deserts and mountain ranges, entire continents and oceans move incessantly beneath it. It passes the ice sheet of the North Pole, approaching the Karakorum just minutes later. Like a narrow white band, the vast mountains and peaks gleam in the midst of what is an otherwise ochre landscape. At its base, weather conditions are ideal – the clouds of the last few days have finally cleared.

It is the perfect day at Masherbrum, the last of 13 mountains to be imaged by satellites for the wealth of geographical, morphological, geological and climatic information they offer. These giants demand everything of those wanting to climb them – and they have also put the DLR Earth Observation Center to the test. For months, the Pleiades satellites have been imaging mountains around the world for DLR. The goal: high-resolution terrain models with unprecedented quality. The technology for this was developed at DLR. Photorealistic views from previously unimaginable perspectives were generated with this data. In the book 'Unseen Extremes', published by DLR, these images are brought together, making an up-close experience of the mountains possible.

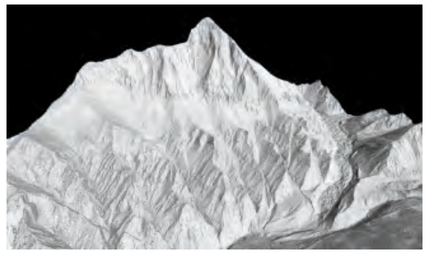
Until recently, only Masherbrum had eluded the view from space. Although both Pleiades satellites, developed by Airbus, can target any point on Earth every day, they had not been able to acquire an image of the 7000-metre-high mountain. The requirements of the DLR Earth Observation Center in Oberpfaffenhofen were too specific – the scientists required a particular recording angle, which is necessary to derive extremely detailed terrain models. But exactly at the times when the orbits of the French satellites allowed for the precise angle of view, clouds veiled the summit of Masherbrum. Clouds, as well as bright white, outshining snow surfaces or deep black shadows can inevitably lead to errors in the developed terrain model. They do not display distinct structures, making the identification of reference points difficult. For this reason, the required exposure settings and viewing angles were determined and repeatedly optimised over the course of several weeks with colleagues from the French space agency CNES and Airbus. With these parameters, it was finally possible to program the satellite for the target.

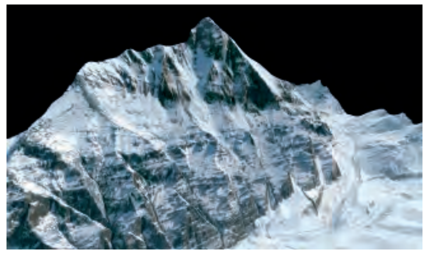
While the Sun makes the temperatures in the valleys rise slowly at the base of Masherbrum, harsh conditions prevail at an altitude of almost 700 kilometres. The satellite instruments must be able to withstand a vacuum and a temperature difference of more than 300 degrees Celsius. Shortly before Masherbrum comes within range of the telescope, the satellite gets into recording position. As it overflies the mountain, it keeps the summit in view at all times. Only a few satellites, such as the French Pleiades or the United States WorldView, have this dexterity. This versatility allows them to quickly align the camera during flight. By doing so, the satellite is able to image Masherbrum three times: in the direction of flight, from above, and against the direction of flight.



The steep wall of the Aconcagua. At 6962 metres high, it is the tallest mountain in the entire American continent. The region, below the north summit, was recorded with a virtual 500mm telephoto lens from an altitude of 21,849 metres. The most difficult ascent route runs through here.

Virtual view along the steep western flank on the north west side of the second highest mountain of India, Nanda Devi. At the foot of the 'Goddess of Joy' runs the Rishi Ganga. The river flows in a western direction through the high mountains, and in the past it was the only accessible route to Nanda Devi and its neighbouring peaks.





The greyscale values are converted into height information in the virtual 3D space. A three-dimensional image of the landscape is derived.

Here, lights can be positioned, shadows created and the colour and texture of the surfaces selected.

For photorealistic views, a satellite image is used as a texture and stretched over the terrain model like a blanket. Even atmospheric effects, such as fog or haze, can be subsequently added in the 3D space.

View of the Diamir face of the Nanga Parbat. Left of the north summit, in the centre of the main peak.

A few days later at DLR in Oberpfaffenhofen, these images are turned into elevation models. An algorithm was initially developed at DLR to enable robots to orient themselves in space. Today, it detects obstacles in the path of German luxury cars, but has been developed further at the DLR Earth Observation Center to derive high-resolution terrain models from image triplets. This so-called Semi-Global Matching method finds correspondences for every pixel in the accompanying photographs. The three-dimensional space can then be reconstructed using the differences in angle between the scenes – similar to human stereo vision. Thus, for the first time ever, it is possible to generate detailed elevation models of any location on Earth, reproducing down to the finest structures and details – with a ground resolution of approximately two metres in the satellite data used here. The measured values of the digital terrain images are coded in grey values. This results in black-and-white images in which high elevations stand out as bright areas in contrast to the dark valleys.

These measurement data become three-dimensional representations on DLR computers. Grey values are converted into elevation values and a spatial model of the original mountain is created. But it is still unlit. Once light sources are positioned, light and shade model the relief and make it recognisable to the human eye. The position of the lights can be chosen freely by the scientists in the virtual space. This makes it possible to simulate days and seasons.

The mountain, however, only gets its photorealism from the satellite image. Like a blanket, it is laid with precision over the 3D model. On very steep walls, closely spaced points are sometimes far apart in depth. Often, these are the only places in which the viewer is able to notice that it is not a photograph, but a computer-generated representation of reality. In this virtual world, the viewer – or the virtual camera – can be anywhere, whether it is an altitude of several hundred kilometres or at close range. Even blocking side peaks can be masked out, revealing previously unimaginable views. Weather effects can also be created in this parallel world.

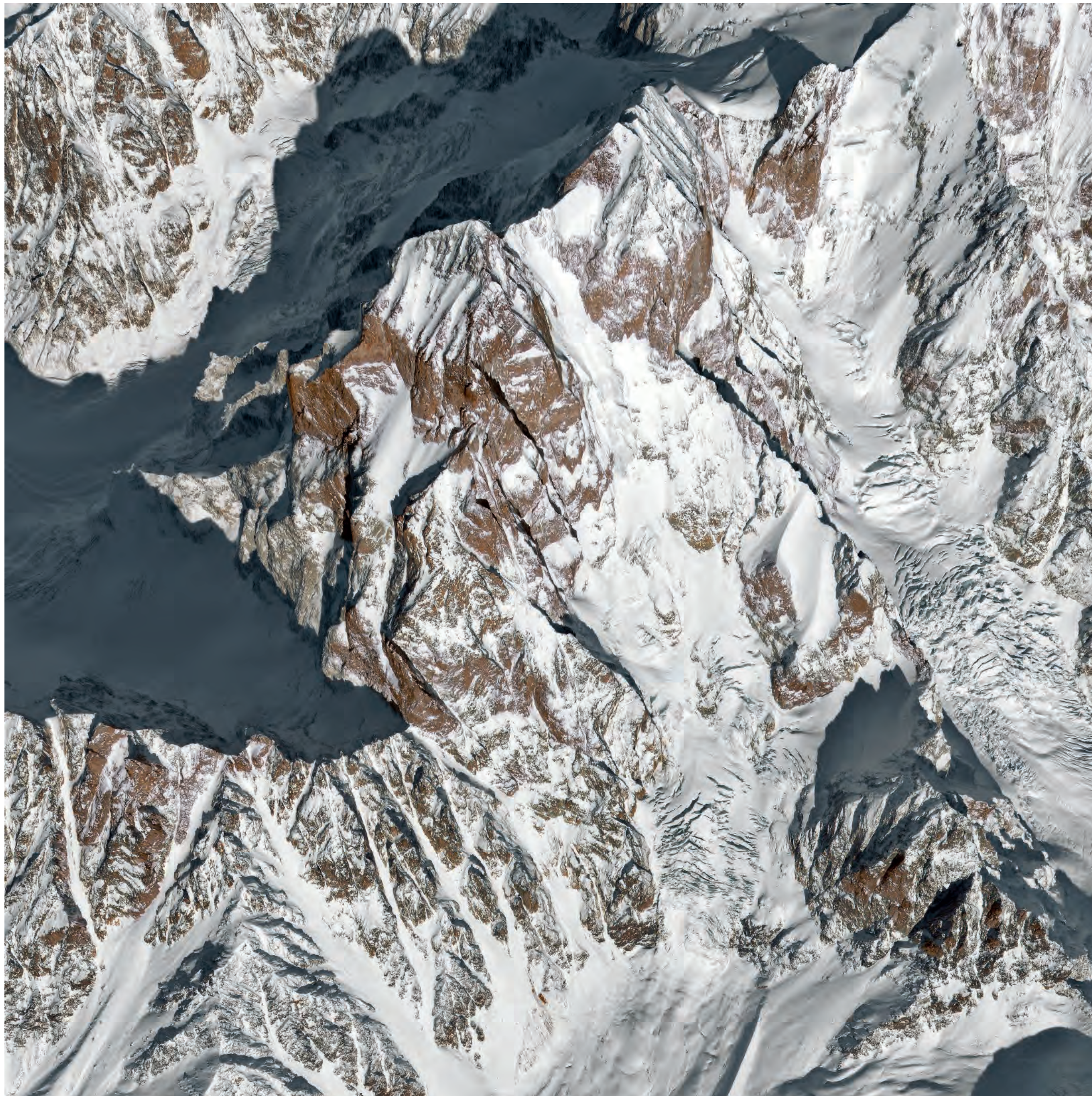
Yet, for all the beauty of the photographs, the photorealism should not obscure the fact that there are highly accurate values in the underlying data – data that have been recorded at an altitude of 700 kilometres and give an idea of the enormous capability of Earth observation satellites. Hence, for the first time, 13 of the world's most prominent mountains can be mapped and virtually explored from all sides. Masherbrum, whose north wall has never been climbed, is not missing from this exclusive tour. It has done justice to its character and made things particularly difficult for the DLR scientists – right until the end.

After a successful survey, the unapproachable has become virtually tangible. The resulting views show the progress that DLR imaging represents for the world of professional alpinists. It opens up entirely new possibilities for route planning. The images in the recently published book are accompanied by personal accounts from the world's greatest mountaineers. Among others, Gerlinde Kaltenbrunner describes how the DLR data helped her climb the K2. Mountaineering legend Reinhold Messner tells stories of the first ascents and inspections, classifies them and provides a framework for mountaineering achievements. His outline of alpine history provides the time component that is understood in science as another dimension. Together with the spatial measurements of the mountains, the book presents these giants in four dimensions. It is mainly these narrative dimensions that make it special. Surveyed by DLR, classified by Reinhold Messner, endured by the best mountaineers in the world and extensively characterised in profiles, this impressive illustration of 13 of the most important and distinctive mountains was born from an accidental encounter of scientists and climbers.

Nils Sparwasser heads the Department of Science Communication and Visualisation at DLR's EOC and teaches remote sensing at the Catholic University of Eichstätt. The geographer is co-editor of the book 'Unseen Extremes' and is responsible for the visualisation of the satellite data.

The book, published by DLR, comprises satellite-based, photo-realistic illustrations of mountains, which represent epochal ascents. Together with topographic maps, infographics, images, personal reports and photographs of the best alpinists in the world, the individual character traits of each mountain become tangible. The book has been published in the United Kingdom, the United States, France, Italy, Spain and Korea.

In the foreground, the southern tip of the Ushba with the 'Red Wall'. Behind the northern peak on the upper edge of the image, the Malaya or Small Ushba.



The designs for the robots of the future are created, sometimes with pen and paper, sometimes on the computer.

NO VOICE – NO MOUTH

A 'stranger' among engineers: Designer Tilo Wüsthoff has clear ideas when it comes to appearance and functionality at the Institute of Robotics and Mechatronics

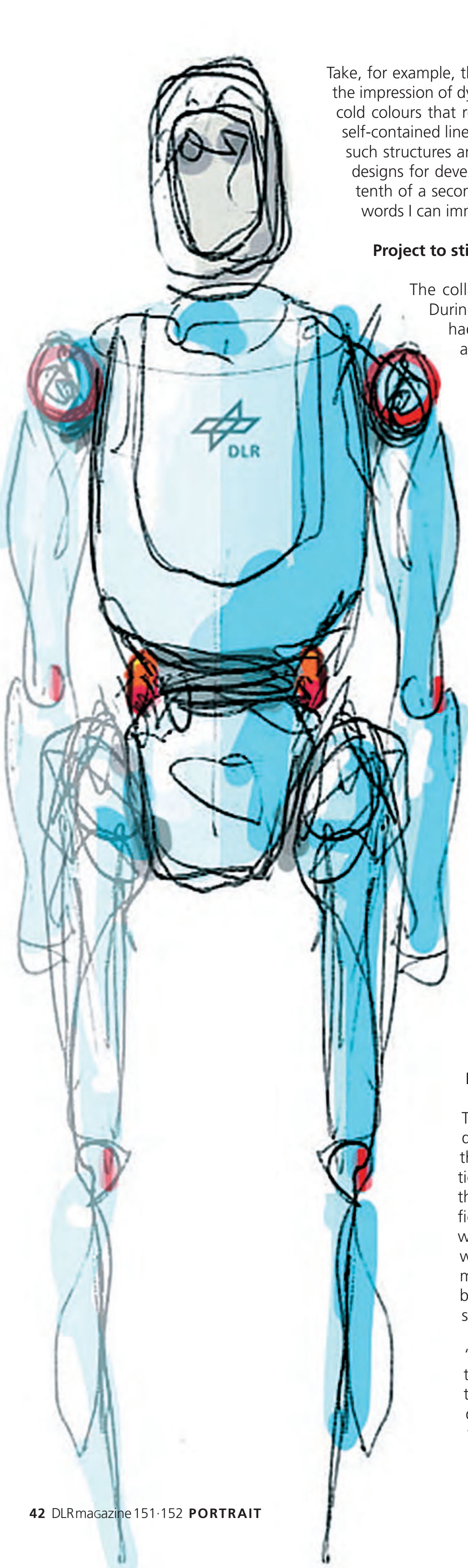
By Manuela Braun

Two dark eyes look around. Silver-smooth and emotionless, Justin the robot's face reflects the neon light in the laboratory. He is somewhat human – but then again, without a nose or mouth, maybe not. "Why doesn't it have a mouth?" Justin's designer Tilo Wüsthoff was asked this by the Institute's then Director one evening after hours. He had decided not to give the robot any natural features and, in so doing, caused irritation.

When Wüsthoff works, he often has to explain what he is doing – and why. As the only designer at the DLR Institute of Robotics and Mechatronics, the 39-year-old is a rare breed. He was able to quickly explain the missing mouth: "Justin doesn't speak, so he simply doesn't need a mouth." The designer shrugs his shoulders. He has quite clear ideas, which he follows. "Design is meant to show what a thing, a project, can do. It should facilitate intuitive operation. But it should not mimic what isn't there." And, while Justin perceives his surroundings with his stereo eyes, a mouth is not appropriate because verbal interaction is not a key research topic for the teams working on Justin.

Research with a high recognition effect

Wüsthoff was able to take a stand with his design. In the meantime, he has also developed a whole series of principles at the Institute beyond simply designing a functional and beautiful exterior for a medical robot, Justin's rolling lower body or a four-legged walking robot. This was done in close collaboration with engineers, because research and design should go hand in hand and not obstruct each other. Wüsthoff has collected the guidelines in a multi-page booklet. Ideally, it should be apparent at first glance whether a robot or vehicle was developed and built at DLR – because it is as if they all came from the same mould.



Take, for example, the curved line. Wüsthoff calls it the 'power-line', which is supposed to convey the impression of dynamism and precision from the outside: edges with a clear light-dark contrast; cold colours that represent technology; slightly arched surfaces that impart tension; circulating, self-contained lines that give a dynamic effect. The designer relies on his feelings for the effect of such structures and shapes – and on those of the respective project managers. He presents his designs for development before them nearly without saying a word. "The reaction in the first tenth of a second – this is the truly authentic feedback. By the facial expressions and the first words I can immediately tell whether the design will catch on or needs to be reworked."

Project to stick with

The collaboration between Tilo Wüsthoff and DLR began with his diploma thesis. During the course of his studies in 'Industrial Design' in Essen, the budding designer had already been involved in projects with other research facilities. "This has always been my dream – to work with research institutes to integrate new technologies into everyday life and into the human environment." For Wüsthoff, this was the real challenge in his industry – to work on things that are still being invented and are intended for the future. An employee from DLR Technology Marketing had contact with the university at which Wüsthoff was studying, and so his professor mentioned the DLR topic to him for his thesis. And so the designer was confronted with a task that had it all – he was to develop the design for a laser scanner to which DLR had contributed sensors and image data processing. It was a heavy device, not exactly futuristic and already developed to the point that it was market-ready. "This was an incredibly dry, technical project," he recalls. "But this was precisely the direction I wanted to head in. So I said to myself, just stick with it." Instead of creative overflights, many ergonomic studies had to be conducted first – the device had to be easily and quickly operated and the workflow optimal. The diploma thesis was successful and the cooperation with DLR was set in motion.

Don't just paint, pitch in!

Wüsthoff's second project with DLR was entirely different – the medical robot MIRO, which is currently produced by a US company under license for use in operating theatres, needed an outer shell. The medical robot was already 95 percent complete. Now, a beautiful exterior was needed. The project manager's message to the designer was clear. "Painting is not enough. You also have to help us build it." Wüsthoff did not have a robotics background. Science fiction was not his thing. Thanks to his knowledge and vocabulary in materials science, he was able to work with the DLR engineers. "I never wanted to work in a traditional design agency. For me, DLR was a chance to make my dream come true – so I took the risk." For this project with DLR, he gave his notice on his apartment in the Ruhr area and moved to Munich. Now, in addition to designing on paper or a computer, he was going to be hands-on. "That is the only way I could participate." The MIRO project worked, although much of it was completely new territory for the designer. "MIRO was a major success, and everyone was astonished that I had been able to do it." Wüsthoff pauses for a moment and laughs. "And, yes! I was also amazed."

My colleague, the robot

The collaboration between research and design proved to work. The outer-shell design for the medical robot won the 'iF International Forum Design Award' in the 'Advanced Studies' category. This is an internationally renowned competition to which countries from all over the world submit their products. In 2013, the medical robot MIRO even made an appearance in Hollywood in the science-fiction film 'Ender's Game'. Today, all sorts of designs and photos hang on the wall of Wüsthoff's office – a four-legged robot crawls across a Mars landscape, while a poster combines robotic hands and heads, medical robots and shiny metallic upper bodies. Right next to that is a drawing of a robot. Featuring a few black lines and the blue tones that characterise DLR robots, Wüsthoff has sketched a robot that has no feet or hands – yet. Human-like, but still a robot.

"I don't want to make the robots one hundred percent human-like. A robot is a technical system. It is an assistant – not a human being." Wüsthoff believes that this difference must always be clearly visible. However, it may be important to design humanoid robots for operation, for human-machine collaboration. "Interaction with a robot is more intuitive when it is human-like. The human being quickly learns how the robot works and needs to be operated." And human-like components also bring advantages to robotic applications: "The more 'human' the robot is, the better it can work in an environment created for humans."

From vision to visualisation

Tilo Wüsthoff's work is seemingly a world apart from the goals and strategies of the engineers. So the Institute of Robotics and Mechatronics is taking a new approach with the designer. "The design phase usually begins when the product is being prepared by a company for the market." And Wüsthoff thinks that is much too late. Design is not merely the visual appearance – it can make a major contribution during the development stage in research facilities. For example, when the project is conceived, the idea is still vague. "If the engineer sees a first design from me at that point, it could perhaps clarify much of what didn't yet concretely exist as an idea." And, thus, the visualisation can therefore also be a source of inspiration and motivation for the developers.

In Vibrotac – a device that can transmit a variety of information to humans by means of vibrations – for example, Wüsthoff became involved when the device went into the test phase. In the laboratory, Vibrotac was mainly composed of cables, sensors and a fabric sleeve. Flight controllers were supposed to use it to test whether or not they could receive and use information from Vibrotac during their work. "The developed working version had been good enough for the 'proof of concept' to demonstrate its feasibility, but impractical and not so user-friendly for testing with external test persons," the designer explains. So Wüsthoff designed a bracelet that was easy to put on and easy to use. "This time, the design was not just about a nice exterior appearance, but rather about improved functionality."

Design with detours

Wüsthoff's work at the Institute of Robotics and Mechatronics often means that he has to once again start designing from scratch during the development stage. This can happen as projects evolve or take a completely different direction because the strategy or goal has changed. Or simply because the basic research always enters new territory and, in so doing, sometimes takes a wrong path or a detour. "Only if I can be directly involved in the projects at the institute can I understand the research and provide efficient proposals. Timing is everything so that the design can give support at the right time."

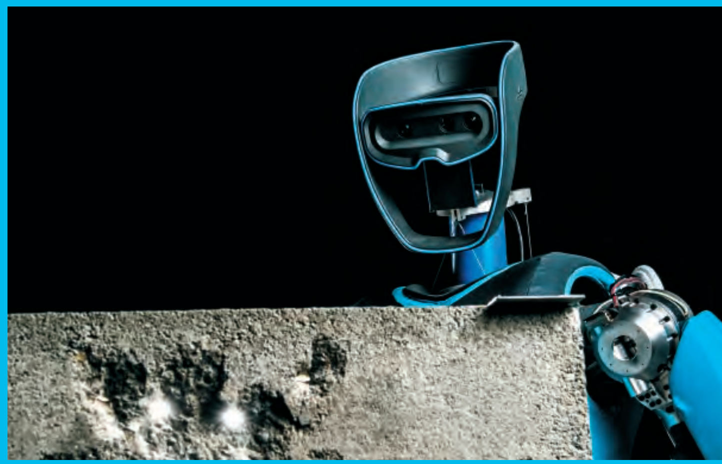
And coffee is also important. Coffee breaks with engineers give Wüsthoff the opportunity to learn about ideas and developments. Some projects run for a year or two until the actual work can begin. Not every engineer considers that design is important to their research. "But I am extremely enthusiastic about combining design and research – and this gives me the patience to explain how I can assist not only with the appearance, but also with the development and the functionality."

Forearms like Popeye

There is one thing Wüsthoff says he is definitely not: "I'm not a magician." And that is precisely why the forearms of the Hand Arm System on DLR's David robot are like Popeye's. The robot is packed full with electronics that are absolutely necessary for the researchers – not exactly well-proportioned. No design can change that because the development work always takes precedence. The robot system sits on an aluminium rack in the laboratory. It is altogether large, with arms that are clearly too long and an empty upper body. Wüsthoff has given the flexible robot system – equipped with numerous sensors – an athletic personality. So, from the Hand Arm System (HASy) comes the athlete David – with arms like that of a comic figure with great strength, a head consisting of mere contours and no inner life. "Quite simply: Where nothing exists, nothing is implied." On this, Wüsthoff remains true to his principles.

As a trained industrial designer, Tilo Wüsthoff brings new light to robotics development at DLR.

"Painting is not enough here. Help us build it!" – an unfamiliar task that the designer gladly fulfilled.



With the robot David, the focus is on hands and arms, so contours are enough for the design of its face.

In cooperation with engineers, Tilo Wüsthoff approaches the final shape – from appearance to optimal functionality of the various projects.

Quieter flying, but how? Where exactly does the noise originate, and along what paths do the sound waves enter the aircraft cabin? Can something be done about the noise from the turbine or to the components – the structures of the aircraft – to make it quieter for the passengers? To address the issue, DLR researchers are pursuing different approaches, all of which have one goal – to make air transit more pleasant.

TRACKING NOISE WITH 12,000 MEASUREMENT POINTS

DLR researchers investigate the paths of sound waves entering aircraft cabins

By René Winter

Passenger comfort is an important factor in the development of modern aircraft. The two major aircraft manufacturers, Airbus and Boeing, are taking a series of measures to provide passengers with greater comfort, especially on long-haul flights. The Airbus A350-XWB, like the Boeing 787 Dreamliner, was designed to fly with a higher internal cabin pressure, simulating a lower altitude and helping to minimise jet lag. The lighting was optimised and the noise level in the cabin reduced. Because travelling should be pleasant.

But the noise inside aircraft presents the manufacturers with a problem – cabin noise is difficult to predict. In most cases, only measurements on the finished aircraft reveal the actual noise levels – and then, it can only be reduced to a limited extent, for example with additional insulation. But insulation material requires a lot of space and increases the overall weight of the aircraft. Moreover, this measure has little effect on low-frequency noise.

How is it made quieter?

So the question is how to make it quieter in the cabin. To do this, one must first understand how the noise is entering the aircraft. Obviously, sound is emitted from a source, for example the engines, and propagates through the air. The noise can therefore be heard in a place other than where it originates. If the sound encounters obstacles, such as the cabin walls, these absorb and alter it to varying degrees. However, cabin noise has yet another cause – the vibrations of the engines spread through their suspension (pylons) into the wings, and from there into the fuselage structure, which in turn starts vibrating. Similar to a loudspeaker, the vibrating surfaces of the fuselage generate sound waves in the cabin, and it gets louder.

This so-called structure-borne noise is becoming increasingly important for the acoustics of aircraft cabins. New, more economical engines also produce other sound waves. While the vibrations of older engine types are at higher frequencies, novel propulsion concepts such as

A vibration exciter is adjusted on the cabin demonstrator. The shaker, specially modified for this purpose, causes structural vibrations in the particularly interesting mid-frequency range in order to study the path of the sound entering the cabin.

The loudspeaker array used for projecting sound fields onto the demonstrator. It has 132 elements and can be moved to almost any position on the surface.

The cable routing for 200 sensors must be organised in such a way that faults and defects can be remedied as quickly as possible

UHBR (Ultra High Bypass Ratio) or CROR (Counter-Rotating Open Rotor), are moving into a low-frequency range. In this frequency range, structure-borne noise propagates better and its influence on cabin acoustics increases. At the current state of the art, these frequencies present difficulties in both simulation and experiment. The Finite Element Method (FEM) and Experimental Modal Analysis (EMA) can be used in the low-frequency range; statistical energy methods (SEA, Statistical Energy Analysis) are applied in the higher frequency range. However, none of the available tools provides satisfactory results in the mid-frequency range.

What happens in the mid-frequency range?

It is precisely this problem of structure-borne sound, along with its propagation paths, that is being addressed by researchers in the Vibro-acoustics group at the DLR Institute of Aeroelasticity. Particular attention is being paid to the physical understanding of the coupling between structural vibration and acoustic emissions. In particular, they are considering vibrations in the mid-frequency range, between 50 and 500 hertz.

First, the scientists identified the vibro-acoustic sound sources and determined their influence on cabin comfort. Flight-test data were recorded on DLR's Advanced Technology Research Aircraft (ATRA) – a modified A320. The acousticians analysed data from a variety of sensors. This data provides information about, among other things, the structural vibrations as well as the sound pressure in the cabin and on the fuselage outer skin. The data from 330 sensors was recorded under more than 300 different flight conditions – the result, 2.4 terabytes of information. Software was specially developed to process this large, heterogeneous data set. It combines structural dynamics, acoustics and signal processing methods. Thus, it was not only possible to identify the most important source mechanisms of cabin noise, but also to determine which components of the aircraft structure are involved in the propagation path, and thus affect the cabin noise. However, the analysis also showed that, due the complexity of the structures, the vibration transfer paths are difficult to identify.

New analysis tools are needed

Based on the methods of structural dynamics experiments – already available for the low-frequency range – experimental and analytical tools were developed with which the Finite Element Method could also be used for structure-borne sound in higher frequency ranges. If the transmission paths for vibration in a structure are known, noise-reduction measures can be implemented locally, very efficiently and without too much additional weight.

But in order to verify the experimental methods, the scientists need appropriate data. Generating these is a complex endeavour. On a fuselage of the A400M aircraft, the DLR researchers investigated and evaluated mid-frequency structural vibrations for the first time in a large-scale measurement campaign. For this purpose, specialists from the Helmut Schmidt University of the German Armed Forces in Hamburg (HSU) specially erected a hall for the 32-metre-long, six-metre-diameter lightweight structure. A DLR team then studied the cabin-like component for its structural-dynamic and vibro-acoustic properties.

In order to identify the structural waves in the mid-frequency range – much smaller than those in the low-frequency range – a high spatial resolution of the fuselage vibrations is required. How many measuring points are needed to achieve results of the desired quality without dragging the tests on for too long? The scientists finally decided on 2800 measuring points – still a huge number. For comparison: for the vibration identification of the Airbus A350-XWB in the low-frequency range, 500 sensors were distributed over the entire aircraft.

The considerably larger number of measuring points in the A400M vibro-acoustics test required several measurements: 200 sensors were manually moved through the structure using a previously defined model. Again and again, the researchers measured data while exciting vibrations at fixed points on the structure.

GLOSSARY

UHBR – Ultra High Bypass Ratio: concept for a modern, economical turbofan engine with a very large fan diameter

CROR – Counter-Rotating Open Rotor: a turbine engine with two counter-rotating, open rotors

FEM – Finite Element Method: numerical technique for solving physical problems

EMA – Experimental Modal Analysis: determination of the dynamic properties of a structure from vibration measurement data

SEA – Statistical Energy Analysis: method for predicting average vibrational energies of single, lightly coupled substructures of a complete structure

LDV – Laser Doppler Vibrometer: device for the contactless measurement of vibrations using the optical Doppler effect

Better vibration prediction

Comparing simulation and experiment becomes problematic in the mid-frequency range. Established methods are quite sensitive to small inconsistencies of the simulation models and the manufacturing deviations of real structures. Based on the experimental data, the researchers developed a new method that compares vibrational energies averaged over a range of frequencies in a variety of structural areas. In this way, they can better estimate the parameters for the finite element models down to the mid-frequency range and, if necessary, adjust them. Thus, an already-known tool for vibration prediction can now be used for this frequency range.

The measurement process that was validated on the fuselage structure of the A400M and the new correlation method have already been applied. At Hamburg's Center of Applied Aeronautical Research (ZAL), DLR researchers conducted vibration measurements on the Acoustic Flight LAB Demonstrator – a test platform operated by the Hamburg University of Applied Sciences (HAW) and Airbus. The demonstrator – a fuselage structure similar to that of the A320 – is used to investigate measures to improve acoustic cabin comfort. Acoustic measurements are carried out on the ground that would otherwise only take place during flight. DLR used the newly developed experimental methods to characterise the Acoustic Flight-LAB demonstrator. Measuring this structure was the most important milestone of the Vibro-acoustics group. The scientists measured the vibration data of this structure at 12,000 sensor points. The simulation model is now being adapted using the large quantities of data obtained from this as well as the new correlation method.

Measurements with a laser scanner imminent

In order to reduce the huge effort required for such an investigation in the future while increasing the accuracy of the measurements, the Vibro-acoustics group has begun to develop a mobile laser scanner for aircraft fuselage structures. This will enable the automatic measurement and mapping of the vibrations of cylindrical structures, such as the interior of an aircraft fuselage. This had not been possible with any commercially available systems.

The newly developed laser scanner works with a laser Doppler vibrometer (LDV). This measuring system uses the optical Doppler effect to measure the vibrational velocities of surfaces at a targeted point without contact. Special mirror optics automatically direct the laser beam towards a large number of measurement points. Using a camera, the laser scanner can find points on the structure – previously marked with QR codes – and move around autonomously in its surroundings. In combination, the laser scanner and the vibrometer are capable of independently measuring tens of thousands of points in an aircraft cabin to determine their vibration characteristics – day and night, without cables and at a reasonable cost.

With this system, the following experimental challenges will be undertaken: The fuselage structure of the A400M will be surveyed once again at the Helmut Schmidt University of Hamburg. The newly developed scanner will be used instead of the hundreds of sensors. With a microphone array of the university, the laser scanner is coupled to a vibration- and sound-pressure measuring system. But the studies on the Flight-LAB demonstrator are far from finished. Numerous studies will still have to be conducted before the flight tests can be carried out on the ground. In the next study, engine noise will be simulated on the Acoustic Flight-LAB demonstrator using 132 loudspeakers. The methods developed by the DLR researchers will be used to determine the accuracy of these flight tests on the ground and ultimately trace the noise.

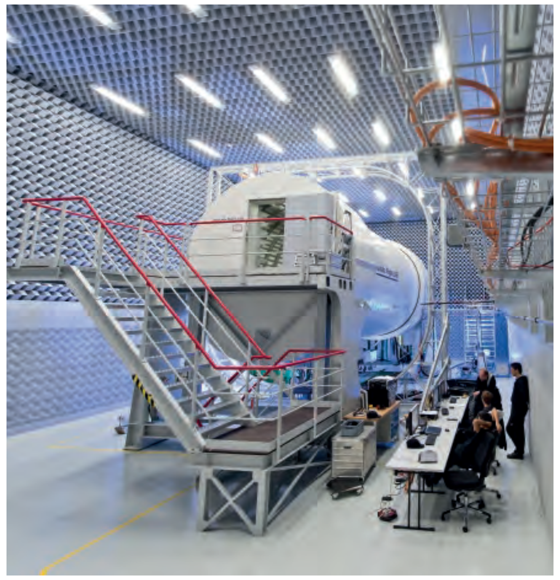
René Winter is a researcher in the Department of Structural Dynamics and Aeroelastic System Identification at the DLR Institute of Aeroelasticity and is Head of the Vibro-acoustics group.

PROJECT PARTICIPANTS

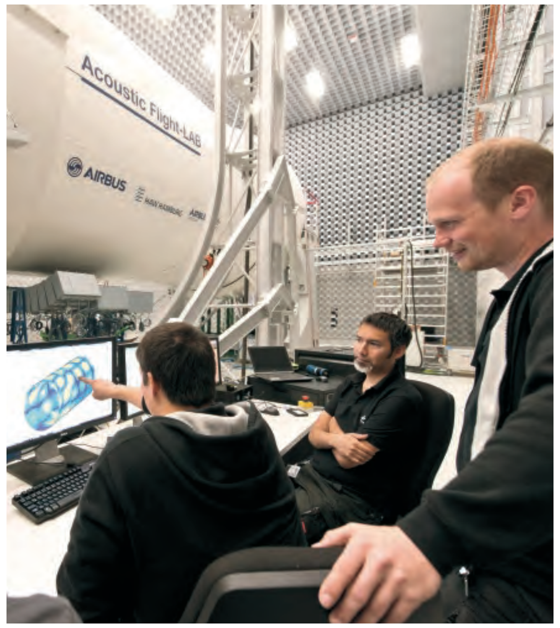
Helmut Schmidt University of the German Armed Forces Hamburg (HSU): provision of the infrastructure for the test on the A400M fuselage.

Hamburg University of Applied Sciences (HAW): owner of the Acoustic Flight-LAB demonstrator.

Airbus Operations GmbH: operator of the laboratory in the Center for Applied Aeronautical Research (ZAL) and project lead.



The Acoustic Flight-LAB demonstrator in the ZAL Hamburg. This environment provides optimal conditions for the measurement.



During the many individual measurements, the scientists from the Vibro-acoustics group constantly check the data for consistency.

Interior of the Acoustic Flight-LAB demonstrator

The Mekong Delta in Vietnam, the mouth of the Yellow River in China – exotic-sounding regions that, from time to time, are the workplace of employees from the DLR German Remote Sensing Data Center. The scientists are developing environmental information systems on-site as part of an international cooperation. For authorities, municipalities and other users in these countries, the specially prepared data from Earth observation represent decision-making support for the development of their region. Population growth, increasing demand for resources, or the effects of climate change require a response to help shape the future of the regions and preserve nature. In China, the DLR team recently handed over the 'DELIGHT' information system to users; this was done in 2014 for the 'WISDOM' project in Vietnam. But a great deal of work is necessary before such a transfer – dealing with language barriers, technical challenges, such as power failures and Internet security, and sometimes also cultural differences in the approach to work. Juliane Huth, a project scientist, and lead of the remote sensing work package in both projects, told the DLR Magazine about this in an interview with DLR space editor Manuela Braun.

KNOWLEDGE TRANSFER WITH AN ASIAN FLAIR

DLR scientists have set up environmental information systems in Vietnam and China while learning to deal with different customs and technical requirements

Two different groups met when the project started – DLR researchers and users in Asia. What prompted this contact, and what needs to be clarified so that an environmental information system is operational at the end and can be used independently in those countries?

: In the Delta of the Yellow River in China, we were in a situation in which the contact was relatively easy from the start. We were lucky: Our research partners in Beijing, as well as on-site, were very familiar with the region and had already been in contact with the end users and future system users for years. It is not just the scientific partners who are invited to the meetings, but also the people who operate the system and work with it. In doing so, one must have knowledge of and respect cultural backgrounds: In China, as a scientist, you are confronted with members of the local government and clearly have a higher place in the hierarchy. We led the dialogue with mayors of large cities, among other people, and in Vietnam, partly at ministerial level. Here, the acceptance and respect of hierarchies is the first step. You cannot treat your counterpart like a colleague – sometimes it simply comes down to something as simple as who can – and must – have the first and last word. Even when it comes to scientists, it works differently in these countries. Seniority is important here.

We also invited the partners from China and Vietnam to come to Germany to see how we work – that meetings, for example, are not so hierarchical. Mutual understanding also helps to create a basis of trust.

How do you deal with the language barriers?

: Qualified interpreters are present at official meetings. If not, the language barrier is, of course, easier for us to handle when we have colleagues who speak the language. The scientists in other countries often speak English, but among the users of our information system, it is often only the younger ones who do so. Among the hierarchically key decision-makers, the situation has slowly changed over the past few years.

The Yellow River Delta is also a major oil production area of China. Environmental monitoring in the nature conservation region is therefore a special challenge.

DELIGHT cooperation partners from the Franzius Institute of the University of Hanover and from the company Hydromod during measurements on the Yellow River. Data on flow velocity and sediment concentration as well as turbidity and salt content were recorded.

You come from distant Europe and explain to the local people how the system has to be run. How do you prevent the local partners from getting the feeling that they are being lectured?
: It is important that you are seen regularly on-site to show that it is not only about technology, but also about a close and partnership-based cooperation. One trust-building measure is, as I said, to not just research and develop jointly with the partners in their respective countries, but also to regularly work together in Germany. In this way, our partners get to know our institute. And they get an idea of our workplace and of Germany as a research location.

How do you manage expectations, so that all parties involved are finally satisfied with the result?
: That takes a lot of time! On the one hand, we sit down at the same table with the Vietnamese or Chinese researchers and users right from the start. On the other hand, we also make an inventory of what is necessary on-site. What do users need? How will they use the environmental information system in their day-to-day work? In Vietnam, for example, certain geodata were required for regular reports to ministerial authorities. In China, the updated land use change and the development of urbanisation have to be reported once a year. Users say what they expect from us, and we adjust that with what we can deliver or perform. It is not just about remote sensing data – we also work with partners from the field of hydrology, for example, or from the social sciences. In any case, by conducting a user requirement analysis at the beginning of the project, we ensure that with our research results something usable will be available at a later stage.

Then there are other aspects: What functionality do the users want? Do they want to display information on a map? Do they want to print maps in a certain format?

When we go on holiday, we often find different electric sockets where we are staying, so we have to think of an adapter when preparing our luggage. However, you are building a complete online system, in which collated and processed information can be retrieved. What technical requirements does the DLR team have?
We learned a lot from our time in Vietnam and were able to adapt much more quickly in China because we already knew the core issues. We were in Vietnam for the first time in 2007. Back then, we still had difficulties at first with the availability and speed of the Internet. We had to program in such a way that the environmental information system was accessible and usable at most. Meanwhile, much has been done in Vietnam – we are still active there and notice that the Internet is now much faster. Even power failures are not as frequent anymore. At that time, we had to look for a service provider that guaranteed reliability in the event of a power failure. Such things barely have to be considered in Germany.

In China, there was another challenge. In Germany, we tend to make assumptions when it comes to which Internet browser to use. If you were to ask 100 people on the street which browser they use, most of them would give the same answer. In China, however, quite different browsers are used. So, if we want to offer a web-based environmental information system that is very user-friendly, we naturally have to adapt it to the browser preferred in China. We therefore have to move away from our European standard.

Once the system is up and running, you transfer it to local users who will work with it independently. How do you train the local team so that it can operate the system without trouble when you are not there?
: The knowledge and experience in the various countries differs. In Vietnam, we have instructed the most scientifically and technically qualified partners to be trainers. This means that DLR computer scientists trained local people to, on the one hand, learn to use the system, but also maintain it. These trainers then went with one of our employees to visit the users. The Vietnamese, who have 100 percent of the local people's trust, then carried out the training in their language. This was done in 13 provinces – these local trainers were important to get rid of the local scepticism with regard to the scientists and the technicians. In China, one of our team members spoke Chinese and she took over the training. The scientific and technical knowledge was certainly greater than in Vietnam. We trained researchers and users from the local authorities at the same time.

The local people therefore benefit from the fact that they receive your knowledge and work with it. How does DLR benefit from such projects?
: The benefits for DLR are manifold. Of course, we are able to further develop our techniques and algorithms within the framework of such projects, which are funded by German ministries – whether it is in the area of evaluating Earth observation data or in the field of information technology. We can, of course, also validate many geoscientific products on-site within the framework of mapping. We become visible through publications, conference contributions, as well as through training activities. Through partner countries, we are often faced with unexpected technical challenges, and this allows us to improve in the use of resources, IT security or project documentation. We have also learned a great deal from intercultural cooperation. From a technical point of view, it is also a challenge for us to create environmental information systems that are not too complex to pass on to authorities.

How do you feel when you hand over the project on the last working day and it is over? Reason to celebrate or is it difficult for you?
: We do not simply disappear on the last day and that was it. We hand over the environmental information system and ensure that there are feedback reports. For DELIGHT, the technical transfer took place in spring 2016. However, as the WISDOM project in Vietnam has shown, we continue to be in contact with our local colleagues even years after the project has ended. For the most part, the partners continue to implement the results on a long-term basis within the framework of national projects locally and always come back asking for our expertise. We continue to exchange information, learn from each other and see how the project contents are developing. That is why it is not a wistful parting. We are also curious and want to know how it is going, how it is working on a daily basis.

What makes this work exciting for you? What motivates you to work under sometimes unusual conditions?
: It is definitely the contact with a completely different culture. It is nice to see how similar we are and how we come together during the course of such a project. It is also motivating to reach a broad group of users with your research results. You are not just writing a scientific publication, but creating an environmental information system that is used by many decision-makers. We are seeing this in Vietnam now – I am delighted every time new users register in our operator and user management system. And this is still happening three years after the conclusion of the WISDOM project. It makes me happy to see that our work generates interest over longer periods of time – and we also hope that this will be the case with DELIGHT. We are hoping that the local people can be given planning-relevant information to assist with local decision-making processes.

THE DELIGHT AND WISDOM PROJECTS

The German-Chinese DELIGHT project (Delta Information System for Geo-environmental and Human Habitat Transition) investigated changes in the urban and natural environment at the mouth of the Yellow River, using an inter- and transdisciplinary approach, from 2013 until the summer of 2016. The project was funded by the German Federal Ministry of Education and Research (BMBF) and China's Ministry of Science and Technology (MOST). The environmental information system supports local planning processes in the Dongying district, facilitates land-use planning decisions in the delta, and provides data on coastal erosion and land production, on the expansion of aquaculture, on changes in agricultural land, on urbanisation processes as well as indicators on the sediment and algae content of sea water. Local and regional decision-makers, numerous Chinese scientific institutions as well as small and medium-sized enterprises in the private sector work with the system.

The WISDOM project (Water-related Information System for the Sustainable Development of the Mekong Delta) was funded by the German Federal Ministry of Education and Research (BMBF) and Vietnam's Ministry of Science and Technology (MOST) and focused on the Mekong Delta region in southern Vietnam. The information system helps in the planning and decision-making in sustainable land- and water-resource management, as well as in adapting to climate change. DLR's German Remote Sensing Data Center was responsible for the overall coordination, the evaluation of remote sensing data, as well as the development and initial implementation of the environmental information system in both projects. The environmental information systems will continue to operate in both countries.

Further information: www.wisdom.eoc.dlr.de and www.delight.eoc.dlr.de

Researchers Tobias Leichtle and Mattia Marconcini of the German Remote Sensing Data Center (DFD) plan their field campaign in the Yellow River Delta with their local partner

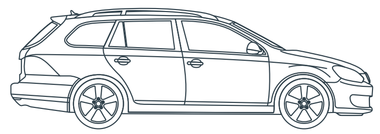
Researchers of the DLR German Remote Sensing Data Center (DFD). Third from the left, interview partner Juliane Huth; right next to her, project coordinator Claudia Künzer.

Driving simulation using DLR's Virtual Reality Laboratory: A 360-degree representation of the surroundings conveys a realistic driving experience.

GLORIOUS GIANTS

They may look like ordinary buildings or aircraft or strange towers standing in the open air; they may go unseen by the human eye, orbiting Earth out in space; but the work conducted in these large-scale research facilities is extraordinary. Be they unassuming equipment, such as modified aircraft, or unconventional tools in architecture and design, such as specialty instruments in laboratories, they are a tremendous asset to researchers worldwide. Large-scale units are complex systems, often operated internationally and certainly used as such. They are a testament to the progress of knowledge that will contribute to its evolution. These are just some of the reasons why we are devoting a series in the DLR Magazine to large-scale research facilities at the German Aerospace Center. Join us in the world of wind tunnels and research aircraft, flight and traffic simulators, satellites and test stands for rockets. Part one of the series takes you to a rather 'different place – the Virtual Reality Laboratory for research into automated and networked driving ...

DRIVING IN A VIRTUAL WORLD



Part one of the 'Glorious Giants' series – Automated and networked driving in the Virtual Reality Laboratory

By Vera Koopmann

A white Volkswagen Golf. The driver activates the indicator, looks in the rear-view mirror and steps on the accelerator. But then, a red light. The driver brakes. He takes a quick glance at the railway station to the right. A message on the instrument panel behind the steering wheel announces that in 30 seconds, the light will turn green. Three, two, one… the journey can continue. Next to the speedometer, a notice appears: "The vehicle can now drive in a highly automated way." With the push of a button on the steering wheel, the driver engages the vehicle automation and leans back in a relaxed position. Looking at the new shopping centre in front of him, he reaches for his tablet and starts scrolling through the latest news.

This is not a scenario from the future: the driver is a test subject and is sitting in a real Golf, in the Virtual Reality Laboratory (VR Lab) of the DLR Institute of Transportation Systems in Braunschweig. Under test is a tool developed by the scientists for automated driving: The vehicle communicates with the traffic lights and adjusts its speed with respect to the preceding vehicle. In certain situations, the driver can hand over responsibility to the car. "This places considerable demands on the vehicle. Extensive test runs are necessary to ensure that all situations are mastered," explains Martin Fischer, who is responsible for the Institute's VR Lab. "The tests are conducted most efficiently by simulation. We save time and money and are able to safeguard the system to such an extent that we can subsequently test it in the real world without great risk. In this way, faulty developments can be prevented at an early stage."

In a so-called modular mock-up, the test driver tests new assistance and automation systems, combined with new vehicle concepts, and has a complete panoramic view.

The DLR research vehicle FasCar II in the Virtual Reality Laboratory

The laboratory was extensively rebuilt in 2013. Today, a 360-degree representation of a virtual world and enough space for a complete vehicle is feasible in the same place where once only a 180-degree projection for a single car seat was possible. This is the optimum condition for conducting the most detailed and realistic tests for driver assistance, automation and cooperation systems. "If we want to test an assistance system for city driving, it must also be possible to have a complete view of the surroundings and, for example, take into account a glance over the shoulder in the simulation. A white wall rather than the sudden appearance of a cyclist is certainly not comparable with a realistic simulation," Fischer explains. Today, scientists and test persons have the all-round view and it is easier for the test subjects to behave as though in real traffic. But this is not the only feature that distinguishes this simulation laboratory from others: The VR Lab is a platform that permits the easy and flexible integration of different types of vehicles – a real road vehicle and so-called mock-ups, replicas of vehicle cabs that can be used to produce traditional passenger car designs as well as futuristic vehicle concepts. Cabins of large vehicles, such as lorries or trams, can also be integrated into the VR Lab.

Over a network, the Virtual Reality lab can be connected with other simulators of the Institute's major facilities, such as the MoSAIC Laboratory (Modular and Scalable Application Platform for ITS Components), a laboratory for multi-driver simulation to test cooperative driver assistance, or with the dynamic driving simulator. This enables the evaluation of the interaction of several different events on the road. The software that makes the realistic driving experience possible was designed so that vehicle mock-ups of future or experimental vehicles can also be integrated via standardised interfaces. The laboratory can therefore also be used by external partners wanting to test their innovations in a virtual world, with a real driving experience.

"The virtual landscapes are modified and created according to the test requirements," Fischer explains. "And we even go as far as to produce accurate three-dimensional representations of cities." In an unprecedented project, the scientists from the Institute have virtually recreated the entire city of Braunschweig, together with its complex infrastructure. At first, they focused on the Braunschweig inner-city ring. To do this, the researchers used a measurement vehicle to accurately measure the streets and combined the remaining roads and their surroundings based on multiple cadastral registries from the city and the infrastructure operators as well as aerial photographs, property and navigation data, and crowd-sourced data from OpenStreetMap. For all this data to ultimately provide the most accurate virtual representation, the scientists developed a fully automated tool chain and a single so-called digital atlas, which contains all the acquired data. So, for example, traffic signs that were placed too high did not have to be moved one by one to the right place – everything was automated. From this data atlas, the researchers can now automatically export road descriptions and 3D models. "We are thus able to digitally recreate any city in the VR lab, as long as data of similar quality and form to that acquired in Braunschweig is available," Fischer notes. The Braunschweig inner-city ring provides a virtual prototype with the best conditions: The entire ring is equipped with communication technology as part of the Application Platform for Intelligent Mobility (AIM). A research intersection, traffic light systems and reference lines already provide scientists with large quantities of information.

In the VR Lab, it is also possible to test psychological matters for driver modelling, human-machine interaction and cognitive driving behaviour. The realistic representation of the environment is very important, especially for traffic psychologists conducting driver-behaviour studies. The more realistic the driving environment appears to the subject, the easier it is to behave as though in real traffic. "These investigations of the driver's behaviour provide us with important hints that can be used as starting points for the development of driver-assistance systems, which support the driver, and thus help to avoid accidents," Fischer says.

The DLR Institute of Transportation Systems' Virtual Reality Laboratory is one of DLR's principal large-scale facilities for research in the field of automated driving, as well as for the development and testing of assistance and automated systems.

Vera Koopmann is responsible for public relations at the DLR Institute of Transportation Systems.
Illustration car on first page: ccvision.de

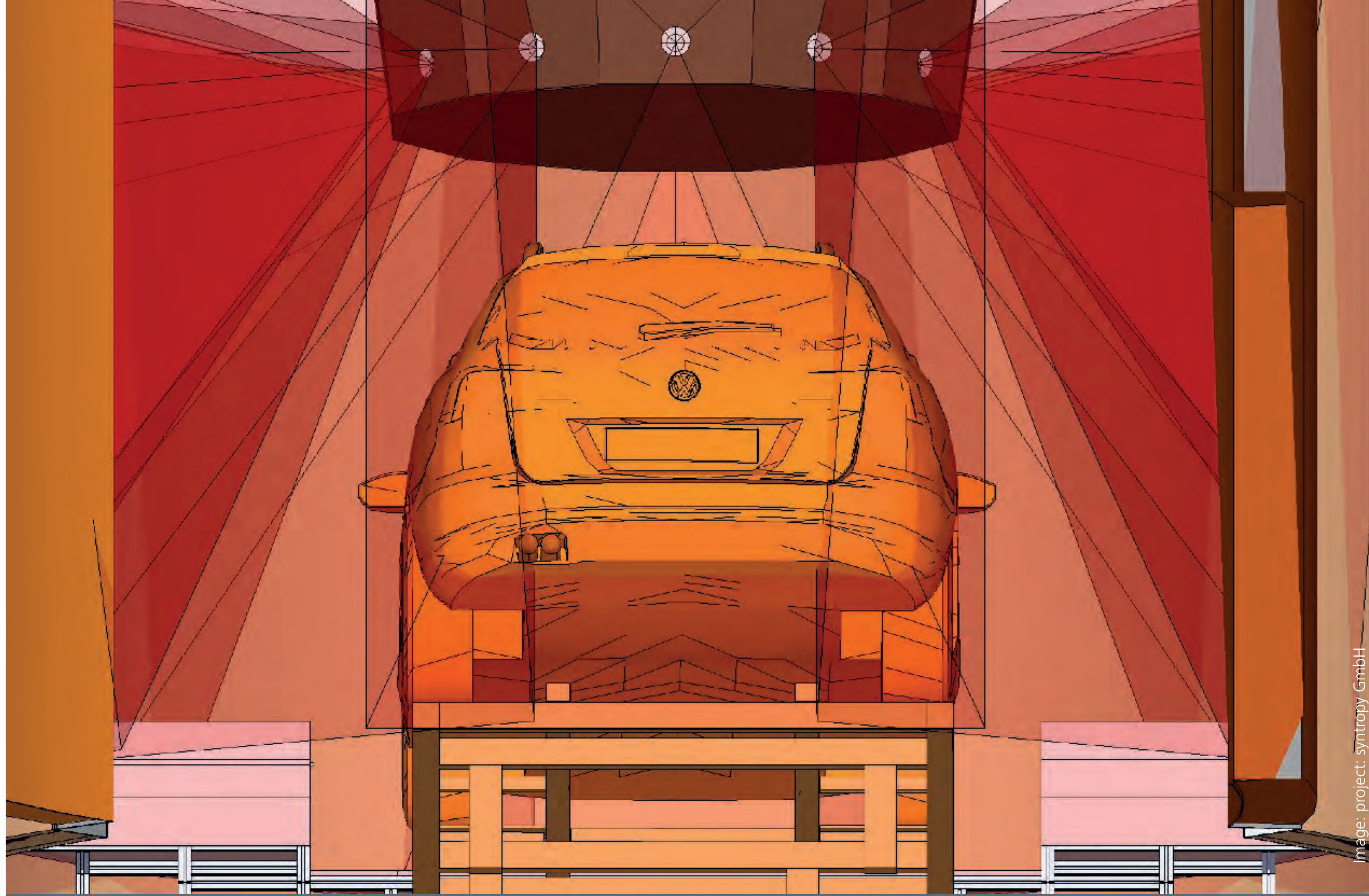


Image: project: syntropy GmbH

THE VIRTUAL REALITY LABORATORY

Facts and Figures

The Virtual Reality Laboratory is a highly flexible and scalable simulation environment. It is able to show a 360-degree representation of the virtual world. The integration of various mock-ups and vehicles permits the testing and evaluation of automation and assistance functions by means of repeatable and reproducible scenarios. The use of a shared software framework makes it possible to link it with other simulators and infrastructure within the Institute.

Equipment:

- Console with a six-monitor matrix and two workstations, KVM switch for access to every computer in the VR Lab.
- 360-degree projection, 12 projectors each 1920 x 1200 installed on the ceiling, 16 computers for graphics output (12 for projectors, four freely usable)
- Software (Dominion and VTD)
- Smart Board

Dimensions: 60 square metres

Investment value: 875,000 euro

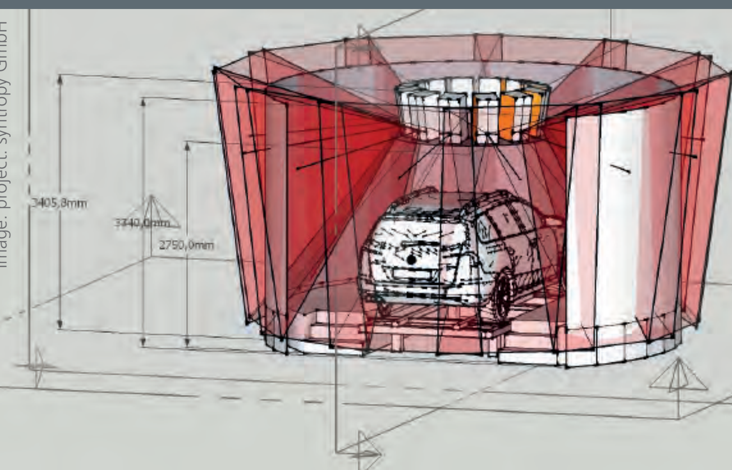


Image: project: syntropy GmbH

Sketches for the renovation of the Virtual Reality Laboratory

Image: Hubschraubermuseum

Well-guarded by a mediaeval herald: the Helicopter Museum's modern glass cube in the middle of the Bückeberg Altstadt.

WILD WORLD OF HELICOPTERS IN THE SHADOW OF THE WESER RENAISSANCE

The Bückeburg Helicopter Museum

By Hans-Leo Richter

In aviation museums, rotary-wing aircraft usually stand somewhat in the shadow of fixed-wing aircraft – but that is not the case in the small but excellent museum that we are presenting today. Unique in Germany and one of only three museum institutions in the world devoted exclusively to the helicopter, its technology and history, the Bückeburg Helicopter Museum is located in the centre of the Lower Saxony city of Bückeburg – right across from the magnificent Bückeburg Palace, a prominent example of the magnificent Weser Renaissance.

Diagonally opposite the palace, a large glass cube draws attention to itself, or more specifically the helicopter that hangs inside it – quite the original business card for a technical museum. The museum showcases approximately 50 helicopters and gyrocopters, a myriad of engines and individual parts, as well as a multitude of helicopter models from all eras in a variety of glass displays. All of these exhibits provide information about the wide world of helicopters and their versatility, to which many people probably owe their rescue from emergency situations – if nothing else.

The museum – built in the 1960s – has its origin in the German Army Aviation, then newly established Army aviator school, where helicopter pilots of the future are still trained today, and is one of the leading helicopter schools in Europe today. Well thought-out from a didactic point of view, upon entry to the glass cube the museum instantly provides you with a history of the helicopter. Stacked up in a large glass cabinet are meticulously recreated models from the early 1940s up to the present day. In front of the display case, a computer invites the visitor to access a detailed information page for each of the numbered models on the screen. In addition to a photograph, the page contains almost all technical details – an introduction to the history of the helicopter could hardly be better.

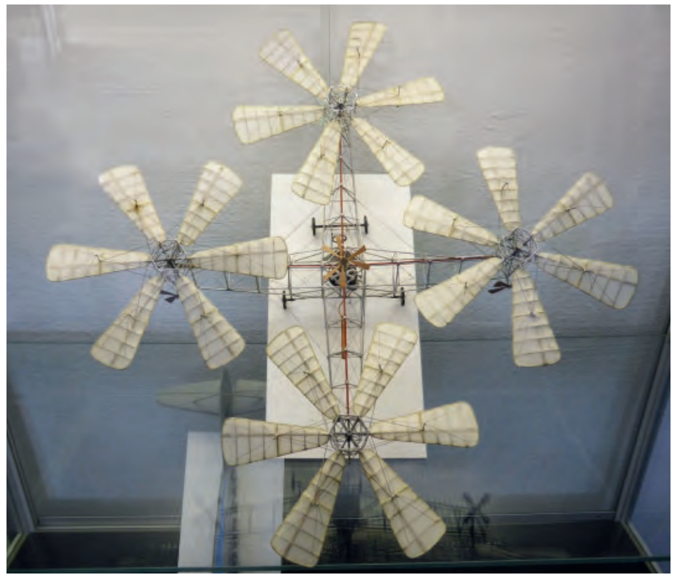
Aviary with constructions that are quite out of the ordinary

On the first floor of the glass cube – aptly called the aviary – one encounters the first 'real' helicopters, which are dramatically suspended from the ceiling. These include an MBB Bo 105 seemingly flying on its head, a Sud Aviation Alouette II, and then a rarity, the replica of a construction by the bicycle engineer Paul Cornu. On 13 November 1907, the vehicle rose approximately30 centimetres off the ground for about 20 seconds. The term 'flying bicycle' was somewhat fanciful, but the construction was something of the kind of the first engineering model for vertical flight. From the normative helicopter frame, as it were, also comes the replica of a Focke-Wulf Fw 61. The twin counter-rotating rotors were a special feature of the early designs of Heinrich Focke and Georg Wulf. After all, these aircraft were regarded as being the first that could be practically used.

The 'flying bicycle' model of the world's first manned helicopter, Cornu Nr. II. Maiden flight: 13 November 1907.

Image: Hubschraubermuseum

The large exhibition hall offers a representative cross-section of international helicopter history, with a Russian Mil Mi 1-light helicopter from the early 1960s in the foreground.



The first model of the largest rotor helicopter – de Bothezat – with four six-blade rotors (model shown here) was created in the USA during the 1920s. Its maiden flight on 18 December 1922 lasted only 102 seconds.

The Wagner Rotocar from 1960 was intended to combine helicopter and motor vehicle systems. The two rotors were powered by a three-cylinder radial engine.

The versatile history of helicopter development is also extensively covered in the large exhibition hall of the timbered building adjacent to the glass cube, in the so-called Burgmannshof, where the museum was initially located. As is well known, helicopters were first considered by the great universal scholar Leonardo da Vinci. At the end the 15th century, he had already etched the first sketches for generating lift by means of an Archimedes screw – that is, a rotating wing. The museum shows a seemingly caringly designed wooden model of this da Vinci draft, in the central cage of which four men clearly endeavour to make the wing-screw rotate by using a spindle.

Of course, all the big names in helicopter history are represented. From Bell, we see the small '47', and also on display is the UH-1D – for many years the backbone, so to speak, not only of the German Army Aviation Air Corps. Numerous helicopters manufactured by Bölkow (later MBB) show the long way from the small two-seat Helitrainer Bo 102 to the Bo 105, the world's first helicopter with a hingeless rotor head. Also interesting is the subsequent model, the MBB Bo 108, from which the Eurocopter EC 135 ultimately originated and is, incidentally, also the base model for today's DLR FHS research helicopter. The famous name Sikorsky could, of course, not be missing – for a long time, it was something like a synonym for helicopters. The museum shows the S 58 (H 34) from the 1950s, a universally deployable 'beast of burden' of its day powered by a magnificent Wright nine-cylinder radial engine.

Visitors can also admire some famous Russian helicopters – several Mil models are on display. Generating special interest are the Kamov Ka-26 Light Utility Helicopters with a coaxial rotor. Another unusual rotor design, which became primarily known as a rescue helicopter, is the United States Kaman HH-43F Huskie with two counter-rotating and intermeshing twin rotors – based on the German Flettner principle from the 1940s. More than anything, the extensive exhibition has a wealth of exotic developments – those that never made it past the prototype stage. One stands out in particular – the United States Hiller VZ-1 'Pawnee', a unique direct-lift rotor aircraft for military observation purposes in which the pilot stood above the shrouded counter-rotating rotors and could control the flight just by body displacement. This machine flew for the first time in 1955.

The US experimental flying platform Hiller VZ-1 'Pawnee' from the 1940s: It was controlled only by the weight shift of the pilot.

Also sensational is the Wagner 'Rotocar' – German engineer Josef Wagner's attempt to combine a helicopter with a car. Especially interesting is the coaxial rotor drive: A three-cylinder, two-stroke radial engine forms, so to speak, the rotor head on whose revolving cylinders the rotor blades are sort of flange-mounted. The upper rotor was also driven by this engine with the help of a gear set. An additional 250cc 'Goggomobil' micro-engine provided the terrestrial propulsion. The project, certainly cleverly devised, proved to be just as complicated and ultimately unfeasible as the construction of its propulsion system. In fact, some road and flight tests were probably conducted, but then – mainly for cost reasons – this peculiar design finally disappeared.

Individual parts, a simulator and extraordinary surroundings

The extensive exhibition is rounded off by several gyroplanes and even some gyrocopter models, such as the VFW H-3E Sprinter, which towards the end of the 1960s, had not yet made it past the prototype stage. Anyone still wanting more helicopter details finds a variety of examples from the wide world of helicopter technology in numerous individual components, such as rotor-head systems, engines and rotor blades – these range from production-ready designs to so-called finger exercises by resourceful engineers.

Last but not least, the museum is home to a special attraction for all helicopter enthusiasts. For a small fee, anyone can experience what it is like to operate the stick, pitch and pedals for the cyclic or collective pitch control in a truly professional helicopter simulator once used by the German Army Aviation as part of its pilot training. A display system consisting of several monitors gives indispensable visual assistance. Should the visitor be in the company of non-technophiles, there is plenty to enjoy nearby. Opposite the museum, the palace, ancestral seat of the Schaumburg-Lippe family, the great Castle Park, and, not least, the picturesque Old City show Bückeburg from a conceivably magnificent and harmonious perspective and are therefore a worthwhile alternative to the museum visit – they are worth a day trip on their own.

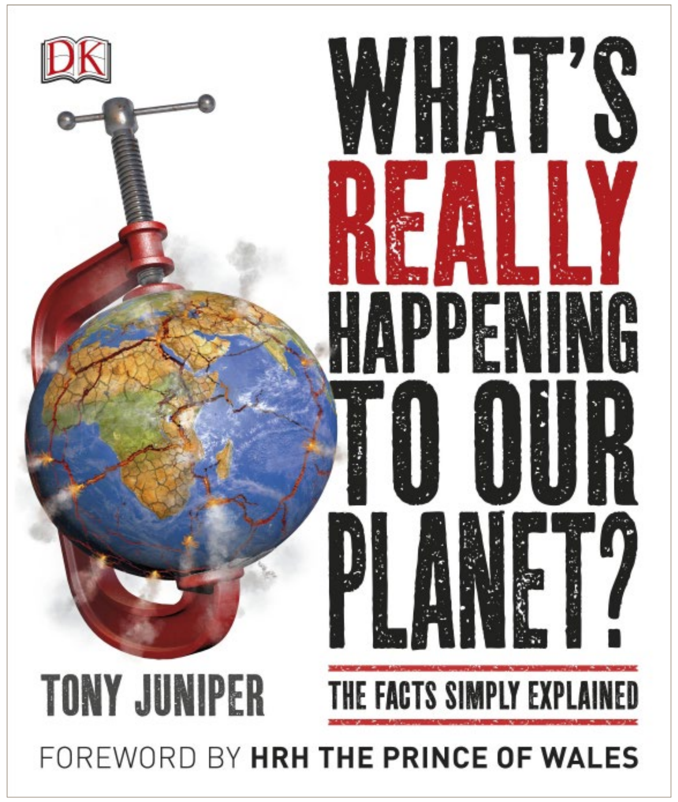
The Bückeburg Helicopter Museum was erected in 1970 in the historical 'Burgmannshof' from 1483. After several extensions, the two-storey glass cube that we see today came into being in 2011.

WWW.HUBSCHRAUBERMUSEUM.DE

Opening times:
Every day from 10:00 to 17:00
(closed only on Dec. 24 / Dec. 25 / Dec. 31 / Jan. 1)

Entry fees:
Adults: 7.50 euro
Children / young people from 6 to 16 years of age: 4 euro
Children under 6: free of charge

The Aérospatiale SA 330 Puma is a medium-sized transport and utility helicopter, and a modern example of a highly versatile rotor helicopter.



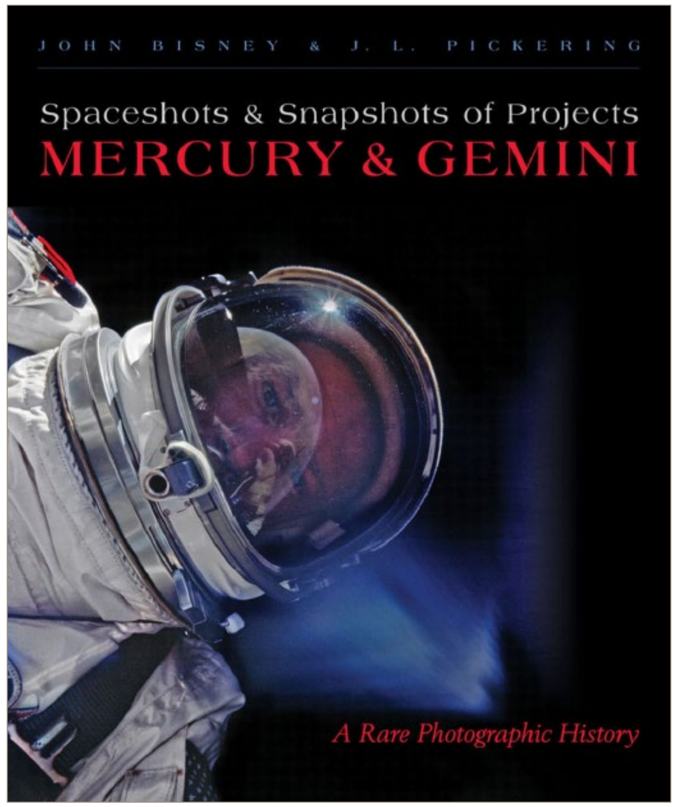
WHAT ABOUT EARTH?

In **What's really going on with our planet**, environmentalist Tony Juniper paints a picture of the current state of our planet through a series of colourful infographics. He charts the impact that the dramatic growth of the human population has had on our planet, and the challenges we face to secure a sustainable future.

The complex and interrelated trends visualised in this book reveal a plethora of threats to the sustainability of life on our planet, such as the increasing use of fertiliser and pesticides, freshwater scarcity, wealth disparity and corruption, terrorism, climate change and the extinction of animal species. But it is not all bad: renewable energy is the fastest-growing source of power worldwide. Technological developments have the potential of steering the world towards sustainable, circular economies in which the human impact on the environment is reduced by treating waste as a new resource. Governments increasingly join together in multilateral environmental agreements to combat climate change, and the book also suggests how the reader can contribute.

The strength of the book lies in its inclusive treatment of the social, economical and ecological challenges we face nationally and on a global level. On a positive note, he leaves the reader feeling that it might still be possible to turn the tide and provide a safe and secure future for the next generation.

Merel Groentjes



SPACE HISTORY IN A DIFFERENT LIGHT

In their book **Spaceshots and Snapshots of Projects Mercury and Gemini**, John Bisley and J. L. Pickering photographically tell the story of the first two projects in the United States' crewed spaceflight programme. Pickering has turned a childhood interest in spaceflight into a 40-year passion, amassing a still-growing collection of more than 100,000 high-quality photographs of the early years of the programme. These form the majority of the source material for this volume; most are previously unpublished and nearly all the others are rare.

An entire chapter is devoted to each of the six Mercury and 10 Gemini missions, beginning with Mercury-Redstone 3, the first crewed Mercury mission, when Alan Shepard made a suborbital flight lasting just over 15 minutes. The exception is a chapter that combines Gemini VI A and Gemini VII, the first missions to demonstrate an in-orbit rendezvous, so it makes sense to combine them.

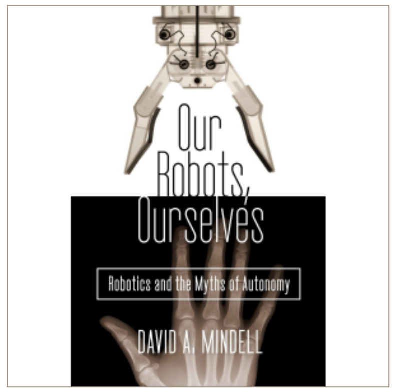
In addition to photographs of the astronauts, their spacecraft and the launchers, the book contains images of some of the first US spacewalks and unusual views inside the launch complex blockhouses. Although the book does not give any particularly new information, the rarity of the images alone make it an excellent choice for a space enthusiast's bookshelf.

Peter Clissold

HUMAN VS ROBOT

Underwater robots, drones, rovers – all of these came to existence thanks to humans.. But, will robots eventually replace humans? In **Our Robots, Ourselves**, David Mindell takes a look at the field of robotics today, how it has developed over time and explores the long-lasting and ever-changing relationships between humans and machines. The author takes us on a journey with robots, so we can experience first-hand what they do and see, and how human's thirst for knowledge has helped shape the technology behind them. Mindell tells us of lessons learned during 40 years of remote and autonomous systems in extreme environments. His stories are truly fascinating, ranging from deep sea explorations to the vast and hostile space environments, and everything in between.

Mindell shows us the myriad of applications of robotics – more than one will be surprised. Robots are used to uncover remains at the bottom of the sea, providing a view into ancient civilisations and how they lived; they are used to map some of the world's largest geological features, and even to travel to distant places in the Solar System to explore new worlds.



But Mindell also clarifies misconceptions about the autonomous robot. One of the relevant points he makes is that, although robots can help us to expand human consciousness, they cannot replace humans or even exist without them.

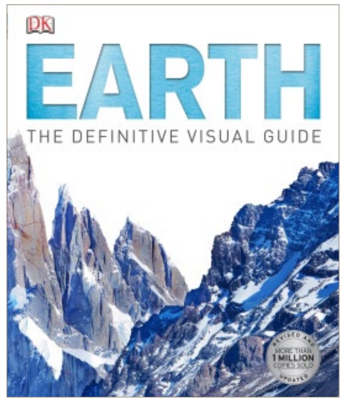
A great and entertaining read for anyone interested in how the field of robotics has developed, the role of robots in our daily lives, and what could await us in future.

Karin Ranero Celius

IN-DEPTH LOOK AT OUR SPACESHIP

Much about the book **Earth: The Definitive Visual Guide** has already been praised in numerous reviews. As they rightly noted, it features stunning images of Earth and is jam packed with useful information about our planet. The layout is accessible, the organisation neat, and the information easily manoeuvrable. The visual guide begins with a history of our planet's formation and composition, and builds on this canvas through its gradual exploration of the environments, ending with a 3D atlas of Earth.

But when the same information about our planet is instantly available on our smartphones and tablets, why bother with a heavy, not-easily-portable encyclopaedia? In this digital age, information is available at the touch of a button, but it is also transient. Out of quick sight on our phones often means out of our minds at the same rate. Therein lies the added value of Earth: The Definitive Visual Guide. It not only provides a visually pleasing wealth of information but also a constant reminder of the current state of our planet and, with this, the dangers it faces in an age of rapid global warming. Global consensus is that we must all act now, in whatever capacity we possess, to curb our carbon emissions and transition to more environmentally friendly and sustainable lifestyles. Even the quickest flip through this book helps drive this point home.



Laylan Saadaldin

RECOMMENDED LINKS

WHO IS IN SPACE?
bit.ly/1i8s7rn
Sometimes there are simple answers to questions. This page quickly and easily answers how many astronauts are currently in Space and how many days they have already spent there – a service and app for anyone wanting to stay up-to-date.

STATISTICAL PERSON
bbc.in/2e1W6p5
How often have the cells of my body been replaced in my lifetime? How much does my brain weigh? And how much data is stored in my DNA? You will find the answers in this interactive website. By providing details, such as your age, height and weight, you will get personal statistics.

THE SOURCE CODE THAT BROUGHT APOLLO 11 TO THE MOON.
svtsim.com/moonjs/agc.html
Apollo 11 was launched in 1969 with an almost minute control program. Only 3.3 megabytes of code were needed to take the crew into Space and then to the Moon. This English site provides the launch checklist, tips and an online simulator for anyone wanting to feel a bit like Neil Armstrong.

VIRTUALLY TRAVEL THE WORLD
geoguessr.com
Bolivia or Botswana? In this free online geography game, you can travel to different places at random on the Google Street View service map and have to guess where you are. The closer your estimate is to the actual location, the more points you get. But unless you are lucky enough to discover indicative signs, it is not always easy to distinguish between the Andean steppe and African savannah.

WHERE TO AND WHEN DID ANIMALS CHANGE THEIR HABITAT?
bit.ly/2feGBt1
An animated map, developed by researchers at the University of Washington and the conservation organisation; The Nature Conservancy indicates possible animal migration patterns within America. These are routes that the total of 2954 mammal, bird and amphibian species considered could take if climate change threatens their habitat. One problem: roads, pipelines and fences currently impede their escape routes

THROUGH THE EYES OF A PILOT
bit.ly/1SFQhez
In February this year, pilot Mark Vanhoenacker published his book 'Sky High', about the fascination of flying. For the U.S. magazine VOX, he has listed six things that he keeps encountering during his work that fascinate him. He has complemented each with pictures from the flight deck.

About DLR

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

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

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Cover image
David, the Hand Arm System, is one of the robotics technologies for which Tilo Wüsthoff created the design.

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