DLRmagazine

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THE SKY IS THE LIMIT

THE AIRCRAFT CABIN OF THE FUTURE IS SAFE, HYGIENIC AND COMFORTABLE

About DLR

DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. Two DLR project management agencies oversee funding programmes and support knowledge transfer.

Climate, mobility and technology are changing globally. DLR uses the expertise of its 55 research institutes and facilities to develop solutions to these challenges. Our 10,000 employees share a mission – to explore Earth and space and develop technologies for a sustainable future. In doing so, DLR contributes to strengthening Germany's position as a prime location for research and industry.

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SNAPSHOTS OF THE DLR COMMUNITY

Social media thrives on interaction. Our editors are in constant dialogue with our followers on Twitter, Instagram, Facebook, LinkedIn and YouTube. One topic that receives quite a bit of attention is the Stratospheric Observatory for Infrared Astronomy, SOFIA. A 2.7-metre telescope was installed in the fuselage of this extraordinary research aircraft for astronomical observations in the infrared and submillimetre wavelength range.

From the beginning of February to the middle of March 2021, SOFIA was a guest at Cologne Bonn Airport. For the first time, DLR and NASA conducted an entire scientific flight campaign from a German airport. This delighted us at DLR and a number of plane spotters and aircraft photographers from across Germany who tagged DLR in a host of images and videos on our various channels. We share the fascination of our followers and enjoy seeing every single image we receive! This also helps our social media team stay well informed about which topics are trending on our social media platforms.

DLR can be found under **@germanaerospacecenter** on Instagram, on Facebook at **DLRen** and Twitter **@DLR_en**.

EDITORIAL

Dear reader,

For over a year now, we've been living with the restrictions brought about by the COVID-19 pandemic. It has been clear for some time that this is not a single event we can endure before returning to the way things were. On the contrary, the pandemic has brought a number of problems into focus. But instead of paralysing us, COVID-19 has had an inspiring effect in some areas. One example is air transport. While flight operations are still limited, DLR researchers continue to study how we can travel more safely and comfortably in the future. To do this, they are thinking outside the box and designing entirely new concepts for the aircraft cabin. For the aviation sector, the crisis is an opportunity to question the status quo that has established itself in recent decades. These are the words of Markus Fischer, DLR's Deputy Board Member Aeronautics, who explains how the major challenges of the pandemic and climate change are affecting aviation in an interview.

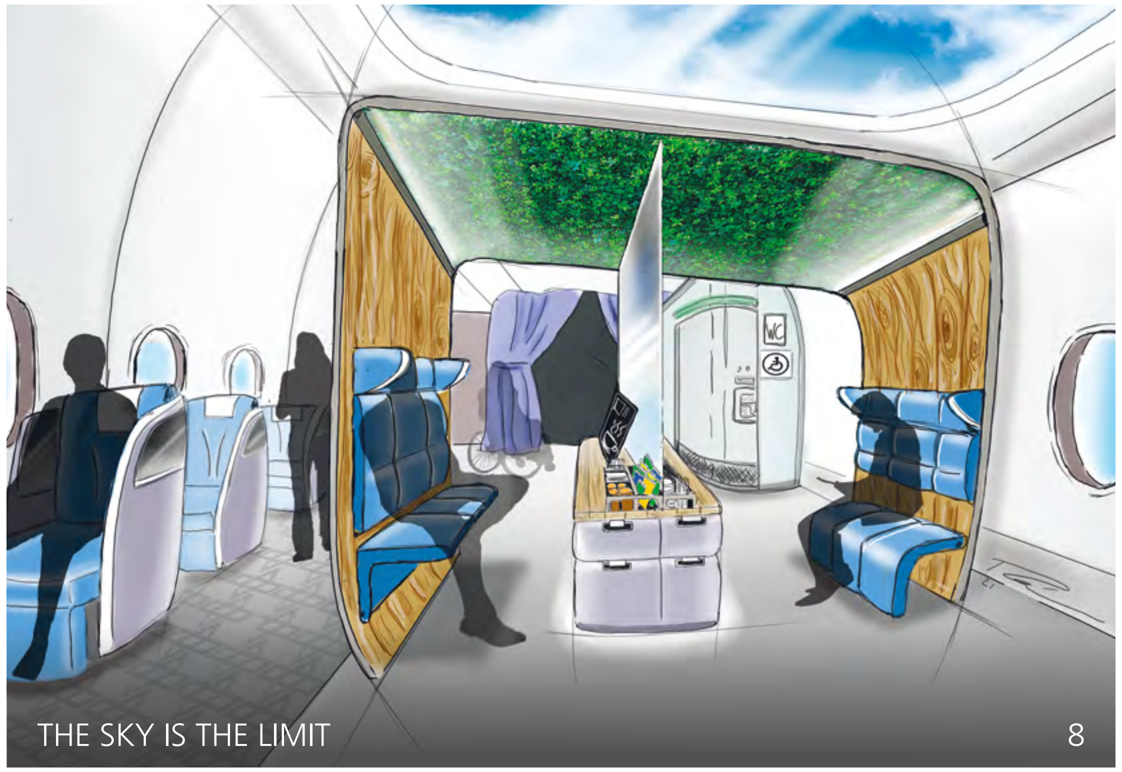
Digitalisation offers many new approaches to accelerating these changes. DLR has been investigating the role that simulation and experimentation will play in the development and evaluation of aircraft and technologies for many years. In this issue, DLR researcher Stefan Görtz describes the advantages and challenges of virtual flight tests and to what extent they already almost match the effectiveness of their real-life counterparts.

DLR transport researchers are also working on the interface between virtual reality and real life. In the HoloLens project, they are using virtual reality glasses to overlay virtual objects onto a view of the real world. Their goal is to give users an idea of what a future automated and connected transport system could look like. Magnus Lamp, Transport Programme Director at DLR, also addresses this topic, sharing his excitement at the prospect of being transported from his suburban home to the city centre in an automated vehicle.

Further topics in this issue include the 60th anniversary of the DLR site in Stuttgart, a solar-powered stratospheric aircraft that flies far above commercial air traffic and weather patterns, and the new residential district currently under construction in Oldenburg that will allow for neighbourhood energy trading.

We hope you enjoy this issue,

Your DLRmagazine editorial team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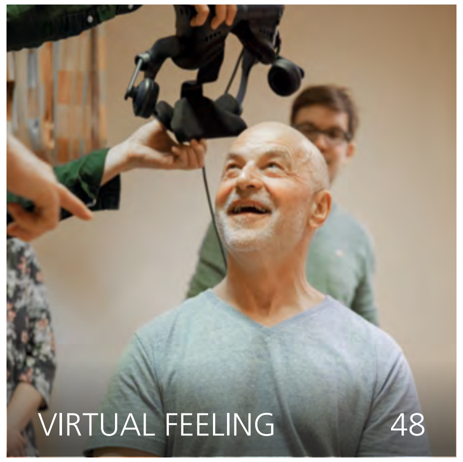
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QUANTUM COMPUTER SIMULATES BATTERIES

DLR is using a quantum computer to research electrochemical processes in batteries and fuel cells. The aim is to significantly increase performance and energy density. DLR researchers use simulations to compare the quantum chemical interactions that occur with various novel materials and electrode structures. Above all else, electromobility requires small, lightweight energy storage systems with high capacities and performance. The material and structure of the electrodes are key factors, as they affect the energy density and the voltage. With optimised materials, it is also possible to prevent decomposition processes and thus prolong the service life of batteries and fuel cells. The DLR Institute of Engineering Thermodynamics, Institute of Quantum Technology and Institute for Software Technology are working with the Fraunhofer Institute for Mechanics of Materials in the QuESt (Quantencomputer Materialdesign für elektrochemische Energiespeicher und -wandler mit innovativen Simulationstechniken; Quantum computer material design for electrochemical energy storage systems and converters with innovative simulation technology) project.

Image: IBM

This quantum computer will simulate electrochemical processes for high-performance batteries and fuel cells

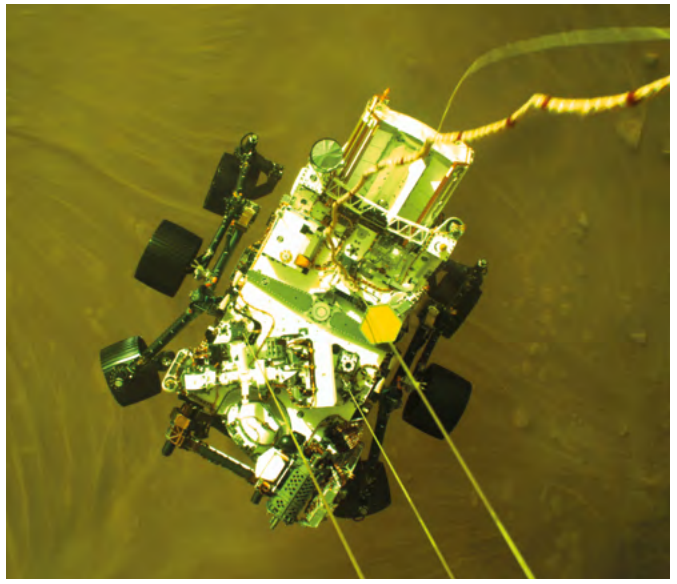

Image: NASA/JPL-Caltech

NASA's Perseverance rover shortly before touching down on Mars

NASA'S PERSEVERANCE ROVER EXPLORES MARS

The Perseverance rover has begun its work on Mars following a successful landing in Jezero Crater on 18 February 2021. It was the most precise landing ever attempted on the Red Planet. DLR is represented on the science team of the Mars 2020 mission and is involved in data and image evaluation. Perseverance will search for traces of past life and collect rock samples that will eventually be transported to Earth by follow-up missions. NASA's most complex rover to date carries more cameras than any other interplanetary mission in history. There are 19 on the rover itself, and an additional four on other parts of the spacecraft that acquired footage during the entry, descent and landing. To collect samples, Perseverance also carries 38 sample tubes that will be filled with cores from depths of up to 20 centimetres. These will be deposited at suitable locations on Mars for later transport to Earth. Two future missions planned jointly by NASA and ESA will bring the samples – which are approximately the size of a pencil – to Earth in the early 2030s.

INTELLIGENT ASSISTANCE IN THE EVENT OF A DISASTER

When disaster strikes, humanitarian aid organisations need to determine the extent of damage to buildings in the affected location and work out which transport routes are safe to use as quickly as possible – ideally in real time. Relief supplies must be delivered to inaccessible areas quickly and effectively. With this in mind, DLR researchers are developing and testing new artificial intelligence technologies that enable drone-based analysis as part of the Drones4Good project. The team will record image data that will be processed in real time on board the drone and test the safe dropping of aid supplies. In Drones4Good, DLR is working alongside the United Nations World Food Programme (WFP), the German Federal Agency for Technical Relief (THW), the aid organisation I.S.A.R. Germany and the international project Wings for Aid.

The drone with the integrated Modular Aerial Camera System (MACS) is used for visual reconnaissance of large-scale emergencies in real time

SAFE AND SECURE SYSTEMS

Artificial intelligence (AI) is a key technology for the future. The new DLR Institute for AI Safety and Security is developing safe and reliable methods and algorithms for use in the aeronautics, space, energy and transport sectors. Researchers here study robust AI-based solutions that meet the high requirements of safety-critical application areas and are protected against attacks. An important goal is the development of AI systems that act predictably, accurately and transparently. The researchers draw on data from DLR's large-scale research facilities and address ethical, legal and societal questions surrounding these systems. To this end, the experts are building up a scientific network that brings together expertise from a range of scientific disciplines and stakeholders. The institute has a focus on fundamental research and also provides other DLR institutes and facilities with the results and insights needed to set up safe AI applications.

Image: DLR / tampatra – stock.adobe.com

Institute for AI Safety and Security

Sankt Augustin and Ulm

Founding Director:
Professor Frank Köster

Planned staff: :
approx. 120 employees

Website: DLR.de/KI/en

DLR ACROSS GERMANY

BERLIN: In the Helmholtz Innovation Lab 'Optical Technologies for Situational Awareness Lab' (OPTSAL) at the DLR Institute of Optical Sensor Systems, researchers are working together with users and industry partners on new optical technologies and methods for situational awareness that, for example, support emergency services. Together with partners such as Quantum-Systems GmbH, DLR will develop new optical instruments for uncrewed aircraft.

BRAUNSCHWEIG: Landing on the deck of a ship out at sea in poor visibility is a challenge even for experienced helicopter pilots. As part of the Helicopter Deck Landing Assistance (HEDELA) project, DLR is working with the Fuhlendorf flight squadron of the German Federal Police to investigate assistance systems for pilots. Augmented reality systems ease the pressure on pilots in poor visibility, highlighting optical landmarks and important information within their field of vision.

COLOGNE: As part of the 'Artist Meets Archive' programme, Spanish artist Joan Fontcuberta examined materials in DLR's Central Archive in Göttingen. The results of Fontcuberta's project, entitled 'Gossan: Mars Mission', will be exhibited as part of the Photoszene United photography festival in Cologne in May 2021.

JENA: In the 'Undercover Ice Agents' project, classes of schoolchildren from Germany and Canada work together to investigate the thawing of Arctic permafrost using drone and satellite images. The participants use a map to record conspicuous features and changes to the land surface. Undercover Ice Agents is coordinated by the DLR Institute of Data Science. Interested schools can register with Christian.Thiel@dlr.de before the end of the year.

LAMPOLDSHAUSEN: This year's Hydrogen Day, which will take place on 22 July, will see experts from the automotive, energy, hydrogen and project development sectors exchange ideas about current developments and trends in the use of hydrogen. Interested representatives from government, science and industry can register at s.dlr.de/WXEGb.

STUTTGART: DLR is developing the world's first aircraft powertrain powered by a fuel cell with an output in the megawatt range. This would pave the way for such technology to be used for 40–60-seater regional aircraft with a range of 1000 kilometres. The DLR Institute of Engineering Thermodynamics is creating a unique test facility for the BALIS project for testing both the complete hardware and the necessary infrastructure.

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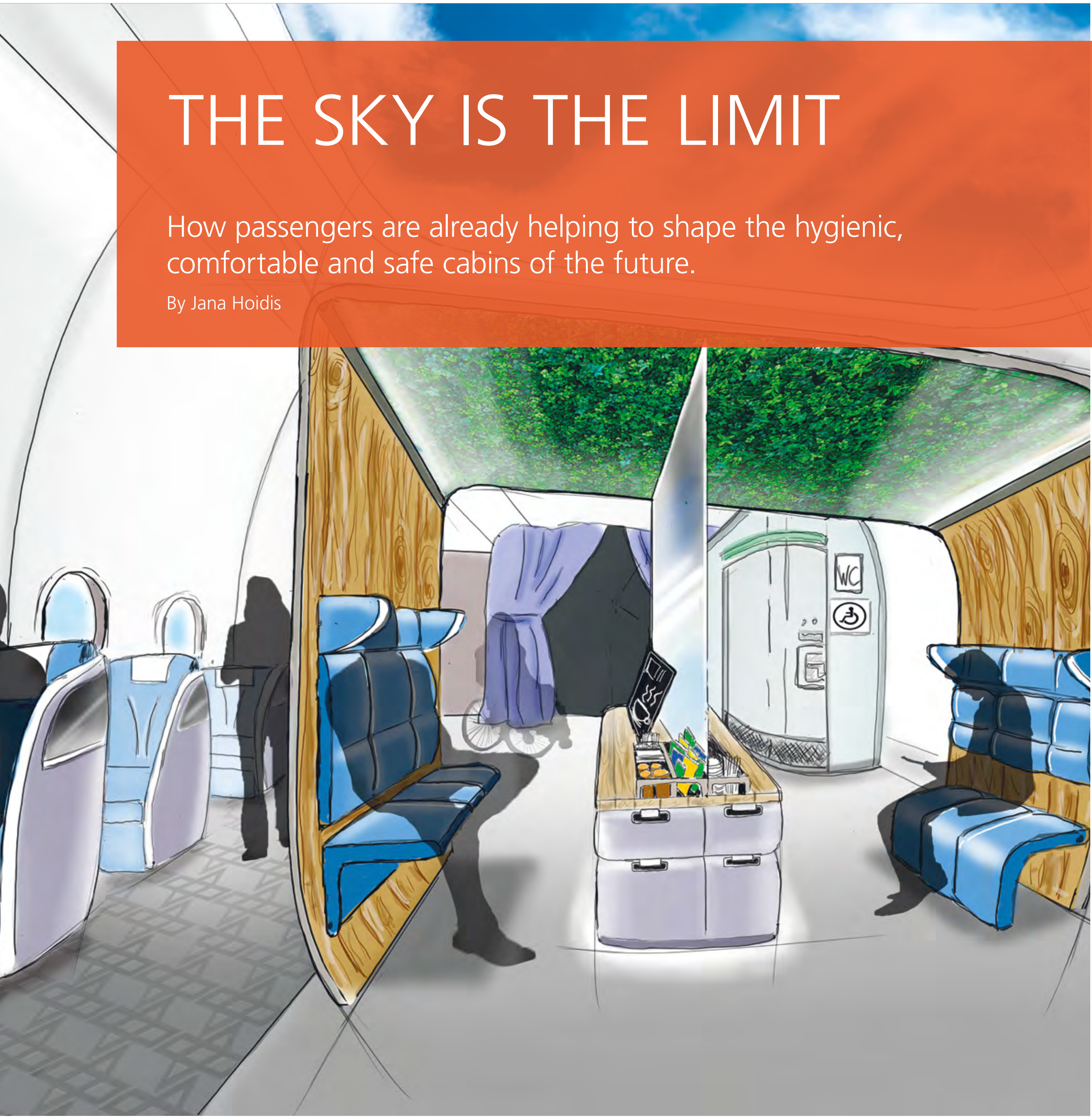
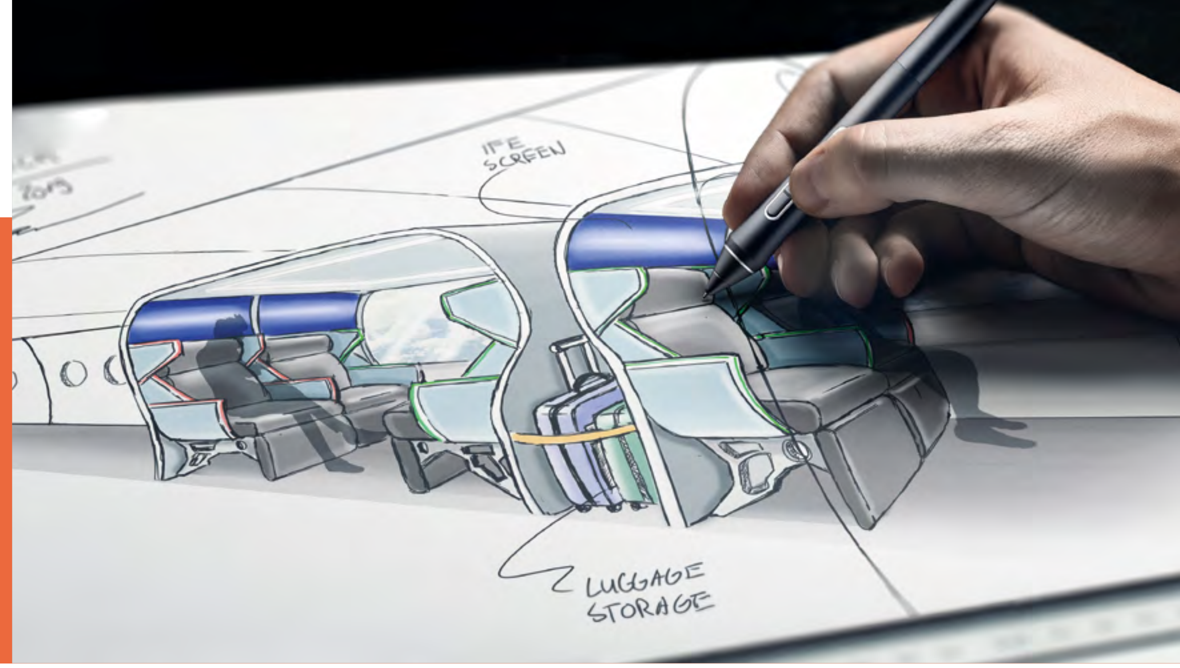
THE SKY IS THE LIMIT

How passengers are already helping to shape the hygienic, comfortable and safe cabins of the future.

By Jana Hoidis



Future aircraft must be as climate friendly and quiet as possible – without compromising comfort. New cabin concepts could help meet these requirements. At the DLR Institute of System Architectures in Aeronautics in Hamburg-Finkenwerder, a team of industrial designers is investigating how people will want to travel in the future, how their travel behaviour might change as a result of the COVID-19 pandemic, and what impact this will have on the design of aircraft. The team is developing new concepts for a modular aircraft cabin that is adapted to people's needs and, to this end, is also involving passengers in the design process.



Digital sketches graphically represent the idea process and can be easily shared electronically. In this design, partitions between the seats provide more privacy. A new way of stowing luggage could speed up the boarding process and thus shorten queues.

To function reliably in the air and on the ground, aircraft must satisfy strict safety requirements. This is an absolute prerequisite and remains the most important factor today. Up until now, industrial designers have taken the entire aircraft as their starting point when designing passenger cabins. The Innovative Digital Cabin Design (InDiCaD) project is creating a technical basis for directly linking the design and layout of cabin concepts digitally. 'Dreaming up the future!' is the motto of Fabian Reimer, Ivana Moerland-Masic and Thomas-Matthias Bock from the DLR Institute of System Architectures in Aeronautics. "Our project focuses on people and how their travel behaviour and needs are changing as a result of current trends," explains engineer and cabin designer Fabian Reimer. First, the team creates concepts and designs for the passenger area. These are adapted to new aircraft and then to an overall digital aircraft concept. Technical components such as air conditioning and cabin ventilation can be considered directly during the development process.

"In the project we have the freedom – which is somewhat rare in aircraft construction – to design the cabin based on the users themselves. Our first step is putting ourselves in passengers' shoes, so that we understand their needs and requirements," explains industrial designer Ivana Moerland-Masic. "Identifying the user group when designing a coffee machine or a designer chair is fairly easy, but air transport includes far more types of users." There are the passengers, pilots and flight attendants, of course, but this can be extended out to include the airlines, certification authorities, suppliers, maintenance staff and service providers. The aim is to make them happy with the final aircraft cabin. This is no mean feat for the designers. "Our goal with the InDiCaD project is to create completely virtual preliminary cabin designs. User and target groups evaluate initial solutions. These are then adapted afterwards. As such, our product testing approach is far better optimised than conventional methods," says Moerland-Masic, describing the advantages of her work.

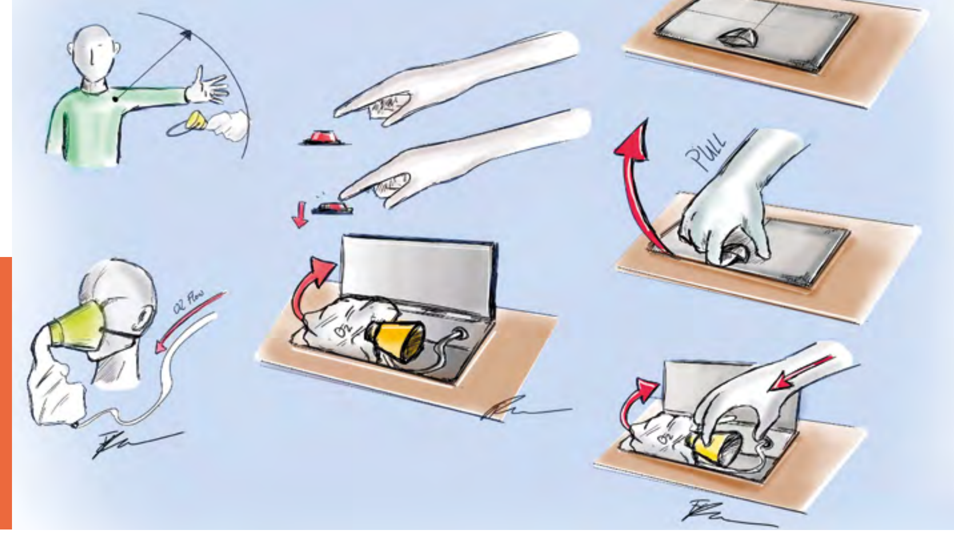
Future travel trends

The travel industry was a lucrative business up until the Coronavirus pandemic. Forecasts now show that air traffic is only expected to return to pre-COVID-19 levels by 2023. Even before the pandemic, opinion researchers, travel providers and design agencies, such as Seymourpowell, were looking at how people might travel on holiday or on business trips in future. "We looked at different travel trends and included possible effects of the current pandemic situation on the aviation of the future," says Reimer, setting out the team's way of working. "However, gauging trends is always a bit like looking into a crystal ball; they are always liable to change at short notice due to external factors."

With rising global prosperity, travel activity is increasing all over the world. It is expected that travellers will seek out individual experiences that are far removed from mass tourism. This is all about 'going against the flow' ('We are travellers, not tourists') and discovering new and unspoilt places. Depending on the generation, moral and political ideas may also play a stronger role. Sustainable travel and ecotourism are moving into focus. Such trips often last longer, as travellers are keen to learn more about a country and its people.

Regular communication, brainstorming sessions and workshops encourage creative thinking within the team. Later in the process, potential user groups are also interviewed to explore their needs.

The 3D model is created on the basis of the digital sketch. Seat distances and proportions in the cabin can be visualised in this way. It serves as the basis for testing in virtual reality, in which the concept becomes tangible and experienceable for the target groups.



Ergonomic design studies are essential for developing ideas and understanding important functions. Concept details such as reach or activation options are visualised early on and in the form of sketches.

From the Best Agers to the Millennials

In addition to the general trends, the design team is looking at more finely nuanced preferences that span different age groups. The Best Ager group encompasses people aged 65 and over. This group is considered to be among the megatrends and is a major influencing factor in future aircraft design. Compared with today's senior citizens, it is expected that their behaviour and needs will be significantly different in 2030 or 2050. The focus will be on newly freed-up time. People in this age group will be fitter and more mobile than they are today and will be more likely to choose aircraft as their means of transport.

In addition, Generation Y or Millennials (born between the early 1980s and late 1990s) will have an influence. This generation is considered the most important to the future of business travel. The design team is working on the assumption that we will see a sharp increase in the number of female business travellers, the Nomadic Business Woman. Nowadays, areas designated for business tend to have a somewhat stark and masculine appearance. The needs of female travellers are set to play a greater role in cabin design going forward. Neutral shapes and colour schemes, more privacy and more spacious lavatory areas are just some of the considerations here.

The travel sector is changing due to the COVID-19 pandemic. DLR has defined the trend of the Post-pandemic Traveller, which serves as an estimated point of reference for passengers whose needs have changed as a result of the pandemic. Due to the high risk of infection and the widespread integration of disinfection measures, protective masks, and an increased awareness of hygiene and social distancing, the designers expect these aspects to have an ongoing impact on the travel sector.

Empathy towards passengers

The team has selected a number of personas on the basis of these trends and more, as well as interviews with different user groups. These personas represent generalised groups. "A flight attendant gave us detailed insights into the day-to-day work of the cabin crew. They explained the challenges that arise when people from different backgrounds fly in the same aircraft," reports Reimer. People with disabilities still find it difficult to move around the aircraft. "One wheelchair user told us that it is almost impossible for him to use the lavatories."

"In our project we focus on people and how their travel behaviour and needs are changing as a result of current trends."

Fabian Reimer

Modular, people-oriented cabin concepts

What all of the personas have in common is that they want to be able to travel more conveniently and in greater comfort. They want their journey to their destination to be safe and pleasant, too. Key requirements include more space in the seating area, aisle and lavatories. With this in mind, the design team sketched out numerous ideas.

One of these was dubbed the 'suspended compartment seat' and consists of a solid, ceiling-high shell that affords greater privacy within the aircraft. Passengers can sit opposite one another, as they would on a train, and those travelling together can be seated as a group. Integrated partitions also increase protection against infection, thus providing a greater sense of safety. Passengers can even create sleeping areas by folding down the seats – an option that is currently only available in a few business class or first-class cabins. Luggage compartments beneath the seats would also free up more space overhead, enabling faster boarding. Passengers would no longer have to queue in the aisle due to the time-consuming task of stowing away luggage in overhead bins.

FUTURE USER GROUPS IN THE TRAVEL SECTOR (PERSONAS)

Best Ager

Malte Jensen, 75

Malte likes the fact that an aeroplane can cover huge distances in a short space of time. He finds lots of waiting around and looking for a place to sit in the cabin rather stressful. Increasing physical ailments make long-haul flights taxing. He uses domestic flights to visit his children, who live in far-away cities. He thinks that longer flights to destinations like Bali should be more luxurious.

Nomadic Business Woman

Alexandra Zimmer, 31

Alexandra loves travelling and is sporty, spontaneous and flexible. Her job is very stressful, but work-life balance is still important to her. She likes flying business class and enjoying films, food and top-quality drinks. However, she finds it difficult to sleep on planes. She associates connecting flights with stress. There is not enough space for her laptop in the cabin, so she cannot work efficiently. She also thinks it is rather unhygienic to have to touch so many things in the cabin.

Person With Reduced Mobility

Tim Neumann, 43

Tim is curious, cosmopolitan and likes to look on the bright side. What he likes about flying is the short travel times compared to the train. However, so far flying is by no means barrier-free. Time is wasted during boarding, there is low accessibility, it is not possible to have one's own wheelchair on board and the use of the lavatory is associated with restrictions and obstacles.

Post-pandemic Traveller

Tina Schröder, 58

Tina takes a more traditional view of things. Safety, happiness and health are paramount. When travelling, she has a clear idea of what she needs and where she wants to go. Planning the journey is extremely important to her. She appreciates the fact that travelling by plane allows her to cover large distances at relatively low cost. She is not so keen on crowds of people in small spaces, long waiting times, poor-quality air and stressed passengers. She would like more roomy seating and lavatories. She is worried about becoming infected if there is a disease outbreak on the plane.

Undertourist

Linus Müller, 19

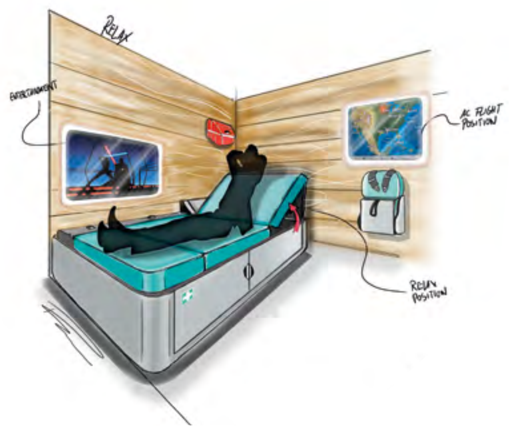
Sustainability is very important to Linus. He needs to be able to reconcile the mode of travel and destination with his conscience. He has clearly defined values and likes ethical and environment-friendly travel. Flying connects countries and cities all over the world and makes them accessible, but he cannot stand the fact that aeroplanes have high pollutant emissions and cramped cabins. He gets the sense that people and their needs are being overlooked. He does not want to support low-cost airlines under any circumstances.

Luxploring Family

Karin and Jonas Weber, 37 and 39, and their children

The Webers are intellectual, open-minded, cosmopolitan and mindful of acting responsibly. They want to combine their careers with family time and lead a fast-paced life. What they like about flying is the anticipation in the run-up to the holiday, the short travel time and the experience that it provides for their children. The downsides are that the seating may not be designed for children, and the entertainment is often outdated.

Space for medical emergencies and for treating sick passengers – but the couch can also be used for relaxation.



In the context of the COVID-19 pandemic, the team even designed a concept for a medical room to care for sick passengers. It can also be flexibly adapted and used as a relaxation area with entertainment. The controls are designed to best meet ergonomic requirements. "We placed the medical equipment on the first-aid couch so that the controls are all quickly and easily accessible in the event of an emergency," Reimer explains.

Next, based on the selected designs, the team generated a 3D model, which can be viewed using a virtual reality (VR) headset. In the past, designers generally used sketches, 3D graphics or elaborate prototypes to discuss ideas for developing cabins. "In our experience, virtual reality is the best way of presenting our designs to users. They can move around the cabin and really immerse themselves within the new setting as a three-dimensional space," explains Moerland-Masic. Testing using virtual reality techniques is also quicker and more cost-effective than building large and expensive prototypes, and optimisation processes run much faster. A test campaign is planned for 2022 as part of the DLR project InDiCaD, in which several test persons from each persona group will experience and evaluate the new designs. Since VR headsets can be worn at home, they make it possible to exchange information with colleagues and participants when everyone is working from home.

The team has the freedom to develop creative ideas without financial constraints. But despite all this, air travel should remain affordable. Follow-up projects with external partners, including airlines, are intended to determine how such conceptual designs can be made a reality. Moerland-Masic believes that the COVID-19 pandemic is an opportunity to change our lives to become more sustainable. "At this point, it's difficult to predict where this journey is going to take us. But one thing is certain – we are at a crossroads and have the option of heading down a new path, towards more innovation, better environmental protection and the possibility of giving travellers a better experience."

Jana Hoidis is responsible for public affairs and communications at DLR's Hamburg site and is looking forward to joining the Post-pandemic Traveller trend, hopefully in the not-too-distant future.

TEAM FROM THE DLR INSTITUTE OF SYSTEM ARCHITECTURES IN AERONAUTICS

Fabian Reimer has worked at DLR since 2019. He studied aircraft manufacturing with specialisations in cabin and cabin systems design at Hamburg University of Applied Sciences. He worked in the Cabin and Cargo of the Future Department at Airbus during his studies. He considers aircraft to be among the most exciting and complex products around. He likes independent travel, loves the freedom of movement offered by trains, and is excited to be helping to design future aircraft. He is also keen on good design and art outside work – he paints with acrylics on canvas in his spare time.

Ivana Moerland-Masic grew up watching Star Trek and has been dreaming of designing technology to suit human needs ever since she was a teenager. After studying industrial design at Delft University of Technology, she joined DLR in Hamburg in 2016. She wants to make air travel more aesthetically pleasing and enjoyable. She and her family like travelling independently and taking the time to get to know other countries in detail. When it comes to business travel, she prefers travelling by plane, as it gets her back home to her family sooner.

Thomas-Matthias Bock studied industrial design and worked in creative cabin design at Airbus in Toulouse for 35 years. He has been involved in the design of almost every aircraft model to be introduced over the last few decades. In the course of his work, he has travelled around the globe, from economy to first class – he has experienced them all. He has created design concepts for more than 50 airlines. Colours and textile design that hint at other countries and the flair of foreign airplane designs always put him in the mood for new destinations. DLR in Hamburg has been benefitting from his many years of experience since 2019.

CRISIS AS AN OPPORTUNITY

Interview with Markus Fischer, Deputy Board Member Aeronautics at DLR

Climate change, a pandemic, noise emissions – how are these major challenges affecting aviation today?

: The air transport system in Germany and Europe as a whole has long had the overarching goals of advancing high-tech capabilities and developing a climate-neutral air transport system with the highest safety standards. These have not changed as a result of COVID-19. However, the crisis and the increasingly apparent signs of climate change have shown us that we need to act much faster than before. We and our partners see the crisis as an opportunity to challenge design paradigms and research topics that have proven ground-breaking and successful for us over the recent decades of constant increases in air traffic volumes. New areas of focus, such as the increasing electrification and digitalisation of aviation, simulation-based design processes, new energy sources, new materials and the principles of lightweight construction will play a major role in all of this. They make appreciable changes to the design space and important design criteria for a future air transport system, and thus merit intensive research. All those involved in the aviation sector have to ask themselves how future flight will differ from the way it is today. This might manifest itself in the size, mission, cruising speed or altitude of the aircraft, for instance, or even the flight path.

What measures seem to be quick wins on the long journey towards climate-neutral flight – sustainable fuels, hydrogen, batteries and fuel cells, perhaps?

: Air transport makes a significant contribution to climate change, as its emissions mostly occur at altitudes at which their impact on the climate is particularly high. This is the typical operating range of large civilian passenger aircraft on short- to long-haul routes. New aircraft gas turbine concepts and thermodynamic cycle processes, the advancement of tried-and-tested engine concepts combined with the use of sustainable fuels to replace fossil kerosene, and the direct combustion of hydrogen all count as quick wins when it comes to making air traffic more environmentally friendly. Climate-optimised flight guidance is another rapid and promising instrument, at least when applied to part of the airborne fleet and within specific areas of airspace. At the same time, hybrid-electric drives that run turbo-electrically or are based on energy storage systems such as batteries and fuel cells must also be further investigated. Within this decade, the energy and power density of such technologies will prove useful in aircraft and operating concepts for feeder flights and regional aircraft that fly on routes within urban areas or to the next-largest airport.

How is DLR contributing towards a greener air transport sector?

: DLR's aeronautics research is oriented towards the European Green Deal. Our aim is to provide application-oriented solutions for zero-emissions flight from 2050. In doing so, we are looking at not only reducing the chemical emissions, but also the physical emissions, for instance by further reducing aircraft noise with quiet aircraft designs and flight manoeuvres. In addition, we will be advising airports, policy makers and municipalities on measures they can take. Thanks to the expertise and capabilities of over 25 DLR institutes and facilities conducting research in the field of aeronautics, not to mention a unique research infrastructure, DLR enjoys an overview and whole-system understanding of the entire air transport system. More than ever before, we want to bring this capability to bear on the aviation network made up of academia, industry, business and government. We want to provide a basis for taking action and making decisions so that we can jointly make air transport fit for the future in an eco-efficient way.

Questions asked by **Julia Heil**, an editor in the Public Affairs and Communications department at DLR.

Markus Fischer has been Deputy Board Member Aeronautics at DLR since earlier this year. He received a Doctorate in Mechanical Engineering from Leibniz University Hanover in 1994 and worked as a researcher at the DLR Institute of Aerodynamics and Flow Technology from 1991 to 1996. He then worked at various companies in the aviation industry, including Airbus and Rheinmetall Defence. In 2017, he returned to DLR and was appointed Programme Director for Aeronautics.

In the VicToria project, the researchers simulated the noise of the high-lift system, the flight dynamics and the wing deformation of DLR's A320 ATRA in the computer. They then compared the simulations with real flight test data and designed a long-range aircraft taking all relevant disciplines into account.

DOWN TO THE VERY LAST DETAIL

As aeronautics goes increasingly digital, how will simulations and experiments complement each other in the future?

By Yvonne Buchwald

Aviation is undergoing a transformation, and the Corona pandemic could accelerate this process. The question of how future aircraft might look is not just a matter of alternative propulsion systems; it is also a question of how to get there. How will new aircraft and technologies be developed and evaluated? Will certain tasks be performed faster and more economically using computers? And will there still be a need for experiments? Will aeronautics research really be fully digitalised before long? And have we not dreamed of all this before? Stefan Görtz was in charge of DLR's VicToria project (Virtual Aircraft Technology Integration Platform), the largest of its kind ever to be conducted in the field of digitalisation in European aeronautics research. It was completed in late 2020. Some 160 scientists from 13 DLR institutes and facilities were involved, developing methods to evaluate new technologies for more economical and environment-friendly flight in a more timely manner in the future and to enable new aircraft to be designed (almost) exclusively using computers.

Professor Görtz, the first crucial steps towards virtual aircraft development and flight testing using high-fidelity simulation methods had already been made in earlier projects. Where do things stand at the moment?

: We are making consistent and purposeful progress towards digitalising aeronautics, but there are always going to be different expectations, setbacks, changing conditions and diverging visions. We are getting closer to the idea of the virtual product, step by step. This is a highly accurate mathematical and numerical representation of the aircraft, with all of its characteristics. Today, we are able to model aircraft geometries in far greater detail.

Image: Private

Stefan Görtz is head of C²A²S²E (Center for Computer Applications in AeroSpace Science and Engineering) at the DLR Institute of Aerodynamics and Flow Technology in Braunschweig. The 46-year-old aerospace engineer has been Professor of Multidisciplinary Design Optimization at TU Braunschweig since December 2019. He was the Principal Investigator of DLR's interdisciplinary VicToria project between 2016 and 2020, was involved in its predecessor project, Digital-X, and continues to be involved in the cross-sectoral project Simulation-Based Certification (SimBaCon).

Most importantly, however, we are no longer looking at technologies and disciplines individually, but rather in combination. We were able to perform calculations for entire aircraft 30 years ago and have done plenty of aerodynamic simulations since that time. But that alone is not enough, of course. An aircraft is also elastic. The wings flex and the fuel sloshes back and forth during manoeuvres. There are a lot of things to take into consideration, and that is precisely what we are doing here. By coupling our new, high-fidelity simulation methods, we are creating an interdisciplinary simulation and design environment that allows us to understand the physical characteristics of an aircraft and the interaction between different disciplines more accurately than ever before.

In 2013 you said, "Only when an aircraft behaves in the computer as it does in reality will a digital aircraft complement a flight-test aircraft on an equal basis". How close are we to achieving that goal?

: Five to 10 years ago, people could not yet claim that simulations were on a par with real test flights, or that a digital aircraft could replace a real one. In the VicToria project, for instance, we compared virtual flight tests with real, highly-instrumented flight- and wind tunnel tests – with a level of detail that is, in fact, unique worldwide. In spring and autumn 2019, we carried out flight tests with DLR's research aircraft A320 ATRA both in the air and on a computer. In doing so, we found that we can very accurately simulate its flight dynamics with the highly accurate methods we have at hand today and create a model of the ATRA in the computer with the help of dedicated virtual flight tests.

"We are no longer looking at technologies and disciplines individually, but rather in combination."

This marks another important step along the path towards digital design and simulation-based certification. That said, we have to achieve even greater accuracy and incorporate even more details into our simulations in order to arrive at a perfect match between virtual and real flight tests.

Apparently minor details, such as the exact mass distribution in the aircraft, play an important role. Simply put, things like knowing whether the pilot was carrying a wallet on the test flight also plays a role in the end. We have to keep thinking about what will get us close enough to reality.

A stereo camera system installed in the aircraft cabin was used to measure the deformation of the wing during various flight-test manoeuvres

Image: Wilbri GmbH

The wings of the A320 ATRA were covered with a special foil in order to optically measure their deformation during flight

THE VicToria PROJECT AT A GLANCE

VicToria is a showcase project because …
"we had the unique opportunity to bring all of the relevant disciplines in aeronautics research together in this DLR project."

This topic is very relevant because …
"the development, testing and manufacturing of new aircraft is associated with considerable timing and financial risks. The Coronavirus pandemic has made it all the more important to step up the introduction of innovative technologies in order to make flying more economical and environmentally friendly, while giving us greater control over the technological risks."

One thing that was completely new was …
"Unlike the projects that came before VicToria, here we combined wind tunnel experiments with real and virtual flight tests based on validated and enhanced simulation methods. In addition, we have considered all relevant disciplines relating to flight physics."

The project in numbers
3.75 years duration (2016–2020)
36 million euro project funding
13 DLR institutes and facilities involved
160 contributing scientists

When will our simulations be good enough that we can rely on them completely? On the one hand, it is important to engage in a dialogue with the regulatory authorities. On the other hand, test pilots will in the future be able to compare a virtual model of the airplane or helicopter with the handling qualities of the actual aircraft in a flight simulator.

The first wave of enthusiasm for digitalisation swept through the research landscape back in the 1970s; conventional experiments seemed to have fallen out of favour. According to the predictions, numerical simulations would replace wind tunnel and flight testing.

: Yes, that was the thinking. When numerical flow simulation methods were first developed and used to tackle problems that appear pretty rudimentary today, people were convinced that they would soon replace experiments altogether. But that was far too optimistic, and not just in terms of timing. Researchers soon realised that there were certain shortcomings, especially when it came to the modelling depth and the lack of interaction between the disciplines involved. Computing resources were also limited; the Cray supercomputers in the 1980s only had the computing power of an iPhone 4. While at that time models were being calculated for comparatively simple cruise flight conditions, today we can model complex flow phenomena and simulate dynamic flight manoeuvres. When all that became clear, wind tunnel and flight tests were reappraised and deemed to be indispensable once again. So much the better for us today, as we can use them to improve and validate our simulation methods.

After the continued importance of experimental research had been realised, numerical simulations, wind tunnel and flight testing were deployed together. Right now, however, the focus seems to have returned to digitalisation. Is this still an equally balanced triad of research methods, or has numerical simulation emerged triumphant after all?

: There were times when it was thought that simulations would soon replace all of the conventional methods. And there were times when scientists believed that wind tunnels represent the absolute truth. The fact is that all methods are mere approximations of reality. But for all that, there has indeed been a shift – today it is clear to us that experiments will continue to be conducted, albeit in lower numbers, but they will be more targeted and of higher quality. And they will take place at a different stage in the design and development process. Simulations have become more important in the early stages of design, as they allow us to perform trade studies and to explore the design space to steer the design in the right direction. In future, it will not be a matter of using a wind tunnel or flight tests to design an entire aircraft. Instead, things will happen the other way around – for example, first come the simulations, then the numerical design, and only then will the experiments take place, for the purposes of verification and validation. What is more, by using not only more powerful computers, but also better measurement technologies, we can continue to improve our computer models through dedicated experiments. In doing so, we are consistently pursuing the path from digital design to virtual certification.

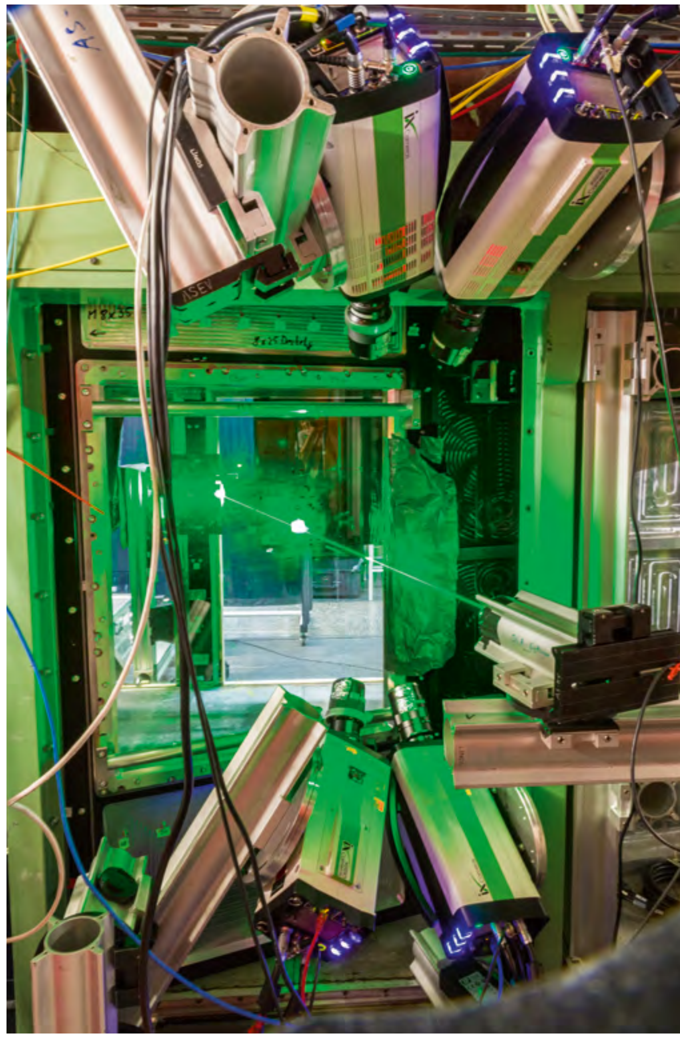
When talking about performing virtual first flights for certifying an aircraft, numerical data continues to be subject to much greater distrust than real tests. Where do you stand on that?

: In the VicToria project, we laid the groundwork for digital development and the characterisation of aircraft and helicopters by means of numerical simulations. The project is unique in the sense that all of the relevant disciplines, such as aerodynamics, aeroelasticity, load analysis, flight dynamics and structure, were brought together for virtual flight tests and multidisciplinary design. Only DLR can do something like this, not a university and, to this extent, not an industrial company. For the first time, we conducted experiments purely to check our models and simulations – several wind tunnel tests and two flight test campaigns with the ATRA. The processed measurement data were used to improve the numerical methods and check the accuracy of their predictions.

"There will continue to be experiments, fewer in number but more focused and of higher quality."

Now, we are in a position to carry out virtual flight tests that can be compared with real flight tests in detail. This means that we can construct a virtual model of an aircraft or helicopter with all of its characteristics. To give one example, such a model could be used to design a system to reduce the loads caused by gust encounters or during manoeuvres, thus increasing passenger comfort. And that's not all – we can now make use of these methods for new aircraft like the iSTAR (see article in DLRmagazine 164) or even use them to design, test and fly aircraft that do not yet exist. In the future, it will be possible to provide a 'digital twin' for an aircraft or helicopter, which can be used to assess the potential of new technologies in a virtual design environment and to determine their impact on the environment.

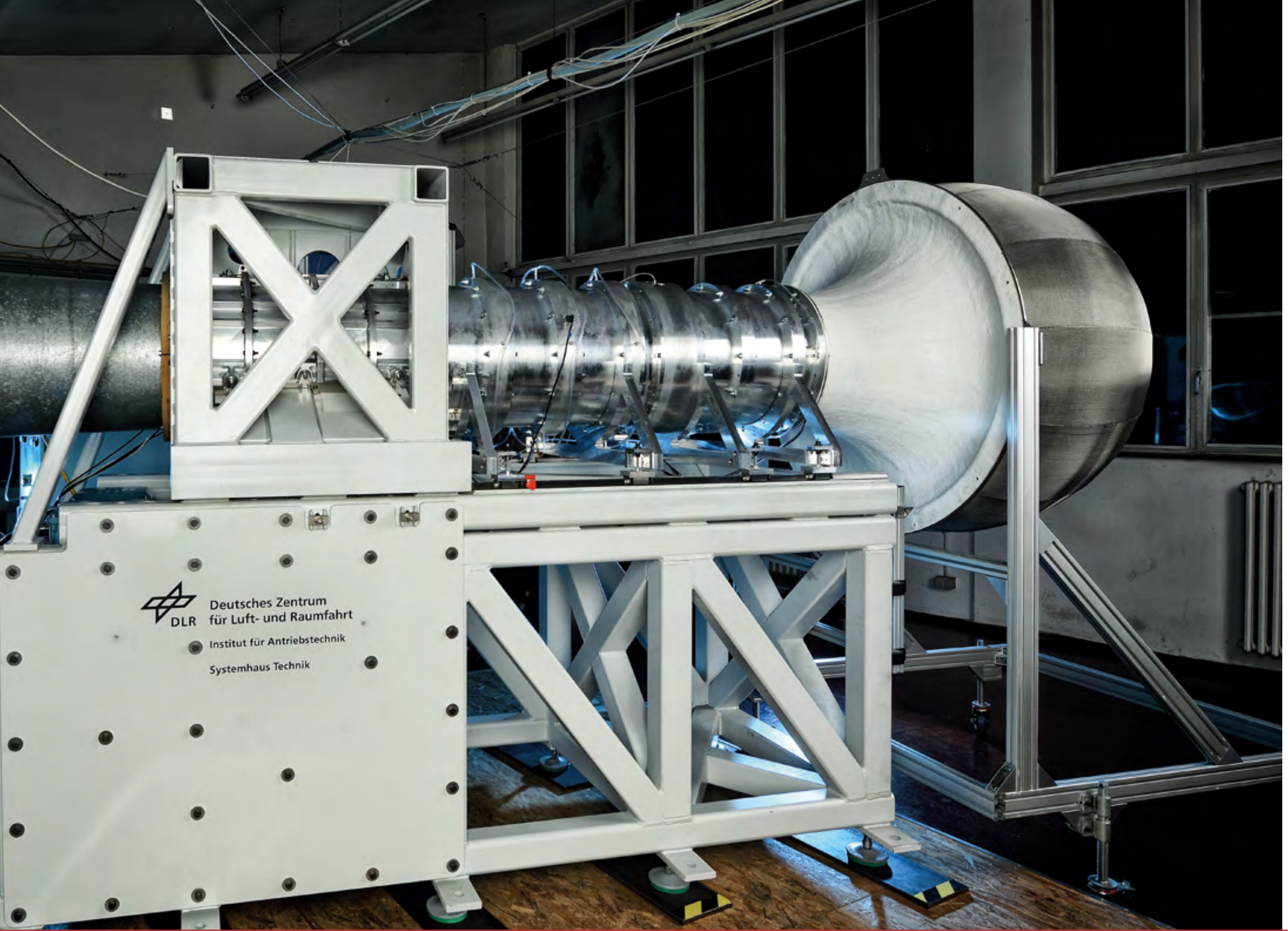
The interview was conducted by **Yvonne Buchwald,** who is responsible for communications at the DLR Institute of Aerodynamics and Flow Technology in Braunschweig.



With a new high-resolution measurement technique, scientists have studied flows in detail, as they occur when air moves around aircraft components, using the Eiffel Wind Tunnel at the Bundeswehr University Munich. With the data, they were able to improve their models and validate their simulation methods.

SIMULATION-BASED CERTIFICATION

It can take several years for new technologies or vehicles to receive certification, including time consuming test drives or flight tests. With simulation-based certification, the majority of the data required for certification can be provided using computers. As part of DLR's cross-sectoral project Simulation-Based Certification (see the article in DLRmagazine 161), several DLR institutes and facilities are working together to develop tools for digitalised certification. The goal is to further develop the simulation processes to the point where the authorities accept them as reliable means of certification.



SHHH

New DLR turbofan test bed in Berlin to research quieter engines

By Melanie-Konstanze Wiese

In future, the societal acceptance of aircraft will truly depend on their environmental compatibility. This concerns not just their impact on the climate, but also noise. The propulsion concepts of modern passenger aircraft range from light air taxis to large airliners. Many future aircraft will be equipped with fans, which can be recognised by their large, shrouded rotors. Researchers at the DLR Institute of Propulsion Technology are working to make these fans quieter than they are today while delivering the same level of efficiency. This involves precisely determining the source of the noise in order to reduce it. DLR researchers have developed a test stand that will allow new engine concepts to be examined at the prototype stage.

This new and unique test environment has been named CRAFT (**C**o/Contra-**R**otating **A**coustic **F**an **T**est Rig). After three years of development, the test stand is now ready for use at the laboratory of the DLR Institute of Propulsion Technology in Berlin-Charlottenburg. "The measurement data from the new test stand will allow us to verify the modelling methods that we use to design low-noise fans," says Lars Enghardt, Head of the Engine Acoustics Department. He adds: "The tests carried out on CRAFT will allow us to draw conclusions on how to optimally integrate new engines into future aircraft – from the next generation of large aircraft, in which the nacelles will be very short or even incorporated into the airframe, to urban air taxi designs featuring electric fans close to the fuselage or on the wing." In this way, Enghardt's team hopes to gradually achieve more sustainable air transport with engines that are both quieter and more efficient than conventional aircraft engines.

Modular, flexible and unique

The distinctive feature of the new test rig is its modular construction. The unique testing environment provided by CRAFT will allow the detailed study of the noise generated by fans. A double-shaft system will make it possible to investigate both the widely used rotor-stator configurations, the aerodynamically efficient rotor-rotor configurations, and two-stage compressors. A long, self-supporting hub allows the acoustic experts in Berlin to flexibly vary the distances between rotor and stator or rotor and rotor, as required. They can even examine rotors independently. In this process, stator blades can also be easily exchanged without requiring cost-intensive modifications.

A further feature of CRAFT is the inflow control device installed at the intake. This ensures a much more even airflow, which in turn helps the instruments measure the aerodynamic sources of noise undisturbed and over a longer period. The generous space around the inflow and outlet provides scope for installing the measurement devices and actuators, such as secondary sources of noise. Aerodynamic probes measure the stationary and turbulent airflow components in the flow between the rotor and the stator and downstream of the fan. A total of 200 microphones record the sound generated by the fan and the sound field radiating from the intake and outlet. The results are interpreted using advanced analytical methods.

View into the inlet of the CRAFT test stand

FROM DESIGN TO CONSTRUCTION

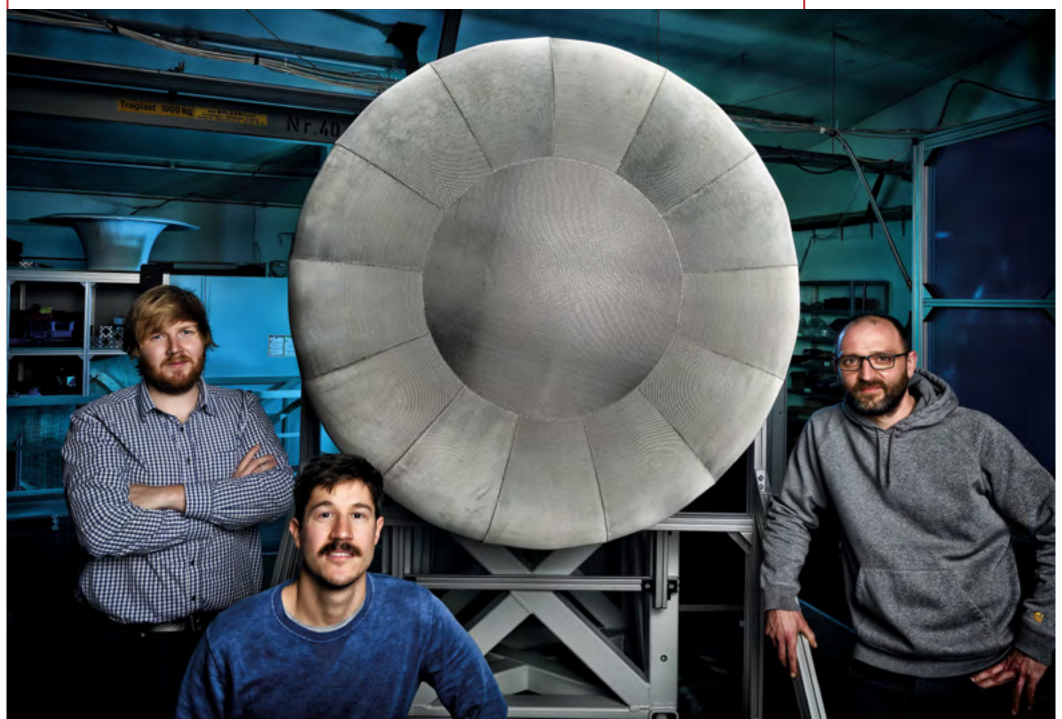
CRAFT was developed by the DLR Institute of Propulsion Technology with the support of DLR Systemhaus Technik. The design and construction of the test rig was completed in three years at a cost of approximately 1.6 million euro. It is located at DLR's Berlin-Charlottenburg site, which is the headquarters of the Department of Engine Acoustics at the Institute of Propulsion Technology. CRAFT will eventually move, together with the whole department, into a new building in Berlin-Adlershof.

New, innovative and quiet

For Enghardt and his team, the newly-acquired knowledge is a basis for developing new, innovative methods of reducing fan noise, for example, by optimising stator and rotor designs. The team will then test them on the CRAFT test rig. Simultaneously, the DLR researchers are taking another approach by influencing the flow around or even at the very locations of the noise emissions to make the entire engine quieter.

The department is also working on novel methods of monitoring to provide more flexibility for the fan components of the engine in terms of maintenance. The noise caused by wear of or defects in the blades can be monitored or predicted in advance, so that components can be replaced before any damage actually occurs. "Because CRAFT offers so many trial variants and is so inexpensive to operate, we can use it to analyse and describe the physical mechanisms of noise generation in a pretty holistic way that was not previously possible," says Enghardt, looking to the future.

Melanie-Konstanze Wiese is responsible for communications at the Berlin, Cottbus, Dresden, Jena, Neustrelitz and Zittau DLR sites.



From left to right: Angelo Rudolphi, Luciano Caldas and Sebastian Kruck from the Engine Acoustics Department

Image: DLR

CROSSING FRONTIERS

A solar-powered stratospheric aircraft combines the advantages of spaceflight and aeronautics

By Florian Nikodem

Satellites have become vital to Earth observation and global communications. However, they are not without their disadvantages. In addition to the costs of construction and then placing them in orbit, their remains are sometimes left behind in space, becoming space debris. In 2020, the International Space Station (ISS) had to make three collision avoidance manoeuvres. Aircraft and helicopters are far more versatile and cost-effective. They can be used for Earth observation activities in cases where the use of a satellite would be disproportionate or simply impossible. However, they have a restricted operating radius and success is often dependent on the weather. Another factor is that even the best pilots need to take a break every now and then. High-Altitude Platforms, (HAPs), offer a possible solution. These solar-powered platforms are permanently stationed in the lower stratosphere, at an altitude of approximately 20 kilometres.

An integrated approach

Given enough sunlight, HAPs can be positioned anywhere on Earth and used for a wide variety of missions. They fly far above civilian air traffic and even above the weather. The concept behind them arose from the rapid developments in solar and battery technologies in recent decades, which have paved the way for this link between aircraft and satellites. HAPs are flexible to deploy and equip with instruments and are also independent of weather conditions or time of use. As part of its cross-sectoral project HAP, DLR is conducting research into technologies and applications for a high-altitude, permanently stationed platform, and developing a research aircraft for future scientific experiments. In this process, not only the solar-powered, unmanned demonstrator is being created, but also a ground station, the operational procedures and three payloads to be carried by the platform, which offer a wide range of future applications. Seventeen DLR institutes from the fields of aeronautics, space and security are working together on this project, which is being led by the Institute of Flight Systems in Braunschweig.

From glacier observation to forest fire detection

A HAP has a wide range of possible application scenarios, ranging from the uninterrupted observation of glaciers and snow cover in polar regions to maritime surveillance, including in the Mediterranean Sea, and all the way through to monitoring herds of animals in Namibia. To that end, the DLR Institute of Optical Sensor Systems is developing a special version of its Modular Aerial Camera System (MACS), which has a very high resolution and can identify target objects independently. The DLR Microwaves and Radar Institute is building the HAPSAR radar, which can perform observations regardless of the weather conditions. A HAP equipped with this system can measure the thickness of ice in the Northwest Passage, but it can also generate maps in the event of a disaster – forest fires or flooding, for example. It is also conceivable that such technology could be used for reconnaissance in peacekeeping missions. In addition, high-altitude platforms are suitable for measuring pollutants, including over busy shipping lanes and cities. The DLR Remote Sensing Technology Institute is developing a Differential Optical Absorption Spectroscope (DOAS) for that very purpose. This instrument is designed to measure the concentration of nitrogen dioxide (NO2) in the air.

Light, robust, precise and durable

Stationing an aircraft at a particular location within the lower stratosphere is no mean feat. At an altitude of 20 kilometres, temperatures usually range from minus 60 to minus 80 degrees Celsius. High above the clouds, the platform is completely exposed to solar radiation all day long, so that areas of its outer shell may heat up to 40 degrees Celsius. Such dramatic temperature fluctuations make it difficult to rely upon thermal insulation materials. While a warm, insulating layer might prove indispensable at night, it is not at all appropriate for the intense sunlight during the day. The low air density at such altitudes means that convection cooling, whereby the inbuilt systems are cooled by air flowing around them, is almost entirely ineffective. As such, the main challenge for a HAP is proper thermal management, as different areas of the aircraft require different means of cooling or insulation.

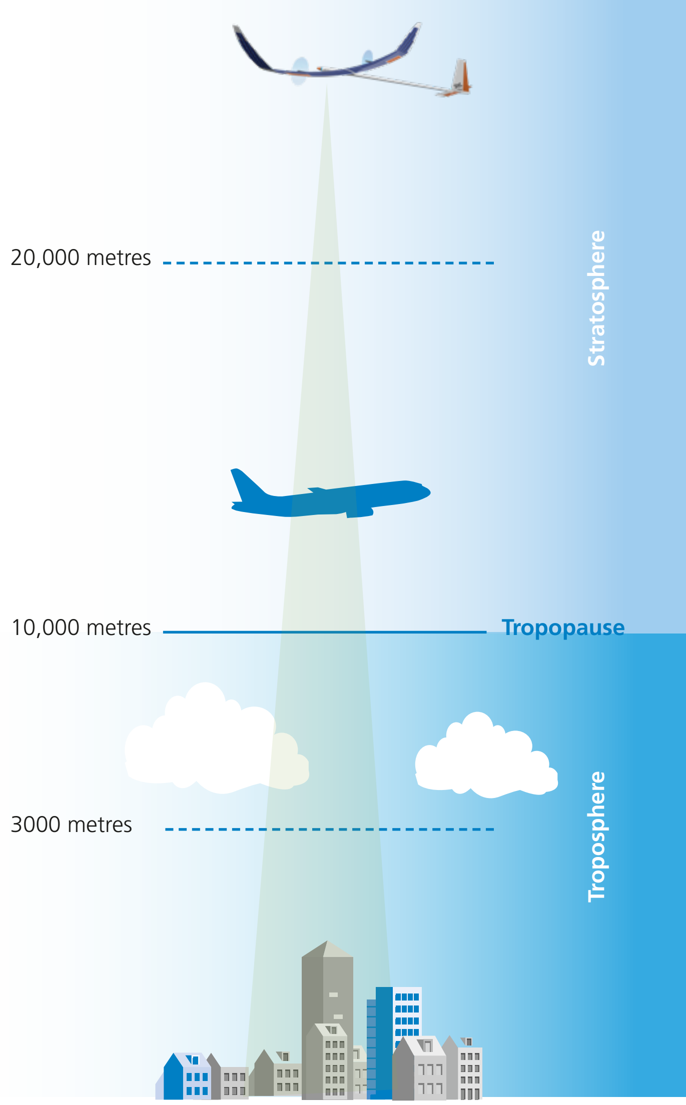
The low air density also presents another challenge; the aircraft has to be either very light or travel at an extremely high speed in order to generate sufficient lift to be able to fly continuously. But increasing the speed also means increasing the energy consumption. Throughout the day, the solar energy is converted into electrical energy via solar cells, with the excess stored in batteries for the night. HAPs that fly for long periods in the lower stratosphere must not exceed a surface area to weight ratio of four kilograms per square metre if they are to be able to generate sufficient lift. By way of comparison, Eta Aircraft's eponymous glider, one of the most powerful mass-produced gliders in the world, has a surface weight of approximately 45 kilograms per square metre, while the Eurofighter combat aircraft weighs in at 310 kilograms per square metre.

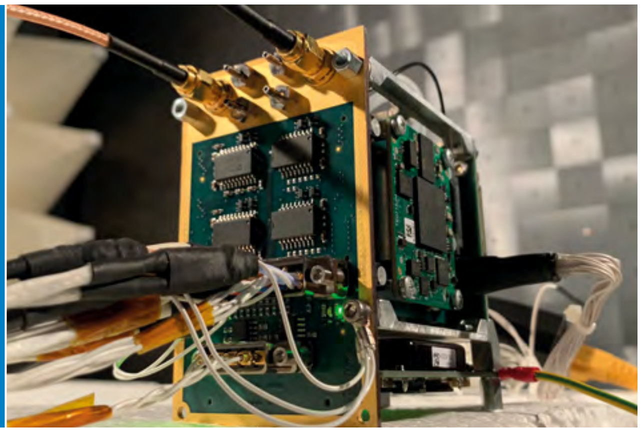
On top of that, there are operational procedures to consider, such as air traffic control for autonomous, long-term operations, or clearance for the aircraft to fly through controlled airspace until it reaches an altitude of 20 kilometres.

THE HIGH-ALTITUDE PLATFORM HAP alpha

- **Wingspan:** 27 metres
- **Launch mass:** 138 kilograms
- **Service ceiling:** Over 22 kilometres
- **Payload capacity:** Five kilograms
- **Platform budget:** 13 million euro
- **Energy generation:** Triple-junction cells based on gallium arsenide (wafer-thin triple-layered solar cells with a high efficiency of 32 percent and a power density of 1.40 g/Wp
- **Storage system:** Rechargeable lithium-ion batteries with silicon anode (energy density per cell: 350 Wh/kg)

Stratospheric aircraft fly at an altitude of 20 kilometres, higher than civilian aircraft and the influence of weather.





The brain of the high-altitude platform, the Flight Control Computer, was developed and built at the DLR Institute of Flight Systems.

The wings of the platform consist of a sandwich rib structure made of carbon fibre reinforced polymers (CFRP). A round CFRP tube forms the backbone. This makes the wing light and stable. In total, the structure of the HAP alpha weighs 36 kilograms, 75 percent of which is the main wing.

Unlike in manned aircraft, the pilot controls a HAP from the ground station. The remote pilot must rely on the aircraft's status information, course data and information from the civil airspace below.

INSTITUTES AND FACILITIES INVOLVED

- German Remote Sensing Data Center
- Institute for Software Technology
- Institute of Aerodynamics and Flow Technology
- Institute of Aeroelasticity
- Institute of Atmospheric Physics
- Institute of Communications and Navigation
- Institute of Composite Structures and Adaptive Systems
- Institute of Engineering Thermodynamics (only in 2018)
- Institute of Flight Guidance
- Institute of Flight Systems
- Institute of Networked Energy Systems
- Institute of Optical Sensor Systems
- Institute of Robotics and Mechatronics
- Institute of Structures and Design (only in 2018)
- Institute of System Dynamics and Control
- Microwaves and Radar Institute
- Remote Sensing Technology Institute
- Space Operations and Astronaut Training
- Systemhaus Technik

The missions of the stratospheric aircraft HAP alpha will be coordinated from the mobile ground station

Long-term Earth observation missions operate over periods ranging from a few weeks to several months. The platform must be able to carry out these missions without regular maintenance of the kind customary in conventional aviation.

Many companies have expressed an interest in the development of these kinds of high-altitude platforms, including Facebook, Aurora Flight Sciences, Prismatic and Ordnance Survey. Airbus has so far been the only company to put the functionality of such a platform to the test, when it assessed its Zephyr over the course of several campaigns and a 26-day endurance flight in 2018. However, even the Zephyr is not yet ready for commercial operation, as was made clear by two crashes over Australia in 2019. This shows that this HAP technology is still almost in its infancy today.

A unique aircraft

DLR scientists are currently developing a technology carrier called the HAP alpha as part of the cross-sectoral project. It Is designed to fly to an altitude of 20 kilometres carrying a five-kilogram payload. At the same time, its robust, modular design is easy to modify. With a wingspan of 27 metres, it is comparable to an aircraft capable of continuous flight, but its structure weighs only 36 kilograms, while the whole aircraft weights 138 kilograms in total. The researchers have been able to achieve this low weight using an extremely lightweight carbon-fibre-reinforced polymer (CFRP) design. The main spar, fuselage and tail spar of the structure are made of circular wound CFRP tubes. These are very light yet highly stable. The HAP alpha does not yet have solar and battery technology for flying during the night, but it is designed in such a way that this can be retrofitted when it becomes available. The project team is setting up a mobile ground station in transportable containers, with the aim of coordinating the missions and data reception. It should be able to exchange data with the HAP from a distance of over 100 kilometres.

The research team is combining traditional processes with new approaches to systems technology. At the end of each phase of the project, the HAP team conducts a thorough review, bringing in external experts for that purpose. This procedure is based on the conventional approach to systems development used worldwide, whereby the technical aspects of the project life cycle are set out and the development process divided up into easily manageable sections. In addition, scientists are also looking at newer methods of system development, such as model-based system engineering. This means that all of the essential information relating to the HAP, such as the requirements, physical architecture and mass data, is stored and characterised in a central place, and therefore, are inherently consistent.

In April 2019, the team conducted a review with external experts. It has successfully shown that the established system requirements and the developed plan form of the aircraft are suitable for achieving the project goals, and that the risks relating to future changes are as low as possible. The researchers are currently preparing for the Critical Design Review in 2021. This will check whether the detailed design meets the project goals. After that, the production and assembly of the individual components will commence. These components will then undergo extensive testing before they can be integrated into the overall system.

All the way, piece by piece

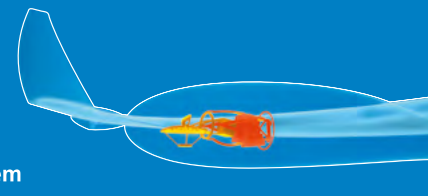
By the end of 2022, HAP alpha should be ready to take off on its first test. Initially, the aircraft will merely perform low-altitude flights over the site of the National Experimental Test Center for Unmanned Aircraft Systems in Cochstedt. The flight altitude will then be increased gradually up to 20 kilometres. For this to happen, the team is in contact with test facilities all over the world that offer a sufficiently large, restricted zone on the ground and prohibited airspace that extends up to high altitudes. One of the most promising candidates is the Esrange Space Center, near Kiruna, Sweden. Unlike the first test flights in Cochstedt, in which the actual test may only last a few hours, a high-altitude flight can take up to 24 hours due to the HAP's slow flight speed, although the platform will only be at 20 kilometres for about two hours. This means that the team not only has to coordinate the flight test itself, but also have several crews available and train their changeover in shift operation.

Payloads will also be used in future high-altitude flights. With every test, the team will gather experience and be able to modify the HAP to enable longer flights. From that point onward, the stratospheric aircraft could be used as an experimental carrier for payloads and new platform-specific technologies. One example would be using the HAP as a hub for digital communication to support the deployment of a 5G network.

Florian Nikodem is a Systems Engineer at the DLR Institute of Flight Systems in Braunschweig. He is leading DLR's HAP cross-sectoral project.

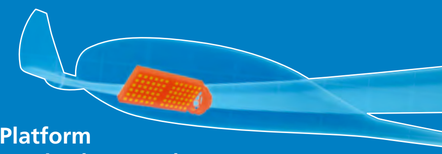
THE PAYLOADS

DLR researchers working on the HAP cross-sectoral project are developing three payloads that can be carried by the high-altitude platform. A unidirectional X-band link will be provided for exchanging payload data.



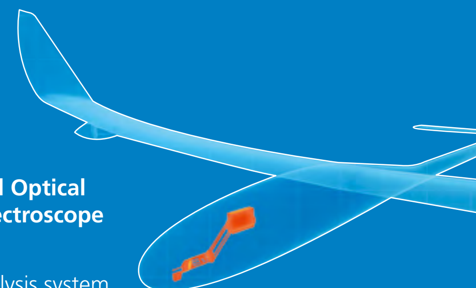
The Modular Aerial Camera System MACS-HAP:

- Self-aligning camera system with mosaic and point modes
- 150 megapixel sensor, ground resolution of 15 centimetres, scan area 400 square kilometres
- On-board image analysis for rapid identification of target objects
- Five kilogram mass



The High-Altitude Platform Synthetic Aperture Radar (HAPSAR):

- Synthetic aperture radar system (SAR)
- Stripmap SAR, Circular SAR up to 3D SAR and detection of moving targets such as ships
- Can be used day or night regardless of weather conditions
- Ground resolution of down to 60 centimetres
- Five kilogram mass



The Differential Optical Absorption Spectroscope (DOAS):

- Optical air analysis system with mosaic and point mode
- Real-time recording of the nitrogen dioxide levels in the air over the target area
- Four kilogram mass

A STRATOSPHERIC ROLLER COASTER

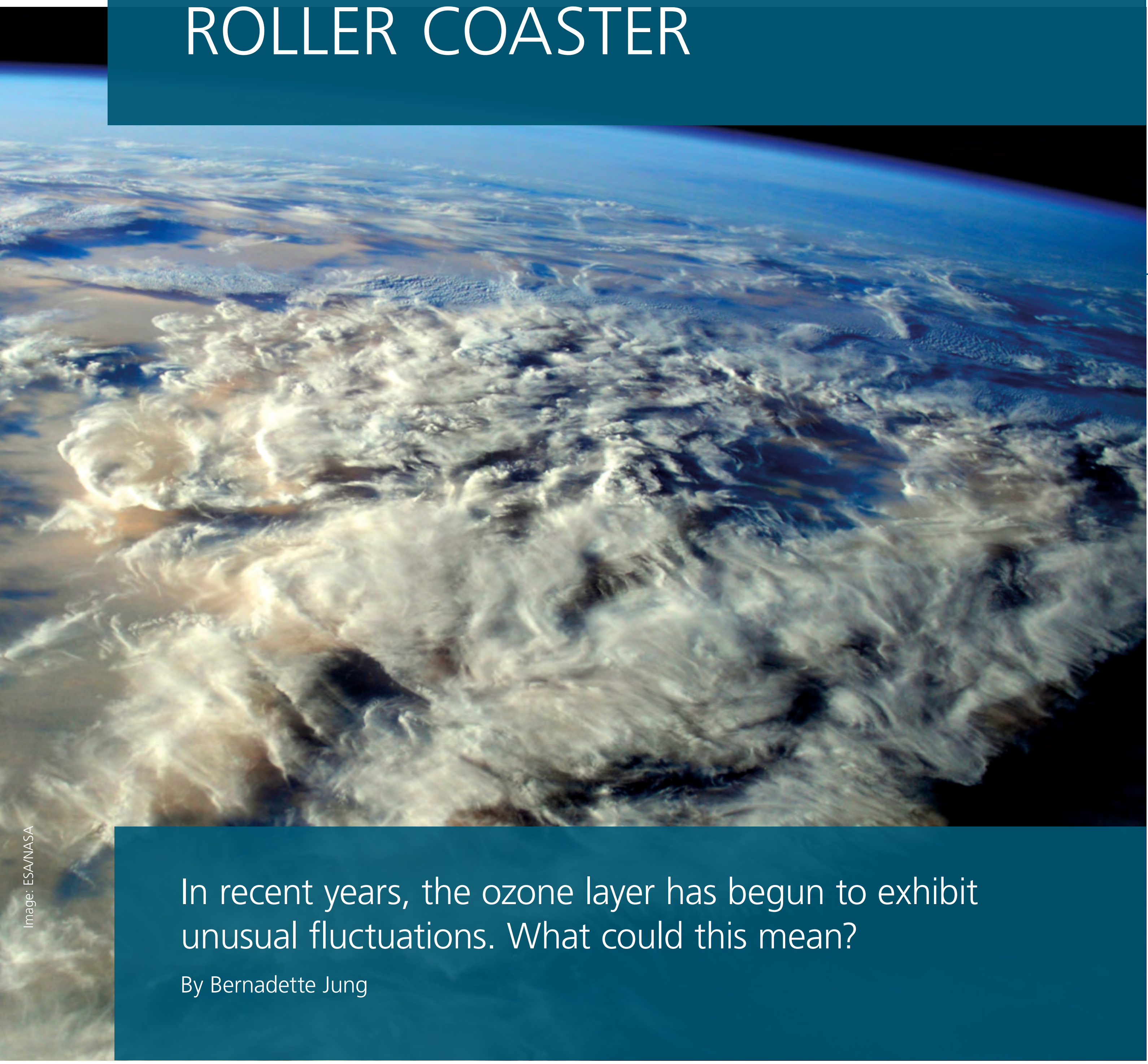


Image: ESA/NASA

In recent years, the ozone layer has begun to exhibit unusual fluctuations. What could this mean?

By Bernadette Jung

First, the good news: the ozone layer is expected to completely recover by the middle of this century and the Antarctic ozone hole will close again. This trend has been evident for several years. The ban on chlorofluorocarbons (CFCs) is having an effect. However, the appearance of a large hole in the ozone layer still sometimes hits the headlines, most recently in December 2020. How the ozone layer will develop and how it will be affected by climate change are among the focuses of the research being carried out by Martin Dameris at the DLR Institute of Atmospheric Physics. In this interview, he explains the state of the ozone layer and why current developments are making him particularly concerned.

Martin Dameris

Martin Dameris is a senior researcher in the Earth System Modelling Department at the DLR Institute of Atmospheric Physics. He is also a professor at the Meteorological Institute of Ludwig Maximilian University (LMU) in Munich. His research focuses on the study of chemistry-climate interactions by means of a numerical troposphere and stratosphere modelling system. Professor Dameris is the author or co-author of more than 100 peer-reviewed scientific publications and has contributed to a series of international reports on the stratospheric ozone layer.

Credit: DLR

Professor Martin Dameris (front) with EOC colleague Diego Loyola in the control room of the DLR Earth Observation Center

It seems like we have had one extreme event after the other lately regarding the ozone layer. Has this surprised you?

: Absolutely. Observations in both polar regions in 2019 and 2020 were quite extraordinary. One year ago, in spring 2020, we saw a structure resembling a hole in the ozone layer over the Arctic that remained over a prolonged period for the first time. The ozone value fell below the critical 220 Dobson units for more than a month and over an area of almost one million square kilometres. This usually only happens in the Antarctic. In the previous year, we had the opposite situation. In March 2019, there was no apparent ozone depletion in the Arctic stratosphere at all. Conditions were so warm there that there was no polar stratospheric cloud formation. These formations, sometimes referred to as 'mother-of-pearl' clouds, are very important in the ozone depletion process. As a result, the ozone layer remained undisturbed by chemical processes. This surprising development was also observed over Antarctica – the hole in the ozone layer was smaller in October 2019 than at any time since its discovery. Here too, this was the result of a significant heating of the stratosphere. Then, in October 2020, we observed one of the largest holes in the ozone layer since records began 41 years ago. Our colleagues at the DLR Earth Observation Center (EOC) monitored a hole in the ozone layer that not only exceeded the total surface area of Antarctica in size, but was particularly persistent and visible well into December. This January, the Arctic stratosphere warmed up to a similar extent as in 2019. As a result, ozone depletion this spring is likely to be very low, once again reversing the situation observed in the previous year.

What causes these fluctuations?

: They are related to atmospheric dynamics, the 'weather conditions' in the stratosphere – high temperatures, low temperatures, light winds, strong winds. When you mention the ozone layer, most people immediately think of CFCs. While the ozone depletion caused by CFCs is an important factor, this depletion is a complex process involving the interactions between various chemical and dynamic processes. The chemical reactions, in which CFCs are also involved, are predictable. Whether these processes take place and to what extent depends on the dynamic conditions. As a result of natural fluctuations, temperatures vary from year to year, and in the warmer years the ozone in the stratosphere depletes significantly less. Last year's extreme ozone depletion over the South Pole was aggravated by unusually persistent and strong polar winds. Dynamic processes have been the subject of discussion for many years in the Ozone Assessments, the World Meteorological Organization (WMO)'s international reports on the state of the ozone layer. Rises and falls in ozone of this kind are initially quite normal phenomena.

So how do you see the most recent extreme events?

: This is the strange part. As I said, over the course of years and decades, the ozone layer is sometimes a little thinner and sometimes a little thicker, but all within a certain range. Observations in both polar regions in 2019 and 2020 – two in the North and two in the South – have been quite extraordinary. Each one is a quite unusual event in itself. But we have never seen these extremes occur in two consecutive years. I cannot find any explanation for this pattern, at least not yet. We have only seen comparable weather events caused by climate change in the troposphere. This causes more frequent extreme weather events, such as regional torrential rains or longer periods of drought. At the beginning of this year, for example, we saw unusually low temperatures and a lot of snow in Spain, while at the same time Greece had very high temperatures. Here in Germany, the last few winters have been erratic and much too mild overall. This makes me wonder – is climate change also influencing processes in the ozone layer, one layer above in the atmosphere?

Credit: ESA/Pierre Carril

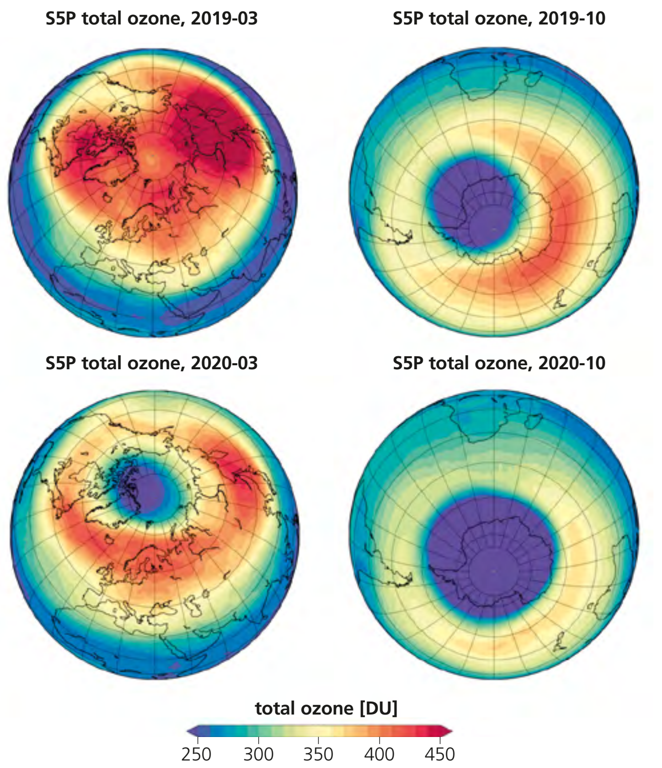
Sentinel-5P is the first satellite of the Copernicus programme to study the atmosphere. The TROPOMI instrument investigates various atmospheric trace gases and their effects on air quality and the climate.

At the end of the day, the entire Earth system is interconnected. We are currently studying how changes in climate affect the ozone layer. Although we already know a lot, there are some areas where all we can do is speculate. To end the speculation, we need additional high-resolution spatial and temporal data and to carry out measurements over longer periods of time. At the DLR Institute of Atmospheric Physics, we use the EMAC chemistry-climate model and create simulations for various climate scenarios.

What is special about the EMAC chemistry-climate model and what data does it utilise?

: We work very closely with our colleagues at the DLR Earth Observation Center, and in particular with the DLR Remote Sensing Technology Institute. Observation data from satellites are the basis of our ongoing analyses and forecasts for how the ozone layer will behave in the future. Observing the atmosphere and monitoring the ozone layer is crucial in my opinion. We use this data together with the simulations generated with climate models and the knowledge we derive from them to review the effectiveness of protective measures and to develop future recommendations for action.

EMAC allows us to accurately reproduce our observations and forecast future developments. Comparing previous predictions made using the model with the real measurements recorded over that same period has repeatedly demonstrated its effectiveness. With this level of confidence in our models, we can begin to look into the future. Such predictions have clearly indicated that the development of the ozone layer will strongly depend on greenhouse gas concentrations. This puts us – both our institute and DLR as a whole – in a prime position, as we have been using EMAC and its predecessors to visualise and calculate the relationship between atmospheric chemistry and climate change for almost 25 years. Put simply, if we implement measures to 'repair' ozone levels but climate change and its impacts persist, there will be continued consequences for the ozone layer. In the short term, this can even have positive results, such as the ozone layer recovering more quickly when the stratosphere is warmer. But in the long term, any number of unforeseen problems could arise.



Springtime total ozone distribution over the polar regions. The data were obtained with the TROPOMI instrument on the Sentinel-5P satellite. Ozone is measured in Dobson Units (DU), with an average ozone distribution value of 300 DU.

What scenarios and consequences could the future hold?

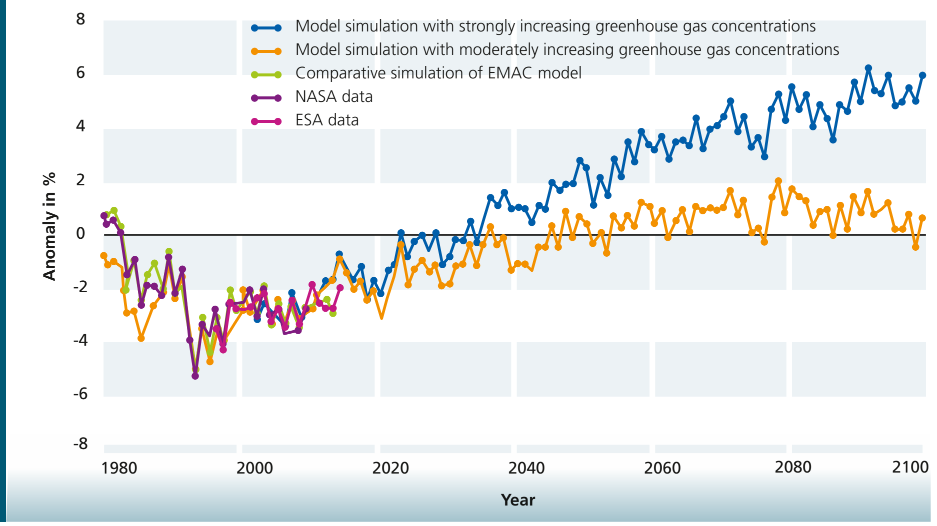
: Taking CFCs as an example: the Montreal Protocol of 1987 banned the manufacture and use of CFCs. With this, the global community not only took steps to protect the ozone layer but also the climate. It turns out that CFCs are also particularly radiatively active greenhouse gases. The consequences of climate change could have been far worse if had the production of CFCs not been controlled – the surface would have warmed and the stratosphere would have cooled much more quickly. The model calculations show that if we continue to observe internationally agreed protection measures, the ozone layer will regenerate completely by the middle of this century. This recovery will certainly be accompanied by fluctuations, including the appearance of holes in the ozone layer. But this does not mean that additional protection measures are unnecessary. On the contrary, it is very important that we improve our ability to understand and quantify these dynamic phenomena. Chemistry-climate models also allow us to study future scenarios in which greenhouse gas emissions are much higher or lower than present level. Such scenarios would result in a correspondingly faster or slower recovery of the ozone layer.

OZONE LEVELS OUTSIDE THE POLAR REGIONS

In the 1980s and 1990s, ozone levels declined due to high CFC concentrations. Since the CFC ban, ozone levels have been rising again. At the same time, the troposphere is warming and the stratosphere is cooling as a result of rising greenhouse gas concentrations. Accordingly, the depletion of the ozone layer in the middle and upper stratosphere is slowing down. In the polar regions, however, a colder stratosphere leads to higher ozone depletion because other chemical processes take place there.

The graph shows possible developments in the total amount of ozone (outside the polar regions between 60 degrees north and 60 degrees south in percentages). The basis is the measured ozone data from NASA (purple) and ESA (magenta). The comparative simulation of the EMAC climate chemistry model (green) shows a high degree of agreement with the real measured data. For the future, the model simulations show that the ozone layer develops differently under different climate scenarios. Moderate increases in greenhouse gas concentrations lead back to 'normal' conditions (orange).

However, if concentrations continue to rise sharply, the ozone layer will 'over recover' and in the second half of this century there would be significantly higher ozone levels (blue). The consequence would be that less ultraviolet radiation would reach Earth, affecting the balance of the ecosystem.



Mother-of-pearl clouds over the east coast of Iceland. This type of cloud forms more frequently as the stratosphere cools down considerably during the polar winter. Various chemical reactions required for ozone depletion take place within them.

If the ozone layer is on the road to recovery, will we still need to study it?

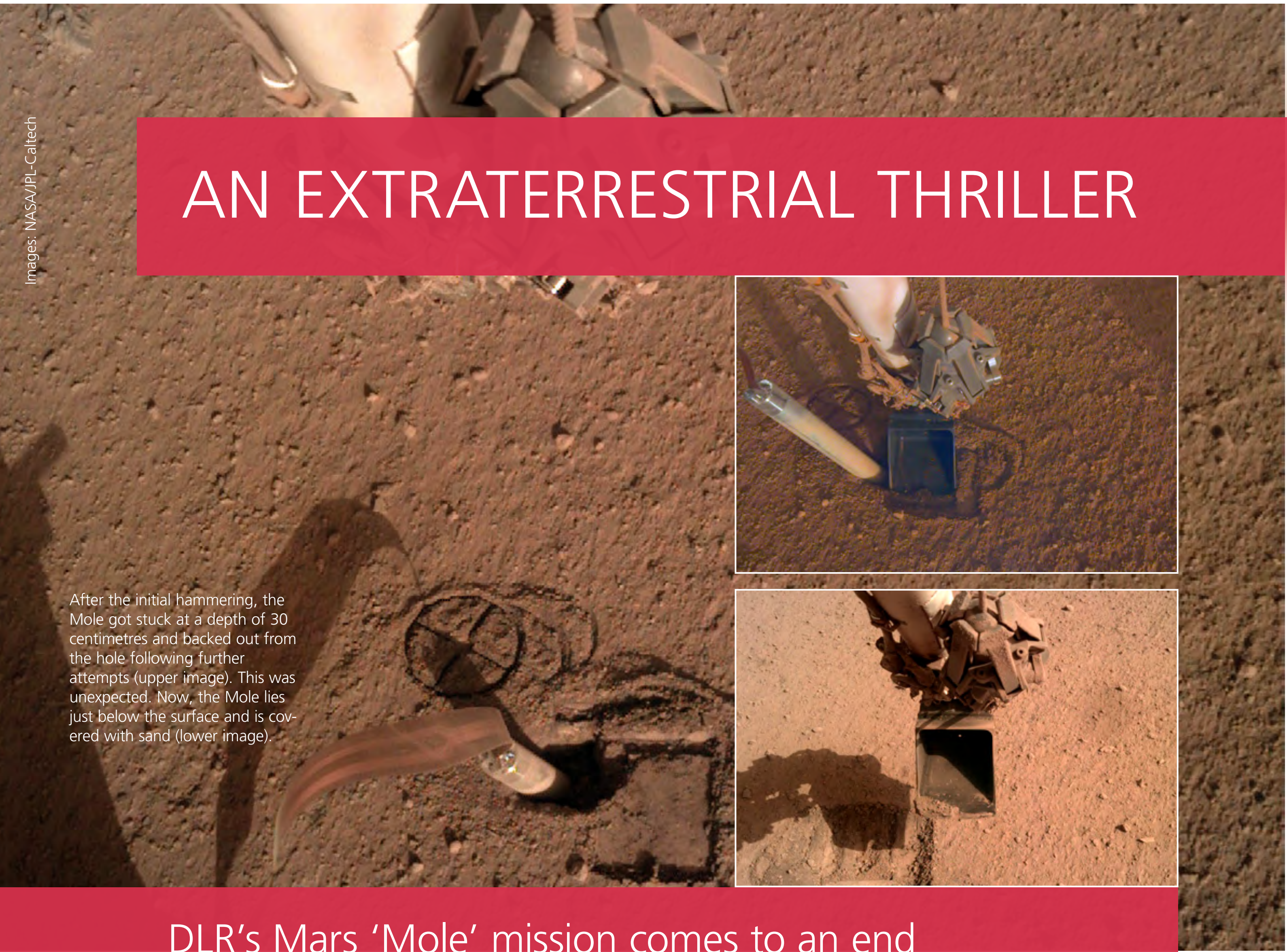
: For some time, there have been people saying 'Ozone is old news. Nobody cares about it anymore. The problem has been solved'. But the development of the ozone layer is actually still a very hot topic. For me, the main question is how our changing climate will impact the development of the ozone layer. There are aspects of this which really get me thinking. As with climate science, we have to observe, analyse and evaluate things in the long term. We can only make robust statements once we have long-term measurement data from the results of chemistry-climate models. We need to know how pronounced the variability in the natural status of the stratosphere is and how the figures compare to the years before or afterwards. It is not enough just to look at a few years – that would be far too little to study the ozone layer. You have to take care not to extrapolate a perceived trend and jump to conclusions. However, if in the next few years the stratosphere proves to be much more variable than before, this could definitely be a sign of the impact of climate change. As yet, however, we have no robust scientific evidence to support this. It may also turn out that the unusual events of 2019 and 2020 were in fact coincidences and not directly related to climate change.

"As with climate research, we have to observe, analyse and evaluate this over the long term. Only from long-term measurement series in combination with the results of the climate-chemistry models can we make reliable statements."

How do you think the situation will develop?

: I am very curious to see whether the extreme conditions in the stratosphere will continue to intensify. We will be watching its development very closely over the coming years and will continue to observe and evaluate it through simulations and our chemistry-climate model. It is still too early to draw any firm conclusions, but as the observation data continue to mature in future, they will help us to produce more accurate forecasts and use them to determine suitable courses of action. It remains to be seen whether the situation over the previous two years was a coincidence. The atmosphere is constantly surprising us, and that is not going to change anytime soon.

Bernadette Jung is an editor at the DLR site in Oberpfaffenhofen.



AN EXTRATERRESTRIAL THRILLER

After the initial hammering, the Mole got stuck at a depth of 30 centimetres and backed out from the hole following further attempts (upper image). This was unexpected. Now, the Mole lies just below the surface and is covered with sand (lower image).

DLR's Mars 'Mole' mission comes to an end

By Tilman Spohn

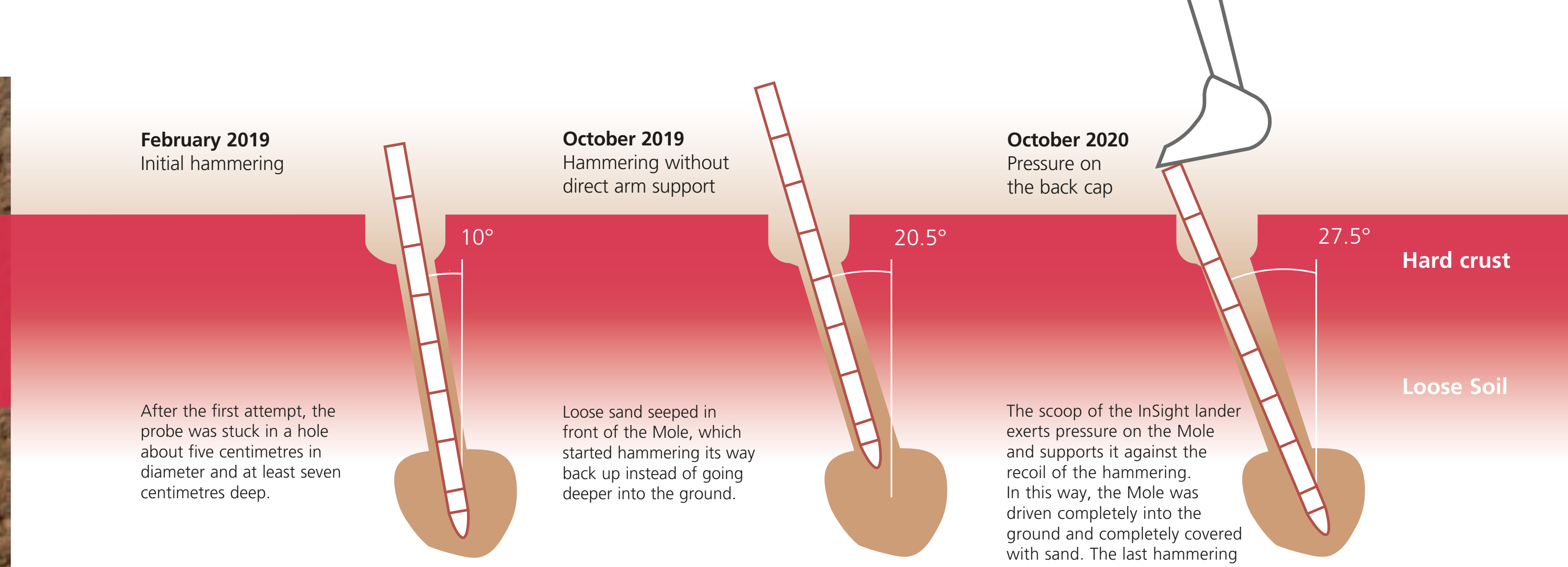
The story of the hammering probe nicknamed the Mars 'Mole' could well be a thriller that began when NASA's InSight mission landed on the Red Planet on 26 November 2018. On board was the Heat Flow and Physical Properties Package (HP³), an experimental bundle with a probe designed to burrow up to five metres into the Martian surface and measure the heat flow from the planet's interior. But things did not go quite to plan. Time and time again, the mission team was challenged to find new technical solutions to get the 30-centimetre-long Mole into the ground. On 9 January 2021, the researchers sadly had to admit defeat and declare the end of this portion of the mission. But unlike the Mole, the dream of conducting measurements beneath the surface of Mars is not yet buried.

By establishing a geophysical observatory on an Earth-like planet, NASA's Insight mission made a long-held wish come true for planetary researchers. The three main instruments on board the InSight lander are a French seismometer to measure Mars' 'pulse', a US instrument that uses radio waves to assess perturbations of the planet's rotation axis, and DLR's HP³. While the first two instruments investigate the static structure of the planet, HP³ was intended to acquire data on the tectonic and vulcanological evolution of the Red Planet.

Part of the HP³ sensor package is a small self-hammering probe known as the Mole. It was designed to penetrate into the soil to a target depth of five metres, pulling behind it a tether fitted with temperature sensors. The package is supplemented by infrared sensors for measuring the surface temperature.

The internal engine

In a physical sense, planets work in a similar way to engines, powered by the difference between their high internal temperatures and their cold surface. One measure that indicates the power of this engine is heat flow. The higher the heat flow, the faster the viscous rock mass within the planet is flowing and therefore the more work it can perform – by arching regions of the surface upward as mountains, for instance. This heat flow can be measured by determining how the planet's temperature increases with depth and its thermal conductivity. Measurements made on the surface would be distorted by seasonal and diurnal temperature fluctuations. As such, they must be taken from sufficiently far below the surface – at least three metres on Mars. For comparison, if we were to conduct a similar investigation on Earth we would have to drill down several tens of metres.



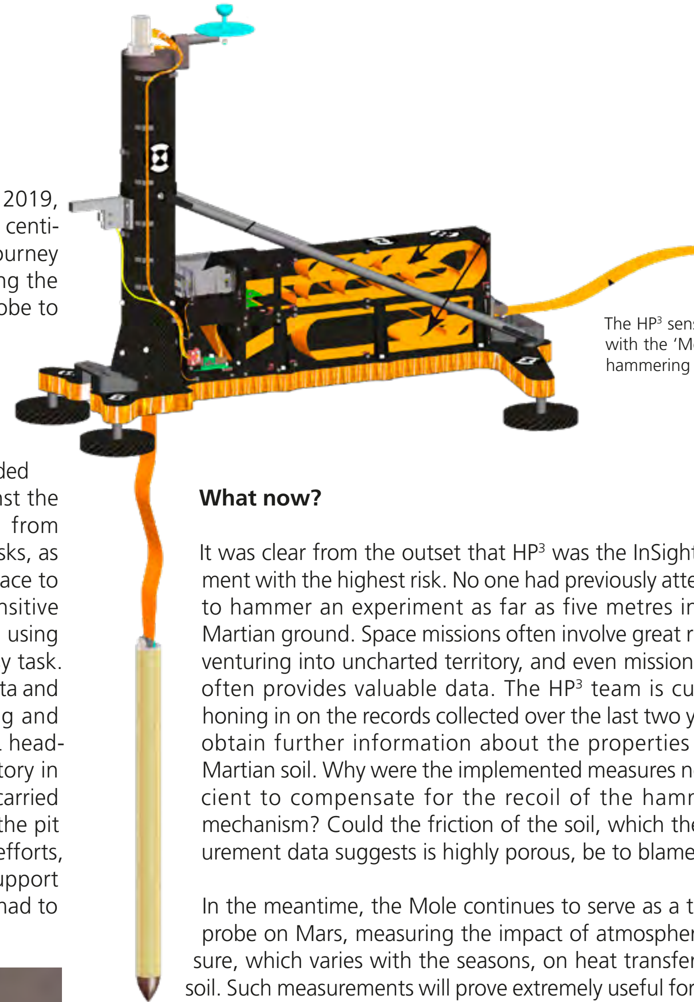
More information at **DLR.de/InSight**

Two years of testing and suspense

The first phase of hammering, which took place on 28 February 2019, was unsuccessful, as the hammering probe got stuck about 30 centimetres below the surface. It was not a rock that impeded its journey into the surface. Rather, the Martian regolith was not providing the necessary friction to compensate for the recoil, causing the probe to rebound back and forth without making further progress.

Over the months that followed, the DLR team worked closely with scientists at NASA's Jet Propulsion Laboratory (JPL) to help the Mole burrow into the soil in stages. Among other things, the teams used InSight's robotic arm, which had originally been intended only for placing down the lander's instruments, to press against the Mole and provide the force needed to prevent the probe from rebounding. This kind of manoeuvre came with considerable risks, as the scoop-bearing arm had only a few square millimetres of space to press on the back of the probe without jeopardising the sensitive science tether. Carrying out such precise operations from Earth using tools that had not been designed for that purpose was no easy task. During weekly conference calls, the team evaluated the latest data and planned their next steps. Those responsible for programming and issuing commands to the probe were in daily contact with JPL headquarters in Pasadena. Every step was first tested in the laboratory in California and also by DLR in Berlin and Bremen before being carried out on Mars. In a final attempt, the team succeeded in filling the pit with sand and completely covering the Mole. But despite the efforts, the attempt to have the Mole continue on its own without support from the arm was unsuccessful. With a heavy heart, the team had to call an end to the mission.

The 'Mole's den' in March 2019. The view through the only 'window' leads directly to Mars and InSight. The DLR and JPL team: Back from left: Troy Hudson, Matthias Grott, Ann Louise Thomas, Tilman Spohn, Christian Krause; front: Cinzia Fantinati, Sue Smrekar.



The HP³ sensor packet with the 'Mole' hammering probe

What now?

It was clear from the outset that HP³ was the InSight instrument with the highest risk. No one had previously attempted to hammer an experiment as far as five metres into the Martian ground. Space missions often involve great risk and venturing into uncharted territory, and even mission failure often provides valuable data. The HP³ team is currently honing in on the records collected over the last two years to obtain further information about the properties of the Martian soil. Why were the implemented measures not sufficient to compensate for the recoil of the hammering mechanism? Could the friction of the soil, which the measurement data suggests is highly porous, be to blame?

In the meantime, the Mole continues to serve as a thermal probe on Mars, measuring the impact of atmospheric pressure, which varies with the seasons, on heat transfer in the soil. Such measurements will prove extremely useful for atmospheric and soil studies. But the scientists have not given up on their plan to burrow into our neighbouring planet. In 2022, ESA's ExoMars rover, named Rosalind Franklin, will set off for Mars. When it arrives, it will dig into the Martian soil using more conventional drilling technology. Unlike DLR's Mars Mole, which had a hammering mechanism, the ESA rover will use a drill rod, which will limit its drilling depth to two metres. Meanwhile, DLR is continuing to develop the Mole's hammering technology. The greatest advantage of this approach is that, in principle, it allows considerable depths to be reached with only modest resource requirements. It remains an exciting prospect to see whether this refined technology will first be deployed on Mars, the Moon or as part of a mission to another celestial body.

Tilman Spohn is the Executive Director of the International Space Science Institute in Bern and is the Principal Investigator for the HP³ experiment on board NASA's InSight mission. Until 2017, he was the Director of the DLR Institute of Planetary Research in Berlin.

LIVE AND TRADE

At the Networked Energy Systems Emulation Centre (NESTEC) at DLR's site in Oldenburg, researchers are investigating the integration of a hydrogen generation plant into the district's energy system.

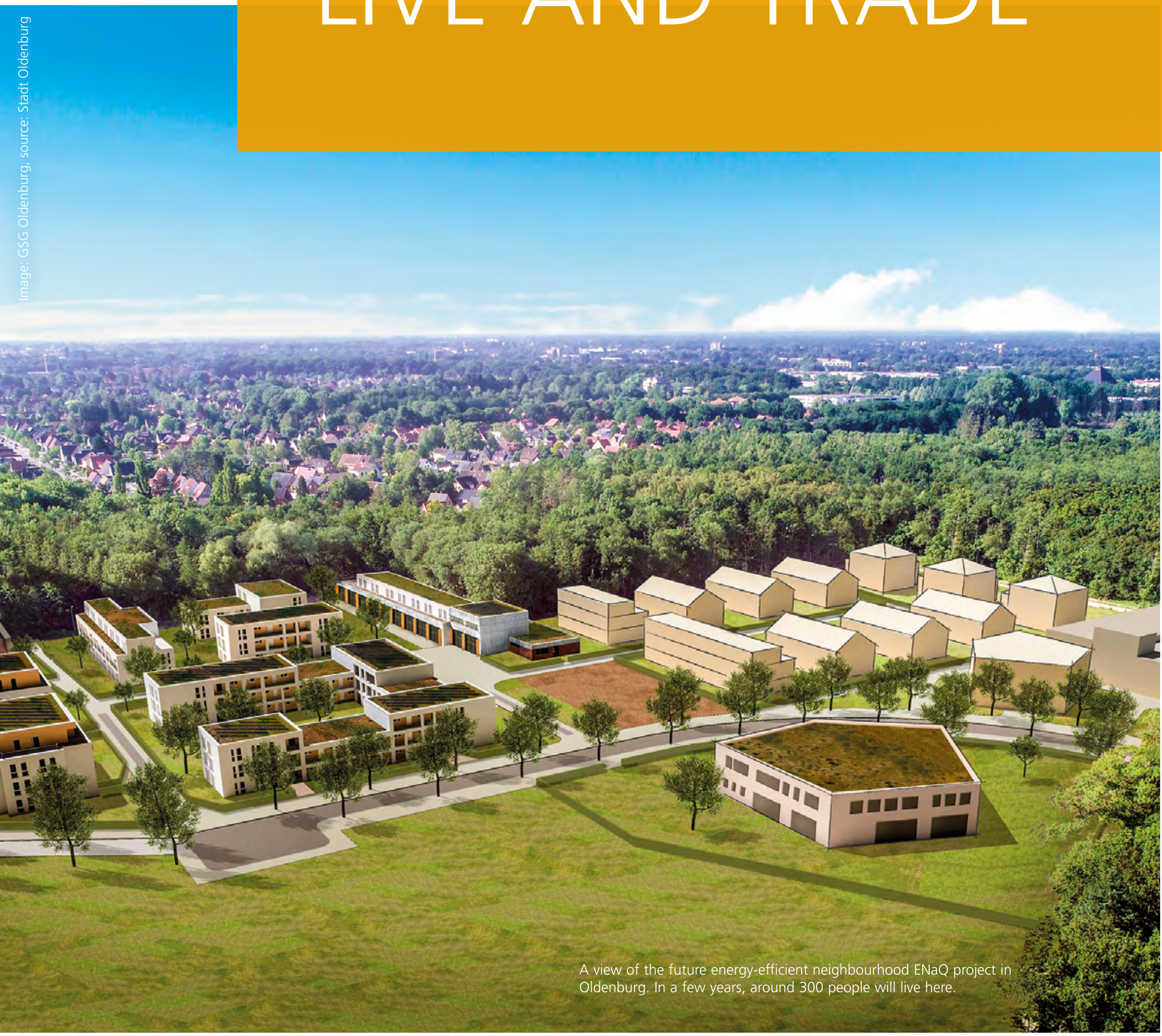


Image: GSG Oldenburg, source: Stadt Oldenburg

A view of the future energy-efficient neighbourhood ENaQ project in Oldenburg. In a few years, around 300 people will live here.

A residential district with a completely new approach to energy is under construction in Oldenburg

By Heinke Meinen

What will the energy supply in the residential districts of the future look like? What infrastructure is needed to generate energy on site and to benefit from it on location across sectors? Using a real residential development currently under construction in Oldenburg, Lower Saxony, DLR is developing a new energy concept that could one day serve as a blueprint for the locally designed energy supply systems of entire city districts. It also involves a groundbreaking approach: the residential districts will be equipped with structures that pave the way for their inhabitants to engage in local energy trading.

To date, our energy supply system has worked like a one-way street. At one end are the power plant, the refinery and the gas pipeline, and at the other the consumers. However, the feed-in of renewable energies in residential areas is on the rise. Solar panels on countless roofs have replaced entire power plants, and this energy can flow through the grid both ways depending on demand. At the same time, the way that energy is supplied is changing. Oil and gas are becoming less important as modern dwellings can be efficiently heated using electricity. And the demand for petrol and diesel is also falling as more and more cars are being recharged at our very homes. As a result, residential areas are increasingly taking on the role of decentralised energy distributors. We decide how we use our self-generated electricity and how much of the residual energy we feed into the grid.

An experimental neighbourhood

Scientists working on the energy-efficient neighbourhood (Energetisches Nachbarschaftsquartier; ENaQ) research project are investigating the extent to which intelligent energy concepts can be integrated into entire present-day residential districts. What makes this project unique is that the research will make use of a real residential area currently under development in Oldenburg. In a few years, it will be home to 300 people, and the way they interact with energy will be different from what they are used to. The exact nature of this difference will depend on the results of computer models developed at DLR. One of the main focuses of the ENaQ team is to achieve maximum energy efficiency from the buildings themselves. In addition to photovoltaic panels, solar thermal collectors, geothermal energy and heat pumps were also taken into consideration.

"The important thing for us was not just to rely on a gut feeling. We defined around 25 technologies which we then evaluated in advance against economic and local criteria by using an optimiser," says Peter Klement, Project Manager for ENaQ at the DLR Institute of Networked Energy Systems. A model was developed specifically for this analysis which makes it possible to virtually test the operating modes, and thus streamline and improve them. When choosing from various heat sources, for example, the optimal choices in terms of operating mode, system size and capacity for interoperability were incorporated into the calculations. This aspect alone has provided plenty of subject matter for several master's degree theses at the Institute of Networked Energy Systems.

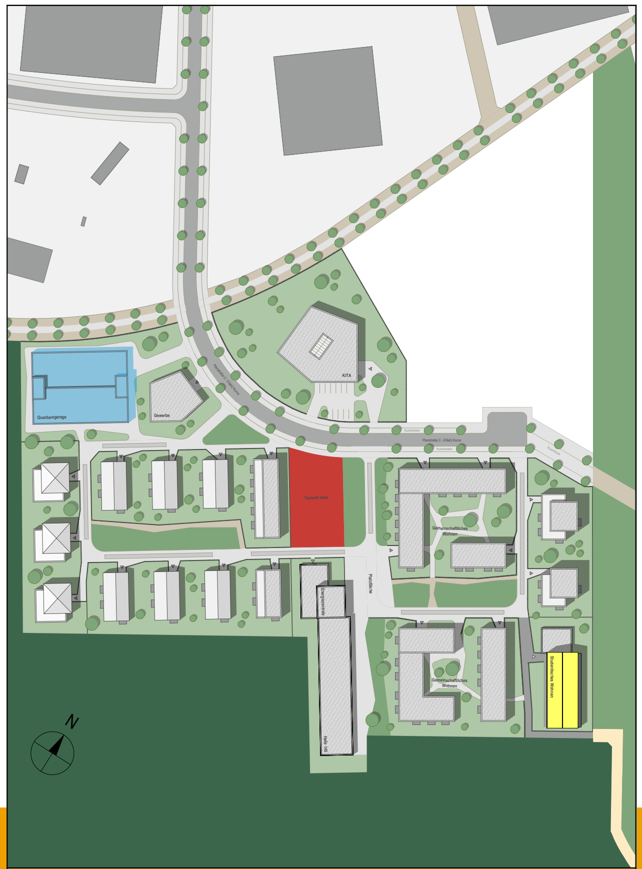
FOCUS OF THE ENaQ WORK AT THE INSTITUTE OF NETWORKED ENERGY SYSTEMS

- DLR created a simulation model for the design of the neighbourhood's networked infrastructure. This model can be adapted to different energy supply scenarios.
- Within this model, additional components of different dimensions can be added, for example an electrochemical energy storage system.
- The results of the simulations are incorporated into the physical implementation. A replica of the neighbourhood in the NESTEC laboratory shows the neighbourhood and its interaction with the higher-level supply network.
- Typical user profiles for the neighbourhood are derived from the measured data in compliance with the applicable data protection regulations and forecast models are developed.
- From the planning, concepts are developed that can be transferred to other neighbourhoods.

Image: Stadt Oldenburg

The residential quarter, which is being developed as part of the project 'Fliegerhorst energy-efficient neighbourhood', offers living space for around 300 people across four hectares of land.

Image: GSG Oldenburg



Urban development plan for the neighbourhood

Housing for a diverse residential population is being created across the neighbourhood. Half of the accommodation units will be reserved for welfare housing. Among the residential units will be student housing, with 30 small flats designed to accommodate one to two people (yellow). As there is likely to be few or no cars on the site, a shared neighbourhood garage (blue) is planned. Car-sharing services and a bus connection with a bus stop on the estate are effective and affordable alternatives to owning a car. Charging stations for electric vehicles and a hydrogen generator are planned for the technology island (red).

Searching for the best technologies

Calculating which of these types of renewable energy would be most efficient under which conditions requires a more comprehensive pool of reference data. For this reason several project partners made their own data available, such as high-resolution weather data for the location, or the electricity and heating consumption profiles of fictitious residents with hourly precision over the course of one year. The energy standards of the planned buildings, forecasts of local mobility patterns, the effects of energy conversion in cogeneration plants or units and of generating and reconverting hydrogen will all then be combined with these data. There will also be extensive public involvement in the ENaQ project. The technological systems implemented should be based on the requirements and habits of people, rather than the other way round.

> *"We want to enable the neighbourhood community to trade energy."*
>
> Peter Klement

In addition to the interplay of various sustainable energy technologies, the DLR project team is also focusing on energy networking and control within the residential estate. This will allow residents to use the generated energy in the most cost-efficient and environment-friendly way. In addition, the researchers aim to create a market-economy component that has not so far existed in this form: "We want to enable the neighbourhood community to trade energy," says Klement. However, current law does not allow people to sell energy to their neighbours. The ENaQ consortium now wants to pave the way for this. The current plan is for a neighbourhood energy aggregator to take over the function of energy trader and also represent the neighbourhood to external parties.

Image: Stadt Oldenburg

Construction at the site is already underway

THE ENaQ PROJECT

The energy-efficient neighbourhood ENaQ project is funded as part of the Solar Building / Energy Efficient City initiative of the German Federal Ministry for Economic Affairs and Energy (BMWi) and the German Federal Ministry of Education and Research (BMBF) FKZ 03SBEE111. The project funding amounts to approximately 18 million euro. Twenty-one primarily regional partners from industry, academia and administration form the project consortium. The Helleheide neighbourhood, which is currently under construction and will house approximately 300 people across more than 100 residential units on the site of the former air base in Oldenburg, functions as a real-life laboratory. The goal is to develop a climate-friendly and future-oriented energy concept for neighbourhoods. The estate's energy demand will primarily be met through locally generated energy. The project began in January 2018 and will run until 2023.

More information (available only in German):

- enaq-fliegerhorst.de
- helleheide.de

Neighbourhood energy trading

The attraction of trading energy within the housing estate is clear: generating and using energy locally reduces the overhead costs associated with transport infrastructure. There are also financial advantages to using as much energy locally as possible. "The more of your own energy you use, the less you need to buy," explains Klement. "If you feed energy generated at home into the grid, it is no longer available for your own use. For this reason, the most important steps in energy trading must take place before the energy is fed into the grid. That is why we are focusing on technologies that are easy to manage and are only considering cost-effective, resource-efficient and low-carbon options."

The project partners are currently developing a client system for the estate that will operate as a local energy aggregator. The system will later be used to buy, sell and trade energy. Additional incentive schemes will be created to help establish local energy cooperatives. These new structures will also address issues such as what type of energy needs to be purchased, and to whom to one sells the energy they have generated. This energy is expected to primarily be electricity. However, there are also other options under consideration, such as hydrogen generated from photovoltaic electricity which could provide energy for diverse applications in the neighbourhood. In theory, surplus hydrogen could also be the object of energy trading.

Despite the economic benefits of local energy consumption and trading, Klement does not foresee total energy self-sufficiency within the neighbourhood: "Maximising local usage does not mean we want to set up a self-sufficient island. Rather, when scaling the power generating facilities, we are guided by the underlying principle of finding the level of local energy consumption that provides the most viable, economic and environment-friendly solution for residents." The initial preparations for construction on the ENaQ site of Helleheide in Oldenburg have already begun. The current plan will see the first residents move onto the site at the end of 2022.

Heinke Meinen is responsible for communications at the DLR Institute of Networked Energy Systems in Oldenburg.

Image: DLR

Public participation is a fundamental element of the ENaQ Project. The mayor of Oldenburg, Jürgen Krogmann (left), attended one of the many drop-in information sessions to discuss the project's progress with local citizens and project partners.

AUTONOMOUS DRIVING – NEXT STOP?

In the AutoAkzept project, DLR is working with partners to develop new functionality for automated vehicles that increases confidence in the technology and prevents uncertainty from arising.

Where are we now, and where do we go from here?

By Denise Nüssle

Imagine getting into your car, sitting back and arriving at your destination safe and relaxed. The idea of autonomous vehicles has long fascinated people, and new technologies are making them ever more feasible. No mere sleight of hand, such vehicles are controlled by algorithms, software, IT platforms and artificial intelligence, and interact with other road users. DLR is working on a large number of projects to advance automated and networked driving as part of sustainable mobility concepts. These include innovative vehicle designs, novel sensor technologies, highly automated driving functions, communication between vehicles, their surroundings and human road users, and studies on economic potential and social acceptance. Magnus Lamp, DLR Transport Programme Director, talks about the current situation, opportunities and technology involved, and the societal and economic shifts associated with them.

DLR focuses on automated and networked driving rather than autonomous driving. What is the difference?

: 'Automated and networked driving' describes DLR's approach a little better. As things stand, vehicles can detect their surroundings automatically and interpret the conditions accordingly. However, this only applies to special situations, such as driving on a motorway. In cases where the situation is more complex, such as an inner-city intersection with poor visibility, things are rather different. This is where networking comes into play, because in order to act with foresight, an automated vehicle has to be able to exchange information and coordinate its movements with other road users. Only then can it truly be considered smarttechnology.

What are we hoping to achieve with smart driving?

: Automated and networked driving is not an end in itself. At DLR, we are trying to develop mobility solutions for the future that are in accordance with people's wishes and requirements. Sustainable and whole-system mobility concepts are also key. Smart driving allows us to make mobility more resource efficient and cost effective. One example is the space required for parking cars in inner cities. Cars owned by individuals are stationary far more than they are in motion. In the best-case scenario, automated, networked shuttles would constantly be moving, with little idle time. This would free up parking areas to be used as new spaces for shared use, which would improve the local quality of life.

What can we achieve with the technology we have today and in the foreseeable future? What remains more of a long-term vision?

: Some initial highly automated driving features are already on the market, such as traffic jam assistants. These systems keep the car in the correct lane in traffic jams and control acceleration and braking as necessary. In other words, they handle the vehicle's steering and maintain the correct distance from other vehicles. However, the driver still has to keep an eye on things and step in where the technology reaches its limits. This already works quite well for simple driving operations.

The next step is to enable these systems to deal with more complex situations and tasks such as those required for driverless shuttle buses to navigate city traffic. They have to communicate with other vehicles and infrastructure, coordinate driving manoeuvres and avoid collisions at all times. Such tasks place considerable demands on the technology, so automated and networked transport within cities is likely to see somewhat slow progress for the foreseeable future.

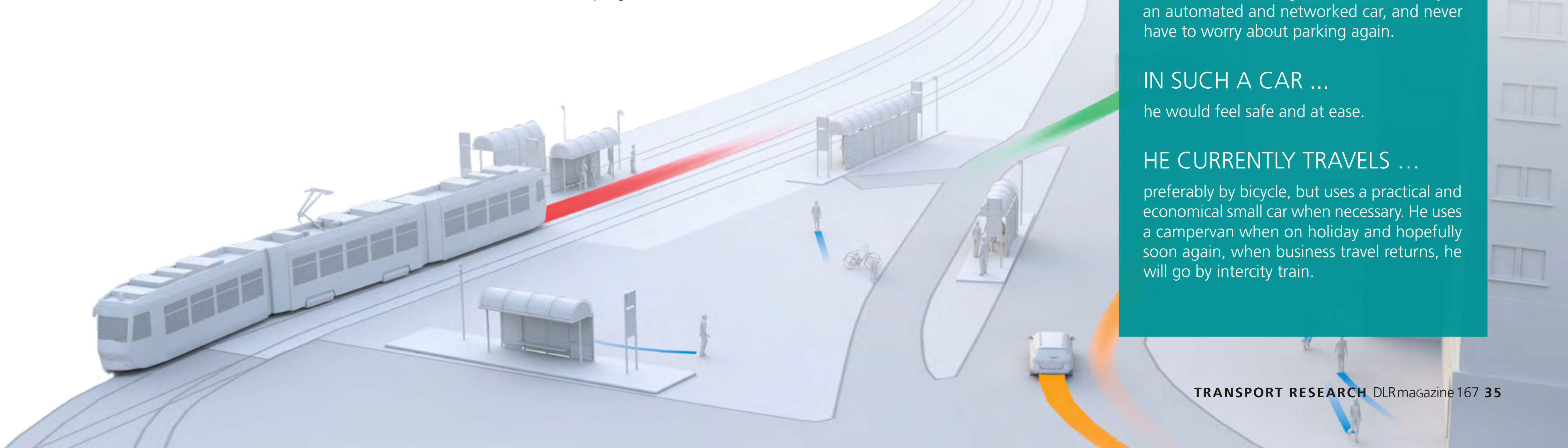


Image: Private

ABOUT THE INTERVIEWEE MAGNUS LAMP...

Magnus Lamp has been the Transport Programme Director at DLR since May 2018. He coordinates research relating to transport systems and road and rail transport. He has a degree in Mechanical Engineering from Braunschweig University of Technology and worked at TÜV Rheinland Consulting for over 20 years, most recently as Head of Research Management, authorised signatory and Member of the Executive Board. He also spent two years deployed on a high-speed patrol boat during his time in the German Navy.

HE FIRST CAME INTO CONTACT WITH ...

an automated and networked car in 2013 as part of a DLR research project, albeit one still in its testing phase.

IN THE FUTURE ...

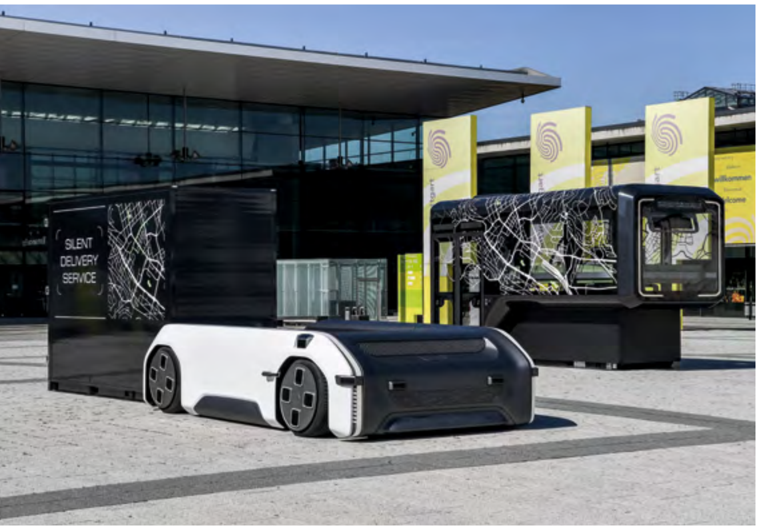
he would like to be driven from his home on the outskirts of Cologne into the inner city in an automated and networked car, and never have to worry about parking again.

IN SUCH A CAR ...

he would feel safe and at ease.

HE CURRENTLY TRAVELS ...

preferably by bicycle, but uses a practical and economical small car when necessary. He uses a campervan when on holiday and hopefully soon again, when business travel returns, he will go by intercity train.



DLR's U-Shift vehicle concept consists of a U-shaped drive unit onto which a variety of capsules can be loaded for transporting people or goods (find out more in DLRmagazine 166)

The decisive elements are the sensors and intelligent systems that the vehicle uses to detect and interpret its surroundings. These must be resource efficient in terms of their computing and electrical power requirements, but also meet the necessary security and trustworthiness standards. This is the great challenge, but I believe that it is possible. However, there is still quite a long way to go before we have safely mastered such technologies and see them on our streets. Technical trustworthiness is an essential factor in ensuring that people accept automated and networked driving.

Is the relevant technology inside the vehicle or in the infrastructure?

: The technology required for automated and networked driving will be primarily located within the vehicle itself. However, certain parts of the infrastructure will also be equipped with intelligent systems. Even in mixed traffic made up of both automated and manually driven vehicles, there will be networked, intelligent traffic light systems at intersections that safely communicate the current signal status and the ideal speed for reaching the next intersection during a green light, in order to minimise unnecessary waiting times.

Equipping infrastructure at critical accident blackspots or intersections with poor visibility with sensor systems that transmit reliable information to vehicles can increase the support for automated, networked vehicles at a local level. A central hub or control centre that enables a certain degree of monitoring and remote control is also a possibility. This could perform tasks such as manoeuvring a driverless vehicle out of a critical situation in the event of a malfunction. Nevertheless, the whole system will only work if all the elements – from the vehicle to the infrastructure and the control centre – meet the same high technological standards and 'speak the same language'. This is a challenge we should not underestimate, given the large number of different stakeholders involved.

The US companies Waymo and Tesla have led the development of autonomous vehicles. What is the situation in Germany and Europe?

: Tesla and Waymo – the successor to Google's Driverless Car project – are both in a very strong starting position. They are especially strong in software development and can draw upon scalable IT systems that have already been implemented globally. They can understand and further develop their cars as part of a larger information network. Germany and the rest of Europe are following suit with projects such as the Mobility Data Ecosystem and GAIA-X. These aim to build high-performance, competitive and secure data infrastructure for Europe that extends beyond the field of mobility.

"Mobility and the freedom that comes with it have a huge impact on our quality of life."

Our strengths lie in areas such as human-vehicle interaction and safety validation for automated and networked systems. Obtaining the evidence required for such validation on the road using conventional methods would require an incredible number of kilometres of test driving. And with each change to the vehicle's functionality, every scenario that could arise in day-to-day traffic has to be tested once again. This is why simulation methods are so vital in providing proof of safety. These are areas in which German and European research and industry are well situated, with the 16 relevant institutes and facilities at DLR playing a major role. Our Lower Saxony Test Field provides a high-performance, flexible test infrastructure which successfully combines different methods of simulation with test driving in real traffic. The new DLR Institute of Systems Engineering for Future Mobility is also conducting research into methods to make automated, networked transport systems as safe and efficient as possible.

Technology is one aspect. What about the business models?

: In the future, automated and networked driving will lead to greater customisation of local public transport. At the same time, personal transport will become more communal. In other words, going without a car will make more sense for at least certain sections of the population. Accessibility and participation will also improve for many people. Provision of passenger transport services will also become increasingly significant. The term 'mobility as a service' is often used by specialists, and it encapsulates this phenomenon very well. This will certainly alter the business models adopted by many market participants. If, for example, an automated, networked shuttle bus or lorry can navigate without a human driver, this will mark a turning point for the economic viability of the associated services. In general, however, we will experience more of an evolutionary shift over the next decade or two, and there are still some unknowns.

"Automated and networked driving will lead to greater customisation of local public transport."

How much of a societal impact will this have?

: Mobility and the freedom that comes with it have a huge impact on our quality of life, and that is not going to change. People cannot and will not give up their mobility. However, the emphasis needs to move away from personal car ownership. Emotional ties will undoubtedly continue to exist, but they will cease to do so in the form with which we have been familiar in recent decades.

Ultimately, at a societal level, we have to determine what we want from mobility in the future. Our research can show the general public and policy makers possible developmental trajectories and the associated consequences from environmental, economic and societal standpoints. This allows us to create the most resilient possible basis for decision-making, especially when it comes to defining the necessary regulatory frameworks. People will be prepared to accept new technologies and services if they recognise the benefits to themselves and the environment. As always, the fundamental question remains: 'How can I get from A to B reliably, safely, comfortably and without wasting resources?'

This interview was conducted by **Denise Nüssle**, Media Relations Editor at DLR.

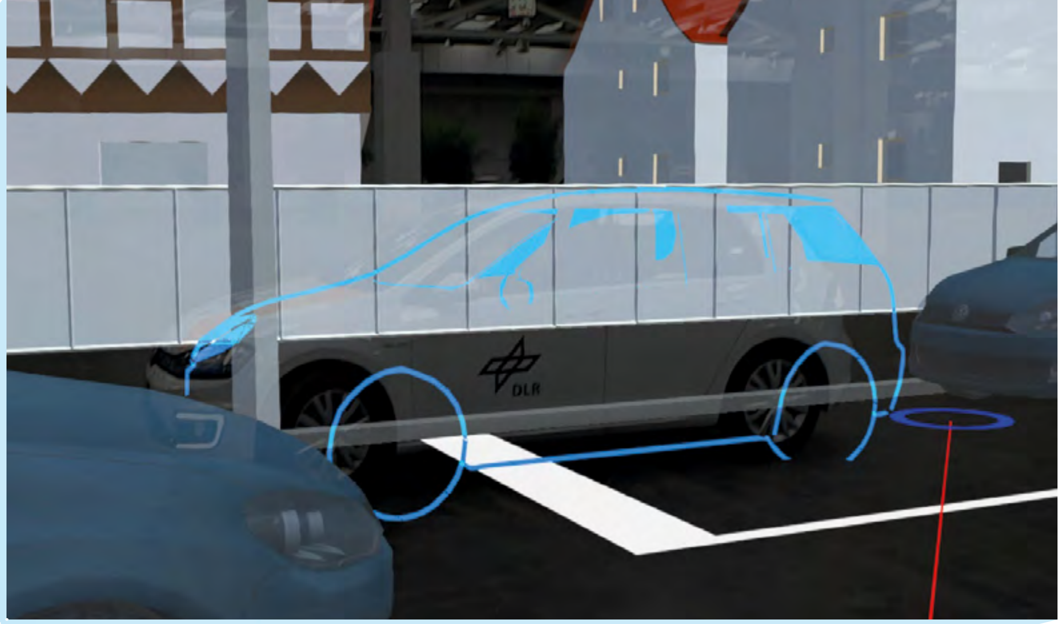
At its Virtual Reality Lab, DLR is conducting research into automated and networked driving. To ensure that tests are conducted under as realistic conditions as possible, there is room in the laboratory for a medium-sized car, and the 360-degree display provides a panoramic view.

DLR tested autonomous parking in the AUTOPILOT project. Using an App, the driver sends the car to search for a parking space. With the help of a drone, the system identifies a suitable spot, navigates the vehicle to it and parks.

AUTONOMOUS OR AUTOMATED?

Whether a vehicle is autonomous or automated depends on the driver's level of intervention. Automated vehicles carry out tasks or even completely take control of the vehicle in certain simple scenarios, such as on motorways. However, the system must always be monitored by humans. For autonomous vehicles, this step is no longer necessary, and the vehicle is able to react completely independently in all traffic situations.

IN FOCUS



A view through the HoloLens. A virtual scene from the digital image of Tostmannplatz junction in Braunschweig.

Special glasses offer a glimpse into a digitalised transport system

By Lennart Asbach and Frank Köster

The digitalisation of transport systems is advancing rapidly. Road and rail transport systems are operating at full capacity, but the demand for transport and mobility continues to rise. By connecting and automating vehicles and infrastructure, transport researchers at DLR hope to optimise traffic efficiency and expand capacity without having to construct many new transport networks. However, visualising this future is no easy task.

Researchers at the DLR Institute of Transportation Systems study the future of transport and mobility. They are not just interested in the technical questions, but also the systematic issues. What will 'the mobility of the future' actually look like? The number and variety of parameters and factors to consider make it difficult to get a clear picture. But such a picture is vital to define a research or development strategy. Existing systems can also be an additional complication. Conventional components of the transport system will likely have to remain in operation for a long time to allow vehicles not equipped with the latest technology to still be used. This makes it even more difficult to visualise the changes that new technology could introduce. Wireless technologies, for example, are invisible. In one conceivable scenario, physical traffic lights could become redundant as vehicles will be instructed when to stop via radio communication with digital infrastructure.

A new world in a hologram

To address this, researchers at DLR are using the Microsoft HoloLens to allow the visualisation of possible versions of future transport systems. The HoloLens is an Augmented Reality (AR) headset that combines real surroundings with virtual space. AR involves overlaying virtual elements on the real world. This makes it possible to project single or multiple simulated objects onto the view of a real location in the form of holograms. Through the headset, the holograms appear as real, physical objects.

This technology makes it possible to project just about any future transport scenario onto real environments. The suitable application for the headset was jointly developed by the DLR Institute of Transportation Systems, the DLR Institute for Software Technology and the company eck*cellent IT GmbH. In addition to collecting data from simulations, the system can also process and display measurement data from real situations. In one application, researchers are using data from the Test Field in Lower Saxony, one of DLR's research facilities for automated and connected vehicles. The data recorded on the test field can be transmitted to the HoloLens in real time and displayed on it.

Enriching reality

As a first example of a use case, the researchers programmed the headset to present the data received by a self-driving vehicle within its field of view in real time. These data could include the positions of other vehicles or local speed limits. Without the headset, all that can be seen is a single car driving around in an open space in circles. With the headset, one can see streets, traffic lights, road signs, people and much more. The car receives this information from various sensors, or wirelessly via radio communication and responds accordingly. Visualising this information makes it easier to understand why a car makes a particular manoeuvre and whether that manoeuvre is suitable for the situation. The superimposed elements are part of an entire 3D virtual world developed by the researchers for the HoloLens and which can be adapted to a variety of situations. Individual objects can be displayed to help visualise a future transport system in an existing scenario, such as a single vehicle in real traffic. Alternatively, a whole scene can be embedded into a real environment. This makes it possible to visualise changes to the urban landscape.

The first prototype of the setup was used at the 5GCMM-fair (5G Connected Mobile Machines) at the Hanover Fair grounds. In the exhibition hall, a real car with precision indoor positioning automatically drove around an obstacle course (with a safety driver). The researchers superimposed a hologram of part of the Tostmannplatz road junction in Braunschweig onto the hall. The projection featured pedestrians, cyclists and other cars animated by a DLR team from the computer centre at the Test Field in Lower Saxony. In this scenario, the position of the actual car was combined with simulated data and both datasets were displayed simultaneously.

This kind of technology can be useful for manufacturers of automated vehicles – to conduct tests in traffic jams, for example. These situations are normally difficult to create in a testing area, so researchers use simulations. They can simulate complex traffic jams while the car navigates around the test area. However, while the sensors are receiving realistic information, the driver can only see the empty test area. The HoloLens makes this digitally simulated information visible. This allows the driver to view complex situations and determine whether the car is responding correctly. Specialists at DLR are working with the Lower Saxony Ministry of Economic Affairs, Labour, Transport and Digitalisation and trade fair organisers Deutsche Messe AG to deploy the system on a larger scale.

Lennart Asbach is Acting Head of the Verification and Validation Department at the DLR Institute of Transportation Systems in Braunschweig. **Frank Köster** is the Founding Director of the DLR Institute for AI Safety and Security.

The first prototype of the setup was presented at the 5GCMM at the Hanover Fair grounds

BRIMMING WITH ENERGY

DLR's Stuttgart site turns 60

By Jens Mende

1954
Foundation of the Research Institute of Jet Propulsion Physics (FPS) at Stuttgart airport

1961
FPS moves to Pfaffenwald in Stuttgart-Vaihingen

1963
Takeover of FPS by the German Laboratory for Aviation (Deutsche Versuchsanstalt für Luftfahrt; DVL)

1969
Foundation of the Institute of Design and Construction Research

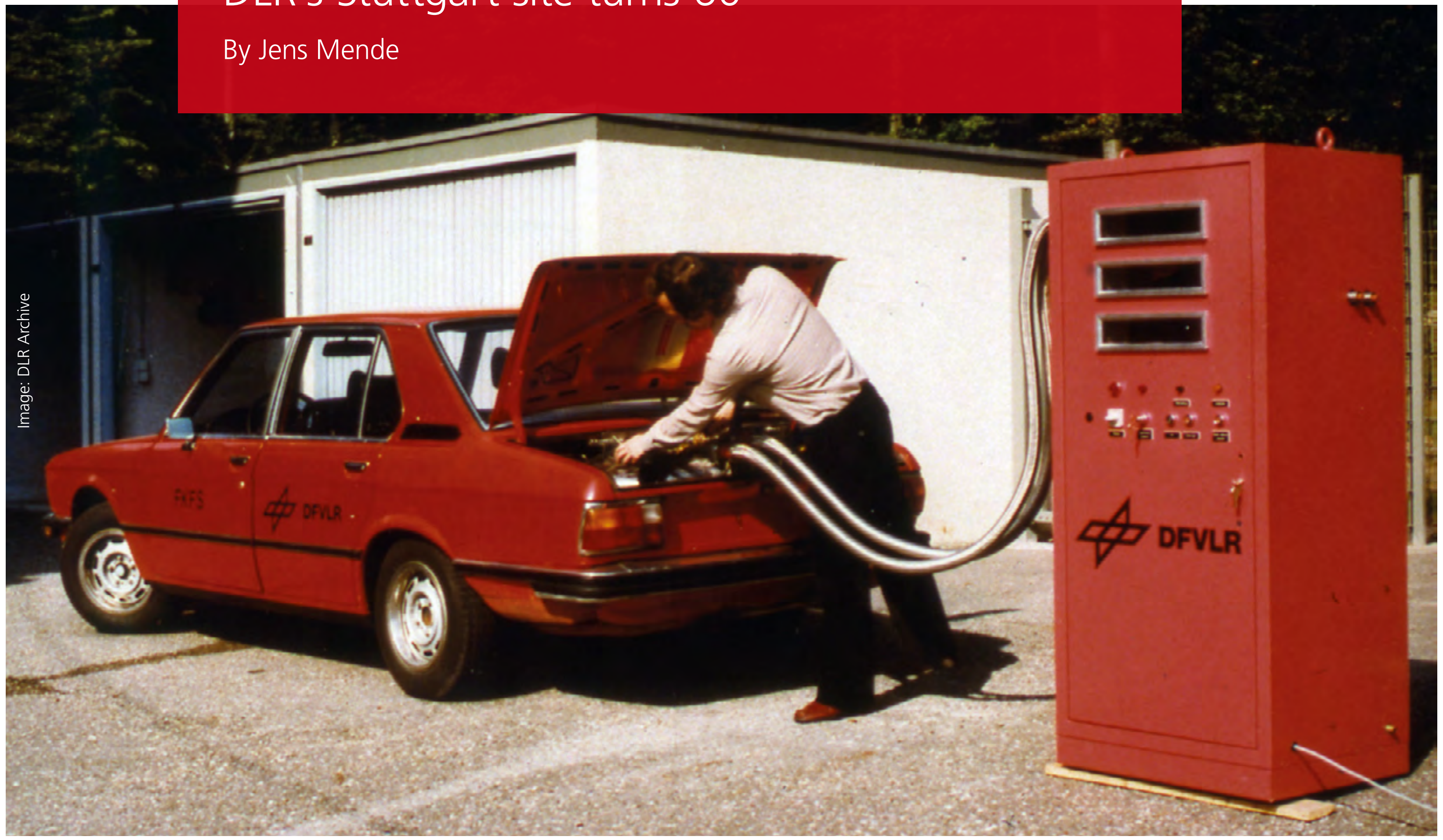


Image: DLR Archive

In 1978, the DFVLR presented the first car in Europe with a hydrogen engine. The tank filled the entire boot. The DLR researchers in Stuttgart converted the car themselves and developed a semi-automatic fuel pump. The car is now at the BMW Museum in Munich.

Energy has always been an important matter in Stuttgart – and it goes far beyond the frugal energy-saving approach of the local Swabians. Engineers, hobbyists and ingenious inventors have long been channelling their creative energy into countless innovations, particularly regarding mobility on land, on water and in the air. Founded in 1954, the Research Institute of Jet Propulsion Physics had even greater ambitions – outer space. In 1961, it became the heart of DLR's Stuttgart site.

Over the following six decades, DLR Stuttgart has become home to a host of new institutes focusing on energy and transport research. Today, the Institute's research topics include safe and carbon-neutral air transport, sustainable energy production using renewable sources, innovative vehicle concepts for the transport of tomorrow, as well as safe and efficient spaceflight.

Already in the 1960s, the research conducted at DLR's Stuttgart site was interdisciplinary. At the time, work at the institutes primarily focused on propulsion technologies, designing re-usable spacecraft and developing energy converters and electric propulsion systems. However, the technologies, knowledge and competencies that arose from aerospace research had to address challenges on Earth – namely in the area of energy supply. The DLR researchers began with the development of new storage and conversion systems for solar and wind energy. One of DLR's predecessor organisations, the German Test and Research Institute for Aviation and Space Flight (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt; DFVLR), was the first major institution to carry out systematic research into renewable energy and the use of hydrogen. In 1977, the International Energy Agency commissioned DLR with the construction of two solar power plants in Almería, Spain, to demonstrate the technical feasibility of this environment-friendly method of generating electricity.

New materials and high-performance components

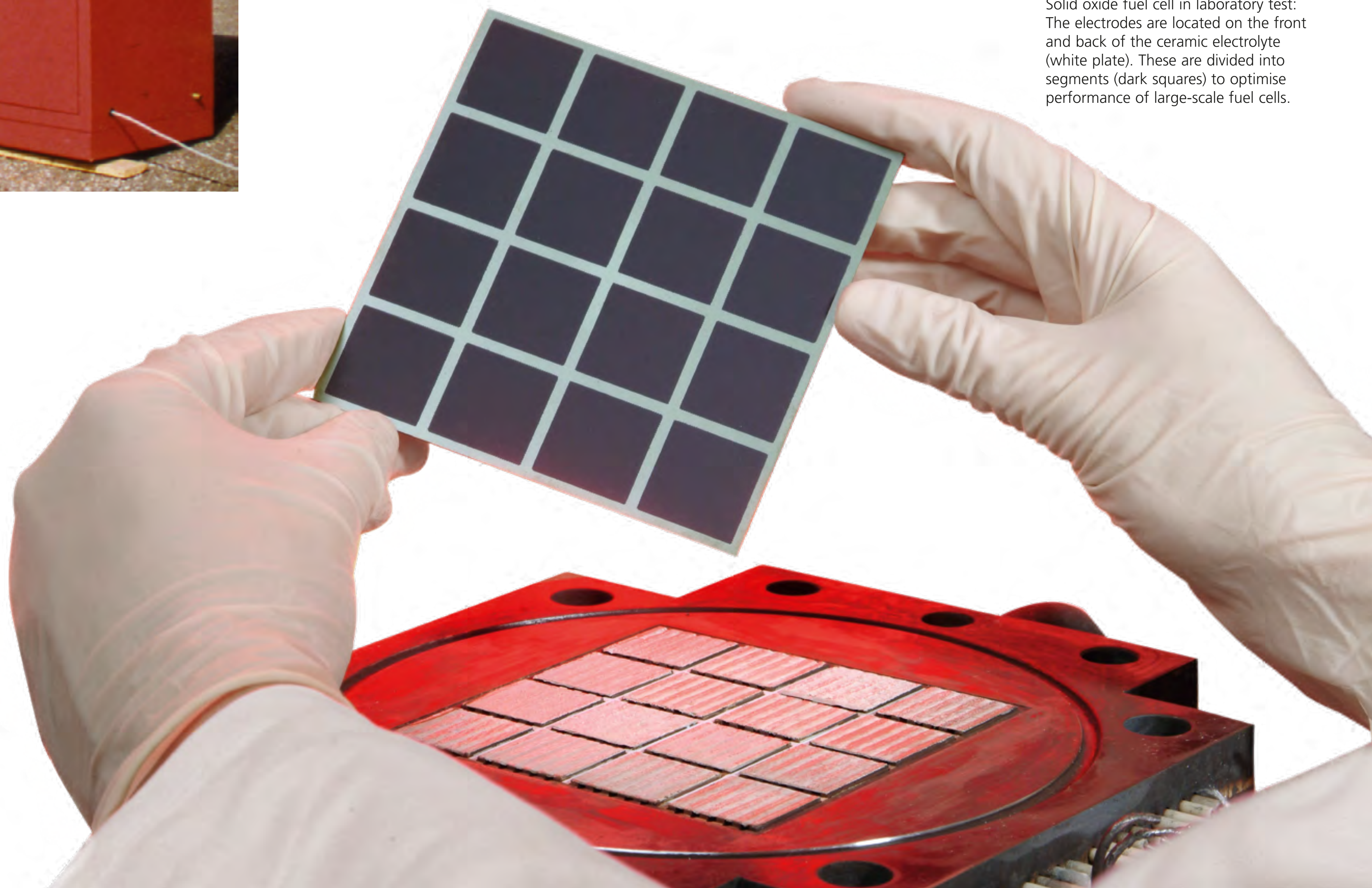
In the 1970s, innovative materials and construction methods began to replace conventional techniques. Newly developed composite materials, for example, could be used to construct ultra-light rotor blades for wind turbines. Fibre-reinforced ceramic components proved more resilient to high temperatures than metals. New manufacturing methods helped DLR laboratories to develop these high-tech materials for use in gas turbines, engines or the heat shields used to protect spacecraft as they re-enter Earth's atmosphere. A Stuttgart-based sports car manufacturer even went on to use similar ceramics in their brake discs.

Lasers in materials processing and standoff detection

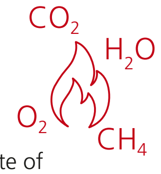
During the 1980s, an entirely different innovation began to establish itself in conventional Swabian mechanical engineering. Lasers were developed for cutting and welding. Microprocessor-controlled laser material processing machines could now manufacture components with a precision almost impossible to achieve using conventional methods. Over the years, DLR Stuttgart has developed numerous prototypes of innovative gas and solid-state lasers with output powers of many kilowatts. Thousands of industrial laser systems today make use of the operating principles developed here. Even the possibility of using laser power to launch microsatellites into space has been tested. Today, researchers at the site are working on laser and optical systems for defence and security, standoff detection of hazardous substances, drone identification, laser-based flight instruments and the detection of space debris.

Hydrogen for energy and transport

The oil crisis of the 1970s was one of the primary drivers of the first hydrogen-powered car, built at DLR Stuttgart in 1978. Specialists used the vehicle to investigate how this alternative fuel could be reliably stored. There was even a hydrogen fuelling station on site.

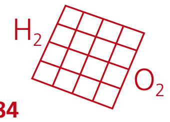

Solid oxide fuel cell in laboratory test: The electrodes are located on the front and back of the ceramic electrolyte (white plate). These are divided into segments (dark squares) to optimise performance of large-scale fuel cells.

1972
Foundation of the Institute of Reaction Kinetics



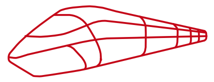
1976
Institute of Reaction Kinetics is renamed to Institute for Physical Chemistry of Combustion

1977
Establishment of the Institute of Technical Physics from the Institute for Energy Conversion and Electrical Propulsion and the Institute for Plasma Dynamics



1984
Foundation of the Institute of Engineering Thermodynamics

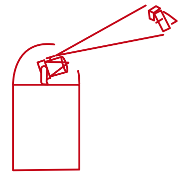
1998
The Institute for Physical Chemistry of Combustion is renamed to Institute of Combustion Technology



2002
Foundation of the Institute of Vehicle Concepts

2011
The Institute of Solar Research is established

2017
The site is expanded with a building for the institutes of Engineering Thermodynamics and Technical Physics



2020
Start of construction of the DLR research observatory for space debris in Empfingen

In 1985, DLR researchers demonstrated how hydrogen could be used to generate electricity on a large scale. They built two photovoltaic electrolysis plants – one in Stuttgart and another in Riyadh, Saudi Arabia, with a power of several hundred kilowatts. This project marked the beginning of fuel cell research in Stuttgart.

During the 1990s, the site carried out pioneering work on the development of membrane fuel cells with several kilowatts of electrical output power. With new types of electrode manufactured by plasma spraying, they achieved 20 percent higher efficiency. The DLR researchers also had other applications in sight, ranging from energy converters for cogeneration plants to high-efficiency vehicle and aircraft engines. A milestone was reached with the maiden flight of the Antares DLR-H2, the world's first passenger aircraft powered solely by fuel cells and a predecessor of the modern four-seater Hy4.

A new millennium – a new age for transport and energy

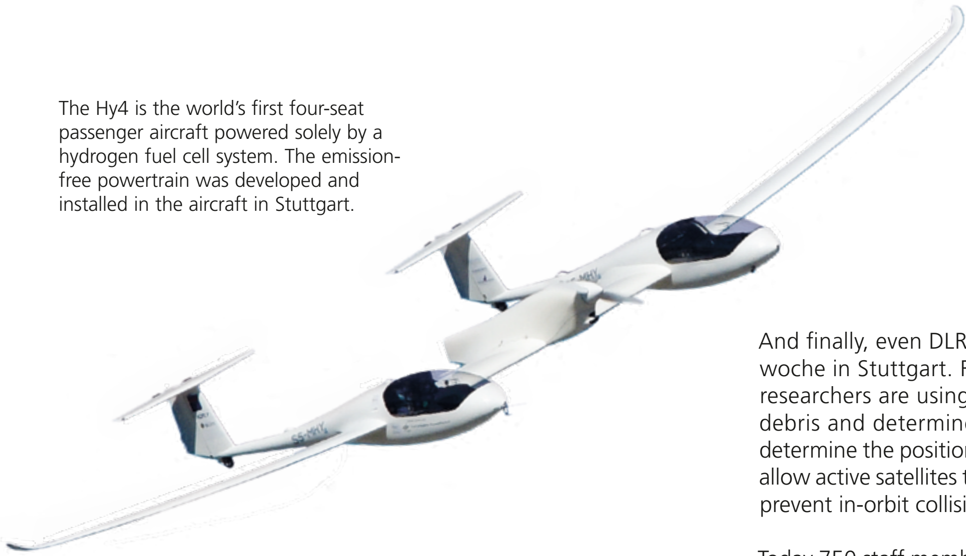
In 2002, a new research focus was established at DLR Stuttgart: the design of innovative road and railway vehicle concepts to facilitate sustainable transport systems powered by renewable energy. Here, researchers developed the first car powered by a fuel cell. This vehicle was the predecessor of DLR's latest road transport concepts: the Urban Modular Vehicle (UMV) People Mover, and the ultra-light commuter Safe Light Regional Vehicle (SLRV). With the U-Shift project, researchers developed a futuristic vehicle concept with a basic chassis and interchangeable capsules for transporting people or goods. The electrically powered driveboard is able to autonomously carry various capsule types round the clock. The Next Generation Train project addresses the future of rail transport: the development of safe, light and robust trains running on high-efficiency electrical, battery or fuel cell power at the speeds at which aircraft take off. Many of these DLR technologies can already be seen in everyday life, including Germany's first hydrogen-powered passenger train.

To ensure a safe and controllable supply of renewable energy, DLR Stuttgart is conducting interdisciplinary research into industrially viable key technologies for heat storage, batteries, green hydrogen and synthetic fuels. Examples are the Test Facility for Thermal Energy Storage in Molten Salt (TESIS) and the research platform for decentralised energy sources (TPDE), which is based on micro gas turbines. With these, DLR researchers are trying to find out how to achieve sustainable power generation nationwide. They are also conducting flights to test environment-friendly biofuels. In view of the rising global demand for energy, DLR researchers are devising concepts to generate power and heat as efficiently as possible. They are even combining various technologies such as high-temperature fuel cells and gas turbines in new hybrid power plants. Researchers at the DLR site in Stuttgart are also working on new technologies and materials for solar thermal power plants to lower the cost of electricity generated using solar power. One example is the CentRec heat receiver concept which is the key element of a pilot solar tower plant providing a factory with climate-neutral process heat.

Reaching even greater heights in 2021

The Integrated Digital Research Platform for Affordable Satellites (IRAS) project is investigating innovative satellite construction methods. 3D printing, green propulsion technologies, novel structural forms and electronic circuitry and manufacturing processes will allow satellites to be manufactured far more sustainably and economically in the future.

The Hy4 is the world's first four-seat passenger aircraft powered solely by a hydrogen fuel cell system. The emission-free powertrain was developed and installed in the aircraft in Stuttgart.



INSTITUTES AND FACILITIES AT DLR STUTTGART

- Institute of Structures and Design
- Institute of Vehicle Concepts
- Institute of Solar Research
- Institute of Technical Physics
- Institute of Engineering Thermodynamics
- Institute of Combustion Technology
- DLR Technology Marketing
- Systemhaus Technik

And finally, even DLR must not forget the traditional Swabian Kehrwoche in Stuttgart. Rather than cleaning the house, however, DLR researchers are using lasers and optical telescopes to detect space debris and determine how best to remove it from orbit. They can determine the position of objects to within just a few metres. This will allow active satellites to carry out effective avoidance manoeuvres and prevent in-orbit collisions.

Today 750 staff members work at six institutes at the DLR site in Stuttgart. Even trainees go in at the deep end as far as research is concerned, working in systems electronics, precision engineering, office management or dual study programmes in mechanical engineering, electrical engineering or information technology. They are also the best in their field, regularly winning top prizes and positions at state and national level – in other words, they are brimming with energy.

Jens Mende is responsible for communications at the DLR Stuttgart site.

And the excavators keep on rolling – the buildings for the Institute for Plasma Dynamics and the central workshop were built in 1967.

The DLR site in Stuttgart today

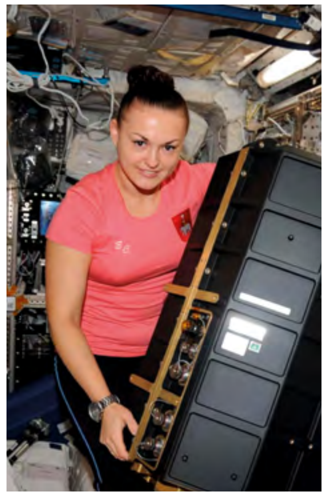
DLR engineers use the all-wheel roller dynamometer to put cars with combustion engines, electric drives and even hydrogen drives through their paces in standardised driving cycles at speeds of up to 200 kilometres per hour.

THOROUGH TESTING

To prepare it for its future space missions, the first upper stage of Europe's new Ariane 6 launcher is currently undergoing refuelling and hot-firing tests at DLR Lampoldhausen. The upper stage, which consists of the Vinci engine, the tanks for the liquid hydrogen and liquid oxygen, piping, valves and the electronic and hydraulic control and steering systems, reached the site in February. It is 11.6 metres high, has a diameter of 5.4 metres and was manufactured at the ArianeGroup factory in Bremen. Ariane's newly developed cryogenic Vinci engine provides the necessary thrust to deploy the payload on board the rocket at exactly the desired position in orbit. The rocket can burn for over 14 minutes and Vinci can be ignited up to four times. This allows one launcher to deploy multiple payloads in different orbits. The next two Ariane 6 upper stages are also nearing completion: the Combined Test Model (CTM), which will be used for joint tests with the main stage at the European Spaceport in French Guiana in the second half of 2021, and the Flight Model 1 (FM-1) for the first flight of Ariane 6, foreseen in the first half of 2022.

Image: DLR

The upper stage of the Ariane 6 launcher is integrated into the new P5.2 test stand at DLR's Lampoldshausen site.



Images: ROSCOSMOS and ROSCOSMOS/ESA

Cosmonaut Sergei Krikalev setting up the first plasma crystal laboratory, PKE-Nefedov, on board the ISS in 2001. Right: Cosmonaut Elena Serova installing the current plasma crystal laboratory, PK-4, in 2014.

TWENTY YEARS OF PLASMA RESEARCH ON BOARD THE ISS

Plasma crystal experiments were among the first and most successful research projects carried out on board the International Space Station (ISS). The first long-term experiments under microgravity conditions started on 3 March 2001. Even today, they continue to provide insights into physical processes at the atomic level. Experiments were being run in the PK-4 plasma crystal laboratory on the ISS as recently as March 2021. Plasma is an ionised gas and has many technical uses, including in fluorescent tubes and plasma televisions. On Earth, plasma is very rare. In space, however, 99 percent of visible matter is in a plasma state. The main goal of this plasma research is to expand our fundamental knowledge of physics. The findings from the experiments lend themselves to a range of applications, especially in the fields of medicine, environmental protection, spaceflight, as well as semiconductor and integrated circuit technologies.

WORLD'S SMALLEST LASER TERMINAL IN ORBIT

The PIXL-1 compact satellite has been orbiting Earth since the end of January 2021. On board is OSIRIS4CubeSat, the world's smallest laser terminal. It enables data transmission up to 100 times faster than conventional radio links and was developed jointly by DLR and the German telecommunications company Tesat-Spacecom (TESAT). Data transmission using lasers can be seen as a 'wireless fibre-optic connection' and will pave the way for far more efficient data transfer to and from satellites in the future. It will also enable an array of new applications in the field of communications and pave the way for new options in the fields of satellite navigation and quantum cryptography. The mission demonstrates that optical communication from space to ground can be achieved with even the smallest satellites. The German Space Operations Center in Oberpfaffenhofen is responsible for operating the satellite.

The PIXL-1 satellite carries the OSIRIS4CubeSat laser terminal, whose system consists of a highly compact combination of electronics, mechanics and optics.

Image: Christoph Otto

FROM PIONEER TO PATHFINDER

Sixty years ago, Yuri Gagarin became the first human to fly into space.

By Reinhold Ewald

In the 1990s Star City – the once mysterious and legendary training centre for Soviet cosmonauts – opened its doors to aspiring astronauts from the West for the very first time. And there, overlooking Star City, in steel-grey bronze and with flowers laid at his feet all year round was Yuri Gagarin, the unequivocal hero of the first human spaceflight.

Despite the political turmoil and economic difficulties of the intervening decades, those involved in Russian spaceflight today still draw inspiration from that pioneering feat and Gagarin's shining example. The inscription on his monument reads, 'He showed us the way to space'. With time, the machinations of political propaganda, which also accompanied Sigmund Jähn's spaceflight in 1978, prove to be irrelevant. These space travellers embodied the positive and humanistic message of a global community. The view of Earth from orbit and sheer pride in the technology that made it possible for humans to fly into space shaped pioneers like Gagarin and Jähn, just as much as their present-day successors. Their message continues to bring astronauts, cosmonauts and taikonauts together through the Association of Space Explorers, which was co-founded by Jähn in 1985.

I've lost count of the number of rituals paying homage to that first spaceflight that we followed on the way to the launch pad – the very one used by Gagarin, of course – during the Mir missions of the 1990s. We visited his office, which has reportedly remained untouched, and his grave in the Kremlin wall and his hometown – renamed Gagarin in his honour – where we visited the wooden house he grew up in. We performed the same rituals in the quarantine area at Baikonur and on the obligatory stop on the way to the launch pad [Editor's note: Gagarin had to relieve himself during the trip to the launch site. This has become a tradition for succeeding generations of space travellers]. All of this placed my flight and all of those that followed and will follow within a successful series of flights that remain a source of immense pride, despite the tragic failures and losses, such as the explosion of the Russian N1 Moon rocket.

We can consider ourselves fortunate that this pride has endured – even through difficult times – and that today, with the International Space Station (ISS), we have the perfect means to bring together developments from East and West. As welcome as the deployment of the new US spacecraft is, the time spent training together in the USA, Germany, Japan and Moscow has always fostered a sense of closeness. It has already helped over 60 expedition teams work together successfully and will provide the foundation for the next joint project – a station within the lunar environment.

It would be a shame if this historic entrance into Star City, watched over by Yuri Gagarin, were one day no longer a part of the general training programme. After all, what inspires and drives space enthusiasts all over the world is this era that began on 12 April 1961 with Gagarin. He showed us the way to space.

Image: ESA–Manuel Pedoussaut, 2016

Reinhold Ewald is an astronaut and professor at the Institute of Space Systems at the University of Stuttgart, where he leads the research department of astronautics and space stations. He is also on the Executive Committee of the Association of Space Explorers (ASE).

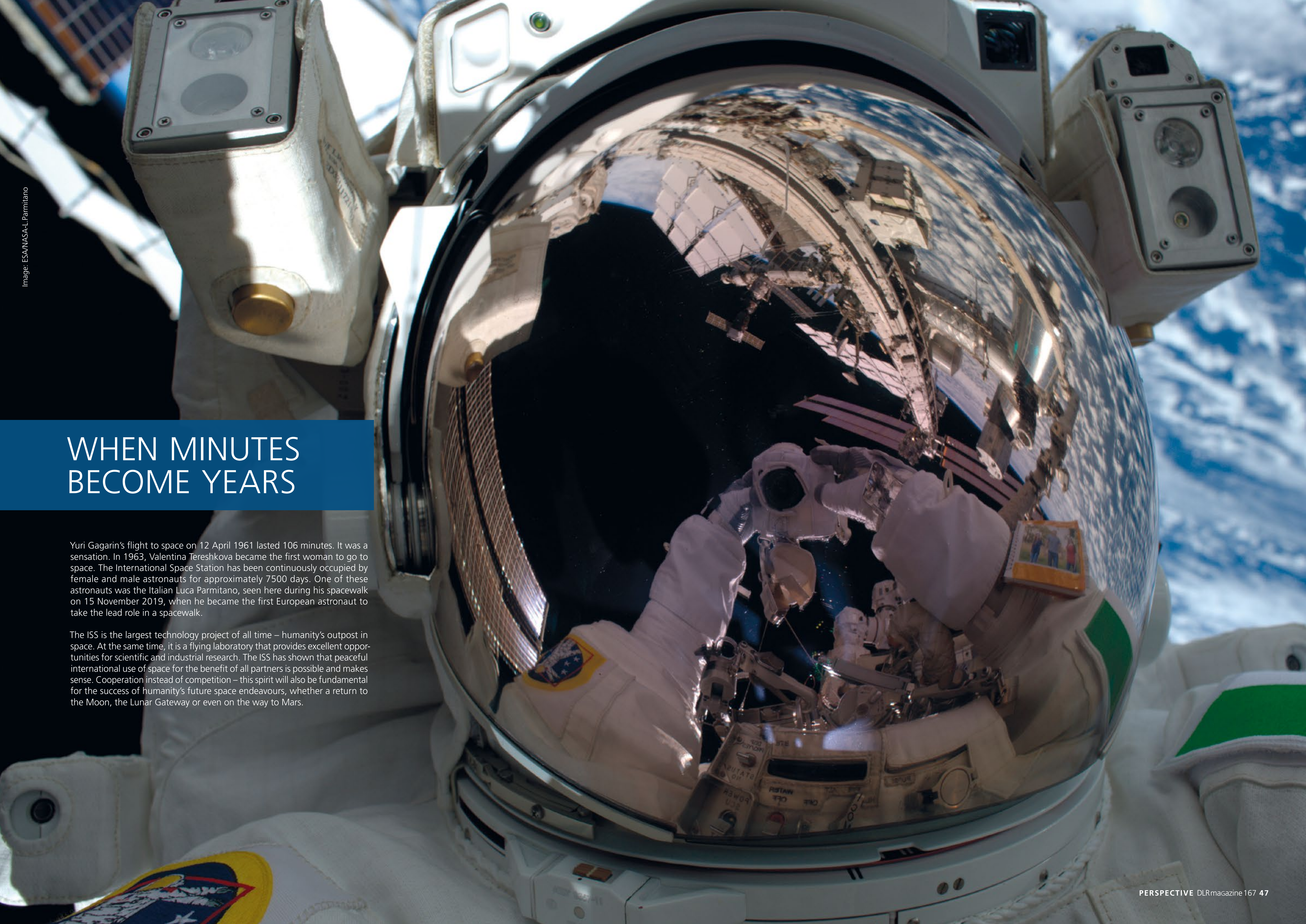


Image: ESA/NASA-L.Parmitano

WHEN MINUTES BECOME YEARS

Yuri Gagarin's flight to space on 12 April 1961 lasted 106 minutes. It was a sensation. In 1963, Valentina Tereshkova became the first woman to go to space. The International Space Station has been continuously occupied by female and male astronauts for approximately 7500 days. One of these astronauts was the Italian Luca Parmitano, seen here during his spacewalk on 15 November 2019, when he became the first European astronaut to take the lead role in a spacewalk.

The ISS is the largest technology project of all time – humanity's outpost in space. At the same time, it is a flying laboratory that provides excellent opportunities for scientific and industrial research. The ISS has shown that peaceful international use of space for the benefit of all partners is possible and makes sense. Cooperation instead of competition – this spirit will also be fundamental for the success of humanity's future space endeavours, whether a return to the Moon, the Lunar Gateway or even on the way to Mars.

VIRTUAL FEELING

The VITA system is being developed and tested jointly by DLR, Pohlig GmbH, LMU Klinikum, as well as the specialist clinics Osterhofen and Fondazione Santa Lucia Rome.

Credit: DLR

An innovative therapy and training system

By Verena Müller

People with limb impairment, particularly after an amputation, often suffer from a specific type of pain known as phantom limb pain. This pain is felt in parts of the body that no longer exist and is the brain's response to contradictory nerve signals. Phantom limb pain can be treated with 'mirror therapy', which involves reflecting the healthy limb onto the missing one. Patients then imagine making identical movements on both sides. DLR's Virtual Therapy Arm (VITA) system adds virtual reality to conventional therapy. People who have lost a limb or suffered a stroke are immersed in a virtual environment and re-experience the fully functional limb. This approach could revolutionise conventional therapy and training systems.

The VITA system was designed by Claudio Castellini, Markus Nowak and Christian Nißler at the DLR Institute of Robotics and Mechatronics. The system consists of a sensor band that measures muscle activity that can be worn on the arm or leg, a Virtual Reality (VR) headset and another sensor that detects the position of the arm or the leg. However, the centrepiece of the system is the software that recognises the intended limb movements via muscle movements, which was developed and widely tested by DLR.

Learning to cut and grip

How does it work in practice? During training with the VITA system, muscle contractions are measured and processed using machine learning algorithms, converted into movement and visualised via the VR headset. Patients can independently explore a virtual lakeside house and perform various tasks, such as chopping different fruits and vegetables in the kitchen. The aim is to train a stable and firm grip, but also to practise sensitive fine motor skills. When preparing tomato soup, for example, it is important not to squeeze the tomatoes too tightly when throwing them in the pot to prevent them from bursting. The system also offers a range of outdoor activities.

Motivation is key for rehabilitation. Studies have shown that only regular and repeated therapy is able to fight phantom pain in the long term. The DLR team partnered with a design studio to create a virtual world that is as engaging as possible. The training takes on a playful nature that prevents it from becoming monotonous and motivates patients to continue. In addition to its use by amputees, VITA can also be used by people who have suffered a stroke. The side of the body impaired by the stroke can be re-mobilised in a targeted manner. Patients grip and release objects on both sides of the body, with the impaired side initially supported virtually by the healthy side. Over the course of the therapy, this support is gradually withdrawn as the affected side gradually regains its mobility. Here too, continued training is crucial to restore the lost functionalities.

Training at home

A further advantage of the VITA system is that therapists, caregivers and patients are able to use the system independently after a short training period. The aim of the DLR team is to make VITA available not just at therapy or rehabilitation centres, but also at home for long-term use. Therapists could then connect remotely and support patients online during therapy sessions.

The DLR team is working closely with users to get the system ready for use as soon as possible. A clinical study, which will be completed at the end of 2021, is currently underway at various rehabilitation and therapy centres. The preliminary results of the tests are already available and indicate that VITA could soon be a part of everyday therapy procedures.

Verena Müller is a coordinator at DLR Technology Marketing.

Image: Roberto Borgogno

THREE QUESTIONS FOR PROJECT MANAGER CLAUDIO CASTELLINI

You are researching human-machine interfaces. Can you please elaborate?

: In the Adaptive Bio-Interfaces Group we design, build and test intelligent human-machine interfaces for people with disabilities. At the moment, VITA is our flagship project, a spectacular application of the technologies we have developed in recent years. We also apply these technologies to artificial limbs, rehabilitation exoskeletons, teleoperation and in many other fields. In doing so, we bring together expertise from a wide range of fields – from materials science and signal processing to mechatronics, physiology and psychology – all connected by and focused on applications for real people, who are always at the heart of our research.

What makes the VITA system different?

: The system greatly exceeds current conventional therapy in its realism. We have successfully created a level of immersion in the virtual world that achieves the sensation that limb functionality is entirely restored. This is impossible using any other method and has been confirmed by both patients and therapists. The system is easy to use and can be rapidly implemented in daily rehabilitation.

You are currently in the validation phase. What does that mean?

: If we want to market the product later, it will be very important to have evidence of the medical and therapeutic benefits. That is why we are now conducting a large clinical study. We are being supported by our project partners in rehabilitation and care, in prosthetics and orthopaedic engineering as well as by stroke clinics and stroke rehabilitation centres. They give us direct access to users and to customers such as health service providers. We are receiving financial and marketing support from the Helmholtz Validation Fund and DLR Technology Marketing.

IT'S ALL ABOUT THE FUTURE

Image: fotolia

Collaboration is becoming increasingly important in science

By Stefanie Huland

Human beings are living beyond their means. If we believe the calculations of the Global Footprint Network, on 22 August last year, humanity's demand for ecological resources and services in a given year exceeded what Earth can regenerate in that year. The Coronavirus pandemic meant that in 2020 'Earth Overshoot Day' came surprisingly late: in the two previous years it had arrived in July. In order to tackle the complex societal challenges of our time, we cannot rely on just a single scientific discipline, says Claudia Müller, research officer at the DLR Project Management Agency (DLR Projektträger). She believes that the interdisciplinary and transdisciplinary approach of social-ecological research is one solution.

Image: Oliver Frör

A project investigates the salination of a river system in Morocco. The picture shows a bridge over the Draa River in Morocco.

Social-ecological research investigates from as many scientific viewpoints as possible how to ensure a good quality of life in the long term. What makes this approach so promising?

: Energy, transport, agriculture, nutrition: humankind is facing major changes in virtually all areas. Social-ecological research is a special approach that addresses these challenges to sustainability in a way that is interdisciplinary and transdisciplinary. This may initially sound rather academic, but what it actually means is examining the major upheavals facing our society through a variety of different scientific disciplines. This entails a major re-think for conventional science. In addition, practitioners are being involved in designing the research from the very outset. And these include representatives from government, business and industry, and civil society. This 'transdisciplinarity' will help us ensure that the research conducted is relevant and gives rise to practical solutions.

"The major issues of sustainability will not be solved by one scientific discipline alone."

Twenty years ago the German Ministry of Education and Research (BMBF) initiated the Social-ecological Research funding priority, and for roughly the past 15 years, the DLR Project Management Agency has been responsible for implementing the measures. What role do young researchers play in this?

: The major issues of sustainability will not be solved by one scientific discipline alone. What we need are young scientists who are able to undertake inter- and transdisciplinary research. We are supporting them in our Junior Research Groups. Twenty years may seem like a long time, but it is actually short compared with the many centuries that some disciplines have been in existence. Anyone who wants to approach a project or a problem from various scientific angles must first accept that every science has its own methodology and terms of reference. Young investigators undergo regular training to learn these approaches and how to apply them. If we want to work on a transdisciplinary basis, things get even more complicated. Science requires protracted validation before reaching a well-founded result. And it is the young investigators who must make special efforts to make their mark in the scientific system. Government, industry and civil society generally demand quick-fix solutions. Reconciling these conflicting interests is something that you have to learn. Here too we are supporting doctoral and post-doctoral researchers, for example, by setting up junior professorships.

Can you give us a specific example of this kind of research?

: One of the groups that we fund is studying the salination of a river system in Morocco. Environmental scientists take water samples and investigate the development of water quality. One PhD student is examining the socio-economic conditions of the rural population that lives along the river and grows crops there. A natural scientist examines how the river water is affecting crop quality and biodiversity. A political scientist addresses the originally political decision which led to the salination: the construction of a dam, which affected water levels. This has been exacerbated by climate change. Together, the members of the group combine the results to help devise joint practical recommendations. This example shows how important an overarching approach to research is. If I were to examine water quality alone, I would learn something about the quality of the water itself, but nothing about the effects on farmers and their crops, or how policy could help improve living conditions. In order to avoid conflicts of interest and to generate solutions, all aspects need to be taken into consideration.

Stefanie Huland works for Corporate Communications at the DLR Project Management Agency.

Image: DLR

Claudia Müller has been responsible for the funding initiative Junior Research Groups in Social-ecological Research at the DLR Project Management Agency since 2011.

SOCIAL-ECOLOGICAL RESEARCH

Social-ecological research has been given special funding priority by the Ministry of Education and Research (BMBF) under the Strategy 'Research for Sustainability' (FONA-Strategie). The DLR Project Management Agency has been on board since 2007. It advises and supports the ministry from the conception of the individual funding measures to the evaluation of the results. The Project Management Agency's central tasks also include organising the review process, approving the individual projects and supporting the funding recipients and their networking activities. In addition to providing recommendations for policy-makers, industry and civil society, the funding of the Junior Research Groups specifically aims to further the academic qualifications of those involved and to open up the science system to this new research approach.

THE EXPLORER'S LEGACY

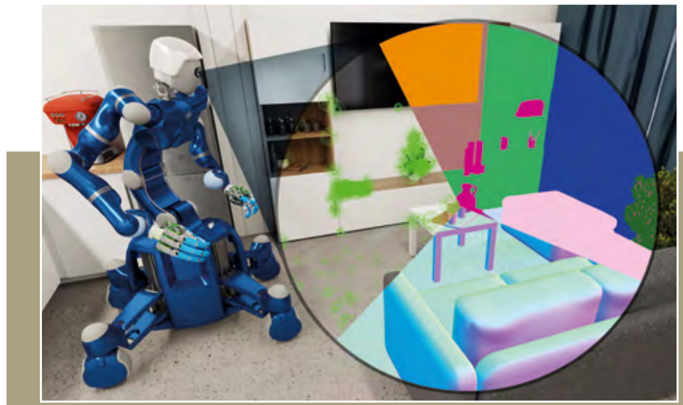
Image: University Archive Heidelberg

Hermann von Helmholtz was born 200 years ago, but his ideas continue to influence modern research.

By Jessika Wichner

Hermann Ludwig Ferdinand von Helmholtz was one of the last great polymaths – a master of mathematics, physics, chemistry, medicine, psychology, music and philosophy. Not only did he achieve a number of major scientific breakthroughs, but various medical devices are also based on his ingenious ideas. Like its namesake, the modern Helmholtz Association of German Research Centres, to which DLR belongs, is active in many different fields of research.

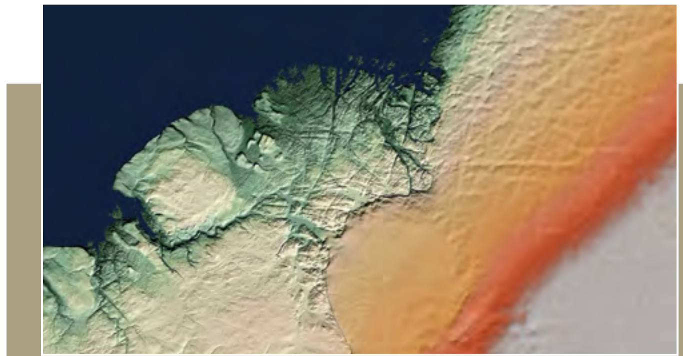
Hermann von Helmholtz was born in Potsdam in 1821 and received his doctorate in Medicine in Berlin in 1842. In 1848, he was granted a physiology professorship in Berlin, followed by another at the University of Königsberg just one year later. He taught at the University of Bonn from 1855 and later held the first Chair of Physiology at the University of Heidelberg. In 1870, he was offered a professorship in physics in Berlin as a result of his previous work in physics. Helmholtz was awarded the title of nobility in 1883. He was a member of various academies, including the Royal Society of Edinburgh and the Bavarian Academy of Sciences. His approach of combining different disciplines and integrating theory, experimentation and practical application made Hermann von Helmholtz a true pioneer of modern science. Many of his concepts and ideas proved to be pivotal even after his time. At DLR, scientists still use his findings, ideas and developments in various research areas today.



DLR's Rollin' Justin robot takes in his surroundings using cameras. He evaluates the camera information using a range of computer science and artificial intelligence methods to carry out his assigned tasks.

Exploring the world with sensor eyes

Hermann von Helmholtz studied spatial vision and perception in depth. DLR continues to make use of his findings in fields such as robotics and space research. The robot Rollin' Justin, developed by the DLR Institute of Robotics and Mechatronics in Oberpfaffenhofen, is equipped with many different cameras that enable him to carry out coordinated movements in three dimensions. Stereo cameras are also very important in space. The European Space Agency's (ESA) Mars Express spacecraft has been orbiting our planetary neighbour for 18 years. On board is the High Resolution Stereo Camera (HRSC) developed by the DLR Institute of Planetary Research in Berlin, which acquires impressive images of the Red Planet. The data it collects are used to create high-resolution digital terrain models for topographical mapping and to answer scientific questions.



TanDEM-X image of the Hiawatha Glacier in Greenland

The secrets of glaciers

Helmholtz was particularly interested in meteorology. He carried out mathematical studies of hurricanes, thunderstorms, air and water waves and extensively investigated the causes of glacier movements. Today, DLR also conducts research into areas of meteorological interest using resources such as specially equipped atmospheric and Earth observation research aircraft like HALO. DLR also operates a number of Earth observation satellites, such as the two radar satellites TerraSAR-X and TanDEM-X, which have been in operation since 2007 and 2010 respectively. In 2019, DLR contributed to improvements in glacier development forecasting with its development of a new technique to analyse TanDEM-X data.

Image: DLR

DLR is conducting a bed-rest study to investigate how microgravity affects the body

Ophthalmology in microgravity conditions

Among Hermann von Helmholtz's most famous inventions are his medical devices, particularly the ophthalmoscope, which is used to view the retina. He also designed the ophthalmometer, which is used to determine the curvature of the cornea. Today, the DLR Institute of Aerospace Medicine in Cologne is investigating the effects of microgravity conditions on visual acuity. At the Institute's medical research building, :envihab, DLR is testing various treatments for reducing these effects on behalf of NASA. For 30 days, the participants will lie with their heads tilted downwards by six degrees and complete a wide variety of tests.

Ver y large wind tunnels such as the Large Low-Speed Facility (LLF) in the Netherlands – one of the DNW's wind tunnels – would not be possible without taking into account the first law of thermodynamics.

Energy conservation in a wind tunnel

The first law of thermodynamics states that energy in a closed system is always conserved. It was first formulated in 1842 by Julius Robert von Mayer and refined in 1847 by Hermann von Helmholtz. According to this law, energy can neither be created nor destroyed, but only converted from one form to another. This physical principle plays an important role in the construction of wind tunnels. Ludwig Prandtl, the founder of the Aerodynamics Research Institute (Aerodynamische Versuchsanstalt; AVA), a precursor of DLR, developed the Göttingen wind tunnel, a structure distinguished by its closed flow circuit. Previously, wind tunnels had been open systems where the wind was blown out into the open after passing through the test section. Most of the expended operating power was converted into heat and lost. In a closed flow circuit, by contrast, this energy is retained and the drive motor only has to compensate for smaller, unavoidable energy losses as a result of friction. Large wind tunnels are technically feasible thanks to this invention. Now, they are indispensable for testing aircraft, cars, rockets and trains. DLR and its subsidiary the German-Dutch Wind Tunnels (DNW) jointly operate a wide array of wind tunnels for research purposes.

Jessika Wichner heads the DLR Central Archive in Göttingen.

Images: HORM

A TRIBUTE TO SPACEFLIGHT

The Hermann Oberth Space Museum in Feucht

By Ulrich Köhler

Willard M. Taub illustrated the journey to the Moon for NASA. His sketches are among the most valuable exhibits in the museum.

Hermann Oberth (centre) together with his daughter Erna Roth-Oberth and Edwin 'Buzz' Aldrin, the second man to walk on the Moon, in Feucht in 1986.

Hermann Oberth is considered one of the founding fathers of space travel. In the town of Feucht, Franconia, where he lived in his retirement, a museum vividly brings his work to life. It reveals his pioneering achievements in the field of rocket science, which ultimately put people on the Moon, and the fraught political climate in in which the technology was developed. The Hermann Oberth Space Museum is a cornucopia of unique objects from the development of rocket technology – a treasure trove of spaceflight history.

"Given the current state of science and technology, it is possible to build machines capable of climbing beyond Earth's atmosphere." This is the first of four declarations that Hermann Oberth wanted to prove to show that launching 'The Rocket into Planetary Space' (Die Rakete zu den Planetenräumen) – as his 1922 thesis was entitled – was more than a dream. These words are carved into one of the beams of the Hermann Oberth Space Museum, alongside the three others. Many visitors likely walk right past them. The few rooms of the museum are filled with so many models and original components, interspersed with display cases full of important documents from the pioneering age of space travel – primarily from 1920 to 1940 – that they are easily missed.

Years ahead of his time

When Oberth presented his manuscript to two professors at Heidelberg University in 1922, the 'rocket' was so far ahead of its time that academia had no clue what to do with the idea. Oberth ended up not submitting the thesis in Heidelberg. Instead, he published it privately as a book in 1923, immediately attracting attention. He left the university in Germany and completed his studies in Cluj-Napoca, where he supported his young family.

In 1929 he published his more comprehensive second book, 'Towards Spaceflight' (Wege zur Raumschiffahrt), which was held up for decades as a bible of space travel. His work culminated in Yuri Gagarin's first human space flight 60 years ago and with Neil Armstrong's famous 'giant leap' into the grey dust of the Moon in 1969. Wernher von Braun, student of Oberth and mastermind of the Saturn V Moon rocket, often stated that without Oberth, there would have been no Moon landing. This is clear from Oberth's second and third declarations: "Future developments will allow these machines to achieve such speeds that, once they are left to their own devices in the aether, they will not fall back to Earth, but will even be capable of reaching beyond Earth's gravitational field." and "It will be possible to build machines of this kind in such a way that humans (probably without detriment to their health) will be able to ascend with them."

The museum illustrates Oberth's series of decisive developments. In the coming years, a new building will be constructed on the Oberth estate at Pfinzingschloss Castle with funding from the Free State of Bavaria. The building will have generous underground space for archives. The plans show a modern, spacious museum with a clear educational purpose. To date, there is no other museum within Germany or Europe which so coherently and thoroughly traces the attempts of the era to achieve spaceflight. In addition to the exhibits, large quantities of printed material in styles common 100 years ago successfully archive the activities of this pioneering age. Feucht is home to a tribute to German rocket technology, which was the world leader at the time. The museum is even a member of the International Astronautical Federation.

Dresden, Vienna, Peenemünde

Even in his youth, Oberth's reputation was legendary. By 1928 he had developed his first liquid-fuelled rocket engine. But he was also affected by the turbulent political and military conditions of the 1930s. Hermann Oberth, however, was not Wernher von Braun, who was more willing to collaborate with the Nazis in order to realise his dreams and mark the period of 1933 to 1945 as a dark chapter in an otherwise impressive career.

Oberth, by contrast, openly shared his knowledge with the world. As a result, the Nazis kept him in Dresden and Vienna, where they could better control him and prevent any information leaking to the enemy. He was primarily kept away from armament projects, but was eventually ordered to developing Peenemünde, on the coast of the North Sea, where he helped developing components for 'Aggregat 4', the deadly V-2 rocket. Despite this, Wernher von Braun remained the prime henchman of the evil regime.

The treasures of Willard Taub

After the war, the second that he had experienced in his lifetime, Oberth moved to Feucht. He continued to work, lecture and conduct research in Italy and Switzerland – rocket research having been outlawed within Germany. On two occasions, Wernher von Braun brought him to Huntsville, USA, to help him with his work on the project of the century, Apollo. Possibly the most valuable exhibit of the museum is from this time period: evidence that even before Kennedy's famous 1961 speech, US scientists were seriously considering sending a man to the Moon. Dozens of superb, delicate and detailed technical drawings reveal how NASA, founded in 1958, imagined this could be accomplished. The museum owns the first drafts of designs for a command capsule and sketches of concept that already very closely resembled that of the Apollo missions.

Willard M. Taub created these large-scale sketches for NASA and we have his twin brother Bill Taub to thank for preserving countless iconic photographs from the Apollo era. Like Oberth, the brothers' ancestors came from Transylvania. They knew and greatly respected one another. Before he died in 1997, Willard Taub bequeathed his original drawings to the Hermann Oberth Space Museum. The unique collection, venerated by everyone with an interest in engineering and technology, is guarded here like the Holy Grail.

Hermann Oberth, the rocketry pioneer and one of the fathers of spaceflight, passed away in 1989. Was he truly a genius? A visionary? This quickly becomes evident during a visit to the museum, and from the foresight of his fourth and final declaration from 1923: "Under certain economic conditions, building machines of this kind could be of value. Such conditions may come to fruition in the coming decades."

A planetary geologist by training, **Ulrich Köhler** works for the Institute of Planetary Research and enjoys dealing with the history of science in his free time.

The Hermann Oberth Space Museum

Address: Pfinzingstraße 12-14, 90537 Feucht

Telephone: +49 (0) 9128 3502

Opening times: Saturdays and Sundays from 14:00 to 19:00 // currently closed due to COVID-19 pandemic

Admission: Adults: 5 euro / Children and young people: 3 euro

oberth-museum.org

REVIEWS

THE AESTHETICS OF DISASTER

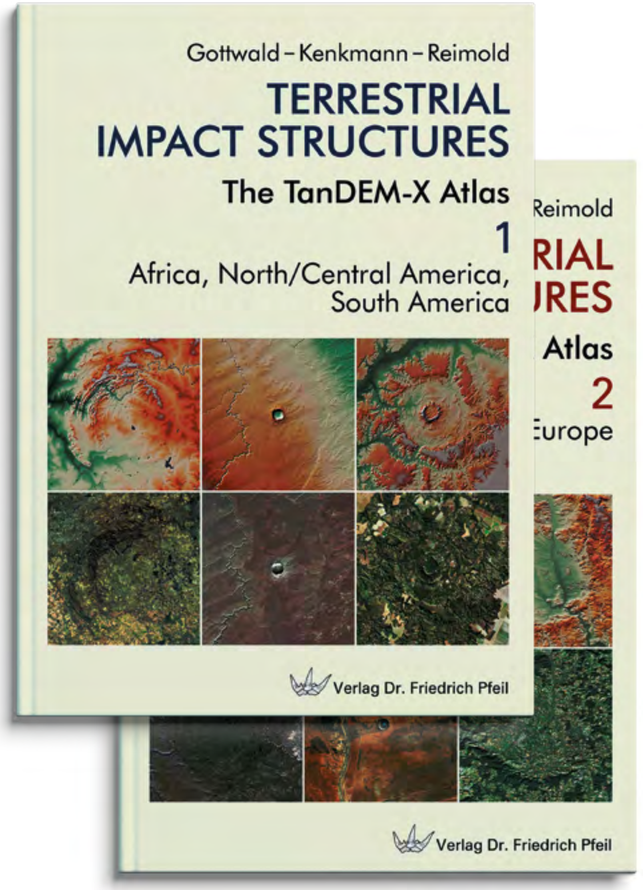
Can we consider a book that focuses exclusively on the detailed consequences of a violent and deadly process almost unimaginable in scale beautiful? In this case, it is possible because the catastrophic events and their effects date back many millions of years in Earth's history. The dinosaurs that fell victim to one of these events 65 million years ago, or the few surviving early rodents, however, might have a different opinion. Hidden behind the highly academic book title **Terrestrial Impact Structures: The TanDEM-X Atlas Volumes 1 and 2** are the legacies of likely the greatest realistic threat from outer space – asteroids colliding with Earth and the traces left behind.

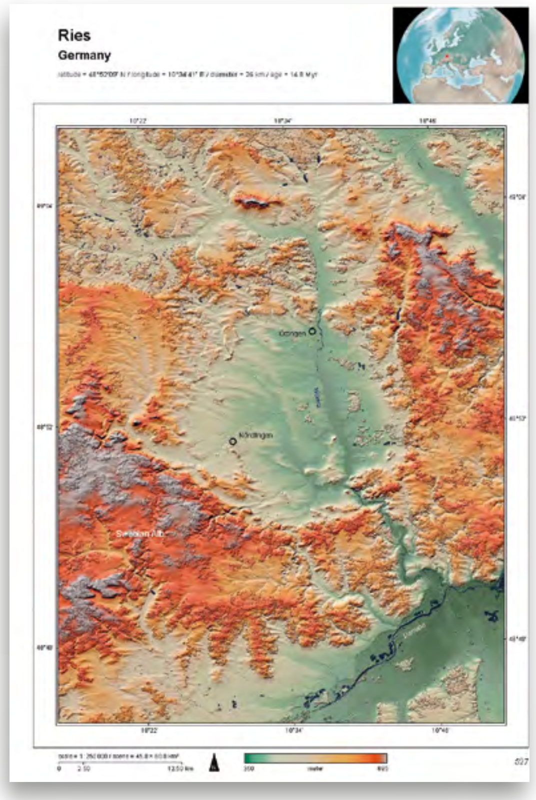
It was not until the 1960s that geologists studying the 20-kilometre circular structure in the Swabian-Franconian Jura, known as the Nördlinger Ries, understood that they were not looking at a volcanic relic. Rather, they were in the presence of an astrobleme, the remains of an ancient meteorite impact structure on Earth's surface, that was formed during a collision with a 1.5-kilometre-across Solar System 'vagabond' 15 million years ago. The energy released during such an event are almost inconceivable; rock debris was hurled hundreds of kilometres through the air.

There are only about 200 of these impact structures on Earth. A glance at the Moon reveals that Earth must have taken thousands and thousands of such impacts in the planet's early days, but plate tectonics, erosion and the atmosphere erased the traces rather quickly. In this wonderful work, they are all described in writing and, above all, by magnificent images and topographical representations. Physicist Manfred Gottwald, now a DLR retiree with a passion for astronomy, visualised these impacts on Earth using radar image data obtained by the German TanDEM-X mission, which provided the first global satellite-based digital elevation model of Earth's surface with high resolution from 2010 to 2016. Based on this, a topographical atlas of all known impact structures was created.

"If the asteroids stay in space, they are the subject of astronomy," notes Gottwald, "if they hit Earth, they become a matter of geology." The two co-authors, Kenkmann and Reimold, are among the world's best specialists in this field and contributed detailed geophysical, mineralogical and petrographic expertise and field observations, so this magnificent book, long awaited by experts, saw the light of day: Jay Melosh, the master of impact research, who passed away in 2020, would have been delighted with the new definitive text for the field.

Ulrich Köhler





OUTBREAKS AND EPIDEMICS

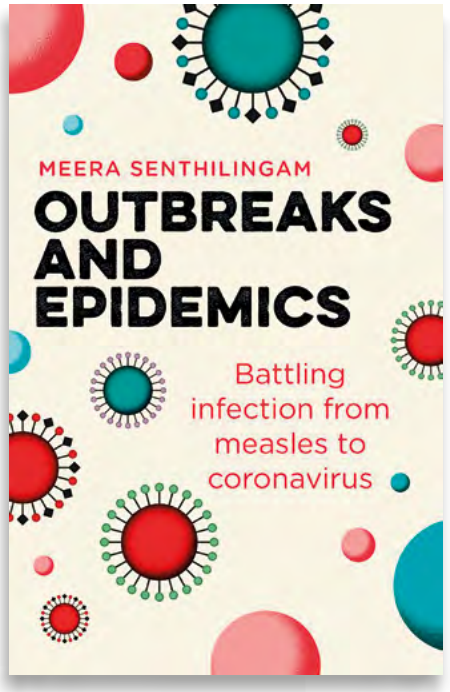
More than one year has passed since the COVID-19 pandemic began. During this time, our days are filled with news about the virus, its spread, how to prevent getting infected, and more. But do we truly understand what this all means? **Outbreaks and Epidemics: Battling infection from measles to coronavirus** makes a great read given the current global situation.

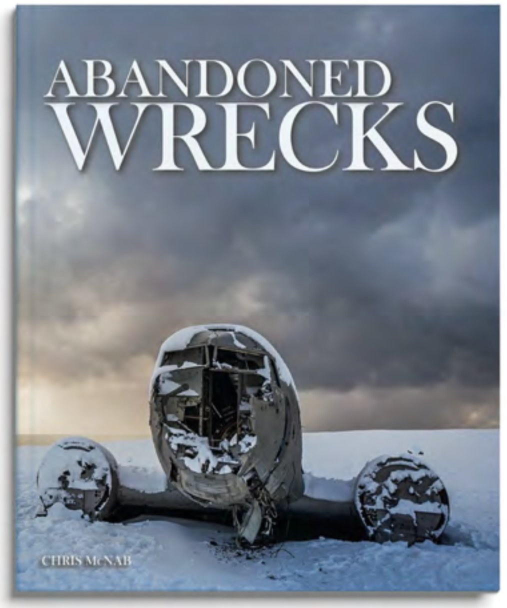
Influenza, smallpox, HIV, Ebola, Cholera, Coronavirus... and the list goes on. Humankind has been fighting infections that, left untreated, would have the power to wipe out communities, or even entire populations. In 176 pages, Meera Senthilingam presents numerous diseases currently afflicting humanity, describes them and tells us what is happening with their current status in humans.

The book is written in an understandable manner, providing an explanation of concepts such as epidemic, outbreak, incidence, prevalence and herd immunity – all terms that we need to be familiar with to understand the current development of COVID-19.

The author presents a timely look at humanity's ongoing battle against infection. It is an informative read for those looking to understand more about infections affecting humanity. Definitely useful in current COVID-19 times.

Karin Ranero



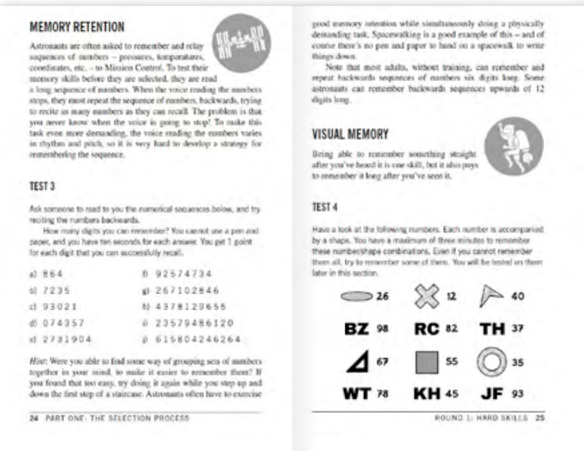


OUR FASCINATION WITH TRANSIENCE

Corroded by rust, overgrown with plants and left to slowly decay, wrecks exert an almost mystical attraction with their morbid charm. In his book **Abandoned Wrecks**, Chris McNab takes us on a journey around the world through jungles, deserts and oceans, but also ordinary neighbourhoods. Over the span of 224 pages, divided into five chapters – Ships, Trains, Military Vehicles, Road Vehicles and Aircraft – carefully selected photographs by various photographers reveal wrecks of all kinds, enriched with technical and historical details. The fact that the author is a British military historian is particularly evident in the remarkably precise details about military machinery.

There is scarcely any resemblance between the various motifs. Iconic shipwrecks like the ghostly Titanic and anchored warships whose grey superstructures, mottled with rust and covered in moss, resemble rocks. The long, colourfully spray-painted trains resemble prehistoric snakes on overgrown sidings. Tanks whose crews may have met a terrible fate or those that, in the end, now serve a positive function as a reef. Aircraft that once gracefully defied gravity remain grounded for good and a Russian Buran shuttle, a technical milestone at the time, now faces oblivion in a hangar in danger of collapse. But the book also depicts wrecks that might remind us of our own experiences: parked caravans with grandiose views, cars and school buses turned to art exhibits or bicycles that – weathered and painted – have become fixtures of urban worlds. Perhaps it is the surreal sight of huge machines in unexpected places, enormous, abandoned material assets and former technological breakthroughs, the stories and fates they tell, or the striking transience of even the greatest endeavour, that fascinate us so much about wrecks.

Daniel Beckmann



"HOUSTON, WE HAVE A PROBLEM SOLVER…"

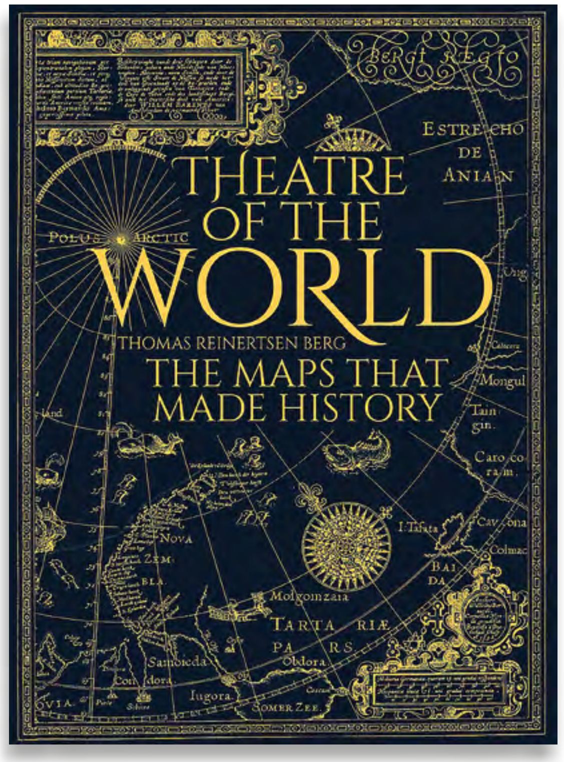
Fancy a nine-to-five in orbit, watching Earth and its approximately eight billion inhabitants turn gracefully below? The European Space Agency (ESA) recently opened its latest call for applications to join the next generation of European astronauts. For many, this is a once-in-a-lifetime opportunity: the previous selection campaign opened 13 years ago in 2008. Do you think you would make the cut? British astronaut and graduate of that 2008 cohort, Tim Peake, has put together a book with ESA that might just convince you to give it a go. **The Astronaut Selection Test Book** is part autobiography, part crossword puzzle book, part astronaut FAQ and part flashback to high school aptitude tests. It offers a glimpse into the entire life of an astronaut – from the job application and the years of rigorous training to the spacewalks and the responsibilities as an ambassador for science and for Europe.

The opening pages throw you right into the action: "Astronaut Candidate, you have crash-landed on the Moon…" From there, the test begins. How will you prioritise the handful of surviving items to ensure your crew makes it safely to the distant lunar base?

Even if you go into the book to learn more about the astronaut experience and with no intention of trying the logic puzzles, memory tests or questions on what to do if the ISS springs a leak, you will still likely find yourself reaching for a pen and paper at some point, thinking: "well, surely to answer this one, you just need to…" The challenges come thick and fast throughout. They pull your mind from one topic to the next and many also note the time limit astronauts are given in the real test – it's not just whether you can answer the question, but whether you can do it under pressure. How is your English grammar? How many of these instrument readings can you memorise in three seconds? How good is your intuition for weights, distances, speeds? Quick – which switch in this circuit do you need to close to get the power (and the air supply!) back on? One test even has you memorise the shapes associated with a series of numbers, and then quizzes you on them 30 pages later to test your longer-term memory.

The book leads the prospective astronaut candidate (that's you!) through the hard and soft skills required to make it as an astronaut, the various stages of the application and selection process, the job interview, the rigorous physical and psychological training regime, how to prepare for the journey to space, what it's like to work in microgravity and finally takes a look at the future of human spaceflight – to Mars and beyond. Written in a light-hearted and humorous way and including interesting photo sections, The Astronaut Selection Test Book is a fun read even if you would never dream of applying. But, if you have always secretly wondered if you have what it takes, and if you happen to be reading this review around the time of ESA's recent call for applications, there is no better time to find out. Maybe, just maybe, one day you'll be reading a future issue of the DLRmagazine from your office out among the stars.

Joshua Tapley



CHALLENGING OUR VIEW OF THE WORLD

The subject is both appealing and perilous – anyone wanting to capture the history of maps and globes and their creators in one book faces a dilemma. The appeal of bringing history to light is countered by the agony of choice: Where to begin, where to end? Which maps to choose – the historically significant ones or the most beautiful ones? What distinguishes a map from a picture? Even more difficult is the answer to the question: Whose view of the world is depicted and to whom is it directed?

The journalist and author Thomas Reinertsen Berg was aware of the difficulty of his endeavour and the title **Theatre of the World: The Maps that Made History**, printed in elegant gold lettering, hints at questions yet to be answered. Using the 49 maps in this 340-page volume (including text and illustrations), the author expertly describes the circumstances behind their creation and explains the role that science, art, technology and ambitions have played in allowing for their various interpretations. Surprisingly, his preface on the history of maps is preceded by an image of Earth acquired from Apollo 8, while the concluding chapter on the digital world, including satellite maps, shows how our view of the world is changing.

As for the elusive difference between maps and pictures, Berg found a definition: In their definitive work 'The History of Carthography' (1987), Harley and Woodward describe maps as 'graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world.' The 'human world', however, describes their surroundings in the broadest sense, all the way into space and beyond. However, this too is a matter of interpretation.

Cordula Tegen

RECOMMENDED LINKS

NIGHT (AND DAY) AT THE MUSEUM
naturalhistory.si.edu/visit/virtual-tour
Being in quarantine can have many complex issues and complications beyond having enough food and supplies for days on end. It also probably means you could be in for some boredom, or not! Why not visit a museum from the comfort of your own home? With its virtual tour, the Smithsonian National Museum of Natural History allows you to take self-guided, room-by-room tours of select exhibits and areas within the museum from your desktop or mobile device. You won't just be able to delve into the collections, you'll be able to do it whenever and wherever you like!

SAVE YOURSELF
Among Us
(free of charge in Playstore/Appstore)
In this mini-game, the players are crammed into a spaceship as part of a crew in which there are some impostors. While the innocent passengers try to complete small tasks as quickly as possible, the goal of the so-called impostors is sabotage, if necessary by killing individual crew members. After each discovery of a corpse, everyone discusses who the culprit could be and should thus be thrown off the ship. The cat-and-mouse game has a huge fan base.

GAZING AT THE UNIVERSE
spacetelescopelive.org
The Hubble Space Telescope is without a doubt one of the most famous space telescopes to date. It has given us amazing views of the sky and has revolutionised our understanding of the Universe. The space telescope has made more than 1.4 million observations in its over 30 years of operation, and will continue to do so for years to come. In fact, it is observing as you read, but what exactly? Here you will be able to see what exactly Hubble is looking at right now and get additional information on the research project.

APPLY, APPLY, APPLY!
DLR.de/jobs/en
Have you recently finished your studies? Are you looking for a change of career? At DLR, we are always looking for bright minds – even during the current exceptional circumstances. We are happy to receive speculative applications for PhD positions, course papers, final theses, internships and student jobs. Permanent positions are always posted on our career site, so we would recommend going there to search for vacancies that match your qualifications.

CALLING ALL FUTURE ASTRONAUTS!
jobs.esa.int
For the first time in over a decade, the European Space Agency (ESA) is looking for astronauts – and women in particular are encouraged to apply. Applications can be submitted until 28 May 2021. These will be followed by a six-stage selection process that is expected to be completed in October 2022.

Cover stories

A blank page can be frightening, but also inspiring. In the same way, the idea of pursuing an existing vision can be motivating. DLR researchers fill such blank pages with their ideas when they develop new concepts for the aircraft cabin and want to use the aircraft interior in a completely different way than before. The topic of digitalisation also plays an important role. DLR researchers have long been working on the question of where we still need experiments and what we can do faster and more economically on the computer. In addition, more than 25 DLR institutes and facilities are working on shaping the current image of aviation in the direction of low-emission and quiet flight. This includes research into climate-optimised flight routes, quieter engines, sustainable fuels, but also advising policy makers and local authorities.

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