METROPOLITAN TRANSFORMER
THE URBAN MODULAR VEHICLE

More topics:
- GO WITH THE FLOE
- NIGHT FLIGHT AT THE END OF THE WORLD
DLR IN THE MEDIA

This is DLRmagazine 163 – the fourth one published in 2019. With each issue, we gain new subscribers. Whereas 10 years ago there were just under 6000 readers for the German-only edition, approxi-
mately 14,000 readers receive the DLRmagazine – in German or
English – in their mailbox every three months. Particularly in
Germany, the media response to DLR topics is extensive – especially in comparison with the overall national scientific research publication landscape. In the second quarter of 2019 alone, 4127 articles
appeared in the press, or on radio or television, and they had a reach
of 1.14 billion recipients.

The DLR Raumfahrt Show (DLR Space Show) attracted particular
attention, as did our education and outreach programme. The
establishment of seven new DLR institutes was also well received.

After these, channels were created on other platforms. Today, DLR
has the most widely viewed channels in German scientific research.

The DLR accounts on Twitter, YouTube, Instagram, Facebook, Vimeo and Flickr have a total of 500,000 followers – and the number is rising.

Examples from DLR can be found in this issue. We explore
processes in the atmosphere. We’re developing power plant technologies that deliver heat and power reliably while using
renewable energy sources. We’re exploring improved vehicle
collective buying. So let’s try another approach to the word sustainability – forward-thinking, compassionate, considerate. Let us look at long-term effects, rather than short-term gains. Our actions will undoubtedly affect the lives of future generations, so the
question becomes – will what we create last? What impact are we having on the environment and our fellow human
beings? And of course, how can we ensure that the results of our work, however beneficial they appear today, do not
become a burden in the future?

Can it be saved? Perhaps, by taking into account what we
really mean when we use it.

Some words have a strange fate. They have a meaning that
implies something ‘good’ but they fade due to overuse. Sustainability is such a word. It has had an amazing career,
but now suffers from what we in Germany refer to as
‘Schlagerkrankheit’ – literally ‘popular song disease’. It has
been heard too frequently and everyone is tired of it. The
word no longer reaches our minds, let alone our emotions.

EDITORIAL

Dear reader,

A broader question is how we can do all this in a sustainable
way. For example, if we fly for research, we only do so as
often as necessary and with as many experiments on board as
possible. There is great potential in creating knowledge
together – both inside and outside DLR. For example, the
Alfred Wegener Institute for Polar and Marine Research has
organised a unique expedition where its Polarstern icebreaker
sailed into the Arctic ice for a year with teams of researchers
from 19 countries. DLR took the opportunity to install an
antenna and receiving system on board to analyse distur-
bances to GNSS signals and improve navigation accuracy in
polar regions.

Implementing such synergies, of course, requires an impetus,
an idea and often perseverance, as well as openness to
collaboration in the best sense of the word. There is a certainty
more that can be done here – both as individuals and in our
work together with partners. You can call this sustainability,
but you don’t have to...

Your Magazine editorial team

About DLR

DLR is the Federal Republic of Germany’s research centre for aeronautics and space. The organisation also
completes research in the areas of energy, transport, security and digitalisation. Such projects are often completed as part of national and international cooperative efforts. Acting on behalf of the federal government, the DLR Space Administration designs and
implements Germany’s space programme, together with national and international partners. DLR is also the umbrella organisation for two project management agencies that promote research.

DLR has approximately 8600 employees at 27 locations in Germany. It also has international offices in Brussels, Paris, Tokyo and Washington D.C.

Imprint

DLR Magazine – the magazine of the German Aerospace Center

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

Editorial staff: Nils Birnchmann (Legally responsible for editorial content), Cordula Tegen, Julia Heil, Eike Heinemann (Editorial management), Karin Ranero Celius (English-language editor, EJR-Quartz BV).

DLR Department of Public Affairs and Communications

Linder Höhe, D 51147 Köln
Phone +49 2203 601-2116
E-Mail info-DLR@dlr.de
Web DLR.de/EN
Twitter @DLR_de

Printing: AZ Druck und Datentechnik GmbH, 87437 Kempten
Design: B+D Agenturgruppe GmbH, Kitschburger Straße 1, 50935 Köln, www.bplusd.de

ISSN 2190-0108
Online: DLR.de/dlr-magazine

To order: DLR.de/magazine-sub

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

All images are property of DLR and published under a CC-BY 3.0 unported licence unless otherwise stated.
The concept of ‘sustainability’ has become omnipresent – almost to the point of overuse. With this in mind, we should make it our mission to give every aspect the necessary attention, to ensure that hasty, superficial decisions do not lead to aimless action simply for the sake of doing something.

What does this mean? All of these factors interact in a highly complex way. In order for us to be able to focus on the essentials, we follow a twin-track strategy in many of our endeavours – ‘research for sustainability’ and ‘sustainable research and work’. For example, video conferencing systems is intended to reduce business travel. This will help to reduce carbon dioxide emissions in line with the two strategies mentioned above. The same applies to our ORIZON project. Hydrogen is produced using wind energy; this ‘green’ hydrogen serves as an alternative fuel for rocket engines and can also be used to produce electricity and heat for the Lampoldshausen site by means of combined heat and power generation.

The energy transition also poses a challenge to Information Technology. With the help of supercomputers, colossal amounts of data can be used to create detailed, informative analyses of energy systems.

**HOW WILL WE GET AROUND IN 2030?**

The ‘Neue automobilist’ (New automobility) study reveals how automated and networked vehicles can be usefully integrated into a user-friendly, efficient and sustainable mobility system in future. Mobility hubs, car sharing and self-parking vehicles can save space and free it up for housing and living. Flexible, time- and space-dependent prices for the use of roads and public transport (mobility pricing) will ensure more evenly distributed usage, which can prevent traffic gridlock and make driving bans unnecessary. Automated trains will be able to operate on currently decommissioned routes. Vehicles will be able to warn each other in dangerous situations. Thanks to clear mutual signalling, today’s day-to-day traffic chaos can be replaced by cooperative mixed traffic, in which road users are able to interact with and pay heed to one another to better effect.

A total of 12 ‘visions of the future’ show how automated, networked traffic could use natural resources, space, vehicles and infrastructure more effectively, thus taking the pressure off cities and local authorities. The study was presented by the German National Academy of Science and Engineering (acatech), and is led by Kanten Lemmer, a member of acatech and the DLR Executive Board Member for Energy and Transport. Science, public transport companies, town councils, the car industry and mobility service providers all contributed towards devising this concept for the transport of the future.
UP AND AWAY!

Otto Lilienthal has long been regarded as humankind’s very first aviator, but actual proof that his designs were airworthy did not exist until now. The DLR scientist Markus Raffel has now demonstrated the flying capabilities of an authentic replica of Lilienthal’s glider. Raffel built upon the Lilienthal Museum in Anklam, was handed over to the museum on permanent loan.

The discovery of the first exoplanet almost 25 years ago changed our perception of the origin and evolution of the Universe and challenged the uniqueness of our own Solar System. This year’s Nobel Prize in Physics 2019 was awarded with one half to James Peebles for his work on structure formation in the early Universe, and the other half to the two Geneva-based astronomers Michel Mayor and Didier Queloz, for their discovery of the first exoplanet orbiting a Sun-like star. In 2009, scientists from DLR, working alongside Mayor and Queloz, used the Corot space telescope to discover the CoRoT-7b exoplanet – the first Earth-like planet outside our Solar System. Today, scientists from DLR and other organisations are using new techniques and instruments on ESA missions such as CHEOPS and PLATO to set their sights even higher – the hunt for a second Earth.

SENSORS PREVENT AIRBORNE COLLISIONS

Modern sensors can process information from their surroundings in the same way as a pilot’s eyes. This was confirmed by the companies Diehl and HENSOLDT together with DLR in a three-week campaign at Braunschweig research airport. The team equipped DLR’s Do 228 research aircraft with a system of radar and electro-optical sensors for this purpose. During the test, another research aircraft conducted extensive manoeuvres from different directions and heights. The sensors on the Do 228 detected the other aircraft even from a considerable distance, followed its course and provided the pilot with timely warning of a potential collision course. This ‘senseandavoid’ sensor technology is designed to prevent collisions and ensure air traffic safety. It is particularly important for the certification and operation of unmanned aircraft.

AERIAL RECONNAISSANCE PROVIDES SUPPORT IN DISASTER SITUATIONS

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. These can be flown over areas that are difficult to access by land. The flight and mission planning for the aircraft was carried out at the UAS ground control station for unmanned aerial systems (UAS), which was set up by the DLR Institute of Flight Guidance in Braunschweig.

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. This enables aid operations to be planned in a targeted way. The use of unmanned aerial systems (UAS) has proven particularly useful, as these can be flown over areas that are difficult to access by land. The EU project Driving Innovation in Crisis Management for European Resilience (DRIVER+) helps those involved in disaster management to find the best ways of coping with disasters. The DLR Remote Sensing Technology Institute supported the project, including the contribution of a special IK camera system. Using this camera system, DLR’s Do 228 research aircraft can capture an area of 80 square kilometres in approximately 10 minutes, create geo-referenced aerial images, and quickly transmit the results to the ground control station via a datalink connection.

SENSORS PREVENT AIRBORNE COLLISIONS

Modern sensors can process information from their surroundings in the same way as a pilot’s eyes. This was confirmed by the companies Diehl and HENSOLDT together with DLR in a three-week campaign at Braunschweig research airport. The team equipped DLR’s Do 228 research aircraft with a system of radar and electro-optical sensors for this purpose. During the test, another research aircraft conducted extensive manoeuvres from different directions and heights. The sensors on the Do 228 detected the other aircraft even from a considerable distance, followed its course and provided the pilot with timely warning of a potential collision course. This ‘senseandavoid’ sensor technology is designed to prevent collisions and ensure air traffic safety. It is particularly important for the certification and operation of unmanned aircraft.

AERIAL RECONNAISSANCE PROVIDES SUPPORT IN DISASTER SITUATIONS

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. These can be flown over areas that are difficult to access by land. The flight and mission planning for the aircraft was carried out at the UAS ground control station for unmanned aerial systems (UAS), which was set up by the DLR Institute of Flight Guidance in Braunschweig.

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. This enables aid operations to be planned in a targeted way. The use of unmanned aerial systems (UAS) has proven particularly useful, as these can be flown over areas that are difficult to access by land. The EU project Driving Innovation in Crisis Management for European Resilience (DRIVER+) helps those involved in disaster management to find the best ways of coping with disasters. The DLR Remote Sensing Technology Institute supported the project, including the contribution of a special IK camera system. Using this camera system, DLR’s Do 228 research aircraft can capture an area of 80 square kilometres in approximately 10 minutes, create geo-referenced aerial images, and quickly transmit the results to the ground control station via a datalink connection.

SENSORS PREVENT AIRBORNE COLLISIONS

Modern sensors can process information from their surroundings in the same way as a pilot’s eyes. This was confirmed by the companies Diehl and HENSOLDT together with DLR in a three-week campaign at Braunschweig research airport. The team equipped DLR’s Do 228 research aircraft with a system of radar and electro-optical sensors for this purpose. During the test, another research aircraft conducted extensive manoeuvres from different directions and heights. The sensors on the Do 228 detected the other aircraft even from a considerable distance, followed its course and provided the pilot with timely warning of a potential collision course. This ‘senseandavoid’ sensor technology is designed to prevent collisions and ensure air traffic safety. It is particularly important for the certification and operation of unmanned aircraft.

AERIAL RECONNAISSANCE PROVIDES SUPPORT IN DISASTER SITUATIONS

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. These can be flown over areas that are difficult to access by land. The flight and mission planning for the aircraft was carried out at the UAS ground control station for unmanned aerial systems (UAS), which was set up by the DLR Institute of Flight Guidance in Braunschweig.

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. This enables aid operations to be planned in a targeted way. The use of unmanned aerial systems (UAS) has proven particularly useful, as these can be flown over areas that are difficult to access by land. The EU project Driving Innovation in Crisis Management for European Resilience (DRIVER+) helps those involved in disaster management to find the best ways of coping with disasters. The DLR Remote Sensing Technology Institute supported the project, including the contribution of a special IK camera system. Using this camera system, DLR’s Do 228 research aircraft can capture an area of 80 square kilometres in approximately 10 minutes, create geo-referenced aerial images, and quickly transmit the results to the ground control station via a datalink connection.

SENSORS PREVENT AIRBORNE COLLISIONS

Modern sensors can process information from their surroundings in the same way as a pilot’s eyes. This was confirmed by the companies Diehl and HENSOLDT together with DLR in a three-week campaign at Braunschweig research airport. The team equipped DLR’s Do 228 research aircraft with a system of radar and electro-optical sensors for this purpose. During the test, another research aircraft conducted extensive manoeuvres from different directions and heights. The sensors on the Do 228 detected the other aircraft even from a considerable distance, followed its course and provided the pilot with timely warning of a potential collision course. This ‘senseandavoid’ sensor technology is designed to prevent collisions and ensure air traffic safety. It is particularly important for the certification and operation of unmanned aircraft.

AERIAL RECONNAISSANCE PROVIDES SUPPORT IN DISASTER SITUATIONS

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. These can be flown over areas that are difficult to access by land. The flight and mission planning for the aircraft was carried out at the UAS ground control station for unmanned aerial systems (UAS), which was set up by the DLR Institute of Flight Guidance in Braunschweig.

In the event of earthquakes or other disasters, real-time aerial photography helps to assess the situation on the ground quickly and accurately. This enables aid operations to be planned in a targeted way. The use of unmanned aerial systems (UAS) has proven particularly useful, as these can be flown over areas that are difficult to access by land. The EU project Driving Innovation in Crisis Management for European Resilience (DRIVER+) helps those involved in disaster management to find the best ways of coping with disasters. The DLR Remote Sensing Technology Institute supported the project, including the contribution of a special IK camera system. Using this camera system, DLR’s Do 228 research aircraft can capture an area of 80 square kilometres in approximately 10 minutes, create geo-referenced aerial images, and quickly transmit the results to the ground control station via a datalink connection.
Power and heat at the touch of a button – clean, reliable and affordable. That is the promise of the energy storage systems that will provide the foundations for tomorrow’s power and transport system. These will be primarily based on electricity from renewable, yet fluctuating sources. Developing reliable storage systems that can compensate for these variations is thus regarded as a key technology for a successful energy and mobility transition. At the same time, the development of the required energy storage concepts is one of the central technological challenges faced by research and industry.

To this end, DLR has initiated the GigaStore project, in which an interdisciplinary team of scientists from 11 DLR institutes are working together to develop and test high-performance, cost-effective energy storage systems.

DLR is exploring a range of possibilities. “There is no single energy storage method, no one technology, that will solve all problems. We need solutions specifically tailored to the respective application,” explains André Thess, Director of the DLR Institute of Engineering Thermodynamics and GigaStore Project Coordinator. The performance requirements for a megawatt-hour system for mobile applications are extremely different to those for a gigawatt-hour, stationary storage system designed to supply a large city with power during the night or a period without sufficient sunlight. “Our aim with the GigaStore project is to adopt a whole-system approach to energy storage research,” says Thess. “We examine both the technological and the economic aspects – facilities and the evaluation of their cost-effectiveness by our systems analysts. DLR researchers in the fields of aeronautics, space, energy and transport are all contributing their expertise to the project. DLR is uniquely equipped to explore this topic with such breadth and depth,” Thess emphasises.

Eleven DLR institutes are working on energy storage systems for the power and mobility sectors within the interdisciplinary GigaStore project

By Denise Nüssle

High storage density batteries for Earth and space

Whether for electric mobility on road and rail, as a component in electrically powered aircraft and for on-board power supply, or as an energy supplier for satellites in space, battery systems should be as powerful, durable and inexpensive as possible. In the GigaStore project, DLR is pooling its existing expertise in battery technologies to advance new concepts with high storage densities to a stage where they are ready for practical implementation and thorough testing in demanding fields of application. The researchers are particularly interested in the use of metal-sulphur batteries. The main advantage of this type of battery is its high energy density – potentially two to three times greater than that of the currently widely used lithium-ion system. Sulphur is also readily available and inexpensive, meaning that such batteries could provide the same energy content while being lighter, more compact and less expensive to produce than those in use today. First, however, a better understanding of the electrochemical processes that take place inside these new types of sulphur-based batteries is required. Only then will it be possible to develop safe and cycle-resistant – that is, long-lasting – batteries of this type for ground and aerospace applications.

Space applications are particularly demanding of their technical components. Excellent performance and reliability are essential, as there is often no opportunity to fix problems once a mission is in progress. As such, batteries for satellite missions must meet the highest standards of safety and reliability. Satellites require large quantities of energy to power their on-board computers, control and communications systems, sensors, cameras and other scientific equipment. A satellite’s power supply system has a major influence on its design, mass and cost. To ensure that batteries can withstand radiation and the vacuum of space, they are tested extensively and at great cost over the course of several years before they are used on a mission. Within GigaStore, DLR researchers are developing battery systems tailored for small satellites, qualifying them for use in space, and planning to test a prototype on a DLR satellite mission. In doing so, they are looking to reduce the costs of the battery-testing phase and allow for less expensive and faster satellite deployment. For this, they are also investigating supercapacitors – special energy storage systems, and designing computer simulations that will enable more rapid development and testing of new storage technologies.

THERMAL STORAGE POWER PLANT FOR CONTROLLABLE ELECTRICITY SUPPLY USING RENEWABLE ENERGY SOURCES

DLR CROSS-SECTORAL PROJECTS

- Future Fuels (DLRmagazine 158, July 2018)
- Factory of the Future (DLRmagazine 159, November 2018)
- Big Data Platform (DLRmagazine 160, March 2019)
- Simulation-Based Certification (DLRmagazine 161, July 2019)
- Condition Monitoring for Safety Relevant Structures (DLRmagazine 162, October 2019)
- GigaStore (DLRmagazine 163, December 2019)
- Cybersecurity for autonomous and networked systems
- Global Connectivity
- Transport 5.0
- Digital Atlas

systems that can provide large quantities of electrical energy over a very short period of time. These could be particularly useful to deal with power-demand peaks caused by attitude control systems during spacecraft manoeuvring, for example.
Carnot batteries and thermal storage power plants – taking energy conversion further

Storing energy on the scale of gigawatt-hours over several days or weeks – to bridge a period of reduced solar power production, for example – stretches conventional battery systems to their limits. To address this need, energy experts at DLR are hoping to make use of Carnot batteries. Named after French physicist and engineer Nicolas Carnot – founder of the study of thermodynamics in the early 19th century – these power-to-heat-to-power storage systems convert electricity from renewable sources into heat. This heat can be stored until energy is needed again and then converted back into electricity. In the Gigastore project, DLR researchers want to use their initial laboratory-scale demonstration units to show that Carnot batteries are an effective solution for flexible energy storage with minimal losses.

Carnot batteries in the form of thermal storage plants have the potential to be a key element of the energy transition and the structural change that will arise from phasing out fossil fuels. In thermal storage power plants, electricity is converted into thermal energy using high-temperature heat pumps and then stored in molten salt, liquid metals, rocks or ceramics. As in a conventional power plant, this heat can then be used to produce steam, which drives a turbine and generates electricity. At the same time, the stored high-temperature heat can be used for industrial processes or be converted into cold via a heat exchanger to, for example, cool data centres.

DLR is conducting research into concepts, operating procedures and storage materials for making the conversion of electricity to heat and back again as efficient as possible. The key challenge is minimising the loss of heat during the transfer to the storage medium. To address this, the recently founded DLR Institute of Low-Carbon Industrial Processes is testing all kinds of batteries in Stuttgart. Here, batteries of all kinds are tested to view of the climate chamber at the DLR Institute of Engineering Thermodynamics. His research focuses on thermal energy storage and electromagnetic process and high-temperature measurement technology.

Energy storage simulation – a task well modelled is a task half completed

As in all areas of innovation, computer simulations and virtual design play a major role in making experimental work more targeted and hence enabling a faster and more efficient development process. Devising energy storage simulations is thus another focus of the Gigastore project. Energy researchers are gaining insights from their colleagues in aeronautics, where simulations are already being used successfully in the development of new technologies. Using computer-based modelling, DLR researchers are, for example, investigating the processes within a battery cell down to the nanoscale level – in other words, studying the most elementary processes at play inside a battery. Simulations also play a major role in the field of energy systems analysis. Here, DLR researchers use them to identify and evaluate the economic, environmental and societal impacts of different technologies, explore how new storage concepts can best be integrated into the overall energy system, and open up new areas of application for energy storage.

Devising energy storage simulations is thus another focus of the Gigastore project. Energy researchers are gaining insights from their colleagues in aeronautics, where simulations are already being used successfully in the development of new technologies. Using computer-based modelling, DLR researchers are, for example, investigating the processes within a battery cell down to the nanoscale level – in other words, studying the most elementary processes at play inside a battery. Simulations also play a major role in the field of energy systems analysis. Here, DLR researchers use them to identify and evaluate the economic, environmental and societal impacts of different technologies, explore how new storage concepts can best be integrated into the overall energy system, and open up new areas of application for energy storage.

Energy researchers are gaining insights from their colleagues in aeronautics, where simulations are already being used successfully in the development of new technologies. Using computer-based modelling, DLR researchers are, for example, investigating the processes within a battery cell down to the nanoscale level – in other words, studying the most elementary processes at play inside a battery. Simulations also play a major role in the field of energy systems analysis. Here, DLR researchers use them to identify and evaluate the economic, environmental and societal impacts of different technologies, explore how new storage concepts can best be integrated into the overall energy system, and open up new areas of application for energy storage.

“Three questions for Gigastore project coordinator André Thess”

What is the economic potential of energy storage technology?

1. In the medium-term, storage technologies have the potential to create high-quality jobs and further strengthen Germany as a business location in the field of energy technology. A lot is currently happening in the field of battery technologies worldwide – both in industry and research – primarily in the context of electric vehicles. It is not possible to predict exactly when stationary storage systems will make their big breakthrough. The Google spin-off MALTA is currently working on a project involving Carnot batteries, and MAN Energy Solutions is focusing on thermal storage in connection with carbon dioxide cycle processes. Whether and how quickly an energy storage industry develops depends to a large extent on political and economic conditions, particularly future price developments for coal, oil and gas as well as the taxation of carbon dioxide emissions.

Will there be a mass market for energy storage systems in the future?

1. I believe that the age of electricity can only begin when adequate energy storage facilities become available. In addition to electrifying the energy supply and mobility sectors as comprehensively as possible, other paths can be taken. Synthetic fuels, which are produced from or with the help of renewable resources, are another option. Here too, DLR has extensive expertise and is investigating the development and application of regenerative fuels in another interdisciplinary project, Future Fuels.

This interview was conducted by Denise Nüssle.

About the cross-sectoral Gigastore project

Participating institutes:
- Institute of Propulsion Technology
- Institute of Flight Systems
- Institute of Optical Sensor Systems
- Institute of Space Systems
- Institute of Software Methods for Product Virtualization
- Institute of Solar Research
- Institute of System Dynamics and Control
- Institute of Engineering Thermodynamics
- Institute of Networked Energy Systems
- Institute of Materials Research
- Institute of Composite Structures and Adaptive Systems

Duration: four years (2018–2021)
Funding volume: 13 million euro

ANDRÉ TESS

Heads the DLR Institute of Engineering Thermodynamics and is a Professor of Energy Storage at the University of Stuttgart. His research focuses on thermal energy storage and electromagnetic process and high-temperature measurement technology.
ON THE TRAIL OF THE WIND

DLR scientists take to the skies over Iceland for the Aeolus mission

By Manuela Braun

Icelanders are said to have more words for snow than even the Inuit, and likely many more for rain and wind. A team of DLR atmospheric scientists and research pilots spent three weeks in Iceland with the DLR Falcon 20E research aircraft to measure wind speeds. Their campaign took place at the same time and, to the greatest extent possible, followed the same route as the Aeolus satellite, which has been orbiting Earth with its on-board Atmospheric Laser Doppler Instrument (Aladin) since 22 August 2018. During their stay, the team also became well acquainted with the many different types of rain and wind – horizontal rain, dreadful drizzle, and the clammy cold rising from the wet floor in the aircraft hangar at Keflavik Airport. All of these were usually accompanied by dense cloud cover over the volcanic landscape. Alternating high and low pressure areas create variable wind speeds. The jet stream – a band of constantly shifting strong winds – often flows nearby. These are ideal conditions for the Aeolus Validation Through Airborne Lidars in Iceland (AVATARI) campaign. It compares the data acquired by the first satellite-borne wind lidar with measurements from an aircraft to validate the wind profiles acquired from space and improve the retrieval algorithms.

The situation is complicated. Nobody can anticipate how fast the low-pressure system will advance in the next few days or whether it might even act unpredictably. “If conditions here develop more quickly, the situation will change completely,” says Andreas Schäfler of the DLR Institute of Atmospheric Physics. Oliver Reitebuch and Christian Lemmerz, who also work at the Institute, carefully study maps showing wind directions and speeds, as well as cloud cover for the next few days. The trio have converted the hostel’s lounge into a conference room, in which they are planning the Falcon’s next measurement flights. The room – with its cozy and somewhat worn armchairs, a coffee table, a floor lamp and a small bookshelf in the corner – is the meeting point for everyone at the end of the day.

Located 40 kilometres from Iceland’s capital city of Reykjavik, the hostel is usually occupied by holidaymakers who either have a very early flight home from Keflavik airport or who arrived in the country late at night. In the past, US military personnel lived and worked here when it was part of the former NATO base, Ásbrú. Nowadays, the area is accessible to the public and some of the residential buildings have been transformed into simple, practical hotels with rooms looking out over the airport’s perimeter fence. For the researchers, pilots and technicians of the Aeolus team, this is ideal as it takes just a few minutes by car to reach the hangar where the Falcon is parked. The hostel has therefore become the ‘base camp’ for DLR’s three-week measurement campaign.

Under the track of the satellite

The first week went so well that the campaign team could hardly believe it. Already during the transfer flight from Oberpfaffenhofen, near Munich, to Iceland on 9 September 2019, the scientists switched on the instrument’s on board Falcon and followed the ground track of the Aeolus satellite north of Scotland. The ‘A2D’ lidar instrument has the same

AEOLUS

The Aeolus mission owes its name to the Greek god of the wind: Aeolus ruled over the winds of Boreas, Eurus, Zephyrus and Notus on behalf of Zeus, the most powerful god on Mount Olympus. In Homer’s Odyssey, he let favourable winds blow for King Odysseus for his journey by sea and gave him a bag containing the unfavourable winds. When the ship’s crew unwittingly opened the bag shortly before arriving at their home port, the winds escaped and drove them back to their point of departure.
system architecture and receiving optics as Aladin on Aeolus, and was used alongside the ‘two-micron wind lidar’, a well-proven system that provides more accurate wind speed measurements. Thus, the first AWARE dataset was stored even before the team arrived in Iceland. Over the following days, the Falcon took off almost daily to measure the wind as synchronously as possible with the satellite. Wind speeds of up to 60 metres per second, mixed cloud coverage – and then a flight on 17 September through the jet stream’s strong winds. “A dream,” says Oliver Reitebuch, Scientific Lead for the Aeolus Data Innovation and Science Cluster (Aeolus-DISC) at DLR.

Hoping for ideal conditions

Now, in the second week of the AWARE campaign, the dream is crumbling a little. During the calibration flight over the Greenland ice, a safety mechanism on the wind lidar caused problems, and not all measurements could be carried out as planned. Troubleshooting will be conducted upon return to the hangar. At the same time, the weather around Iceland is becoming much more unstable. Twice a day, meteorologist Andreas Schäffler retrieves forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF).

An ideal measurement flight must meet certain conditions. The cloud coverage below the predicted satellite track should not be too high or too dense, as the laser pulses from space cannot penetrate dense cloud cover. “However, some clouds on the measurement path are also quite good for observing the reaction of the Aeolus instrument to them,” Schäffler adds. Since the satellite orbits the Earth from pole to pole and only takes measurements transverse to the flight direction, east-west winds are easiest to capture. High wind speeds that vary at different altitudes above the ground are particularly suitable to calculate detailed wind profiles. The jet stream with its strong winds is therefore particularly interesting for atmospheric researchers. “We want sophisticated scenarios that are challenging for the satellite wind measurements,” emphasizes Campaign Coordinator Christian Lemmerz. Falcon’s flight route may not extend south of Iceland into the North Atlantic flight corridor, in which a large proportion of air traffic from Europe to America takes place. If the Falcon comes too close to this area, Air Traffic Control will give a command via radio to turn back. When planning the measurement flights, the rest period between flights required for the crew as well as the pilots RolandWelser and Thomas van Marwick must also be taken into account.

Filling in the gaps in weather forecasting

Aeolus is a European Space Agency (ESA) satellite mission aimed at filling the gaps in medium-range weather forecasting. Such a mission has long been at the top of the wish list of the World Meteorological Organization (WMO), a part of the United Nations to which the German Weather Service also belongs. “We only have a few wind measurements in the upper layers of the atmosphere,” says Reitebuch, referring to localised measurements performed over land with balloons or radarsondes. But what happens worldwide in the various layers of the atmosphere has not been sufficiently measured. “We are lacking data for the southern hemisphere, the tropics and over the oceans.” The wind, however, is crucial for circulation in the atmosphere. Given that the data is sparse, weather forecasts for events such as tropical cyclones or for wind speeds in the jet stream – needed by aircraft operators for optimal route selection – are not very accurate, especially for more than three days ahead.

The first wind lidar workshop took place in the late 1980s, with the aim of determining the requirements for such a unique mission. The development of the Doppler lidar Aladin broke new ground. To reduce the risk and support the development, it was decided to build a prototype of the instrument for tests on board an aircraft. The first flight campaign finally was in 2009 with a demonstrator of the satellite instrument on board the Falcon. Now that the satellite is in operation, the airborne demonstrator collects comparative signals to validate the satellite data acquired from an altitude of 320 kilometres. Reitebuch has been working on the Aeolus mission for two decades – “Actually, most of my professional life”. DLR’s main task is to develop the algorithms and processors that convert the detector signals transmitted to Earth by the satellite into final products.
The decision is made in the hostel lounge: the conditions for a measurement flight look favourable on Sunday morning. A band of south-easterly winds is within range and the point at which the Falcon can turn onto the predicted satellite track seems to be in a region with higher wind speeds. Even though the satellite travels at an altitude of 320 kilometres and a speed of 7.5 kilometres per second, and the Falcon ‘only’ flies at 200 metres per second and an altitude of approximately 10 kilometres, the instruments have the same field of view. The DLR flight operations staff can now take over. The pilots receive the data needed for their flight planning, and their coordinator, Frank Probst, registers the flight and route with Air Traffic Control. The Falcon is due to take off at approximately 07:30 local time and the rendezvous with the satellite will take place at 06:28.

The first team is already in the hangar by 04:10. The instruments are sensitive and need to be switched on before the flight, to achieve the correct temperature. It was cold in the hangar during the night. Christian Lemmerz squeezes between instrument racks and equipment to reach the laser instrument’s control console. One more piece of equipment in the Falcon and there would be no room for the scientists. It took several days before the flight campaign to install and test everything for correct functioning and safety in Oberpfaffenhofen. Lemmerz knows the instruments inside out. Switches are flipped, the cooling for the laser is started, and computer programs are activated. Gradually, A2D and the two-micron lidar come to life. Technician Christoph Grad is responsible for ensuring that the Falcon is able to record the data needed for correct functioning and safety in Oberpfaffenhofen. Lemmerz took several days before the flight campaign to install and test everything in the Falcon and there would be no room for the scientists. It is due to take off at approximately 07:30 local time and the rendezvous with the satellite will take place at 06:28.

After landing at 10:30 it is clear that the decision to conduct the flight was the right one. On the satellite track, the unwanted high clouds were only present over the northern part of the route. Elsewhere, the instruments encountered some clouds in the lower levels of the atmosphere. The wind speed ranged from moderate to higher speeds of about 50 metres per second. A hard drive with the data is transferred from the Falcon into the hands of Stefan Rahm. He has constructed a mission ‘ground segment’ in his hostel room with which the fresh data can be processed and examined to gain a first impression. Each flight yields 200 gigabytes of raw data to be compared with that acquired by the satellite and for optimising the retrieval algorithms. “My colleagues like to fly the Falcon until it almost falls from the sky,” jokes Rahm and disappears to his computer with the data.

Successful results for AVATARI

“There are several reasons why we need such DLR campaigns,” explains Thornton Fehr from ESA. “Firstly, they help prepare the mission for launch. Next, they are also improving the mission by calibrating and validating the satellite data.” A possible follow-up mission can only be defined if the weak points, successes and requirements have been carefully analysed. In addition to DLR and the DISC consortium, only a select group of international lidar teams and weather services currently have access to the Aeolus data from space. The global wind profiles can only be incorporated into existing weather forecasting models when the quality of the data is guaranteed and its processing is optimal. It is anticipated that the data will be made available to the broader scientific community from the beginning of 2020.
The C.R.O.P. biofilter turns biological waste into fertiliser
An interview by Manuela Braun

It was not the first warning. On 25 July 2019, the European Commission once again requested Germany to comply with the 1991 Nitrates Directive of the Court of Justice of the European Union. In particular, fertilisation with manure and slurry contribute to excessive levels of nitrates in groundwater. As such, measures should be taken to significantly reduce the contamination of water by nitrates from agriculture. The Court denounced the fact that German regulations – for example with regard to the spreading of fertilisers – continue to be insufficient, and threatened to impose substantial fines. Of course, manure is a natural by-product of livestock farming. But storing it and using it in a timely manner as plant fertiliser is difficult. If too much fertiliser is applied, the nitrate content cannot be completely absorbed and utilised by the plants. The excess nitrate is then washed out into groundwater, lakes and rivers.

One method for converting agricultural animal waste products into a more easily dispensable solution is derived from space technology. Jens Hauslage of the DLR Institute of Aerospace Medicine has been developing and testing the Combined Regenerative Organic food Production (C.R.O.P.) biofilter since 2011. One example of this biofilter is currently travelling through space on board the Eu:CROPIS satellite. It could one day be used to produce a nutrient solution for plants during missions to the Moon or Mars by recycling astronauts’ urine, and has potential applications on Earth. In this interview, the DLR scientist explains how volcanic rock and microorganisms could also be used to reduce nitrate concentrations in soils and groundwater here on Earth.

A C.R.O.P. filter is currently on board the Eu:CROPIS satellite, orbiting Earth at an altitude of approximately 560 kilometres. How does the filter work and what are its potential applications in space travel? If human waste as fertiliser to, for example, grow tomatoes, is not possible on a space station or in an extraterrestrial habitat. Doing so would be far too unhygienic. If we were to use the microorganisms that actually do the work within Earth’s soil in these environments, then they would need a habitat. That is why we take solid but porous volcanic rocks and “trickle” water and urine over them in our C.R.O.P. biofilter. The small pores and cavities in this type of rock provide an ideal environment for the types of organisms that convert ammonia from urine or liquid manure into nitrates here on Earth. This community within the lava rocks thus takes on the function played by the soil in agricultural fields.

How can a biofilter that may eventually be used to turn human waste products into a nutrient solution help to reduce high nitrate levels on Earth? Our soils play an important role in converting liquid manure into fertiliser. The problem is that there is far too much manure for the number of plants actually using the fertiliser. Due to this surplus, we have to store it to avoid the risk of contaminating our drinking water. It goes without saying that no one wants to have a “lake of manure” on their doorstep, and storing and transporting it is not economical. But the C.R.O.P. filter is capable of using natural means – without the need for chemicals and high-energy inputs – to produce a detoxified fertiliser solution that is no longer foul smelling and is easy to store in a concentrated form. This new fertiliser can be used in a much more controlled way, without contaminating the soil or groundwater. In addition, the filter uses bacteria that can also break down substances such as drug residues, which pose a very serious problem during the treatment of drinking water.

How much liquid manure is produced in Germany? I estimate the amount to be approximately 250 million tonnes per year. In addition, another 30 to 60 million tonnes from the Netherlands and Denmark are transported to Germany, where they are spread.

Why is storing manure and spreading it on agricultural land in line with demand such a problem? Liquid manure is actually a hazardous substance. It contains high concentrations of ammonia, which can be a potent toxin for humans. In addition, ammonia plays a key role in the formation of particulate matter. As I said, millions of tonnes of manure are produced every year. It can be stored in open ponds or in closed silos – although nobody wants to finance them. The C.R.O.P. filter produces a biologically derived solution that takes up far less space and is also more stable when stored. Safety is a real problem in storing large quantities of liquid. Imagine if a lake of liquid manure were to leak. Hundreds of thousands of litres of liquid waste would immediately flow into the ground. This does not happen with a dry substance.

The interview was conducted by Manuela Braun, who is responsible for communications strategy at DLR’s Space Research and Technology division.
During the night of 24 to 25 December 2003, the European Space Agency’s (ESA) control centre reported that its first planetary mission – Mars Express – had successfully entered orbit around the Red Planet. On board was the High Resolution Stereo Camera (HRSC) developed by DLR. Originally intended to operate for just two Earth years, the mission has been repeatedly extended by ESA, most recently until the end of 2022. On 26 October 2019 this marathon runner among spacecraft – only NASA’s 2001 Mars Odyssey mission has been in orbit for longer – completed its 20,000th orbit around Mars. During the mission, HRSC has acquired terabytes of high-resolution image data in stereo and colour. While very useful for scientific purposes, the images are frequently also aesthetically pleasing. This image shows the Promethei Planum region near the South Pole. The carbon dioxide ice formed during winter gradually sublimates in the Martian summer, once again revealing the underlying landscape. Laci Crater, which can be seen in the upper right of the image, has a diameter of approximately 120 kilometres.
Algorithms detect cracks

The team in the Department of Metallic Structures and Hybrid Material Systems is assisted by artificial intelligence (AI) methods that allow them to develop precise material-characteristics and predictive models more quickly. Two examples are Digital Image Correlation (DIC) and Deep Learning. During post-processing of DIC data, a virtual image is overlaid on a component to reveal areas of higher and lower strains. Cracks will arise in the metal where the stresses are highest. Fatigue of materials is a normal phenomenon during the operational life of an aircraft. If the cracks become too large, the affected component has to be replaced during routine maintenance. AI algorithms used in the evaluation of the DIC data identify these cracks and can compute their local crack tip loadings. Once the software has detected such a crack, it is imaged by automated tracking microscopes to observe the local crack tip field. This technique is used to investigate the interaction of the mechanical loading conditions with the local microstructure of the materials. The experts can use this new technology to create new life-time models of materials.

In order to include the influence of the microstructure, the scientists need more than surface data generated by DIC. For this purpose, they use 3D computer tomography to create a virtual model of the internal structure of the material in which the individual constituents are clearly visible. Previously, DLR scientists had to analyse these highly detailed images manually—a time-consuming process. But the first generation of trained deep-learning algorithms is now taking on this work. The software determines and evaluates the composition of the material in a fraction of the time that it would take a human to complete the same task. Machine learning processes, particularly Convolutional Neural Networks (CNN), are now being used very successfully for pattern recognition and semantic image segmentation at the DLR Institute of Materials Research. These techniques help to evaluate large amounts of computed tomography data quickly and accurately, providing insights into areas such as the damage process within aircraft components to an extent that is not possible using conventional methods.

Tested to the max

The materials are tested using the biaxial testing facility at the Institute of Materials Research in Cologne. Specimens are subjected to non-constant loads in two directions using four hydraulic cylinders until they fail. This experiment makes it possible, for example, to reproduce the loads of a fuselage accumulated over a service life of several decades within just a few hours. “The system has been in operation for some time, but Al has opened up completely new possibilities for us,” says Breitbarth. In addition to Al, robotics will be used in combination to automate the entire testing sequence up to the evaluation of the results.

Frank Seidler is responsible for marketing and communications at the DLR Institute of Materials Research.

3D computed tomography reveals the internal structure of a cast aluminium-silicon alloy (grey). Such materials are used in the automotive industry—for pistons, for example. The Al system identifies the individual constituents of the alloy and assigns them different colours: silicon is blue, while what is known as the intermetallic phase (aluminium mixed with other metals such as copper or magnesium) is shown in red. Aluminium is transparent in this representation. This provides the researchers precise information about the composition of the material and how it will behave. When will it break? How strong is it? After a week of training, a neural network can supply this information within a few minutes. Without this technology, it would take researchers six months to one year to produce similar results with this level of detail.

PUSHING AEROSPACE MATERIALS TO THE LIMIT

Artificial intelligence detects cracks in aircraft fuselages

By Frank Seidler

Metallic materials are an integral part of the structure of modern aircraft. Their safety and efficiency depend on an expert understanding of how such materials behave during daily flight operations, where they are subject to the highest loads, and when parts need to be replaced.

DLR materials researchers are conducting extensive tests on aircraft materials—from entire components up to their microstructures. They subject these specimens to mechanical forces occurring during flight and observe how they perform using special camera systems. This provides them with a deeper insight into the behaviour of the materials and their limits. “We want to exploit the materials’ properties to their maximum. Knowing those limits enables us to determine when an aircraft needs maintenance and to estimate the overhaul intervals more accurately,” says Eric Breitbarth, who works in the Metallic Structures and Hybrid Material Systems Department at the Institute, and adds, “This saves time and money.” It also protects natural resources as it allows the use of heavy, durable metals only where they are really needed. This makes the aircraft lighter and reduces its fuel consumption while preserving its safety and ability to withstand loads caused by wind gusts or cabin pressurisation.
Antarctica is one of the most remote and least-explored regions on Earth. At first sight, what is happening there seems very distant, yet it has a great impact on the global climate and, therefore, on all of humankind. The behaviour of the global population, in turn, affects events in these distant polar regions. And although the ozone hole over Antarctica is now slowly shrinking again, the chemistry and physics of the atmosphere above Antarctica, and hence the processes relating to global warming at play there, will influence the global climate for decades to come. Only a few people – scientists, engineers, research pilots – travel deep into the southern sub-polar region to measure, explore and understand these interrelationships and processes. In 2019, a team from Germany joined them, on a mission with the High Altitude and Long Range (HALO) research aircraft.

Into the waves

In the event of a night flight, the crew arrives at the hangar in the early evening. Take-off is scheduled for 20:00, while the last twilight remains over the mountains. The cabin and flight deck offer room for 13 instruments, five scientists, two pilots and one on-board engineer, which means that each scientist has to work with several instruments simultaneously. In addition, various teams on the ground monitor the flight. After take-off this evening, HALO will first fly across the Chilean Andes to the Pacific Ocean. There, it will come into direct contact with mountain waves. This type of gravity wave is one of the subjects of the current research programme. Mountain waves are formed by the interaction of updraft and gravity in the atmosphere and...
are also referred to as lee waves, because they are generated on the sheltered (lee) side of mountains. “We notice that we are passing through the waves due to changes in airspeed,” explains DLR test pilot Marc Puskeiler. “When this happens, the autopilot gently oscillates back and forth between higher and lower thrust in order to maintain altitude and speed.”

Once over the open Pacific, HALO will make a 90-degree turn so that it is flying parallel to the Andes, until it is some 100 kilometres from Santiago de Chile. Then, the research aircraft can really show its capabilities, ascending to a maximum altitude of approximately 14 kilometres. During the nocturnal flight, only the Moon and stars can be seen from the flight deck windows, together with the laser that scans the skies above HALO for gravity waves up to just below the boundary of space, at an altitude of 100 kilometres.

ALIMA shines through the atmosphere

“HALO has an additional optical window at the top of the fuselage for the new Airborne Lidar for Middle Atmosphere research (ALIMA) experiment. The laser beam is directed upwards through this window and the instrument captures the backscattered return signals,” explains Bernd Kaifler of the DLR Institute of Atmospheric Physics. “To be more precise, we record periodic fluctuations in temperature, pressure and wind that extend up to 90 kilometres into the middle atmosphere – the stratosphere and mesosphere.” These are triggered when strong wind systems from the Pacific meet high mountains such as the Andes. In the tropopause region – the transition from the troposphere to the stratosphere – the research team on board is investigating the chemical and dynamic processes that influence the climate-relevant trace gases ozone and water vapour.

Following another 90-degree turn over the Pacific, HALO will embark on a course across the South American continent until it is 220 kilometres from Buenos Aires. Here the pilots will turn and fly a similar course back to the starting point. After approximately nine hours and a few cups of coffee on board, the crew will be back in remote Rio Grande.

The most important atmospheric conditions for the formation of the ozone hole over Antarctica are low temperatures and a reduced exchange with mid-latitude air masses. The latter is ensured by a stable atmospheric system – the Antarctic polar vortex. But this can be weakened by strong wave activity. Until now, this effect has not been sufficiently taken into consideration in climate and weather models. SOUTHTRAC is now providing the data needed to supplement existing climate models with this crucial piece of the puzzle.

Other flights conducted as part of the mission flew out over the Atlantic, above the Andes and across the Antarctic Ocean all the way to the Antarctic Peninsula, which HALO overflew for the first time. In September and November, the team collected a wealth of data on the climate and climate change in the southern subpolar region. After travelling to the southernmost tip of the world for a total of eight weeks, the researchers have returned to Germany satisfied and confident that they have taken a major step towards understanding past and future climate changes on the basis of the data collected. At home, extensive analysis of the data will begin, while HALO is prepared for future missions to Barbados, Brazil and Iceland.

WHAT ARE GRAVITY WAVES?

Gravity waves are waves in the atmosphere or ocean caused by gravity acting on a stable, layered medium (that is, by uplift in air or water). They should not be confused with gravitational waves, which are waves in space-time. Gravity waves occur if, for example, air masses encounter mountains, are lifted by the pressure of the wind and then descend again on the other side of the mountain. This vertical displacement of air masses generates waves that propagate vertically and horizontally through the atmosphere. The world’s strongest single source of atmospheric gravity waves is the southern Andes. In the region of the Antarctic peninsula and South America, the wind comes predominantly from the west, and the Andes – which, if run north to south – present an enormous obstacle; they thus form a powerful gravity wave generator. If there are high wind speeds at ground level in the stratosphere and mesosphere, these waves can spread high into the atmosphere, up to an altitude of 90 kilometres. This happens at the southern tip of South America when the polar night jet reaches the Andes during winter. This creates a perfect waveguide upwards through the atmosphere. The SOUTHTRAC mission is investigating the effect of gravity waves on the climate.
works at the Lidar Department of the DLR Institute of Atmospheric Physics and is responsible for all projects dealing with lidar-based exploration of the middle atmosphere. Over the past seven years, he has developed systems that have been deployed in the most remote regions of the world – from New Zealand to northern Scandinavia – and for the last two years in Tierra del Fuego. Last year, he and his team flew the world’s first balloon lidar for the middle atmosphere on a NASA balloon.

we were able to conduct temperature measurements at altitudes of up to 90 kilometres, despite turbulence and vibrations within the aircraft. During the next measurement campaign in two years time, we want to go a step further and measure wind profiles in the direction of the laser beam, high above the aircraft. Wind measurement is the hardest discipline when using lidar instruments. We have done pretty much everything we can to prepare ALIMA, all that remains is to improve the laser’s stability.

Space must be a bit tight inside HALO, with all the instruments. Who else is on board for this mission? How does it feel for the five of you to be responsible for so many measurement devices simultaneously, sometimes for 10 hours at a time?

On board HALO there are two pilots, a flight engineer and five scientists, who look after the 13 scientific experiments. One of the scientists is appointed as mission scientist, this is a special role. The mission scientist is in constant contact with the pilots and the other scientists for matters such as adapting flight routes, turns and changes in attitude to the scientific requirements during the flight. But cooperation is always a must. Preparing and dropping probes is always a joint effort. The task of operating the inlet valves for the trace gas measurement devices is generally assigned to whoever is within reach of them, regardless of which experiments are officially their responsibility. We receive support from scientists and technicians on the ground, some in Rio Grande itself and others back in Germany. We can communicate and get advice from people on the ground using a chat program connected via a satellite link. This comes in useful if a device is causing problems, the software crashes or simply if we see something interesting come up on the live instrument displays, which means that we might have to change the measurement device settings. The people who spend hours preparing and calibrating the instruments before every flight, and then switch them off under controlled conditions and service them afterwards, also play a vital role. It goes without saying that the crew on a 10-hour flight cannot manage everything on their own. Not only does this exceed the usual working hours, but nine to 10 hours of flying time is also physically and emotionally draining. The instruments require constant attention, which in most cases means checking a seemingly endless scroll of numbers, graphs and controls.

Nowadays, this is mainly done electronically, on a laptop screen. The instruments require constant attention, which in most cases means checking a seemingly endless scroll of numbers, graphs and controls. Regardless of which experiments are officially their responsibility. We receive support from scientists and technicians on the ground, some in Rio Grande itself and others back in Germany. We communicate and get advice from people on the ground using a chat program connected via a satellite link. This comes in useful if a device is causing problems, the software crashes or simply if we see something interesting come up on the live instrument displays, which means that we might have to change the measurement device settings. The people who spend hours preparing and calibrating the instruments before every flight, and then switch them off under controlled conditions.

The southern Atlantic, the Pacific, the Andes and Antarctica are all far from Europe. Why do you need to fly there in a research aircraft? Could you not just obtain the information you need from space, using satellites?

Dr Kaifler, in September 2019 you spent several weeks in Rio Grande, Argentina, at the southernmost tip of South America. What impressed you most during your time there?

Dr Kaifler explains the SOUTHTRAC mission in Argentina, where a team of scientists is investigating the impact of gravity waves on the climate and the transport of air masses in the atmosphere.
From the hangar generally begins five to seven hours beforehand, with the preparations for the experiments. A colleague comes to collect me at 17:00 and takes me to the hangar. At that point, the decision is made as to whether or not the flight will take place. At the hangar, the team makes sure that all the experiments have to be shut down as quickly as possible and, most importantly, at the same time, in a coordinated action. Once HALO has been rolled out of the hangar and the experiments have been powered up again, there is just one hour to get them into their flight configuration. All those who will not be flying exit the aircraft 15 minutes before take-off. We begin a ground test for the lidar and the green laser beam is visible over the aircraft for two minutes. All those who have gathered to wave off the aircraft pull out their camera to take photographs of HALO and the green beam. No sooner has the laser been turned off than we start taxiing. HALO takes off at exactly 20:00, heading into the dark towards the Andes. And we begin our measurements.

Approximately nine hours later, just before 05:00, we land back at the airport in Rio Grande. The ground team is already waiting for us at the hangar. They help us to shut down the experiments and secure the measurements. This takes about 45 minutes. There is a short debrief at about 06:00 and we finally make it back to the hotel at 07:30, just in time for breakfast. No one opts for the coffee, and shortly after we fall into bed, tired but happy. Once again, the measurement flight has been a success and tomorrow will be spent on the ground.

What will we learn about Earth’s changing climate from the wealth of data acquired by the SOUTHTRAC HALO mission? 1 We still know very little about the impact of climate change on the middle atmosphere. This is largely due to the fact that the current climate models do not incorporate gravity waves, and their effects are only taken into consideration in a very approximate way. In order for us to be able to better characterise the effects of gravity waves, we must first understand where the waves originate and how they propagate. One specific question, for instance, is whether a strong source is necessary for gravity waves to reach an altitude of 90 kilometres. Or do these waves become unstable along the way, breaking up and failing to reach high altitudes precisely because of their large initial amplitude? In that case, it would instead be the weak waves that could reach high altitudes under good propagation conditions.

Where would you like your next research destination to be, and why? 1 I would like to return here, to Rio Grande, and repeat the flights in the southern winter, perhaps in July. Shortly before our arrival in Rio Grande there was an occurrence of stratospheric warming, which contributed in part towards the collapse of the polar vortex and had a massive effect on the propagation conditions for gravity waves. This happens extremely rarely in the southern hemisphere; the last time was in 2002. So, on the one hand, the campaign was fortunate enough to be able to study the effects of stratospheric warming. On the other, however, it could also be seen as rather bad luck, as it meant that studying the undisturbed propagation of gravity waves was no longer possible. That is why I am keen to repeat the measurements, and South America is still the perfect place to do this.

The interview was conducted by Falk Dambrowsky

The aircraft technicians tow HALO out of the hangar two hours before take-off. This is a dramatic event for the experiments, as taking the aircraft outside means interrupting the power supply. This is problematic, as heated detectors cool down and vacuum pumps come to a standstill. To keep the interruption to a minimum, all of the experiments have to be shut down as quickly as possible and, most importantly, at the same time, in a coordinated action. Once HALO has been rolled out of the hangar and the experiments have been powered up again, there is just one hour to get them into their flight configuration. All those who will not be flying exit the aircraft 15 minutes before take-off. We begin a ground test for the lidar and the green laser beam is visible over the aircraft for two minutes. All those who have gathered to wave off the aircraft pull out their camera to take photographs of HALO and the green beam. No sooner has the laser been turned off than we start taxiing. HALO takes off at exactly 20:00, heading into the dark towards the Andes. And we begin our measurements.

Approximately nine hours later, just before 05:00, we land back at the airport in Rio Grande. The ground team is already waiting for us at the hangar. They help us to shut down the experiments and secure the measurements. This takes about 45 minutes. There is a short debrief at about 06:00 and we finally make it back to the hotel at 07:30, just in time for breakfast. No one opts for the coffee, and shortly after we fall into bed, tired but happy. Once again, the measurement flight has been a success and tomorrow will be spent on the ground.

What will we learn about Earth’s changing climate from the wealth of data acquired by the SOUTHTRAC HALO mission? 1 We still know very little about the impact of climate change on the middle atmosphere. This is largely due to the fact that the current climate models do not incorporate gravity waves, and their effects are only taken into consideration in a very approximate way. In order for us to be able to better characterise the effects of gravity waves, we must first understand where the waves originate and how they propagate. One specific question, for instance, is whether a strong source is necessary for gravity waves to reach an altitude of 90 kilometres. Or do these waves become unstable along the way, breaking up and failing to reach high altitudes precisely because of their large initial amplitude? In that case, it would instead be the weak waves that could reach high altitudes under good propagation conditions.

Where would you like your next research destination to be, and why? 1 I would like to return here, to Rio Grande, and repeat the flights in the southern winter, perhaps in July. Shortly before our arrival in Rio Grande there was an occurrence of stratospheric warming, which contributed in part towards the collapse of the polar vortex and had a massive effect on the propagation conditions for gravity waves. This happens extremely rarely in the southern hemisphere; the last time was in 2002. So, on the one hand, the campaign was fortunate enough to be able to study the effects of stratospheric warming. On the other, however, it could also be seen as rather bad luck, as it meant that studying the undisturbed propagation of gravity waves was no longer possible. That is why I am keen to repeat the measurements, and South America is still the perfect place to do this.

The interview was conducted by Falk Dambrowsky

Almost immediately, the ALIMA instrument is tested one last time and the green laser beam, which is directed upwards through a small window in the aircraft fuselage, is briefly visible.
The influence of the weather on the energy system has become a serious economic factor. The situation demands complex technological innovations, but also opens up new opportunities for industry and environmental conservation. Since 2009, the Bremen-based company swb AG has been focusing on integrating the power and heat sectors with the operation of a hybrid regulating power plant. This innovative power plant concept combines a large stationary battery system with a thermal storage system and an electric boiler. The advantage of this system is that the battery can compensate for fluctuations in the grid extremely quickly by absorbing and releasing energy (positive or negative frequency containment reserve). When the battery is fully charged, excess renewable energy, for example caused by strong winds from the North Sea, is converted into heat and can be fed into the district-heating network.

Compensating for fluctuations

Although the Bremen power plant is already in operation, the hybrid concept offers plenty of potential for optimisation. To this end, swb AG is working in cooperation with AEG Power Solutions and DLR in the ‘HyReK 2.0’ research project funded by the German Federal Ministry for Economic Affairs and Energy. The DLR scientists participating in this project are focusing on analysis, evaluation and optimisation of the processes involved in the Bremen plant. “The growing use of renewable energies is giving way to increasing fluctuations in the supply of power,” explains Theys Diekmann, HyReK Project Manager at the DLR Institute of Networked Energy Systems. “So far, these fluctuations have primarily been offset by fossil-fuel burning power plants. We would like to demonstrate ways in which this and other services can be provided by a flexible hybrid power plant in a decarbonised energy system.”

At the moment, Diekmann and his team are developing a simulation model based on real data from the plant to help optimise the power plant concept for future applications. The aim is to use a high-performance computer to conduct detailed analyses of the behaviour of the grid and to observe how the plant positively influences this. The model will also simulate the constituent devices of the power plant such as the inverter, which serves as the interface between the battery and the power grid. “We want to use this as a basis for developing technology in such a way that the activities of individual power plant components are not viewed separately, and are instead aligned towards the overall system behaviour,” says Diekmann. “This will enable us to optimise the efficiency and durability of the system and the individual components, thereby making it possible to derive an economically viable operator concept.”

Power plant technology put to the test

How valid the simulation will become clear as the project progresses through the transition into simulated practice. At this point, the simulation data will be implemented in a real laboratory equipped with the power plant technology together with the power plant operator. However, Diekmann adds that the simulation has scientific merit of its own. “This model can be used to simulate energy scenarios that we expect to occur in the future. From this, we can determine possible future commercial applications,” he explains. “In addition, the model enables us to identify potential further options for flexibility around the hybrid concept. We want to develop strategies to shape the future energy system without having to expand the grid.”

While Diekmann’s team is working on the technological aspects of the project, a second HyReK working group at the Institute is focusing on analysis and evaluation. What potential is there for implementing the hybrid concept in Germany? What do the lifecycle assessments look like? Which business models could emerge? “On the basis of such questions, we are analysing the hybrid concept and conducting a multi-criteria evaluation. At the end, we will be able to make specific recommendations for action,” says Henrik Wigger, leader of this part of the project. This roadmap is intended to provide recommendations about regulatory incentives and identify key players in the implementation of such hybrid concepts.

In order to assess the power plant’s contribution to climate protection, Wigger also takes a whole-system view at the plant as part of the lifecycle assessment. “We look at each of the installed components over their entire lifecycle – from cradle to grave as it were. In some cases, this goes all the way back to the extraction of the ore itself and examines the conditions under which a component was manufactured, as well as the emissions produced as a result.”

Keeping an eye on new developments

In addition to numerous other parameters, such as energy payback time (EPBT) or recycling concepts, the scientists take a range of scenarios into consideration as part of their assessments. These may relate, for example, to possible future developments in carbon dioxide pricing. Wigger is still unsure about whether the standard computer program designed to process the plant’s operational data will be able to incorporate these complex requirements. “We are still considering whether it would be easier to develop our own program.” Whatever the choice, the Bremen-based hybrid concept will have to directly compete with other technologies – from hydrogen production to the delivery of surplus power to cold storage facilities.

Insights into how close Bremen’s hybrid power plant will come to its ideal future condition with its current technology will be available at the end of the project in Autumn 2021. In the meantime, those setting out on a walk along the stormy North Sea coast will see why a more flexible energy system could provide the energy transition with the decisive tailwind that it needs.

Heinke Meinen is responsible for communications at the DLR Institute of Networked Energy Systems in Oldenburg.
A vast white expanse, the endless night of the Arctic winter, a distant outpost of humanity, cut off from civilisation – almost as remote as the International Space Station. On 20 September 2019, the Polarstern was waved off from Tromsø harbour in northern Norway. The German research icebreaker, which belongs to the Alfred Wegener Institute (AWI), embarked on its journey to the Arctic Ocean, where it would become frozen in the sea ice for one year. The largest Arctic research expedition of all time has been given the name ‘Multidisciplinary drifting Observatory for the Study of Arctic Climate’ – or MOSAiC.

The crew reached their destination in October. Shortly after, they identified a suitable ice floe for drifting and moored to it. As the Arctic winter set in and temperatures dropped, the sea ice thickened and the Polarstern froze fast. It has since been drifting across the Arctic Ocean, carried along by the forces of nature alone. This will be the first mission to conduct extensive and highly accurate measurements and experiments in the Arctic over four seasons. For more than two months, the Polarstern will be less than 200 kilometres from the geographic North Pole. MOSAiC will focus on climate and environmental research. The researchers are hoping to obtain fundamental data and insights into climate change. A better understanding of the physical and chemical interactions of ice, snow, atmosphere and ocean in the Arctic will enable the development of more accurate climate models. Over the course of the mission, the research vessel will travel approximately 2500 kilometres.

Exploring the epicentre of climate change

Teams of scientists from 19 countries and over 70 institutions are participating in the MOSAiC project, under the leadership of the AWI, the Helmholtz Centre for Polar and Marine Research. The researchers will carry out numerous experiments above, on, in and under the polar ice with the aim of cracking the ‘Arctic puzzle’. They want to find out how the atmosphere, sea ice, ocean, ecosystem and biogeochemical processes interact with one another. Like the pieces of a mosaic, when viewed together, the results of the different MOSAiC research projects should provide an accurate picture of the Arctic system as a whole.

The Arctic reacts much more strongly to climate change than regions at lower latitudes, and it has an enormous impact on the global climate. The atmosphere here is warming faster than anywhere else. The ‘eternal ice’ is becoming ever thinner as the years go by. The increasing reduction in the ice surface is constantly changing the face of the Arctic and its ecosystems. In August 2008, the Arctic’s Northeast and Northwest passages were both simultaneously free of ice for the very first time. What was once eternal is threatening to become temporary as time goes by.
An expedition of extremes

MOSAiC is a mammoth undertaking – both scientifically and logistically. Four icebreakers from China, Russia and Sweden will supply the Polarstern with fuel and provisions over the course of its mission. The crew will be rotated at regular intervals, with a total of 600 international experts working on site throughout the mission – from researchers, to the ship crew, and through to polar bear guards. Three research aircraft will require a landing strip of their own on the ice. A network of diverse research stations will be set up around the Polarstern, with the vessel as the base station. The various measuring stations will investigate the Arctic ecosystem as comprehensively as possible.

A single expedition day costs 200,000 euro, with the budget for the entire expedition amounting to 140 million euro. Some 50 percent is financed by Germany, mainly with funds from the Federal Ministry of Education and Research. The remaining amount is borne by international partners.
Satellite signals are particularly susceptible to interference at the poles. The DLR Institute of Communications and Navigation is investigating a robust positioning system.

Several teams of DLR experts support the MOSAiC mission. The German Remote Sensing Data Center (DFD) is providing sea ice maps for the Polarstern. DLR’s Maritime Safety and Security Lab in Bremen is developing new methods for differentiating between different types of ice using samples collected over the course of the mission. The DLR Institute of Communications and Navigation is conducting research into improved positioning in areas close to the poles. To this end, a team of researchers installed a receiving station for satellite navigation signals on board the icebreaker. For the first time, this mission will establish an extensive base for these signals close to a pole. As the facility is self-sufficient, it requires no on-board presence from the DLR team.

Why is DLR involved in the MOSAiC mission, an expedition focusing on polar climate research?

Broadly speaking, the MOSAiC expedition has the overarching goal of better understanding the Arctic system as a whole. In addition to measurements and experiments on the Arctic Ocean, the ice and the lower atmosphere, the lower ionosphere and its interactions also include phenomena in the upper layers of the atmosphere.

The solar wind exerts a particularly strong effect within the ionosphere in the regions around the North and South Poles, most famously manifested in the Aurora Borealis and Aurora Australis. These solar lights make the interaction between the Sun and Earth visible to the naked eye, but they can also interfere with satellite signals. When it comes to navigation signals, this can lead to incorrect positioning data. These errors can be considerable in polar regions. Looking ahead, within two to three years we will have tangible results and will have developed algorithms capable of coping with scintillations. But we are still a long way from the finished product.

What could go wrong on the long journey?

Our on-board technology consists of an external unit – the antenna on the tap deck – and the core system inside the Polarstern. The computing unit receives, processes and stores the incoming raw signals. The devices have to work self-sufficiently, as no one from our team will be on board.

The hardware is vulnerable, particularly the antenna and the cable in the exterior. They will be directly exposed to temperatures of up to minus 45 degrees Celsius, ice, salt and storms with high waves. The cable attached to the antenna could give in or fray during a storm. The hardware inside the vessel is relatively calm. The data being picked up by the receivers. Improving safety in polar regions is another aim of MOSAiC’s aims.

How are you measuring atmospheric interference?

This interference is a natural phenomenon known as scintillation, which takes place in the ionosphere. The effects are stronger in the polar regions, where the Earth’s magnetic field is weaker than at mid-latitudes. Here, the energetic particles of the solar wind can penetrate into the atmosphere more easily. Our devices do not measure these energy particles in the ionosphere itself, but rather the satellite signals. With our monitoring equipment, we can detect changes in the signals caused by scintillations. In the event of a disturbance in the ionosphere, the disturbometer records the raw signals from the Galileo, GPS and GLONASS systems until the scintillation is over. We need the data from the satellites to recognise patterns and develop more robust navigation receivers.

Before MOSAiC, the necessary data from polar regions were not yet available in sufficient quantities. We hope that the scintillations that occur during this year in the Arctic are enough to yield a wealth of data for analysis upon the return of the Polarstern. Maritime operations. In future, navigation receivers will be ‘smarter’ in this regard, or more resilient. They will be able to compensate for signal interference and display reliable and precise positions, even in polar regions.

How did DLR become involved with the Polarstern?

Plass’ work now covers a fascinating spectrum of research, project management, departmental management, execution of measuring campaigns and implementation of the technology transfer of the results into industry – at the interface of research, industry and government.

Why is it necessary? DLR can make a significant contribution towards developing, implementing and running robust systems that can be operated at an on-board voltage of 230 Volts, it did not see a need for DLR to become involved with the Polarstern. DLR’s Maritime Safety and Security Lab in Bremen is developing robust navigation receivers.

How did DLR become involved with the Polarstern?

... at the interface of research, industry, government and diplomacy. For instance, government representatives have been able to understand what we are doing, and why it is necessary. DLR can make a significant contribution towards climate research and environmental monitoring in this regard, by providing the expertise, tools and data required – not just for Germany, but worldwide.

The Arctic Council is all about diplomacy at an international level. It addresses cross-border cooperation. Given the geography of the Arctic, it is vitally important to think in a ‘pan-Arctic’ manner by working out comprehensive solutions across the sovereign territories of the neighbouring states. This is far from easy at times. Ensuring smooth operation across these interfaces is one of my tasks at DLR. I support these different areas and maintain contact with all parties. This allows for close and direct exchange, and ensures that every part of my work. Every interface has an aspect of its own, and its own requirements – not just for Germany, but worldwide.

How did it feel to install the technology in Tromsø and then disembark?

... the Polarstern happy yet somewhat exhausted. We worked intensively for several days. I came away from Tromsø having had a marvellous experience and took lots of wonderful memories home with me.

I envy the crew for this unique opportunity to be part of such an expedition, especially given that they will be conducting measurements and taking samples on site. That said, during that time they will be completely isolated in a highly inhospitable environment – almost like being on the International Space Station. Although in the Arctic you are much more likely to come face-to-face with a polar bear than you are with aliens during a spacewalk!
Sustainability at the DLR Project Management Agency

By Stefanie Huland, Corporate Communications, DLR Project Management Agency

Sustainability – this buzzword has been on everyone’s lips ever since the ‘Fridays for Future’ movement, led by the Swedish climate activist Greta Thunberg. Sustainable behaviour is now a goal to strive for. Sustainability – this buzzword has been on everyone’s lips ever since the ‘Fridays for Future’ movement, led by the Swedish climate activist Greta Thunberg. Sustainable behaviour is now a goal to strive for.

In the near future, we will see players in healthcare – General Practitioners (GP), university hospitals, pharmaceutical companies, as well as researchers – increasingly working together in networks, even across national borders. The ultimate goal is to integrate data and knowledge. Imagine a patient in Munich who goes to see his GP and is found to have a rare disease, such as a specific kind of tumour. Almost at the touch of a button, the GP will find similar cases in other cities, and see the drugs that were used to treat the condition successfully. In addition, the doctor will also be able to access the latest research results from Germany. This will directly benefit the patient. That is precisely where we are heading.

The Medical Informatics Initiative is overseen by the DLR Project Management Agency on behalf of the Federal Ministry of Education and Research. It is aimed at strengthening medical research and improving patient care. The first step is the establishment and networking of data integration centres at university hospitals and partner institutions. This is the prerequisite for connecting research and healthcare data across different locations. The initiative will run for four years and receive 160 million euro of funding from the BMBF.

The DLR Project Management Agency

For over four decades, the DLR Project Management Agency has been committed to making Germany a strong location for research, education and innovation. As one of the largest project management agencies in Germany, highly qualified employees currently manage approximately 10,000 projects and contribute to solving some of the world’s most pressing challenges. We are driven by a desire to make a difference, and our work is recognized for its impact on society and the economy.

Rainer Girgenrath

is Head of the Clinical Research, University Medicine and Digital Health Department at DLR’s Project Management Agency. Previously, he worked as a neuroscientist and university lecturer for psychology in Düsseldorf, Regensburg and Leicester, UK.

Artificial intelligence, Big Data, telemedicine – digitalisation has long been part of the healthcare sector. The foundations for tomorrow’s networked medical world, in which doctors and researchers alike have access to anonymous patient data, are being laid today. The aim is to achieve better and faster provision of care that can save lives in case of an uncertain diagnosis. At present, the flood of digital data is akin to having the internet without a search engine. Rainer Girgenrath, Head of the Department of Clinical Research, University Medicine and Digital Health at the DLR Project Management Agency, explains how we can improve the current state of affairs.

Medicine is facing major challenges. Digitalisation is affecting medical research and treatment alike. What do you expect over the coming years?

1. In the near future, we will see players in healthcare – General Practitioners (GP), university hospitals, pharmaceutical companies, as well as researchers – increasingly working together in networks, even across national borders. The ultimate goal is to integrate data and knowledge. Imagine a patient in Munich who goes to see his GP and is found to have a rare disease, such as a specific kind of tumour. Almost at the touch of a button, the GP will find similar cases in other cities, and see the drugs that were used to treat the condition successfully. In addition, the doctor will also be able to access the latest research results from Germany. This will directly benefit the patient. That is precisely where we are heading.

How can we make that happen?

1. All of Germany’s university hospitals are currently busy building data centres that will become the backbone of our digital healthcare system. They are laying the groundwork for the exchange of data. This large-scale project is being realised thanks to a funding initiative that will make it possible to control how we, as a society, can achieve specific research goals over the medium and long term. This is exactly where our work as the DLR Project Management Agency begins. The creation and expansion of overarching data centres is part of the Medical Informatics Initiative, which we have been instrumental in developing over the past three years on behalf of the German Federal Ministry of Education and Research. That said, it will be another two years before data exchange is available to and utilised by all university hospitals, and it will probably take a few more years before its use is widely spread among GPs.

Why is it so difficult to get digitalisation moving faster?

1. First of all, all those involved must agree on a standard procedure to follow. This happens in the concept phase of a project. In the case of the Medical Informatics Initiative, university hospitals were asked to submit their own ideas for a central data centre. Ultimately, only the best concepts received funding, but university hospitals that did not submit a winning proposal were given the possibility to adopt one of the approved concepts. Despite this competitive situation, we succeeded in getting everyone on board. In my opinion, this shows how important the topic is for the health care system.

There seem to be increasing reports about leaks of patient data, most recently in September, when MRI images of millions of patients worldwide became freely available on the internet. German patients were among those affected. How can you ensure that the data in the centres are secure?

1. Data protection and security are incredibly important. These are concerns that we and the Federal Government need to take care of ourselves; we cannot leave it to commercially driven companies. It is our responsibility to protect people. Personally, however, I would argue that Germany’s standards of data protection are higher than that of any other country. This is clear from the process that we are going through as part of our initiative. Data privacy specialists, researchers and hospital representatives all sit down with us to reach an agreement on a joint data standard. This takes time, but it is certain that in the end, if the process continues to be adhered to, all data will be stored securely. Indeed, there is no other alternative. We cannot just say that we will reject digitalisation because we are scared of data leaks. If we do that, people will ultimately die from diseases in cases where they could have been helped.

THE DLR PROJECT MANAGEMENT AGENCY

To submit your own ideas for a central data centre. Ultimately, only the best concepts received funding, but university hospitals that did not submit a winning proposal were given the possibility to adopt one of the approved concepts. Despite this competitive situation, we succeeded in getting everyone on board. In my opinion, this shows how important the topic is for the health care system.

There seem to be increasing reports about leaks of patient data, most recently in September, when MRI images of millions of patients worldwide became freely available on the internet. German patients were among those affected. How can you ensure that the data in the centres are secure?

1. Data protection and security are incredibly important. These are concerns that we and the Federal Government need to take care of ourselves; we cannot leave it to commercially driven companies. It is our responsibility to protect people. Personally, however, I would argue that Germany’s standards of data protection are higher than that of any other country. This is clear from the process that we are going through as part of our initiative. Data privacy specialists, researchers and hospital representatives all sit down with us to reach an agreement on a joint data standard. This takes time, but it is certain that in the end, if the process continues to be adhered to, all data will be stored securely. Indeed, there is no other alternative. We cannot just say that we will reject digitalisation because we are scared of data leaks. If we do that, people will ultimately die from diseases in cases where they could have been helped.
Applications in one vehicle

DLR’s Urban Modular Vehicle research platform combines numerous applications in one vehicle

By Julia Heil

A car slowly rounds the corner, gliding by almost silently. It has four seats, but possesses neither an accelerator pedal nor a steering wheel. Developed by researchers at the DLR Institute of Vehicle Concepts in Stuttgart, this car is a design for tomorrow’s urban vehicle.

Both people and goods need to be transported in a city, and in varying numbers and quantities. Together with transport researchers in Berlin, the DLR team investigated how many people the vehicle should accommodate, from a user’s perspective. The team also investigated the range that electric vehicles need to have in order to be attractive, as well as under what conditions people would prefer to use a shuttle rather than their own car.

Their results revealed the diverse expectations regarding vehicles. “We need different solutions for transporting cargo and moving people safely, quickly and comfortably from A to B. So we have to think in a modular way,” says DLR Project Manager Marco Münster. The answer is the Urban Modular Vehicle, or ‘UMV’, a versatile urban vehicle. It is a concept for an electrically powered, largely automated road vehicle that is truly multipurpose – a modular body construction combines different vehicle types in a single platform.

The basic version of the UMV has four seats and a light metal chassis structure. The body design, powertrain and level of automation can be adapted to satisfy the respective requirements. The DLR researchers designed a total of nine different models – from urban cars to vans. The length (3.7 to 4.1 metres) and height (1.6 to 2.3 metres) of the central module can be adjusted. The front and rear modules remain common to all variants but can also be modified as required, and the vehicle body can be adapted according to its intended use. Thanks to the lightweight construction, the vehicle’s basic structure weighs just 182 kilograms. “The basic idea behind the vehicle is that of a modular system, with which a large number of variants can be produced cost-effectively while retaining as many common components as possible,” says the DLR researcher.

From cargo vehicle to ‘skateboard’

The variable UMV design allows researchers to investigate a concept for the development of conventional cars with human drivers, before progressing to fully autonomous vehicles. In the ‘Cargo’ variant, the user still does the driving. But the researchers are also simulating autonomous variants. In one scenario, a mobile delivery service drives independently through residential areas between 21:00 and 23:00, so that parcels can be delivered or collected when people are at home.

The Stuttgart team are also working on a ‘skateboard’ variant of the UMV. They are designing a substructure to which different, interchangeable body units can be attached. “This is already the case with cargo vehicles that can accommodate different bodies. We would like to develop something similar for transporting people,” Münster explains. For now, however, the Skateboard UMV only exists in the virtual world.

Peoplemover as a first prototype

Münster and his project team have created the UMV Peoplemover 2+2 as the first prototype. In contrast to the Cargo variant, this concept has been exclusively designed to transport people and would complement public regional transport by acting as a shuttle. Its interior has a simple design and the large surfaces are easy to clean. Passengers can charge their electronic devices via USB ports. At the front of the vehicle, a display shows travel information such as route, arrival time and weather data. In addition, it also displays possible stops where other people can get on or off. Through this link, the scientists hope to reduce individual traffic in cities and offer passengers the optimal route to their destination.

The UMV is part of DLR’s ‘Next Generation Car’ (NGC) project, in which transport researchers from 22 DLR institutes are jointly developing technologies and concepts for future road vehicles. In addition, in the overall NGC project they are looking into the powertrain, energy management, vehicle structure, chassis and vehicle intelligence. They are also cooperating with colleagues from the research specialities of transport systems and railways. The next-generation vehicles will have alternative powertrains, provide optimised safety components for passengers and road users, and be able to drive autonomously. Their body structures are all lightweight, and it will be possible for them to be fully integrated into the transport environment.

In addition to the UMV, the Stuttgart team have produced vehicle designs for commuter transport and long-distance journeys. Marco Münster and his project team have more plans: “The Peoplemover offers a versatile development platform for many DLR researchers over the coming years and can be used in inter-institute and interdisciplinary projects. Examples include the design of the interior, the development of climate control concepts, the upgrading of the vehicle with sensors and computers and much more.”

Julia Heil is an editor at DLR’s Public Affairs and Communications Department.

In contrast to conventional cars, the Peoplemover does not park near the door of the user’s home, but is summoned using an App when needed. “Most cars stand around for 90 percent of the day and occupy already scarce space in the city. Our UMV would also spare people the tedious search for a parking place,” adds Münster. The researchers’ aim is for the concept to provide assistance in areas where, for example, public transport connections are poor or where passengers would otherwise only be able to reach a destination by following a circuitous route. Additionally, the Peoplemover could also alleviate the burden of rush hour traffic. To this end, the vehicle could be integrated into local public transport and be able to display route options in combination with subways, suburban trains, buses, cycle paths or footpaths. A display on the vehicle ceiling shows travel information such as route, arrival time and weather data. In addition, it also displays possible stops where other people can get on or off. Through this link, the scientists hope to reduce individual traffic in cities and offer passengers the optimal route to their destination.

The UMV is part of DLR’s ‘Next Generation Car’ (NGC) project, in which transport researchers from 22 DLR institutes are jointly developing technologies and concepts for future road vehicles. In addition, in the overall NGC project they are looking into the powertrain, energy management, vehicle structure, chassis and vehicle intelligence. They are also cooperating with colleagues from the research specialities of transport systems and railways. The next-generation vehicles will have alternative powertrains, provide optimised safety components for passengers and road users, and be able to drive autonomously. Their body structures are all lightweight, and it will be possible for them to be fully integrated into the transport environment.

In addition to the UMV, the Stuttgart team have produced vehicle designs for commuter transport and long-distance journeys. Marco Münster and his project team have more plans: “The Peoplemover offers a versatile development platform for many DLR researchers over the coming years and can be used in inter-institute and interdisciplinary projects. Examples include the design of the interior, the development of climate control concepts, the upgrading of the vehicle with sensors and computers and much more.”

Julia Heil is an editor at DLR’s Public Affairs and Communications Department.

In the future, it should be able to achieve a range of 400 kilometres with a 400-volt battery. The battery will be located in the double floor of the vehicle.

Vehicle summoned using an App

In contrast to conventional cars, the Peoplemover does not park near the door of the user’s home, but is summoned using an App when needed. “Most cars stand around for 90 percent of the day and occupy already scarce space in the city. Our UMV would also spare people the tedious search for a parking place,” adds Münster. The researchers’ aim is for the concept to provide assistance in areas where, for example, public transport connections are poor or where passengers would otherwise only be able to reach a destination by following a circuitous route. Additionally, the Peoplemover could also alleviate the burden of rush hour traffic. To this end, the vehicle could be integrated into local public transport and be able to display route options in combination with subways, suburban trains, buses, cycle paths or footpaths. A display on the vehicle ceiling shows travel information such as route, arrival time and weather data. In addition, it also displays possible stops where other people can get on or off. Through this link, the scientists hope to reduce individual traffic in cities and offer passengers the optimal route to their destination.

The UMV is part of DLR’s ‘Next Generation Car’ (NGC) project, in which transport researchers from 22 DLR institutes are jointly developing technologies and concepts for future road vehicles. In addition, in the overall NGC project they are looking into the powertrain, energy management, vehicle structure, chassis and vehicle intelligence. They are also cooperating with colleagues from the research specialities of transport systems and railways. The next-generation vehicles will have alternative powertrains, provide optimised safety components for passengers and road users, and be able to drive autonomously. Their body structures are all lightweight, and it will be possible for them to be fully integrated into the transport environment.

In addition to the UMV, the Stuttgart team have produced vehicle designs for commuter transport and long-distance journeys. Marco Münster and his project team have more plans: “The Peoplemover offers a versatile development platform for many DLR researchers over the coming years and can be used in inter-institute and interdisciplinary projects. Examples include the design of the interior, the development of climate control concepts, the upgrading of the vehicle with sensors and computers and much more.”

Julia Heil is an editor at DLR’s Public Affairs and Communications Department.

In the future, it should be able to achieve a range of 400 kilometres with a 400-volt battery. The battery will be located in the double floor of the vehicle.
With the Urban Modular Vehicle, DLR transport researchers have completely rethought tomorrow’s urban car. An intelligent and safe electric vehicle, the special feature of the UMV is that all vehicle variants are based on the same basic module, making its design extremely versatile. The modular design also enables researchers to investigate different technologies and concepts using a single platform.

The UMV Basic is the standard version of the Urban Modular Vehicle with 2 + 2 seats and a length of 3.7 metres. It is designed to achieve automation levels between three – assisted driving – and five – fully autonomous. This vehicle’s structure forms the basis of all UMV derivatives.

In contrast to the cars with a driver’s seat, the UMV Cargo-Mover is completely autonomous. It can deliver parcels independently and has a cargo volume of 3800 litres.

A special feature is the ‘skateboard’ variant, in which a variety of body designs can be attached to the substructure. This has the advantage that this vehicle can be used for transporting either people or cargo.

The two-seater UMV Cargo is a small delivery van, ideal for smaller businesses that need to flexibly move their materials and products across an urban setting. The standard version is 3.7 metres long, while the extended version is 4.1 metres long.

As part of the Next Generation Car project, DLR is working on several concepts for the car of the future. The vehicles need to be energy-efficient, emission-free, safe and cost-effective.

Perfect for commuters:

The Safe Light Regional Vehicle (SLRV) is the most lightweight member of the NGC family. At just 400 kilograms, it weighs the same as a golf buggy. Its body is made from a light aluminium foam sandwich with an inner ring structure. This economical two-seater is ideal for commuters and can be used in areas with insufficient train or bus connections. For this design, the DLR researchers used selected safety standards for a conventional car on a vehicle in this size class (L7E) for the first time. The Stuttgart team want to make lightweight vehicles more attractive. The DLR specialists are currently integrating the powertrain – based around a fuel cell – into the test vehicle. With one tank of hydrogen, the SLRV will be able to travel approximately 100 kilometres during test operations. With the finished test vehicle, the researchers want to assess how the vehicle components interact in real situations.

For long distances

The Interurban Vehicle also comprises a fuel-cell-based powertrain and will be able to achieve a range of up to 1000 kilometres – perfect for journeys between cities. Thanks to the alternative powertrain, the vehicle is completely emission free. It will accommodate up to five people with their luggage. It is designed for an automation level of up to SAE four. This means that the car can take over the driving task in certain situations. As the ‘latest’ development, it currently exists only as a bodywork demonstrator, without a powertrain. Researchers at the DLR site in Stuttgart want to use it to investigate how different electrical functions can be integrated into the structure.

Sensors for the autonomous driving functions and identification of the surroundings will in future be installed on the vehicle’s exterior. Devices for communicating with other vehicles and with the infrastructure, as well as antennas for receiving satellite signals, are integrated into the roof. Radar systems are located in the bumpers and optical sensors are installed in the front and rear windows. Eighteen ultrasonic sensors around the vehicle will support proximity detection in the future.

The vehicle is summoned using an App. Passengers also use this to authenticate themselves by means of a display in the Peoplemover’s side window.

After successful authentication, the sliding doors open. The journey can begin once the seat belts have been fastened.
A contemporary of the first German in space remembers the cosmonaut, who passed away on 21 September 2019.
By Gerhard Kowalski

When Sigmund Jähn was born in 1937, there was certainly nothing to indicate that he would one day travel into space. His father was a sawmill worker, his mother a housewife, and his birthplace, Morgenröthe-Rautenkranz, a village with a population of just a few hundred – inauspicious circumstances for the birth of a space explorer. Neither was there any sign that Jähn’s journey would one day help draw East and West Germany a little closer together. Space journalist Gerhard Kowalski remembers.

My first journalistic involvement with Sigmund Jähn’s great adventure began in late May 1978, a few months before the first spaceflight by a German. I was the only newspaper journalist commissioned by the East German Ministry of Defence to compile material about Sigmund Jähn and his backup, Eberhard Köllner – all in the strictest secrecy. Two press officers took me to their offices and introduced me to their former instructors, teachers and families. As a result, I drafted 20 typewritten pages of material on each of the candidates. I was also tasked with submitting a launch report six weeks before the actual event took place. Fortunately, I was able to draw upon my experiences at the launch of the US-USSR Apollo-Soyuz Test Project in 1975 and the first flight of the East German MKF 6 multispectral camera in 1976.

I was then lucky enough to be chosen to accompany Jähn’s launch from the Baikonur Cosmodrome, on the Kazakh steppes. Before meeting him in person, I feared that the East German leadership had selected a brisk, dyed-in-the-wool “Red Russian”, who would no doubt spout party slogans all day long. Instead, I met a friendly yet extremely modest and rather measured Saxon, who almost had to be persuaded to talk. Indeed, it was precisely his quiet and thoughtful manner that helped Jähn achieve an almost pop-star-like status in East Germany following the flight. The party and state leadership were happy to bask in his reflected glory and took their cosmonaut hero all over the country.

For his part, Jähn never made any secret of his commitment to East Germany, but big statements were never his style. Instead, whenever he could, he set the speeches that had been prepared for him aside and spoke to the people in his own words. When faced with western journalists who sought to provoke him into making critical statements about East Germany, he resorted to the formulaic phrase that he was “there of his own free will”. And his commitment to German unity was clear from his Solomon-like statement: “The last thing we need is a fraternal war.” This was not enough for many journalists and politicians, but little effort was made at getting better acquainted with, or indeed understanding the man who became the first German and 90th human being to go into space. Sigmund Jähn brought this pioneering achievement to a united Germany.

By sheer coincidence, the second German to travel into space, Ulf Merbold, was also from the Vogtland region. It is a peculiar irony of this dual German history that Merbold left East Germany before the wall went up and flew into space as a Payload Specialist on the STS-9 Space Shuttle mission. It is to his credit that he helped Major General Jähn, who had been discharged from the National People’s Army, start afresh in the west and recommended him to DLR and the European Space Agency (ESA) as a consultant. That is how Jähn ended up in Cologne, while also making recurrent trips to Baikonur and Star City, near Moscow. He assisted five German astronauts from the former West Germany, including Merbold, with preparations for their spaceflights with the Russians – first to the Mir space station and later to the ISS. He helped the youngest of them, Alexander Gerst, even after he had officially retired.

On 26 August 2018, to commemorate the 40th anniversary of Jähn’s spaceflight, the German astronaut corps celebrated with their friend and longest serving representative in Morgenröthe-Rautenkranz. Alexander Gerst called in from the ISS. Gerhard Thiele summed up everyone’s thoughts in his address: “I am glad you were the first.” The cosmonauts Aleksandr Ivanovich Leonov and Pavel Belyayev there were on behalf of Jähn’s former spaceship commander Valery Bykovsky, who passed away in March 2018, and also conveyed warm wishes from Star City’s director, Pavel Vlasov. Jähn, who had pushed so many boundaries on his travels, was moved to tears by these tributes.

Gerhard Kowalski, who was born in 1942, is a space journalist, author and technical translator. In the former East Germany he worked as a correspondent for the state news agency ADN, before becoming a freelance journalist. Sigmund Jähn and I were friends for over four decades.

“Sigmund’s life revolved around space travel, his family and his friendships, which transcended international borders that are not visible from space. We German astronauts have flown and will continue to fly to space on his shoulders. Despite being over 80 at the time, Sigmund never missed a chance to travel to the remote Baikonur Cosmodrome for either of my launches. On the day before my first launch, I even saw the completely isolated quarantine area, and remember him standing outside my window with a mischievous grin on his face, asking whether I wanted to go for a walk.”
Alexander Gerst, Astronaut

“With the death of Sigmund Jähn, the German space community has lost a world-renowned cosmonaut, scientist and engineer. The first German to go into space always saw himself as a bridge builder between East and West and an advocate for the peaceful use of space. We will preserve and perpetuate his message, for Earth and space, in his memory.”
Pascale Ehrenfreund, Chair of the DLR Executive Board

“My greatest memory of Sigmund Jähn is the transfer of two cars to Star City in December 1990. The purpose of this adventure was to keep our two German cosmonaut candidates, Klaus-Dietrich Flade and Reinhold Ewald, mobile on Earth as well. Sigmund guided us through Poland and the then still existing Soviet Union. He showed his professionalism, which identified neither as a hero of the Soviet Union, to the amazed officials at the Soviet border. It was a matter of course for him to lead us safely to Star City.”
Rolf-Dieter Fischer, former astronaut trainer

“My most vivid memories of Sigmund Jähn are from his early days as a consultant for DLR. He was simply irreplaceable in the negotiations with the Russian team during preparations for the first flight by a German astronaut to the Russian space station Mir. With his calm, friendly and reasoned demeanor, Sigmund helped us all to understand the situation in Moscow at that time – the uncomfortable feeling when handing over passport to immigration control, the moshie in the hotel, the menus … He also gave me tips on how to survive the mandatory vodka toasts. However, I am not sure that the plants behind my chair fared quite so well.”
Beate Fischer, Head of the Astronaut Training Department at DLR Space Operations

“On 9 November 1989 we were in Riyadh; it was the eve of the conference of the Association of Space Explorers (ASE). We stood around the European astronaut representatives, as we witnessed the fall of the Berlin Wall live on television – arguably the hardest day in Sigmund’s life. Many years later, as head of the European Astronaut Centre from 2000, I benefited greatly from his early involvement in our astronaut training, which Ulf Merbold had helped arrange. Sigmund’s presence always allowed us to benefit from his Russian experience on many occasions.”
Ernst Messerschmidt, Astronaut
IN HUMBOLDT’S COSMOS

Researching, dreaming and bringing worlds together
Peter Zarth interviews author Andrea Wulf on behalf of the DLRmagazine

The 250th anniversary of Alexander von Humboldt’s birth has prompted publishing houses, the media and various other organisations to pay tribute to him. He is praised as a tireless explorer, a visionary, a diplomat and a diplomat, he 250th anniversary of Alexander von Humboldt’s birth has prompted publishing houses, the environment movement, and indeed people of all ages. “Nature must be experienced,” says Humboldt. “It is apparent that Humboldt and Andrea Wulf both see beauty as a characteristic of nature, and a facet of humans, art and science. Humboldt could speak about the beauty of nature, about tropical plants or deep mountain gorges. He approached scientific language poetically,” she says. “Humboldt wanted to draw his readers into nature, he wanted comprehensibility. It is precisely that emotion that appeals to children like those of the ‘Fridays for Future’ movement, and indeed people of all ages. “Nature must be experienced,” says Humboldt.

Humboldt and climate change
Andrea Wulf wrote the international bestseller “The Invention of Nature: Alexander von Humboldt’s New World”. She “still cannot believe” its success. The effect of her book, especially on young people, makes her happy. Andrea Wulf loves conversation. “Through conversation, even the most contrasting scientific disciplines can come together.” She loves speaking to anyone, anywhere, and is often invited to give lectures across the world – and she listens, too. Questions concerning climate change are “the most important topics.” It was these that led her to Humboldt. “My listeners are often interested in climate change. Young people are rightly very concerned.” The environment could do with more “heroes and role models like Humboldt.” Yes, the historian Andrea Wulf really did say “heroes”, as Humboldt warned early on about the destruction of the environment. In 1832, he predicted that man would change the climate in three ways: “… by destroying the forests, by artificial irrigation and by producing large amounts of steam and gas from industrial hubs.”

The magic of nature
Andrea Wulf has conducted brilliant research and travelled to many of the significant places related to Humboldt’s life, so she knows exactly what she is talking about. Very much a 21st-century historian, she has a wonderfully varied sense of humour. “Sometimes it is as if I am Humboldt’s spokesperson,” she says. Her enthusiasm is obvious, even over the phone. It is clear that this is much more than public relations work for her. Wulf has researched Alexander von Humboldt and wants the present to build on his work. “History helps us to understand, to think, and to know how to think,” she stresses. Humboldt brought art and science together, and within this pairing lies the magic of nature. “Basically, science and art are the same – they are driven by curiosity. The human imagination – essential for both science and art – was formed in nature.” This should not be forgotten. Wulf then follows up with one of the most compelling sentences of our quiet conversation: “We will only protect that which we love.”

“Nature needs to be experienced”
“Beauty” is a term that comes to Andrea frequently, and in surprising places. It is apparent that Humboldt and Andrea Wulf both see beauty as a characteristic of nature, and a facet of humans, art and science. Humboldt could speak about the beauty of nature, about tropical plants or deep mountain gorges. He approached scientific language poetically,” she says. “Humboldt wanted to draw his readers into nature, he wanted comprehensibility. It is precisely that emotion that appeals to children like those of the ‘Fridays for Future’ movement, and indeed people of all ages. “Nature must be experienced,” says Humboldt.

Close your eyes, and what you see then belongs to you
It is 26 July 2013 and Andrea Wulf and her best friend Julia Niharika-Sen are climbing Chimborazo. “Above the clouds, at an altitude of more than 5000 metres, the air is clean.” It is a clear day. Some 211 years earlier, on 23 June 1802, shortly before reaching the summit of this mountain – which at the time was considered to be the highest on Earth – Alexander von Humboldt seems to have been lost in a nebulous land, spellbound by an empty, almost uncanny space. Suddenly the fog clears, and he sees the snow-white peak of Chimborazo towering against the blue sky …

The friends take out their copies of Alexander von Humboldt’s diary and begin to read: “… On 23 June (…) we climbed Chimborazo. (…) Since the day was very dark and foggy, the summit was only visible from time to time. A lot of snow had fallen during the previous night …”

The stillness of the surroundings envelops Andrea Wulf and Julia Niharika-Sen. They see the world from above. Silence. “Sometimes, when I write, I close my eyes,” says Andrea Wulf, “as our conversation comes to a close. “I have a vivid imagination.” Imagination is the sister of art, of beauty, of science. It would be wonderful to listen to this connector of worlds forever, and thus learn about ourselves along the way.

Peter Zarth, DLR Public Affairs and Communications

Andrea Wulf enjoys talking with people from all over the world and values life’s quiet moments
“I see ‘my’ Humboldt with the historian’s gaze, including the ambiguity of his person,” says Wulf. “My new, illustrated book is almost like an homage, as I consider Alexander von Humboldt to be an artist, too.”

Peter Zarth, DLR Public Affairs and Communications

The Invention of Nature: Alexander von Humboldt’s New World’ by Andrea Wulf. © Antonina Gern
This book is a risk. A 272-page adventure, it is illustrated in great detail but contains a lot of text for a graphic novel. Mind you, it is still a novel. The adventures of a 19th-century researcher and explorer, it is longer than many modern novels. Is it unwieldy? Or perfectly readable? How will it be received in these days of swiping and scrolling?

Adventures take time. They are inherently chaotic, even conceptually. When recounted and illustrated between the covers of a book, they require structure and rigour – far more than just talent. Finding a balance between text and images, and creating a good guide for people who want to feast their eyes and read at the same time is vital.

Lillian Melcher and Andrea Wulf have largely succeeded in this. While it might seem overly pedantic to add ‘largely’, when the result is so impressive, we fear only a lack of patience on the part of the reader. In this coming year, before busy work and school schedules begin, readers should have plenty of time for birds and plants, for the page on the Orinoco, for the white-water rapids and Havana, for electric fish and for Chimbora– and also for all the other little wonders in the book.

After the worldwide success of Wulf’s Humboldt biography, his diaries inspired the author to create a book that would show Humboldt’s artistic side and, as she says, “the incredible ease with which he unites science and art.” The Adventures of Alexander von Humboldt follows Humboldt’s South-American journey.

To a certain extent, this complements Wulf’s ‘The Invention of Nature: Alexander von Humboldt’s New World’, but this graphic novel also goes beyond that. It is emotive and full of surprises, and a young genius has put the ‘adventures’ into images. Lillian Melcher, just 23 years old and fresh out of university at the time of the book’s creation, is truly gifted. As Wulf states in her introduction to the themes and text, Melcher combines the visible with the invisible using her paintbrush, with naivety in its original sense – conveying open-mindedness and authenticity. Our only question is what prompted the publisher to change the colour gradient of Melcher’s original image for the front and back covers so radically that they no longer have much in common with the style of the novel itself. The intense colour and the golden print of the title page and experience pure exoticism. Even the ordinary is portrayed with Lillian Melcher’s detailed visual presentation of the content.

Lillian Melcher draws Humboldt’s fellow traveller, Bonpland, often had trouble drying plants and notes in the humidity of the tropics, and as a result they became mouldy. In order to faithfully depict this, the illustrator sprinkled paper and plant samples with milk, orange juice, coffee and tea, placed them in her damp shed and let them become mouldy. We, the readers, can rely on the detail of Lillian Melcher’s meticulous approach saw her delving into a kind of archaeoastronomy in researching Humboldt’s 1803 journey from Guayaquil to Mexico, on which the ‘Southern Cross’ moved ever closer towards the horizon. Wulf questioned astronomers in order to find out exactly how this constellation changed on this route at that time, and Melcher drew accordingly. But she not only drew Humboldt’s fellow traveller, Bonpland, often had trouble drying plants and notes in the humidity of the tropics, and as a result they became mouldy. In order to faithfully depict this, the illustrator sprinkled paper and plant samples with milk, orange juice, coffee and tea, placed them in her damp shed and let them become mouldy. We, the readers, can rely on the detail of Lillian Melcher’s detailed visual presentation of the content.

Antisana? Melcher’s meticulous approach saw her delving into a kind of archaeoastronomy in researching Humboldt’s 1803 journey from Guayaquil to Mexico, on which the ‘Southern Cross’ moved ever closer towards the horizon. Wulf questioned astronomers in order to find out exactly how this constellation changed on this route at that time, and Melcher drew accordingly. But she not only drew Humboldt’s fellow traveller, Bonpland, often had trouble drying plants and notes in the humidity of the tropics, and as a result they became mouldy. In order to faithfully depict this, the illustrator sprinkled paper and plant samples with milk, orange juice, coffee and tea, placed them in her damp shed and let them become mouldy. We, the readers, can rely on the detail of Lillian Melcher’s detailed visual presentation of the content.

“Really, really great,” says Andrea Wulf about her collaboration with Lillian Melcher. Her enthusiasm stands out all the more in the otherwise more reserved interview presented on the previous pages. Melcher has a commendably calm eye. Her pictures and ideas are captivating. The choice of unexpected imagery, by turns bold, cheeky and joyous, dispels any exaggerated belief in the authority of science – all with ease, humour and wit. She does not draw in an overly elaborate style, as has often been said, and as might be expected from the odd, albeit intriguing cover image. Lillian Melcher reimagines the moment. What an adventure!...
INSIDE THE INTERNET: 50 YEARS OF LIFE ONLINE

A National Geographic documentary
Published June 2019

Some 50 years after its inception, the internet is ubiquitous, and many can’t imagine living without it. If you should, it’s probably because you’re using it. We are now living in an “internet” world, and the internet is everywhere. It’s not just a tool for communication; it’s a way of life. This is a story of the internet, the internet and the internet. It’s not just a story of the internet; it’s the internet.

With a mere 5 minutes of playtime, we can’t expect them to cover every aspect of a subject as big as the internet, but we think this special does a good job at covering a variety of topics relating to it. At first, the focus is on the history of the internet, from its early days in the dungeons of the US Department of Defense, to global penumbresas in modern times. It gradually transitions to exploring different applications and aspects of the internet that no one could have imagined 50 years ago. We often don’t really think about the possibilities and cultural shifts that the internet has induced. Nowadays, we can find dates, talk, entertain ourselves, learn and much more in a few sweats, or even almost leaving the sofa. But even though the growth of the internet was explosive, these concepts were introduced quite gradually over the course of the internet revolution. The story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

In fact, the illustrations throughout are great. In a style reminiscent of Steins; Tenma, the close-ups of flora and fauna encountered on the journey are a fitting tribute to the sketches of the flora and fauna encountered on the journey. The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

There are numerous links to previous and additional articles as well as videos, blogs, and posts from social networks.

FOR MORE ON CHEOPS:

Cheops: The CHEOPS mission

ESA's CHEOPS mission on Twitter. Planned for launch in December 2019, CHEOPS is primarily tasked with studying previously primarily tasked with studying previously

Archaeology from Space

Archaeology from Space

The 2019 Nobel Prize in Physics was awarded in part to the discoverers of the first exoplanet orbiting a Sun-like star. As the exploration of exoplanets continues, so be it to follow ESA's CHEOPS mission on Twitter. Planned for launch in December 2019, CHEOPS is primarily tasked with studying previously primary tasked with studying previously

And today they have an impressive array of research tools at their disposal, including high-resolution satellite imagery.

The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

In fact, the illustrations throughout are great. In a style reminiscent of Steins; Tenma, the close-ups of flora and fauna encountered on the journey are a fitting tribute to the sketches of the flora and fauna encountered on the journey. The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

In fact, the illustrations throughout are great. In a style reminiscent of Steins; Tenma, the close-ups of flora and fauna encountered on the journey are a fitting tribute to the sketches of the flora and fauna encountered on the journey. The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

In fact, the illustrations throughout are great. In a style reminiscent of Steins; Tenma, the close-ups of flora and fauna encountered on the journey are a fitting tribute to the sketches of the flora and fauna encountered on the journey. The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.

In fact, the illustrations throughout are great. In a style reminiscent of Steins; Tenma, the close-ups of flora and fauna encountered on the journey are a fitting tribute to the sketches of the flora and fauna encountered on the journey. The book is a narrative retelling of Darwin’s personal account of his 1831–1836 voyage aboard H.M.S Beagle, focused on his time in South America and the Pacific. Its story-within-a-story format, as an older Darwin recounts tales from his travels to his children, works as a real declarator that this is a work of both fact and fiction meant to entertain and inspire. It’s not a textbook, it’s lighter on the science and serves more as an introductory text, but encapsulates the intoxicating awe and wonder the young man himself must have felt as he sailed around the world. That isn’t to say it avoids darker topics. Of the牠s monsters Darwin encounters, it’s Marx, not giant lizard, that is the most terrifying. Grolleau does a good job of presenting Darwin’s encounters with brutal colonialism and his anti-slavery views, uncharacteristic of the time and putting him at odds with the Beagle’s captain. To the horror and wonder of Darwin’s companions, it’s Man, not giant lizard, that is the most terrifying. The Inverness do not provoke any real emotions, and the book is a more thought-provoking way without over-the-top depictions of violence.
Cover image
Urban vehicles should bring people and goods from A to B safely, comfortably and in an environment-friendly manner. In the Urban Modular Vehicle, DLR combines various vehicle types on a single platform. The ‘Peoplemover’ variant can be used as a shuttle to supplement the local public transport system and saves individual parking spaces.