March 2026 | German Aerospace Center

Technology platform
Power-to-Liquid fuels

Autonomous driving
What will get autonomous vehicles onto the road

Cover image

The ATHEAt research rocket, shown here awaiting its launch in Andøya, Norway, is 13.5 metres long. It is powered by two engines: the lower stage, known as RED KITE, is a very powerful solid rocket motor developed by DLR in cooperation with the company Bayern-Chemie. The second stage uses a Canadian 'Black Brant' rocket motor. This combination is particularly well suited for microgravity and hypersonic research. The payload sits at the tip of the rocket, serving both as a research experiment and a heat shield. With ATHEAt, DLR is investigating reusable components for space transportation vehicles, including the challenges associated with atmospheric re-entry.

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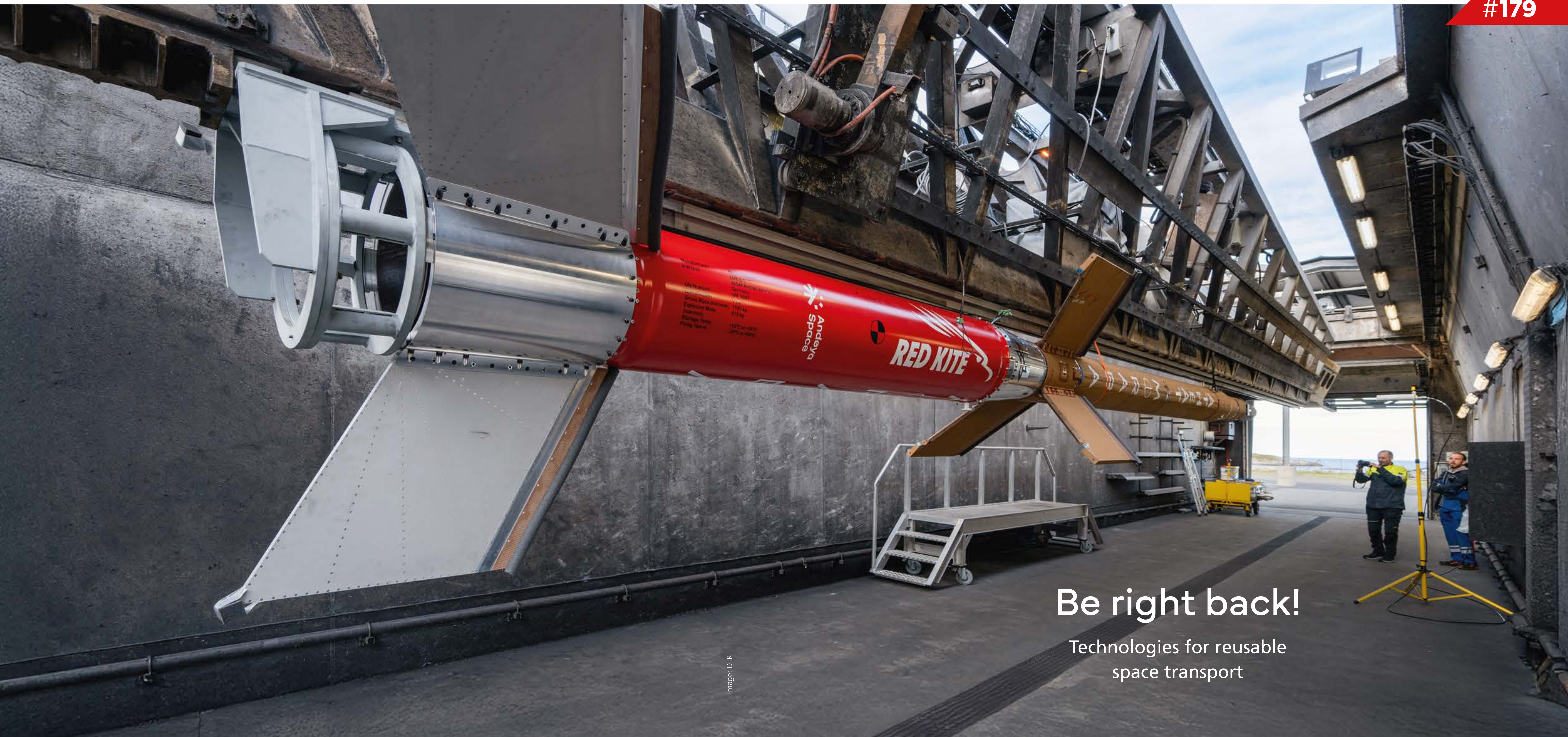


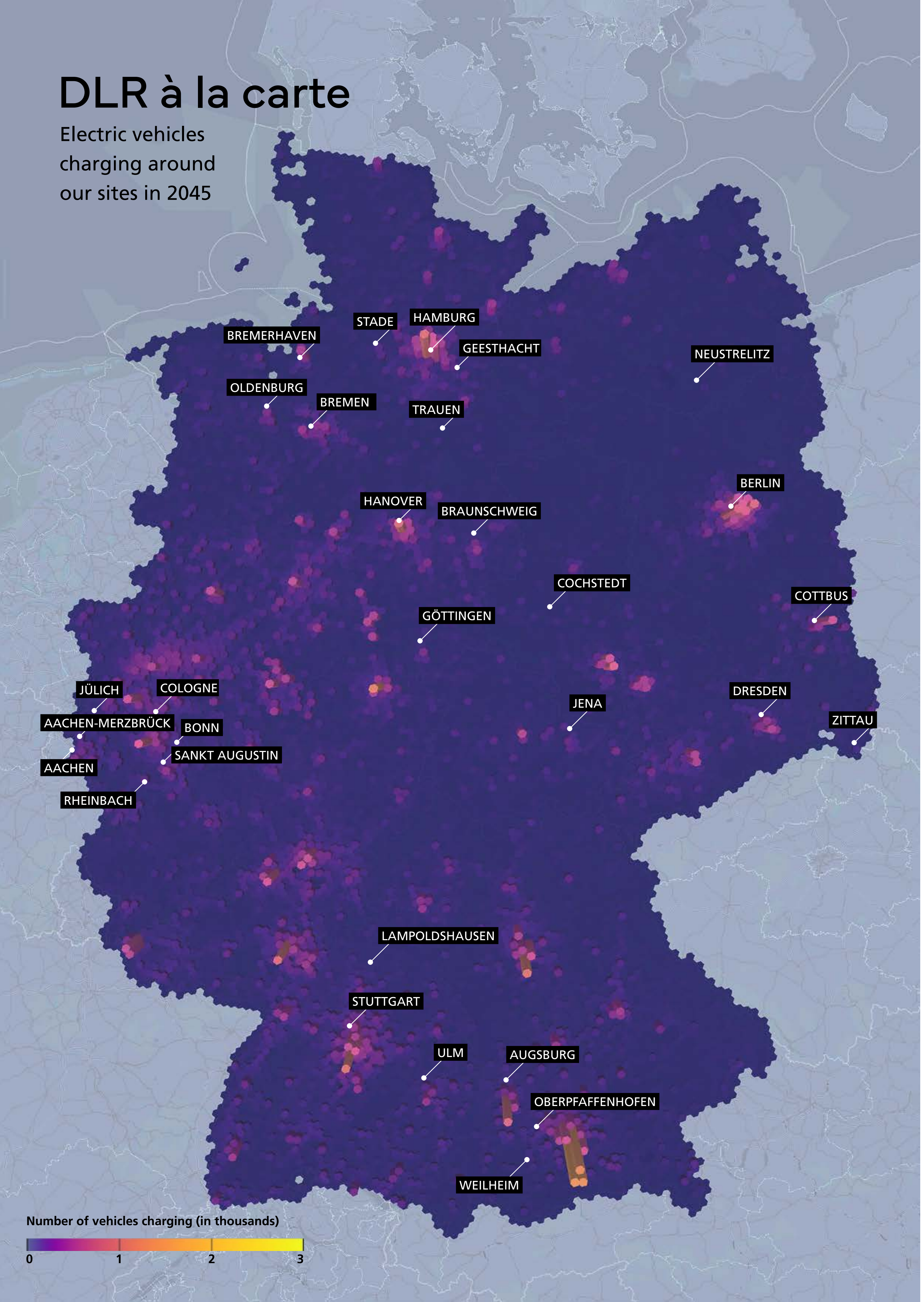
Image: DLR

Be right back!

Technologies for reusable space transport

DLR à la carte

Electric vehicles charging around our sites in 2045



Powered up

It's a weekday in 2045, at 9 a.m.: particularly in cities, electric vehicles are plugged in to the power grid and charging. The data shown here comes from the PowerForecast-Mapper (PFM), developed through a collaboration of several DLR institutes under the leadership of the Earth Observation Center. Modelling approaches like this serve as important reference points for advancing electromobility – which can only succeed with a robust and comprehensive infrastructure in place.

Head straight to the PFM

IMPRINT

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p. 02 map: DLR; p. 03 illustrations: raufeld/sora

What drives us...

"Campaigns like ATHEAt give everyone involved – and especially our early-career researchers – a unique opportunity to actively help shape cutting-edge spaceflight technology."

More on page 10

Ali Gülhan
DLR Institute of Aerodynamics and Flow Technology

Christoph Arndt
DLR Institute of Combustion Technology

"Aviation of the future needs sustainable fuels to take off. That's why I'm delighted that the TPP in Leuna is now becoming a reality and helping to make aviation a little more climate-compatible."

More on page 42

"I'm lucky to work at the interface of two very fascinating research subjects: brains and aircraft. Not many people can say that."

More on page 44

Anneke Hamann
DLR Institute of Flight Guidance

Max Friedrich
DLR Institute of Flight Guidance

"A few years ago, in an interview, I was asking whether a human could control several aircraft at the same time. Today, we can not only demonstrate this in simulations, but show it live."

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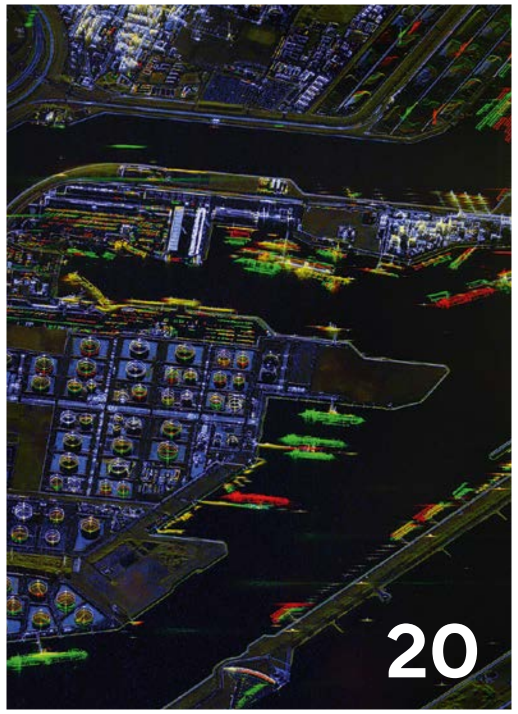
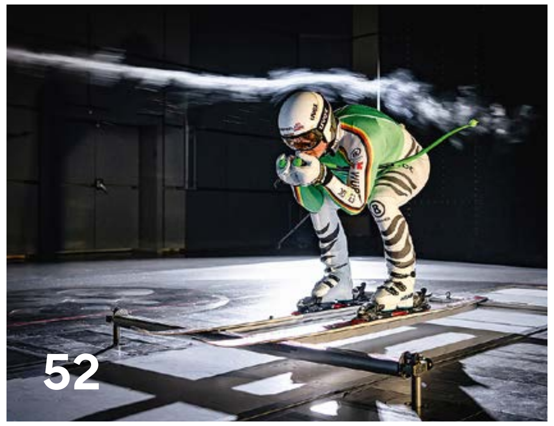




DLR's solar towers in Jülich

Autonomous solar tower power plant

JÜLICH: Solar thermal power plants have, until now, largely been operated manually. That could change. DLR researchers in Jülich have successfully tested a concept for the autonomous operation of a solar tower power plant. The system continuously, rapidly and reliably evaluates large volumes of measurement data and complex processes, meaning the optimal operating state can be selected autonomously in any situation.

Secure quantum communication

ERLANGEN: Precisely transmitting individual photons from an aircraft, capturing them at a ground station and reliably detecting them is no easy task. However, DLR researchers have now succeeded in doing exactly that. On multiple occasions they have managed to measure various quantum channels between an aircraft and a ground station, transmit photons to an ion trap and test technologies for quantum key distribution. The flight experiment took place as part of the QuNET initiative, which is developing technologies for quantum-secure communication. Using photons – particles of light – quantum cryptographic keys can be generated to make future communications eavesdrop-proof.

From Lampoldshausen into space

Vinci upper-stage engine for Ariane

ArianeGroup will in the future manufacture the Vinci upper-stage engine for the Ariane 6 rocket at DLR's Lampoldshausen site. DLR's Institute of Space Propulsion will then carry out the final tests of the Vinci engine – verifying its performance and reliability, as well as its operational readiness for flight. This means the entire final production and system integration, along with the flight acceptance tests for the Vinci engine, will be relocated from Vernon in France to Germany. Installation of the engine into the Ariane 6 upper stage will continue to take place in Bremen, as before.

Flexible and long-lasting

The Vinci engine is crucial to the performance of Ariane 6, with its long service life, the ability to be reignited multiple times and its use of the highly efficient propellant combination: liquid hydrogen and liquid oxygen. The engine means the European rocket can launch a wide range of missions, including the transport of multiple payloads on a single trip. Germany has contributed approximately 800 million euros to the development of Ariane 6, while the German Space Agency at DLR coordinates the German ESA budget.

Centre of excellence for space propulsion

DLR's site in Lampoldshausen is Europe's centre of excellence for space propulsion and therefore a key location for Europe's independent access to space. For more than six decades, DLR's Institute of Space Propulsion has operated unique test benches and test facilities for liquid rocket engines here – from research through to flight qualification. A standout example of the site's capabilities is the Vinci upper-stage engine for Ariane 6. The engine was qualified for the launcher's inaugural flight at test bench P4.1 in Lampoldshausen under real altitude conditions – a capability unique in Europe. The future final assembly and acceptance testing of the Vinci engine in Lampoldshausen will further strengthen the close relationship between development, integration and testing.

The Vinci engine of the Ariane 6 rocket at test bench P4.1 in Lampoldshausen

Image: p. 06 (bottom) DLR

Safe airspace for drones

BRAUNSCHWEIG/COCHSTEDT: Together with the company Frequentis AG, DLR is developing procedures to safely integrate drones (uncrewed aircraft systems; UAS) into airspace. To this end, the 'U-Space' is being established at DLR's National Experimental Center for Unmanned Aircraft Systems in Cochstedt – a designated area in which drones can carry out coordinated flights. As part of the cooperation, DLR is providing essential services such as network identification, geo-awareness, UAS flight authorisation and traffic information. These services are intended for use not only in research projects but also in practical application scenarios.

DLR's National Experimental Test Center for Unmanned Aircraft Systems in Cochstedt

24

hours is how long it took for the particularly fast solar storms in January 2026 to reach us. Normally, it takes two to three days before the effects of a solar eruption become noticeable on Earth.

DLR's Falcon 20E research aircraft measures contrails where they form

Fewer contrails, lower climate impact

The EU project A4Climate explores how contrails can be avoided

Under DLR's leadership, 17 project collaborators from nine countries are working to reduce the formation and climate impact of contrails – through intelligent flight routes, innovative engine technology and alternative fuels.

Fully automated route recommendations

To test the effectiveness of these measures under real-world conditions, DLR is conducting measurement flights together with the German airline TUIfly and the Austrian aviation company Flightkeys. Wherever possible, flights avoid regions in which contrails form. The project team is working on a fully automated data transmission system that delivers route recommendations in real time. Satellite imagery is later used to verify whether the strategy results in fewer contrails in practice.

Flying in a more climate-compatible way

Contrails form at high altitudes when hot exhaust gases meet very cold, humid air. The resulting ice clouds trap heat in the atmosphere and contribute to global warming. Their climate impact is comparable in magnitude to that of all carbon dioxide (CO_2) emissions from aviation. For this reason, the EU is aiming to systematically monitor these non-CO_2 effects.

Modern engines, sustainable fuels

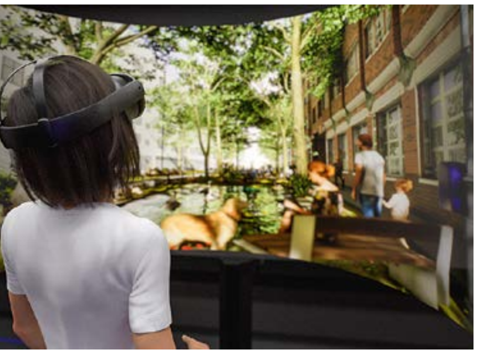
Beyond flight planning, A4Climate is investigating how new engines and alternative fuels influence contrail formation. Soot particles produced during fuel combustion are considered important nuclei for ice crystal formation. However, whether less soot automatically leads to fewer contrails has not yet been conclusively proven. To test this, DLR's Falcon 20E research aircraft is currently accompanying TUIfly passenger aircraft equipped with low-soot lean-burn engines. These flights deliberately pass through regions favourable to contrail formation.

New DLR institute established

COLOGNE: With the establishment of the DLR Institute of Frontier Materials on Earth and in Space, DLR is consolidating its expertise in materials research. The new institute focuses on the development of high-tech materials and next-generation manufacturing processes that are adaptive, resource-efficient and robust under extreme environmental conditions. By locating the institute in Cologne, DLR is strengthening North Rhine–Westphalia as a hub for innovation and research and underlining Germany's role as a leading nation in science and technology.

Mobility with all the senses

BERLIN: Does this new stop make public transport more pleasant? How can the interior design of a vehicle enhance well-being and safety? How attractive is the concept for local public transport? Questions like these are made tangible in a holistic way by the new DLR facility mozu – 'Mobilitätswelten der Zukunft' (Mobility Worlds of the Future'). From November 2026, visitors at the Berlin site will be able to experience mobility scenarios in a virtual 3D environment, interact with them and take part in the design process. Effects such as sound, smells, wind, rain, heat and cold can also be integrated.



Immerse yourself in new virtual mobility worlds at the mozu facility

Farewell to BIROS

After ten years in orbit, fire detector burns up in the atmosphere

For almost ten years, the small satellite BIROS (Bi-spectral InfraRed Optical System) detected forest fires, volcanic eruptions and other high-temperature events on Earth. On 22 January 2026, it burned up completely in Earth's atmosphere.

Alongside the nearly identical TET-1 satellite, BIROS was the second satellite of DLR's FireBIRD mission. The primary payload of both orbiters consisted of a highly sensitive infrared camera system. Not only could vegetation fires be assessed more precisely using the satellite pair, but other high-temperature events could too, such as active volcanoes, burning ships or smouldering underground coal seam fires.

A versatile fire scout

BIROS was able to detect and assess fires or lava with temperatures between 300 and 1300 degrees Celsius – a unique feature for a satellite of this size. It simultaneously detected both small fires covering areas of just ten square metres and vast bushfires, without saturating the infrared camera.

BIROS was developed and built in Berlin-Adlershof at what was then the DLR Institute of Optical Sensor Systems – now the DLR Institute of Space Research – in cooperation with the company Astro- und Feinwerktechnik Adlershof. The DLR Institutes of Software Technology and Aerodynamics and Flow Technology, the University of Würzburg and the company Aerospace Innovation were also involved.

Illustration and photo of the BIROS satellite (top and bottom)

The **FORSCHtellungsgespräch** podcast is available (in German) at **dlr.de/podcast** and on all major streaming platforms. A video version is also available on Youtube and Spotify.

The satellite godfather

"Supporting new small-satellite technologies in Germany is one of my core responsibilities. Through constant exchange with research and industry, I can assess which technologies should be funded in line with the space strategy and actively support their development."

Andres Bolte from the department of Robotics, Digitalization and AI at the German Space Agency at DLR

Image: DLR

ATHEAt stands for 'Advanced Technologies for High Energetic Atmospheric Flight of Launcher Stages'

Mach 9.2 over the Norwegian Sea

The successful launch of the ATHEAt flight experiment marked an important milestone in the development of reusable space transport systems.

by Denise Nüssle

Image: DLR

The launch of a rocket into space is a magical moment. Its return to Earth, by contrast, is far less poetic: the atmospheric re-entry of a spacecraft is like a ride through purgatory. After a tough mission, both people and materials find themselves once again pushed to their limits. At speeds of up to 28,000 kilometres per hour (25 times the speed of sound, or Mach 25), conditions are extreme. From Mach 5 onwards – the hypersonic regime – additional phenomena occur: the air behind the shockwave and in front of the vehicle is heavily compressed. Depending on the speed, this raises gas temperatures to several thousand degrees Celsius. This tremendous heat puts immense stress on spaceflight structures and triggers chemical reactions on their surfaces. Aerodynamic forces are just as extreme at these speeds and technologically challenging to manage.

Reusability and re-entry

Space transport systems that can be used multiple times have the potential to make spaceflight more cost-effective, sustainable and fast. DLR is developing and testing the technologies required to achieve this, one example being the ongoing ATHEAt project. Like its predecessors, ATHEAt builds on a combination of sophisticated simulations, computer-based design, component testing on the ground and flight experiments aboard sounding rockets.

With each project, DLR researchers push the boundaries of what is technically feasible a little further. Their goal this time is to fly for longer than before at very high speeds between Mach 8 and 10. "The requirements we recreate in the ATHEAt flight experiment are conditions that the thermal protection systems of future reusable space transport vehicles must reliably withstand multiple times during atmospheric re-entry," explains project lead Ali Gülhan. "Re-entry at extremely high speeds is a sticking point in the development process – including for space companies. With projects like ATHEAt, we are working specifically to close this remaining technology gap. That's why stakeholders from research and industry around the world are closely watching our progress."

Nature, Northern Lights and space technology

Understandably, anticipation and tensions were high in mid-September 2025 as the ATHEAt team, after years of development work, made their way to the far north of Norway with the completed flight experiment. The small island of Andøya normally attracts visitors drawn by the rugged nature, keen to spot sea birds and whales or to revel under the Northern Lights. Yet just a few kilometres from the main town of Andenes, home to 2500 residents, lies a rocket launch site known only to spaceflight insiders. Located directly by the sea with a mountain range behind it, Andøya Space offers ideal conditions thanks to its location and flight corridor over the Norwegian Sea. The location is also well suited to launch DLR research rockets – particularly when their payload is not recovered post-flight.

Before launch, teams from DLR and Andøya Space go through every step together, supported by a checklist tailored for each scenario – the 'countdown procedure'.

View of Andøya Space, where more than 700 sounding rockets have been launched since 1962

High-tech ceramics at the tip

The payload accounts for the first 3.5 metres of the 13.5-metre-long research rocket. It contains scientific experiments as well as the service module for measurements, power supply and data transmission during flight. The front part of the payload, known as the forebody, is shiny grey. Its surface is made from a special fibre-reinforced ceramic. Manufactured entirely at DLR, it is extremely effective; as a high-performance material, it can withstand temperatures in excess of 2000 degrees Celsius, is mechanically very stable and yet comparatively lightweight.

“One challenge when working with fibre-ceramic materials is manufacturing them in the geometries and extremely precise dimensions required for spaceflight,” explains DLR engineer Thomas Reimer who, working in a small team, designed, manufactured and assembled the forebody structure. Thin-walled, curved shells like those used on the forebody of ATHEAt are particularly difficult to manufacture, because during production the components are, for example, heated in a furnace and shrink in the process. This must be carefully factored into calculations in advance so that everything fits together at the end. “The know-how we gain from projects like ATHEAt is also important if we want to manufacture such components in large numbers in the future,” Thomas adds.

The forebody not only represents a great deal of development work – it has a dual function during flight, serving as both thermal protection and as a research experiment. With it, two different active cooling methods are being tested to reduce surface temperatures in certain areas across the forebody. In one method, nitrogen is forced through specifically created pores in a ceramic sample to produce a cooling film on the exterior. In the other, a cooling gas flows at high speed along the inside of one of the fibre-ceramic structures.

Upon arrival, it’s time to unpack and get to work: the DLR crew and a Norwegian team assemble the individual components into a rocket and carry out final functional tests.

One new feature is the flaps on the forebody – in the future, such flaps could be used to steer rockets.

Images: p. 12 DLR; p. 13 (centre) DLR

For the first time, four unique, slightly protruding rectangular flaps – equipped with sensors and designed to change their deflection angle in flight – are mounted on the flight experiment’s payload section. Also made of fibre-reinforced ceramic, they are designed to fold out in flight. In the future, such flaps could be used to steer rockets. Due to their exposed position, however, they too get extremely hot.

Hundreds of sensors collect unique data

Inside the payload, space is extremely limited. A multitude of cables and wires crisscross each other as more than 300 sensors are on board – including all the necessary infrastructure to control them, supply them with power and transmit data by radio. Among these are some very special measurement techniques – the first of their kind. They include laser distance measurement systems and a laser line scanner. Beneath the flaps, two infrared cameras and radiation thermometers are also installed.

ATHEAt’s instrumentation incorporates DLR’s specialised expertise and many years of experience. At the same time, it is designed to generate reliable and comprehensive datasets, which form the foundation for all further technological developments. During flight, all data is collected and transmitted by radio to receiving stations near the launch site, where they are stored. Since the payload is not retrieved after the flight, the team has precisely one chance to get their hands on this unique treasure trove of data. Accordingly, extensive functional tests are carried out on the sensors, including during a virtual flight simulation. Meanwhile, another part of the ATHEAt team prepares the two motor stages.

Integration and final checks

To transfer research from the laboratory onto a rocket and then into the air or space, DLR operates its own facility: the Mobile Rocket Base (MORABA). It plans, oversees and launches suborbital sounding rockets – and has done for almost 60 years, from locations almost everywhere on Earth.

"For the ATHEAt flight experiment, we don't need great altitudes; instead, we fly along a relatively flat trajectory to reach the necessary high thermal loads for as long as possible," explains Dorian Hargarten from the MORABA team. The trajectory is calculated in detail in advance since the research rocket cannot be actively steered after launch – making such experimental flights particularly cost-effective. "The payload mass, aerodynamics, motors used and the direction and angle of the launch rail all play an important role in these calculations. Factors such as wind speeds at different altitudes are also vital variables – yet cannot be controlled and so always involve assumptions."

To achieve the planned trajectory and high speeds, the team relies on a custom-configured two-stage propulsion system. The first, lower propulsion stage – RED KITE – was jointly developed by DLR and Bayern-Chemie. Hidden beneath its casing is a particularly powerful solid rocket motor, produced entirely in Germany. The second, upper stage uses a Canadian 'Black Brant' rocket motor.

While the payload is already combined with the upper stage and waiting to be transported to the launch pad, technicians connect the lower motor stage to the launch rail. All work is carried out under strict safety protocols, as explosive materials and a whole lot of fuel are used for every rocket launch.

Finally, DLR and Andøya Space carefully roll the payload with the upper stage to the launch site and begin the final integration steps. Although the launch is angled upward, the fully assembled rocket is first erected vertically. Once the final preparations are complete, the launch rail is lowered back down and locked. To protect against moisture, the upper part of the research rocket is covered with a Styrofoam casing.

Dress rehearsal for launch

When it comes to rocket launches, nothing is left to chance. A crucial component of launch preparation is therefore the test countdown, conducted one or two days before the launch window opens. This provides reassurance to everyone involved as excitement builds – and reveals whether the carefully planned sequence also works in practice. At this stage, all threads come together: phones are in constant use, heads huddle together and turn back to the phalanx of monitors in front of them. The countdown is halted multiple times. These 'holds' are used, for example, to allow more time for important steps, restart subsystems or wait for better weather. By late afternoon, the test countdown is complete. A day off follows to relax and clear one's head – with a run, trip to the sauna or on a hunt for the island's best cinnamon roll.

Everything ready – except the wind

Just in time for the opening of the launch window on 3 October, the weather takes an unfortunate turn for the worse. Persistent cloud cover and strong winds in the middle and upper atmosphere are particularly critical. The campaign plan allows nine days to launch the ATHEAt flight experiment. After this, the next projects are already lined up. Now begins a period of waiting and weighing up options: should the team hope for better conditions in the next days? Would that risk time pressure if the weather gets worse?

Here, as with many other launch scenarios, routine, experience and preparation prove invaluable. On the first three days, teams from DLR and Andøya Space meet each morning to discuss the weather conditions, and despite the odds they begin preparations. They work through the countdown up to 40 minutes before launch, then wait in standby position. Should the clouds dissipate and winds ease, they can respond quickly and seize any good opportunity. On the first day, everyone waits in hope until late afternoon. On the following two days, the countdown is aborted earlier.

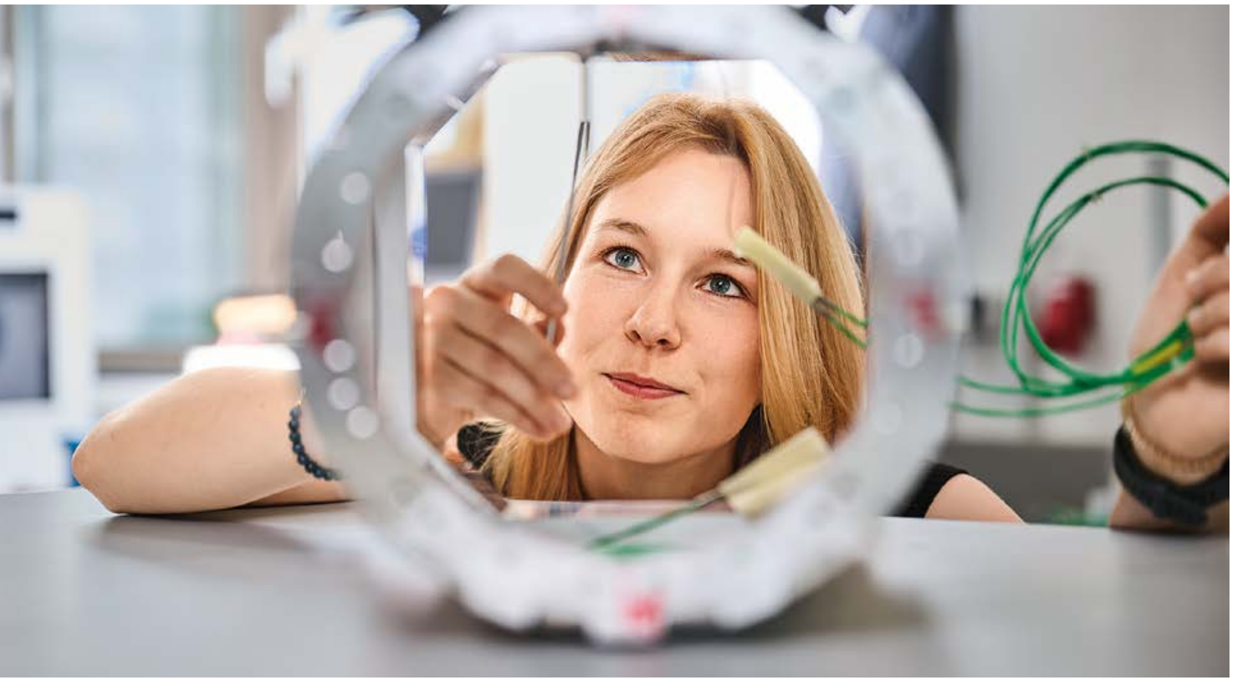
The fourth day finally brings the change in weather they hoped for. After the morning meeting and review of the latest meteorological data, spirits lift and fresh momentum is injected into the countdown. Even 40 minutes before the scheduled launch, the weather continues to play ball and the clock ticks away. The lid above the launch rail opens and the rocket raises into position. At 20 minutes before launch, the final weather balloons rise into the sky and confirm:

Even at night, Andøya offers a stunning backdrop (left).

On a lifting platform, two colleagues with a head for heights tighten the final connections between the rocket components and check everything one last time (top).

Image: p. 15 (bottom) DLR

Developed entirely in Germany by DLR and Bayern-Chemie, the RED KITE motor lifts the rocket off the ground.



conditions are good to go. The Norwegian safety officer reports that the area around the launch pad is clear, the road is closed and the airspace over the sea secured. Radar and telemetry stations are ready to receive and begin recording. Three minutes before launch, a loud siren sounds and all participants are fully focused. Ninety seconds to go – all stations report their "go" loud and clear. A computer voice counts down the final seconds, and the Andøya Space mission director pushes the button to initiate ignition. Flames and a cloud of smoke appear, followed by a jet of fire along the launch rail. It takes just under a second for the bang to reach those team members not sitting in the control room but observing the liftoff from outside the safety zone or from the mountain ridge. By then, the rocket has already left the launch rail. Seconds later, it is barely recognisable in the clear blue sky above the sea.

Even with the successful launch at 10:45 a.m. on 6 October, the mission is far from over. Tension in the control room remains palpable. Just seconds after launch, the first propulsion stage burns out and separates. The second stage then ignites, accelerating the ATHEAt flight experiment so quickly that it flies for a total of four minutes – including two minutes in the hypersonic range above Mach 5, reaching a top speed of Mach 9.2. Roughly speaking, that's just under three kilometres per second. At the end of the flight, the burnt-out motor stages and payload splash down in the designated and secured area. Joy and relief spread through the control room – especially when it is confirmed that the telemetry stations have received and secured comprehensive measurement data.

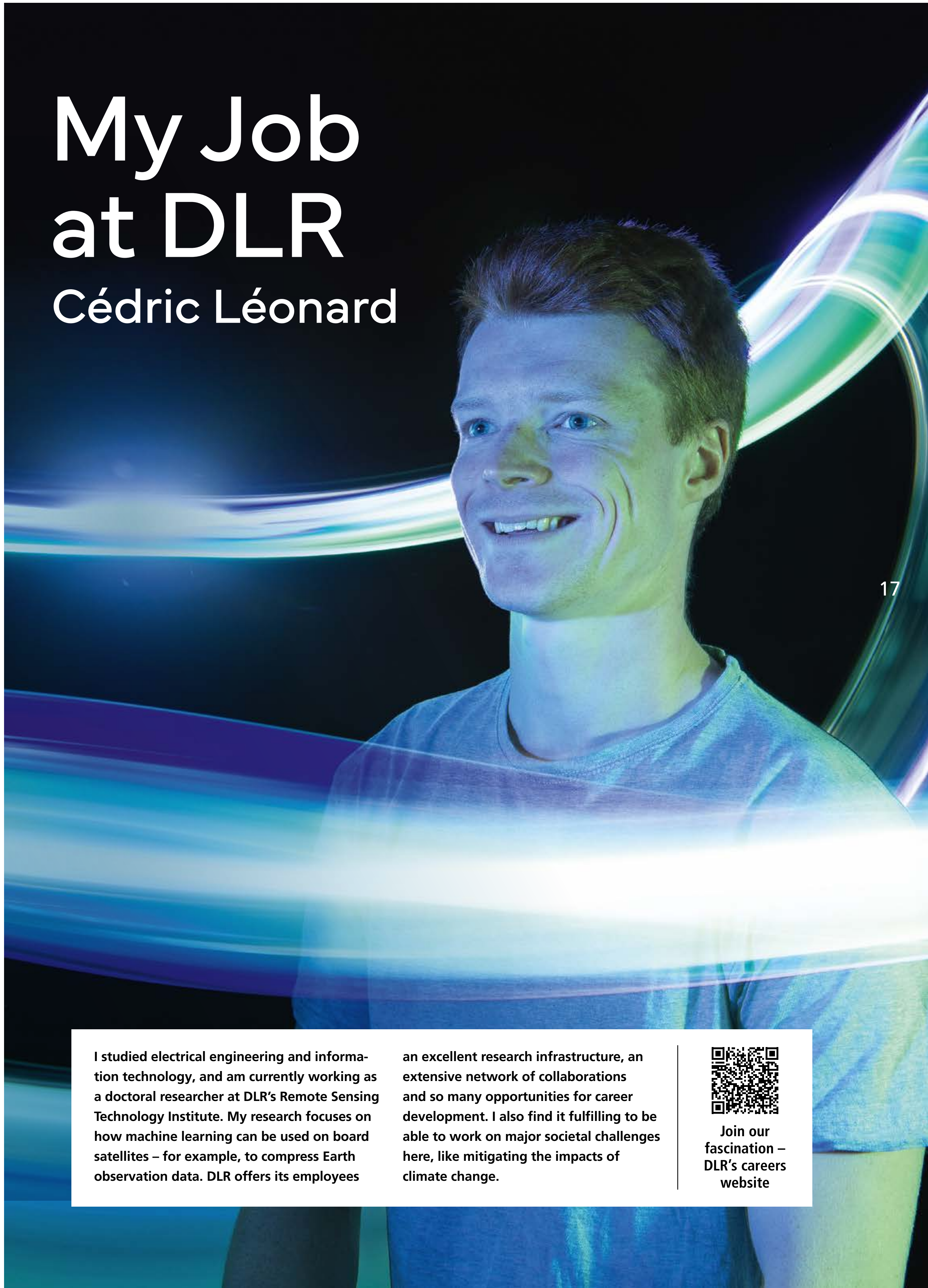
The forebody structure is prepared to mount the thin-walled, shell-shaped components made of fibre-reinforced ceramic.

A treasure trove of data for further development

"In total, we received several gigabytes of measurement data from the sensors. For a mission in which all data was transmitted by radio during flight under extremely challenging conditions, that is an excellent result," sums up project lead Ali Gülhan. Preliminary data show that the flaps deployed as planned. The in-depth assessment of this successfully collected wealth of data will take time: first, the individual data series from the more than 300 sensors must be pre-sorted and their plausibility and reliability reviewed. Only then can researchers make robust statements about temperatures, pressures and aerodynamic and aerothermal effects. This new knowledge will then be compared with models, simulations and wind-tunnel tests – with the goal being to launch a more advanced flight experiment in the next project.

Denise Nüssle is a press editor at DLR. She reports on research in energy and transport, but also regularly ventures into the world of spaceflight. For DLRmagazine, she accompanied the campaign on site.

Images: DLR



My Job at DLR

Cédric Léonard

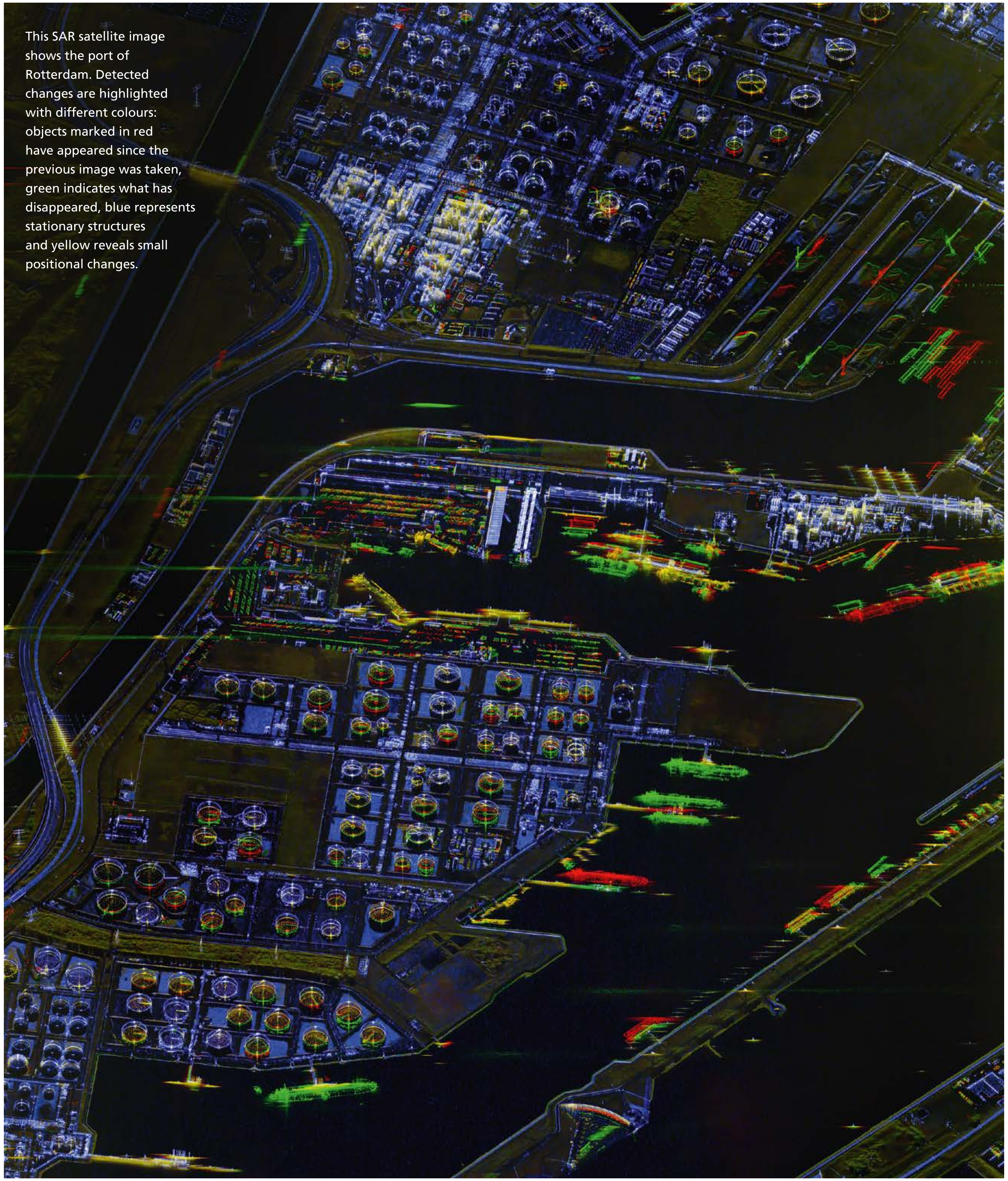
I studied electrical engineering and information technology, and am currently working as a doctoral researcher at DLR's Remote Sensing Technology Institute. My research focuses on how machine learning can be used on board satellites – for example, to compress Earth observation data. DLR offers its employees an excellent research infrastructure, an extensive network of collaborations and so many opportunities for career development. I also find it fulfilling to be able to work on major societal challenges here, like mitigating the impacts of climate change.

Join our fascination – DLR's careers website

Image: DLR

Boosting efficiency under pressure

Research into improving aircraft engines has been ongoing for decades, with one key aim being to reduce the climate impact of aviation. One central strategy is to increase efficiency – delivering the same performance while lowering fuel consumption. The next generation of gas turbine engines is expected to make a significant contribution through improved compressor technologies, including designs optimised for the use of sustainable aviation fuels (SAF). Aircraft compressors increase the pressure of incoming air, which is then mixed with kerosene in the combustion chamber and ignited to produce hot, high-pressure gases that generate thrust. Together with MTU Aero Engines and GKN Aerospace Sweden, DLR has been working on the validation of new compressor technologies as part of the European Clean Sky 2 research programme. The goal was to reduce carbon dioxide (CO_2) and nitrogen oxide (NO_X) emissions in aviation by 20 to 30 percent compared with 2014 levels. Up until November 2025, tests were carried out on the multi-stage two-shaft compressor test rig at the DLR Institute of Propulsion Technology in Cologne. The test campaign focused in particular on improving the interaction between low-pressure and high-pressure components, as well as the transition duct between the two compressors. The extensive findings confirm the ambitious design targets of the tested concept, marking an important step towards achieving the Clean Sky 2 objectives.



This SAR satellite image shows the port of Rotterdam. Detected changes are highlighted with different colours: objects marked in red have appeared since the previous image was taken, green indicates what has disappeared, blue represents stationary structures and yellow reveals small positional changes.

Image: TerraSAR-X, copyright DLR e.V. (2017), distribution by Airbus Defence and Space GmbH, processed by TerraLens GmbH

DISCOVER
Satellite data

Searching for a needle in a haystack

DLR spin-off TerraLens uses AI to analyse satellite data

by Jonas Daniels

Founding a company," says Manfred Hager, "was a challenge that appealed to me." With a degree in electrical engineering, he has been part of DLR since 1997. Together with his colleagues Carlos Villamil Lopez and Harald Anglberger, Manfred co-founded the start-up TerraLens in 2022. Until then, the three had worked at the DLR Microwaves and Radar Institute. Their work had long been focused on the analysis of satellite data, yet their interest in Earth observation developed in a roundabout way: Manfred and Carlos studied electrical engineering, while Harald is a technical mathematician. Eventually they ended up in the same research group and worked on analysing SAR satellite data – a technology that fascinated them from the very start.

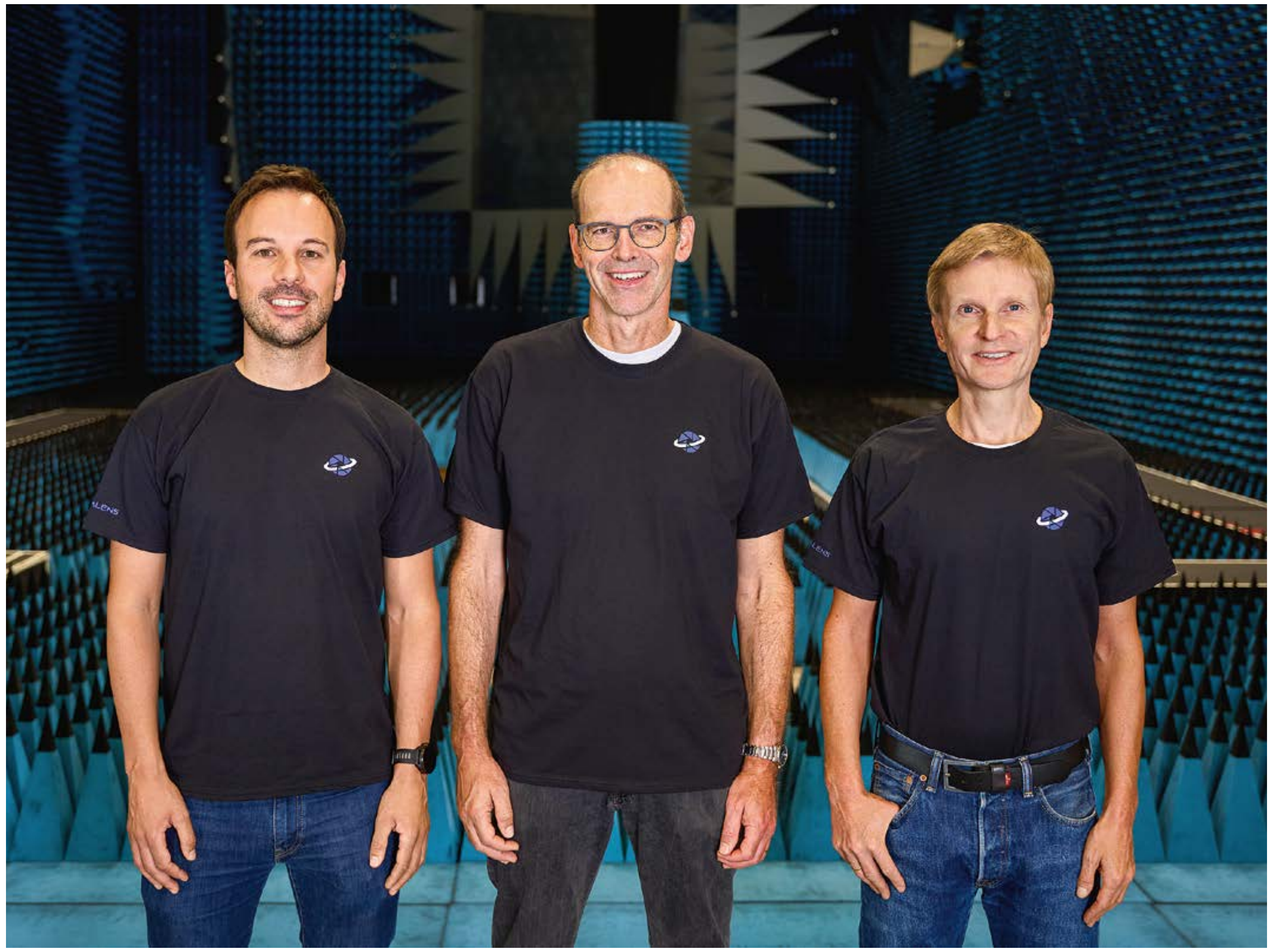
Earth observation, day or night

Satellites carrying Synthetic Aperture Radar (SAR) sensors typically operate in low Earth orbit. As Harald puts it, these satellites "essentially bring their own torch". They send radar waves towards Earth's surface, enabling them to generate images independent of light conditions. The radar waves even penetrate clouds, providing images whatever the weather. Radar images generated in this way can achieve levels of detail similar to images captured with visible light.

Germany has been operating its own SAR satellite missions since 2006. Most recently, the European Space Agency (ESA) launched the Biomass mission, with a satellite of the same name using SAR to precisely determine forest biomass – the mass of living things (see page 32, 'Flying in sync over the jungle').

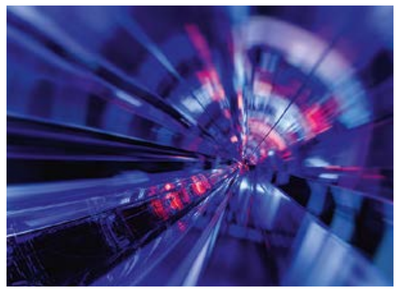
The rising number of satellites is also leading to an increase in available SAR data – which is both a blessing and a curse. While swathes of data ensure a more comprehensive image of the Earth, human analysts are no longer able to process the flood of data. Picking out relevant information is akin to the proverbial search for a needle in a haystack.

Check out the TerraLens website



THE DLR_STARTUP FACTORY

Since 2023, DLR has offered a comprehensive and systematic framework programme through the DLR_Startup Factory to get successful, research-based start-ups off the ground. These businesses put research insights into practice, bringing them to market. They generate new ideas to drive innovation. Through products and services, they create value and help solve society's challenges.



The three TerraLens founders (from left: Carlos Villamil Lopez, Manfred Hager, Harald Anglberger) set up their business four years ago based on their idea that AI could help assess SAR satellite data.

AI helps trawl through the data

This is where the idea behind TerraLens comes in. The start-up markets software that, with the help of artificial intelligence, supports the analysis of SAR satellite data. This is a real technical challenge as radar images are subject to a variety of disruptive effects, including strong noise and 'layover' effects – areas with ambiguous information in the pixels. The TerraLens software helps to visually process the images so that they are easier to interpret. What's more, it enables the automated detection of changes over time, ranging from alterations to infrastructure or buildings through to the identification of previously unknown objects.

Images: p. 22 (above) TerraLens; p. 23 DLR

Suddenly, an entrepreneur

Making the switch from scientist to entrepreneur isn't easy. Besides keeping up with scientific and commercial developments impacting their business, entrepreneurs must also deal with personnel responsibility, project funding and attracting investors.

"It is important to us that our research results provide added value for people. They can do so if they are transferred into the commercial world, for example in the form of start-ups," says Karsten Lemmer, DLR Executive Board Member for Innovation, Transfer and Research Infrastructure. Of the 94 spin-offs that have emerged from DLR since 1993, approximately 90 percent are still in business.

In 2023, to support DLR researchers through the spin-off process, the DLR_Startup Factory was established – a company-building programme that guides DLR employees step by step as they realise their founding aspirations. Start-up coaches support teams in developing a business idea based on their research and assess its market potential – above all, they help strengthen entrepreneurial skills. The aim is to form the basis for a start-up's long-term success.

Business idea driven by geopolitical developments

TerraLens is now almost four years old. Since its founding, the European market has changed. "The defence technology market is currently being shaken up," says Harald. "New fields of business are constantly emerging, and competition is fierce." Manfred adds: "Our time at DLR means we have many years of experience in the security sector. As a small, agile company, we offer another key advantage – we're fast!"

Jonas Daniels is an editor for the DLR Executive Board department for Innovation, Transfer and Research Infrastructure.

3 questions for...

Georg Seydel, Departmental Head at DLR and Director of the DLR_Startup Factory

Who does the DLR_Startup Factory support?
We support employees who want to start their own business based on DLR research. The programme is open to all colleagues – from scientific staff to institute directors. Those interested in founding a company can even come to us without a concrete idea, and we will explore together whether a viable business concept can be developed.

How is the programme structured?
The programme consists of five successive stages, starting with idea generation and followed by the development of a business model. This model is then validated through a market study involving customer interviews. If the study findings are positive, the teams start to build their entrepreneurial skills and prepare for the formal establishment of the company. In the final stage, funding models are devised for the start-up and the opportunities for DLR to get involved are examined. Every team of founders is accompanied by one of our DLR_Startup Factory coaches, who remain on hand for support.

What's in it for DLR?
DLR benefits in many ways from spin-offs. They bring our research into real-life application, benefiting both society and the German economy. Numerous examples show that start-ups continue to cooperate with DLR after being founded, further developing technologies together. As a result, hands-on insights flow back to DLR. Last but not least, DLR's various institutes also benefit from licensing revenue – every start-up whose operations build on DLR patents licenses the relevant technology under standard commercial terms.

DEPA 2070 – the future of flight

Evolution of passenger aviation up to 2070

Image: Shutterstock/dragunov

ABOUT THE STUDY

In DLR's DEPA 2070 project (DEvelopment Pathways for Aviation up to 2070), researchers investigated how global aviation could evolve over the coming decades – and how climate protection and growth can be reconciled in the process. Together with five DLR institutes and under the leadership of the DLR Institute of Air Transport, researchers analysed technological, economic and societal developments. The focus was on future trends, scenarios and the assessment of new aircraft technologies. The result is tangible prospects for a sustainable and competitive aviation sector.

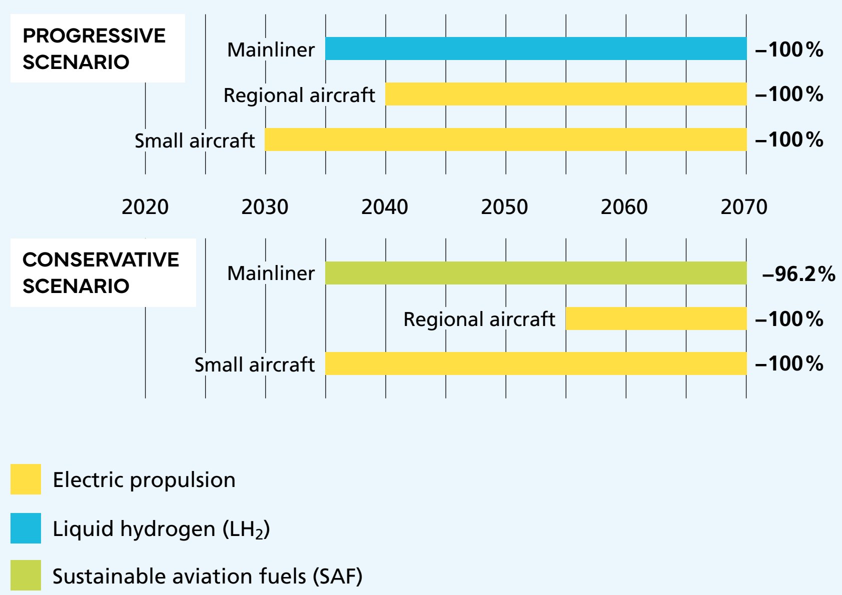
More information on DLR's DEPA 2070 project

Two scenarios, one goal: climate-compatible flying

	CONSERVATIVE	PROGRESSIVE
Energy source	primarily sustainable aviation fuels (SAF), battery-electric and hybrid-electric propulsion	liquid hydrogen, battery-electric and hybrid-electric propulsion
Technology rollout	2030 to 2060	2025 to 2050
Potential CO_2 reduction per 100 passenger-kilometres compared with 2025	–23%	–89%
Focus	primarily today's aircraft technologies, including retrofitting or upgrading existing aircraft	new aircraft types and infrastructures

The study presents two potential pathways into the future – one conservative scenario and one progressive. Both make clear that, in the long term, aviation can only become climate-compatible through new propulsion systems and energy carriers. The conservative scenario focuses primarily on more efficient aircraft and increased use of sustainable aviation fuels (SAF). The progressive scenario takes a more ambitious approach, factoring in the early adoption of hydrogen-based and battery-electric propulsion systems.

Aircraft roadmap by fuel



>100% increase in air traffic,

–89% CO_2 per 100 pkm*

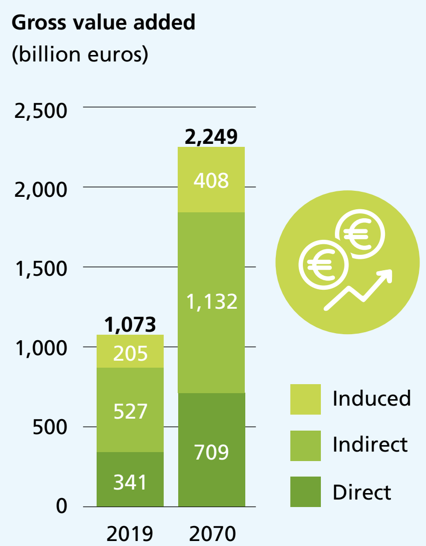
Despite an expected doubling of air traffic volume by 2070, CO_2 emissions per 100 kilometres travelled by one person could be almost entirely reduced compared with 2025 – provided new technologies are rolled out consistently. The modelling shows how alternative propulsion systems, sustainable fuels and more efficient aircraft can together deliver major emissions reductions across all aircraft types, from mainliner to small aircraft.

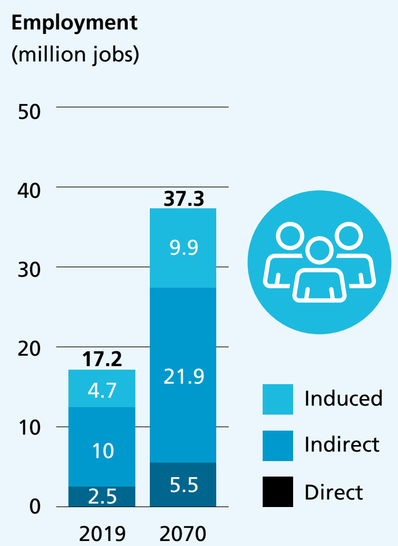
* passenger-kilometres

A wind of change for the economy and society

The transition to climate-compatible flight is also an economic opportunity. According to DEPA 2070, the global value created by aviation could double between 2019 and 2070, reaching approximately 2.2 trillion euros. At the same time, worldwide employment would grow from 17 million to more than 37 million people.

New technologies and propulsion systems generate innovation, jobs and momentum for the entire sector. Mobility solutions are changing travel as we know it: hybrid-electric aircraft, improved airport access and supersonic connections could make flying more flexible, fast and sustainable in the future.





OUTLOOK: DEPA – EXT.

In the follow-up project DEPA – ext. (extended), DLR is analysing how uncertainties – such as energy availability, infrastructure or geopolitical developments – could influence aviation from now until 2070. The aim is to develop realistic yet alternative future scenarios for the next 45 years and derive robust strategies from them.

More information on DEPA – ext.

Licence to post

Between the office, hangar and laboratory: thirteen DLR employees report on their everyday work on social media

by Melanie Dorweiler

Image: DLR

DISCOVER
People at DLR

Robert Schültzky seems like someone who isn't easily flustered. In fact, he sounds like a career as a radio presenter or voice actor might once have been on the cards for him. Nevertheless, he works at DLR's Flight Experiments facility where he installs measurement equipment in helicopters, supports flight test campaigns and evaluates the resulting data. His enthusiasm is not purely professional – Robert is also working towards getting his private pilot's licence. He speaks with such energy about their flexibility, manoeuvrability and panoramic views that even I – an airline passenger prone to travel sickness and a fear of heights – feel a flicker of euphoria. It is precisely this enthusiasm that Robert wants to share on LinkedIn.

"Tinkerers welcome!"

Daniela Heine wasn't particularly interested in social media before becoming a DLR Ambassador. Together with her team, she investigates the aerodynamic behaviour of trains as they enter tunnels. The tunnel simulation facility she works with is a 60-metre-long test track on which 1:25-scale models travel at speeds of up to 100 metres per second. Daniela and her team build both the models and the technology to measure them. "Tinkerers are always very welcome here," she explains, because test campaigns often require creative solutions. These are precisely the kinds of tinkerers she hopes to inspire in her work via LinkedIn.

At home in uncharted territory

Carina Kanitz likes to get her hands dirty at work. The experimental physicist screws, drills and solders in the lab – and is currently building an experiment at the DLR Institute of Quantum Technologies in which matter waves are diffracted. With her work in the field of quantum sensing, she is breaking new scientific ground. Carina approaches her role as a DLR Ambassador with the same pioneering spirit that led her to give up her work as a nuclear physicist at CERN and switch to quantum technologies for her doctorate at DLR. "People should know what happens in science and how it is done."

Steampunk in the workshop

Nick Evers is also someone who enjoys tinkering and working with his hands. His training as an industrial mechanic focuses on manufacturing extremely precise components for equipment and experimental set-ups. He has already completed his apprenticeship piece – a steam engine. At first glance, this may seem somewhat anachronistic, but the skills he has learnt are now used to carry out commissioned work and his own projects. He is particularly attracted by the fact that, in his role, no two parts are ever the same: "Every job is unique."

Connecting and inspiring

Carolin Altmann also came to DLR to try something new. A few years ago, she was tasked with establishing the DLR_School_Lab in Jena. Carolin is eager to inspire children and young people to take an interest in science – especially those who do not come from academic backgrounds. "I always take pleasure in interacting with others," she says. "I love adapting to each class and thinking about how best to engage the children." As a DLR Ambassador, connecting and inspiring is also her approach online – for the researchers of the future.

"People trust people"

Direct interaction with people is a crucial factor in Arti Kalra's everyday research. She develops control systems for helicopters that support pilots during maritime operations, such as rescue missions at sea. "It's not about replacing people," she emphasises, "but taking the pressure off them. People trust people, not machines." It was professional curiosity that drove her to join the DLR Ambassadors Programme, hoping that she can reach other researchers on social media as well as scientific and political decision-makers.

"Everyone has an opinion on it"

Julia Jarass knows what it means to engage in dialogue. The geography graduate, whose research focuses on mobility and sustainability, has organised, conducted and evaluated several real-world experiments at the DLR Institute of Transport Research. She sees social media as an opportunity to draw attention to successful transport projects. If she could choose one thing, it would be for people to take centre stage in road planning – with lots of greenery and creative approaches to rethinking how space is used.

Find our Ambassadors on LinkedIn:

Robert Schültzky

Daniela Heine

Carina Kanitz

Nick Evers

Carolin Altmann

Arti Kalra

Julia Jarass

Where food isn't found, but grown

Green is Jess Bunchek's keyword. The American astrobotanist works at DLR on the question of how to grow food in hostile conditions. For fourteen months, she grew vegetables in Antarctica as part of DLR's Eden ISS project. Originally, the agricultural scientist had farmers in mind. Now, she is thinking more in terms of spaceflight, as the experiments she is conducting aim to enable the cultivation of fresh food on future missions to the Moon and Mars. Jess now looks forward to reporting directly on social media and connecting with fellow DLR Ambassadors.

The Moon on Earth

Maria Hallinger is responsible for Moon missions – at least, for those taking place on Earth. For nearly two years, she has worked for DLR on the LUNA project – a joint undertaking with ESA. LUNA is a unique test facility where researchers can simulate Moon missions under realistic conditions. Maria is part of the team that oversees these test campaigns and ensures conditions in the facility are always right. She is happy to now officially share her insights as part of the Ambassadors Programme: "You could say I now have the licence to post!"

Satellites made of wood?

For Isil Sakraker Özmen, the Moon is not the priority. This aerospace engineer is more interested in what's going on down in Earth's orbit. She works on making satellite structures more sustainable – so that they completely burn up at the end of their operational life and don't leave behind any space debris. This concept is known as Design for Demise. Together with colleagues, Isil experiments with new materials, even including wood, and examines their effect on the environment and atmosphere. As a DLR Ambassador, she hopes to raise awareness for sustainable spaceflight: "I like the idea that I can be a role model," she says. "I'm happy to take the time for that."

Feeling the breeze

Closer to the ground, between the sky and Earth, you'll find Lukas Firmhofer – at least whenever he's at DLR's 'WiValdi' research wind farm. Lukas is project lead for the OPUS 3 project – an experimental turbine designed primarily as a test platform for aerodynamic and aeroelastic research. The facility can be modified in a near limitless number of ways as individual components can be swapped to suit requirements. Lukas was himself involved in building the nacelle – "That's where the mechanical engineer in me comes in," he says. As a DLR Ambassador, Lukas wants to achieve one thing above all else: to raise awareness for the project – and thereby gain new collaborations with the worlds of research and industry.

Find our Ambassadors on LinkedIn:

Jess Bunchek

Maria Hallinger

Isil Sakraker Özmen

Lukas Firmhofer

Anika Weber

Simon Mechenbier, Project Lead of the DLR Ambassadors Programme:

Breathing new life into PhD ideas

Anika Weber's research also sits at this interface between science and industry. As part of her doctorate, she is developing a novel reactor concept that produces synthesis gas using concentrated solar radiation. Anika almost became a maths and physics teacher, but the appeal of going into research was ultimately stronger. "I don't want to look towards a retirement spent reading about one disaster after the other," she says, explaining her decision to choose energy research. In her view, solar energy has massive societal and economic potential. That is precisely why she is now a DLR Ambassador. Good research must not remain trapped in the laboratory, she stresses: "It's of no use if we develop something great but nobody knows about it."

Melanie Dorweiler works at DLR Projektträger and is looking forward to getting to know her employer from a new perspective thanks to the Ambassadors Programme.

THE DLR AMBASSADORS PROGRAMME

Showcasing DLR in all its diversity, highlighting team members' achievements, sparking fascination for research and perhaps even inspiring a career at DLR – these are the goals of the Ambassadors Programme. "Research doesn't happen in an ivory tower," explains Simon Mechenbier from the social media team, who leads the programme.

Innovation for medicine

North Rhine-Westphalia is a hotspot for the healthcare industry – and DLR Projektträger connects the key players

by Sarah Sommer

Image: Getty Images/Solskin

Could people breathe through their intestines if their lungs fail? A biomedical start-up in Aachen is researching precisely this question. Meanwhile, in Duisburg, chemists are developing metal nanoparticles that could help proton lasers combat tumours more effectively. And in Wuppertal, an interdisciplinary team from policy and medical research is investigating how local authorities can best address health risks caused by climate change.

Around universities and leading research institutes in North Rhine-Westphalia, numerous start-ups, small and medium-sized enterprises, research-intensive clinics and large international corporations from the medical technology and pharmaceutical industries have established themselves. Innovative medicine is taught, researched and developed at nine medical faculties and university hospitals, approximately 80 teaching hospitals, 30 higher education institutions and more than 50 non-university research and development institutions. With the Medizin.NRW cluster, DLR Projektträger has established a central competence platform that connects all of these players – ensuring their ideas and research results reach practical application more quickly.

Visit the Medizin.NRW cluster website

Cutting-edge medicine for tomorrow

There are few current trends in medical science and practice that are not being researched, tested or reimagined in Germany's most populous federal state. "Nanotubes, biosensors, neuroimplants – some research topics still sound like science fiction, but they have the potential to revolutionise medical practice as breakthrough innovations," says Patrick Guidato, manager of the Medizin.NRW cluster at DLR Projektträger. Wherever cutting-edge research is conducted, the question arises as to how patients can benefit from it in everyday medical practice. Interdisciplinary collaboration is essential to ensure that innovations actually make it into healthcare provision – and quickly. This is where the Medizin.NRW cluster comes in, promoting strategic networking in North Rhine-Westphalia as a hub for innovation and medicine. DLR Projektträger manages the cluster on behalf of the North Rhine-Westphalia Ministry of Culture and Science. “Our most important task is to create analogue and digital networks that bring together key players in the world of cutting-edge medicine,” says Patrick.

Improving medical care

Since its establishment in 2019, the four-person cluster management team at DLR Projektträger has already set up six such networks, with more than 300 experts at various career stages in science, industry and healthcare actively involved. “We identified strategic cross-cutting issues that bring together stakeholders from as many different disciplines as possible – and then developed a range of offerings and events around these topics to facilitate the exchange of knowledge and experience,” explains Patrick.

What all these lighthouse projects have in common is their focus on the perspectives and needs of patients and civil society. Because the fundamental question for the ‘translation’ of research results from the laboratory into clinical practice is: what is actually needed?

Finding clinical trials more quickly

One of the cluster’s most recent projects also emerged from this question: an information platform for clinical trials. “Clinical trials are the linchpin of every medical and medical-technology innovation,” says Patrick. Only once a medical innovation has been proven in a study to be safe and effective, and to provide a measurable improvement in healthcare, can it actually be used in clinical practice.

For many stakeholders in this process – such as medical practices, companies and other researchers – it is often a challenge to identify relevant studies and trial locations, suitable partner companies and appropriate patients. “There are various national and international databases available to search for suitable trials,” explains Cluster Manager Patrick, “but they are so complex that even experts find them difficult to use.” This led to the idea of creating a platform that provides an overview of clinical studies in North Rhine-Westphalia.

Impressions from the cluster conference ‘Zukunftsfähige Spitzenmedizin in NRW’ (Future-proof cutting-edge medicine in NRW) on 1 April 2025 in Düsseldorf

DLR start-up analyses data

The digital platform klinische-studien.nrw has been live in a test version since October 2025, for the first time bringing together structured information on clinical trials in North Rhine-Westphalia. The platform is based on an AI-supported tool developed by the DLR spin-off Kwintely Intelligence, which was originally designed to evaluate patent and publication databases. “We then asked: can you also extract and process data from medical registers?” reports Patrick.

The challenge is that the data in the existing trial registers is not recorded in standardised formats, which makes them difficult to interpret. The Kwintely AI solves this problem by collecting publicly available trial data from various international registers, standardising it and linking it to scientific publications. A team from DLR Projektträger has also developed an interactive web interface allowing users to search and analyse studies conducted in North Rhine-Westphalia by keyword, start year and end year.

Even during the test phase, feedback from as many different stakeholders as possible – from science, industry and clinical practice – is now being sought, emphasises Patrick: “We want to gather diverse feedback – and also use the new trial platform strategically to better connect North Rhine-Westphalia’s healthcare industry and improve patient care.”

Sarah Sommer writes for DLR Projektträger and is fascinated by advances in modern medicine.

Images: p. 30 Vogelheim TV/Jens Koch; p. 31 DLR

DISCOVER
DLR Projektträger

“We make the possible visible”

The framework conditions in the healthcare sector are complex. Patrick Guidato, Cluster Manager at Medizin.NRW, explains how innovation can still succeed.

Mr Guidato, why do innovations fail in the healthcare sector?

The framework conditions are challenging: anyone seeking to implement a medical or medtech innovation into routine care has to deal with complex approval procedures, questions of cost reimbursement and patent law. At an early stage, they must demonstrate that the innovation delivers tangible benefits – under challenging organisational and technological conditions. But that doesn’t mean you should let this discourage you.

How can these obstacles be overcome?

By recognising that there is always someone who has succeeded before and from whom you can learn something. All players in the healthcare sector operate within these challenging conditions and can learn from one another how to successfully implement innovations in this environment. But first, they need to know about each other – to meet and start talking. This is where we see a key role for our cluster: we make the possible visible.

Which topics are currently particularly relevant for the development of the healthcare sector?

There is a wide variety of topics and trends that we are addressing. In today’s tense geopolitical and international environment, many researchers and companies are concerned with issues such as the availability of raw materials and skilled personnel – and we are in close exchange with other healthcare clusters across Germany and Europe. Innovative solutions are also needed, especially when it comes to the impacts of climate change on health. Age-related medicine is another topic that concerns many professionals in the industry: how can we pool medical expertise – from paediatricians to geriatric specialists – to better address the consequences of demographic change for the healthcare system and patient care? Of course, advances in biohybrid medicine are also equally fascinating: breakthroughs in this field could completely transform medicine as we know it. In short, it remains exciting! In all of these areas, the Medizin.NRW cluster will be called upon in the coming years to bring innovators together.

PATRICK GUIDATO

has been Cluster Manager at Medizin.NRW since 2019. A biochemist, he has many years of experience in research management and technology transfer.

Flying in sync over the jungle

The Central African country of Gabon offers ideal conditions to study the biomass of tropical forests. DLR has already conducted two measurement campaigns there using its research aircraft. In autumn 2025, the DLR Microwaves and Radar Institute launched another special research project in collaboration with ESA and the Gabonese space agency AGEOS. During the radar measurement campaign, DLR's Dornier DO 228 flew over the same forest areas shortly after ESA's new Earth observation satellite, Biomass. Carrying the specially developed and precisely calibrated F-SAR airborne radar, the aircraft collected reference data used to fine-tune and validate the Synthetic Aperture Radar (SAR) on Biomass – helping to ensure the highest possible data quality. With the European Biomass mission, forest biomass and structure can now be determined with unprecedented precision, using cutting-edge SAR technology from DLR. This knowledge is essential to calculate how much climate-relevant carbon dioxide forests absorb, store and release through deforestation.

At the DLR Institute of Transportation Systems, researchers are investigating how vehicles can be controlled remotely – known technically as 'remote operation'.

Image: DLR

Getting ready to roll

For years, autonomous driving has been one of the megatrends shaping the automotive industry. Despite significant technological advances, its introduction remains challenging. In this interview, Tobias Hesse, programme spokesperson for DLR road traffic research, outlines what's needed to get autonomous vehicles on the road and into the market. He also discusses the role teleoperation can play – and why it's worth thinking of mobility as an integrated system.

Interview by Denise Nüssle

What is the current state of autonomous driving – in Germany and Europe, but also in the US and Asia?

In the US and China, companies like Waymo and Apollo Go offer 'robotaxi' services on public roads. Both are working at Level 4 of the five possible degrees of automation (see page 37, 'Levels of automation'). This means the vehicles can drive autonomously in defined areas under certain conditions – for example in good weather – without human intervention. To date, German companies have focused on Level 2 and Level 3 functions, gaining experience in the process. In these cases, the automated system controls the vehicle in certain situations. At Level 2, drivers may briefly take their hands off the steering wheel, but must continuously monitor the system and be able to intervene at any time. At Level 3, the vehicle drives in certain situations without being monitored. The human driver must then be ready to take back control when prompted.

Country-by-country scenarios can only be compared to a limited extent, as the approaches – and associated risks – differ. In the US, access is driven by the market, while in China it is mandated by the state. Germany and Europe are pursuing an approval-based approach: first, comprehensive evidence is required to show that automated vehicles and services are safe and secure before they can operate on public roads on a large scale. The question of resilience is also becoming increasingly important, including the resistance of autonomous systems to cyberattacks or sabotage.

Could you once again address the situation in Germany in more concrete terms?

Both in terms of technology and regulations, we are in a better position than it may seem. Germany is setting the standards, particularly regarding 'automotive connectivity'. Connectivity in this context refers to a vehicle's ability to connect wirelessly to the internet, to other vehicles and to infrastructure. This allows data to be exchanged, for example to improve safety and traffic management. At the regulatory end, the German Federal Government and the EU have laid the legal foundations to make autonomous driving possible.

We now need to muster up the courage to test existing technologies and solutions in practice; to bring them into service in the real world while continuing to study them. This calls for simpler experimental approvals, living labs, test fleets and model regions. What's important is that these projects are scalable in terms of the number of vehicles and users and the size of the deployment areas. Only then can we arrive at economically attractive products, applications and services. At the same time, we need patience and perseverance – including with regard to investment and funding. After all, new technologies go through an innovation cycle with typical phases, including what is known as the 'valley of death', which to some degree we are currently experiencing in Germany. Autonomous driving has not yet proven to be a lucrative venture – partly because its added value at system level is still underestimated.

Image: DLR

"We now need to muster up the courage to test existing technologies and solutions in practice; to bring them into service while continuing to study them."

Tobias Hesse, DLR Institute of Transportation Systems

TOBIAS HESSE

currently serves as one of two Acting Directors of the DLR Institute of Transportation Systems in Braunschweig, northern Germany. He has been researching autonomous road transport for around twenty years. Although he has a driving licence for cars and motorcycles, he has never owned a motorised vehicle.

What is DLR's approach to autonomous driving?

What sets DLR's transport research apart is precisely this systemic approach, including in the field of autonomous driving. We develop technological ideas, concepts and solutions that go beyond the individual vehicle. We are also looking into the interaction between manually operated and self-driving vehicles, different modes of operation and use cases. What's more, we investigate what responsibilities transport infrastructure can take on in terms of autonomous driving – for instance, intelligent traffic lights and cameras or computers in control centres and at key traffic points such as complex intersections. In an ideal scenario, all future road users will be interconnected so that they can benefit from autonomous driving. One compelling, pioneering example is DLR's IMoGer project, which stands for Innovative Modular Mobility Made in Germany. In this project, DLR develops and tests, together with companies, a mobility service that is unique in its versatility and practicality, providing autonomous, flexible and demand-based transportation of people and goods for the 'last mile'. This can mean taking people home from the train station or handling the final leg of the parcel delivery transport chain from the distribution centre to the customer. From 2027, a small fleet of U-Shift vehicles – also developed at DLR – will be out and about in a district of the city of Braunschweig to do exactly that. These vehicles comprise an electrically powered, U-shaped drive module that, depending on the task, carries a capsule for the transportation of passengers or goods. Here too, we are looking at the entire system to support the most effective market ramp-up of autonomous driving. This naturally includes automation, as well as the vehicle concept, different operating modes, integration into the existing public transport system, new and additional mobility services and societal acceptance of the project. The Federal Ministry of Transport is funding IMoGer with approximately 35 million euros.

LEVELS OF AUTOMATION

... developed by the Federal Highway Transport Research Institute and adopted internationally by SAE International (Society of Automotive Engineers).

LEVEL 0:
NO AUTOMATION
No functions continuously influence vehicle control. Drivers are always in full control.

LEVELS 1 AND 2:
ASSISTANCE SYSTEMS
Assistance systems support drivers in operating the vehicle safely, such as cruise control, distance control or lane-keeping.

LEVEL 3:
AUTOMATED DRIVING SYSTEMS
Systems that independently take over driving in certain phases. Drivers must remain constantly ready to resume vehicle control immediately when prompted by the system.

LEVEL 4:
AUTONOMOUS DRIVING
Vehicles can take over driving within specific operational domains, without drivers needing to be able to intervene in their control (a passenger role). From Level 4 onwards, this is referred to as autonomous driving.

LEVEL 5:
AUTONOMOUS DRIVING
Vehicles with Level-5 systems can operate wherever a normally qualified driver would typically be able to drive. Passengers are not required to be able to take over control. In some cases, vehicles may have no steering wheel or controls at all.

Source: Strategy of the Federal Government for autonomous driving in road traffic

In current discussions on autonomous driving, the terms teleoperation, teledriving and teleassistance often come up. What do they mean?
These are very important topics, as they can help to speed up the introduction of autonomous driving. Germany's Federal Highway and Transport Research Institute uses the umbrella term 'teleoperation' to describe two operating modes – teledriving, or remote control of vehicles, and teleassistance, where autonomous vehicles are remotely supported by a technical supervisor.

Teledriving can take place permanently or on a temporary basis. It requires a workspace in a control centre with pedals and a steering wheel, and of course a connection to the vehicle. For teledriving, the vehicle itself does not require any automation whatsoever. One practical use case here would be the provision of car-sharing or rental cars. It could also be an add-on to support the introduction of new autonomous driving services.

Teleassistance has a permanently prescribed role in Germany's Autonomous Vehicles Approval and Operation Ordinance (Autonome-Fahrzeuge-Genehmigungs- und Betriebsverordnung; AFGBV) which governs the operation of driverless cars in Germany.

Teleassistance involves people in a control centre supporting a vehicle's automation if it runs into trouble on the road. Operators look at the situation the vehicle is in, suggesting manoeuvres or approving a manoeuvre proposed by the vehicle, which it then carries out itself. However, teleassistance requests must not be of an urgent nature. The vehicle must already be in a safe state – for example, stopped or parked in compliance with traffic rules.

At present, teledriving and teleassistance are still considered separately. In the future, it may also make sense to combine the two. After all, we will continue to have mixed traffic involving non-automated, partially automated and autonomous vehicles for a long time to come. The transition between these operating modes must be carefully planned – both in technical terms and from the users' perspective. Further research in this area is necessary and in fact prescribed by law. DLR has been active in this field for many years, carrying out both in-house research and acting in an advisory capacity. Among other things, we have developed a workstation for technical surveillance to carry out teleassistance tasks. The focus is on the interface between the autonomous vehicle and the human operator, who intervenes remotely when necessary. With the Remote Operation Workplace, DLR is among the pioneers in this field. So far, few proposals have addressed what such workplaces should look like to comply with the law.

This is what a workstation for teledriving in public road traffic could look like – one person operating a vehicle remotely from a control centre.

Images: DLR

EXPLORE
Autonomous driving

> "The Remote Operation Workplace puts DLR among the pioneers in this field. So far, few proposals have addressed what such workplaces should look like to comply with legislation."

Tobias Hesse, DLR Institute of Transportation Systems

Digital infrastructure – such as sensors at traffic lights, on street lamps or buildings – can support autonomous vehicles in complex situations.

Who's going to pick up the tab for this? Or, put differently, will autonomous driving ever pay off?
I would argue the opposite: in the long run, we cannot afford not to automate our mobility. Both a strong economy and full social participation depend on efficient and attractive passenger and freight transport. The shortage of drivers is already clearly evident. Both sectors stand to benefit significantly from automation. In the longer term, automated transport will not only become more efficient, flexible and safer, but also more affordable. This is ultimately a matter of scale. Autonomous shuttles and buses, in particular those operating on a demand-responsive basis, could significantly improve the quality of public transport, leading to shorter waiting times, less traffic on the roads and, as a result, reduced climate and environmental impacts.

Where will Germany and Europe stand in ten years when it comes to autonomous driving?
Development is very dynamic right now. In just a matter of months or a few years, we could reach new major milestones – similar to the evolution of the smartphone, where Apple's first iPhone marked a breakthrough. If we translate what we are developing together with collaborators from research and industry into practical application, we will not only have autonomous vehicles on our roads, but we will also avoid having them on the road as uncooperative 'lone wolves'.

Instead, a wide range of autonomous yet interconnected systems will emerge – from lorries and buses to cars, as well as smaller vehicles and delivery robots. These systems will continue to learn over time and will cooperate with one another and with us as humans. That is why connectivity and interoperability are so crucial, and why they must be built into our research from the very outset. Looking at the development of autonomous driving from a broader perspective, we as a democratic society must confront a key question: who will develop and market the technologies and systems required – and will they be designed in a way that reflects what we, as a society, want and need?

Denise Nüssle is a press officer at DLR, primarily reporting on the energy and transport research areas. As a self-confessed "Stuttgart region native", she experiences the transformation of the automotive and mobility sector first-hand.

Driving ideas on asphalt

Autonomous mobility is researched and tested at the Lower Saxony Test Bed

Very few people driving along the A39 motorway near Braunschweig will realise they are passing through a research site. Nothing seems out of the ordinary, except perhaps the 71 eight-metre-high masts lining the roadside. Equipped with sensors, they anonymously record all vehicles that pass by. This is part of the Lower Saxony Test Bed, a model region unique in Germany, operated by the DLR Institute of Transportation Systems. Since 2020, automated driving has been tested here in real traffic conditions over a distance of 280 kilometres. Virtual reality plays a key role: parts of the test field also exist as a 3D simulation, allowing vehicles and technologies to be trialled digitally before they hit the road. Data collected around the clock from the test field serves as a basis, for example, for developing new driver-assistance systems and communication technologies. It also helps researchers improve their simulations. The test field can be used by both academic institutions and interested parties from industry .

The Lower Saxony Test Bed includes 71 masts fitted with sensors to monitor traffic conditions (above).

Some sections of the test field are also represented as 3D simulations, such as Tostmannplatz in Braunschweig (left).

> "The DVR is committed to road safety in Germany. Findings from practical projects such as the Lower Saxony Test Bed provide us with a solid basis for well-founded advice to policymakers, committees and across our entire professional network."

Andrea Kulpe-Winkler, German Road Safety Council (Deutscher Verkehrssicherheitsrat; DVR)

> "For reliable testing of information and communication technologies in the field of smart mobility, a combination of simulation and test drives on real roads is ideal. With the Lower Saxony Test Bed, we have such a platform right on our doorstep."

Jens Bläsche, OECON Products & Services GmbH

What's been:

At the end of 2025, as part of the MAD Urban (Managed Automated Driving) project, DLR demonstrated autonomous driving with strong infrastructure support for the first time. Two sensor columns at an intersection in Braunschweig captured – in line with data protection regulations – the outlines of passing objects, creating an overview of the traffic situation. As the DLR research vehicle approached the junction, the columns' computers took over control like air-traffic controllers, calculating the safest route and monitoring the execution of driving manoeuvres. Once the vehicle had passed, control was handed back to the onboard automation system.

What's to come:

From 2026, DLR will begin construction of a modular remote operation centre in Braunschweig for road, rail and traffic management. This facility will be used to research and test 'teleoperation' – the remote monitoring and control of vehicles. Workstations will be available for different levels of automation and operating modes, ranging from event-based teleassistance to direct remote steering and control. New control centre concepts will also be developed and tested here, with operators actively involved. The existing infrastructure of the Lower Saxony Test Bed is ideally suited to testing teleoperation under real-world conditions.

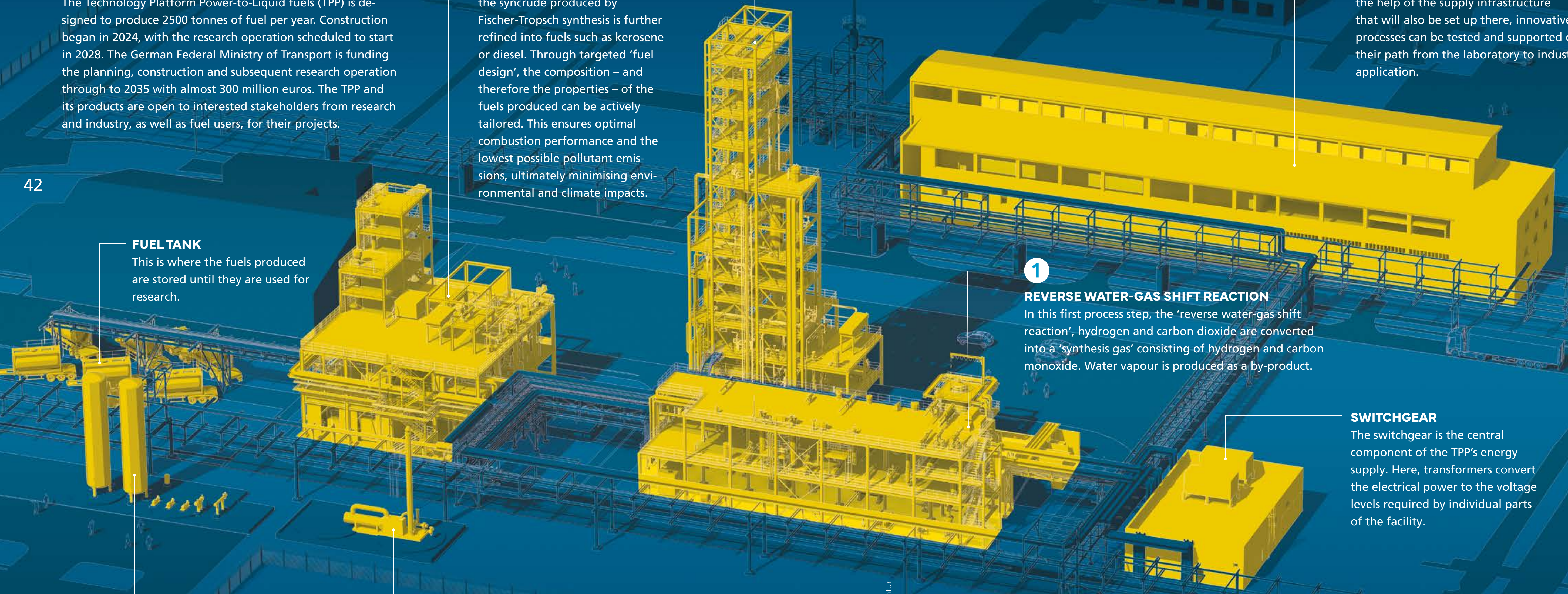
From electricity to fuel

Technology Platform Power-to-Liquid fuels (TPP)

The world's largest research facility for electricity-based fuels is currently being built in Leuna, near Leipzig, under the leadership of the DLR Institute of Combustion Technology. Using the 'Power-to-Liquid' process, electricity will in the future be used to generate ready-to-use fuels from carbon dioxide and hydrogen. These fuels are of particular interest for sectors that are difficult to electrify, such as aviation and maritime transport.

The Technology Platform Power-to-Liquid fuels (TPP) is designed to produce 2500 tonnes of fuel per year. Construction began in 2024, with the research operation scheduled to start in 2028. The German Federal Ministry of Transport is funding the planning, construction and subsequent research operation through to 2035 with almost 300 million euros. The TPP and its products are open to interested stakeholders from research and industry, as well as fuel users, for their projects.

Learn more about the Technology Platform Power-to-Liquid fuels



3 FUEL PROCESSING
In the fuel processing stage, the syncrude produced by Fischer-Tropsch synthesis is further refined into fuels such as kerosene or diesel. Through targeted 'fuel design', the composition – and therefore the properties – of the fuels produced can be actively tailored. This ensures optimal combustion performance and the lowest possible pollutant emissions, ultimately minimising environmental and climate impacts.

2 FISCHER-TROPSCH SYNTHESIS
Standing almost 54 metres tall, the demonstration reactor is the heart of the TPP. Here, synthesis gas consisting of carbon monoxide and hydrogen is converted into a synthetic crude oil known as syncrude. The composition of the syncrude can be influenced through parameters such as pressure, temperature, different catalysts or 'residence time' – average duration spent in the reactor.

RESEARCH BUILDING
A small-scale version of the TPP will be established in the research building. With the help of the supply infrastructure that will also be set up there, innovative processes can be tested and supported on their path from the laboratory to industrial application.

FUEL TANK
This is where the fuels produced are stored until they are used for research.

1 REVERSE WATER-GAS SHIFT REACTION
In this first process step, the 'reverse water-gas shift reaction', hydrogen and carbon dioxide are converted into a 'synthesis gas' consisting of hydrogen and carbon monoxide. Water vapour is produced as a by-product.

SWITCHGEAR
The switchgear is the central component of the TPP's energy supply. Here, transformers convert the electrical power to the voltage levels required by individual parts of the facility.

CO_2 STORAGE
Carbon dioxide is delivered to the TPP in liquid form and temporarily stored. It comes from a biogenic (living) source and meets the sustainability requirements for renewable fuels.

AFTERBURNING
In the afterburning stage, exhaust gas streams that cannot be reused within the facility are incinerated. This minimises emissions and ensures compliance with statutory limits.

Infographic: DLR/CD Werbeagentur

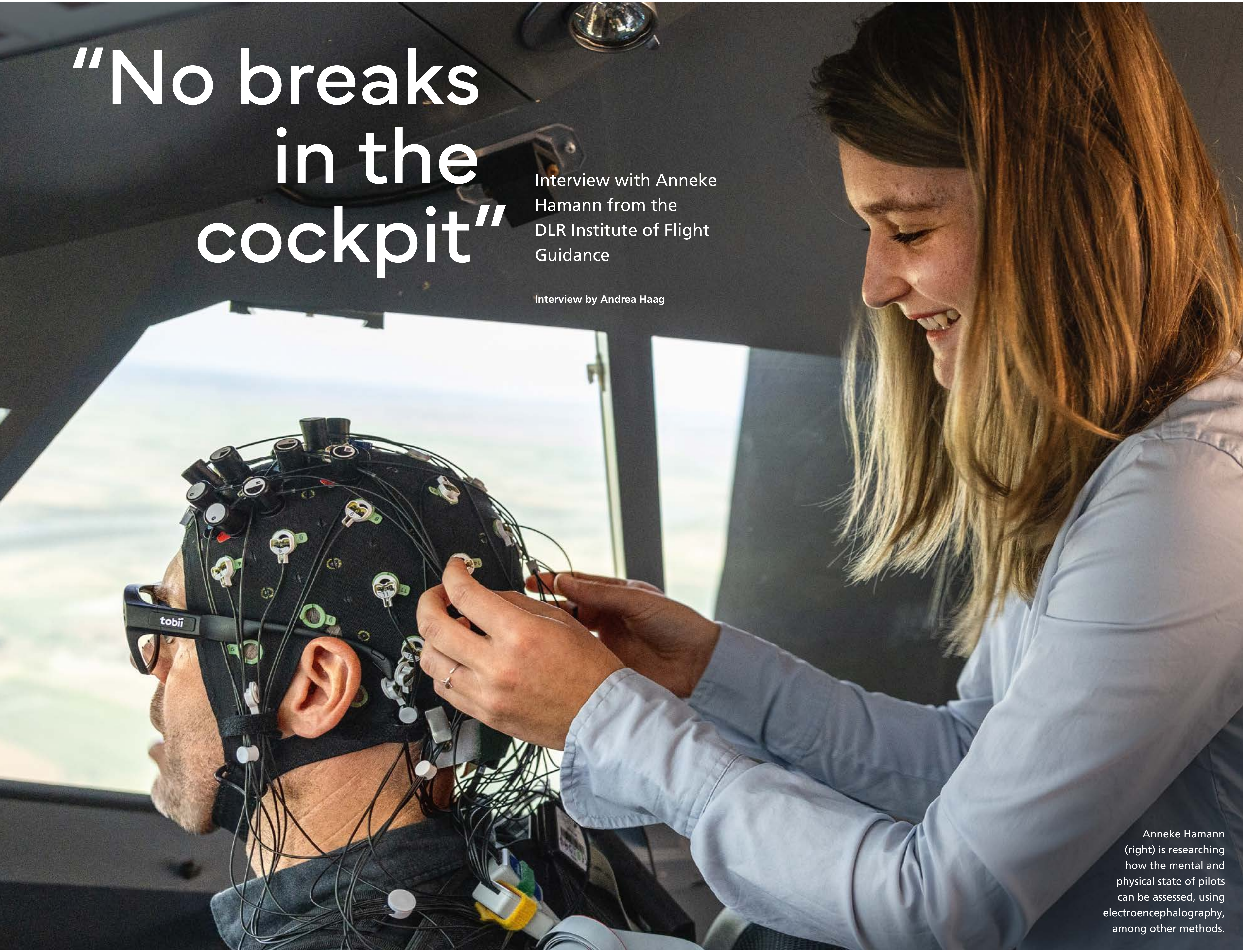
Funding programme Renewable Fuels
With funding from the Federal Ministry of Transport by decision of the German Bundestag
Coordinated by NOW NOW-GMBH.DE
Project management agency VDI|VDE|IT

EXPLORE
Interview

"No breaks in the cockpit"

Interview with Anneke Hamann from the DLR Institute of Flight Guidance

Interview by Andrea Haag



Anneke Hamann (right) is researching how the mental and physical state of pilots can be assessed, using electroencephalography, among other methods.

Image: DLR

Pilots have an extremely demanding job with enormous responsibility; they have to make multiple decisions simultaneously within a short period of time. Anneke Hamann researches how pilots' mental and physical states can be measured and interpreted. The aim of her work is to use brain data, heart rate, breathing and other physiological signals to detect states such as high mental workload and fatigue – before they become critical.

Anneke, how do you approach this complex topic?

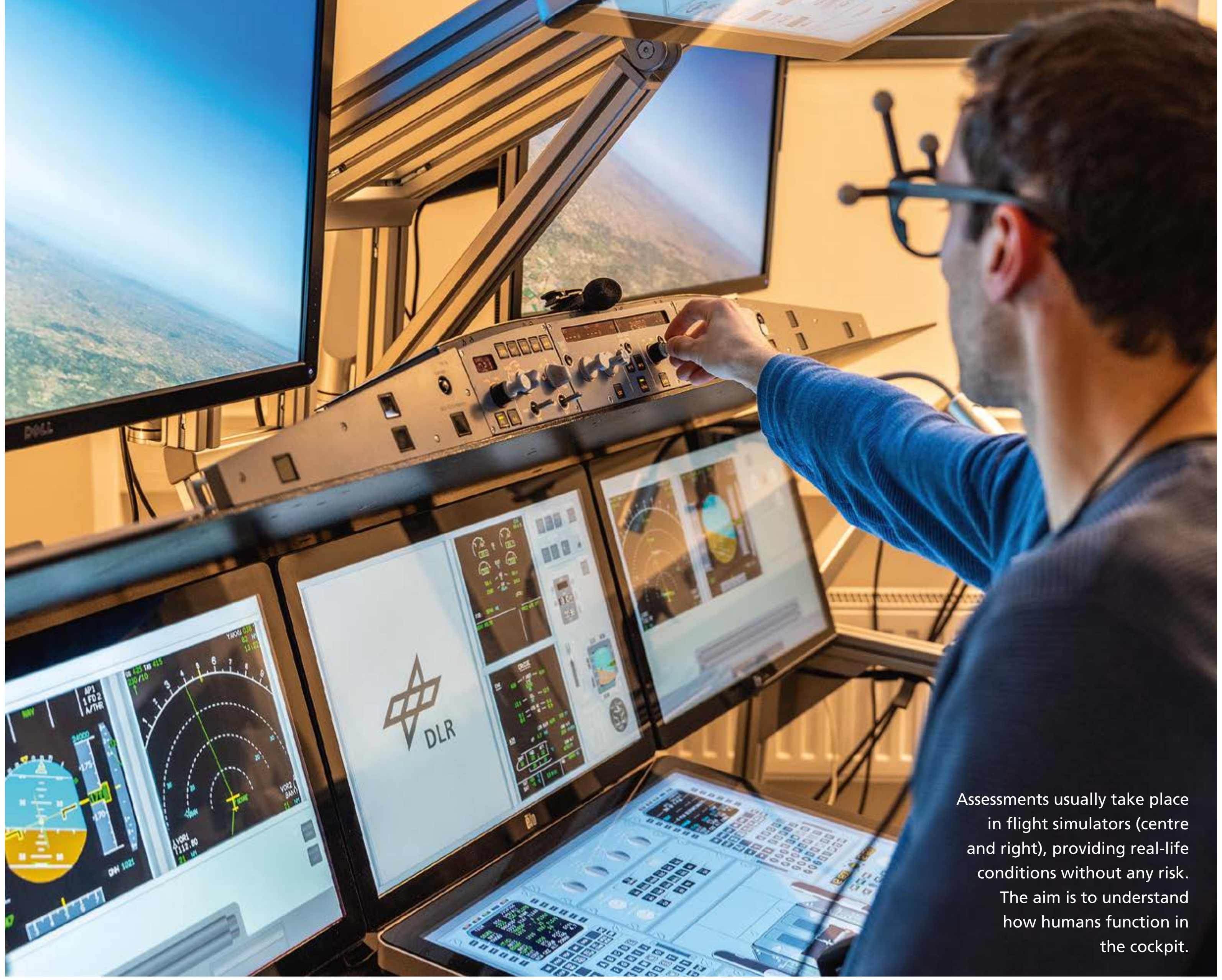
We start by asking ourselves which states are actually relevant for pilots. These include mental workload – that is, how difficult a task is perceived to be – stress, time pressure, drowsiness and mental fatigue. Physical factors can also play a role, for example when someone is simply having a bad day or feels unwell.

What methods and tools are used?

Our main focus is on cognitive processes – in other words, what happens in the brain when information is absorbed, processed and translated into actions. To make these processes measurable, we use methods such as electroencephalography; EEG for short. This involves placing electrodes on the scalp to record electrical signals. When many nerve cells are active at the same time, a measurable pattern emerges. This allows us to determine which areas of the brain are working hardest – for example, whether someone is highly concentrated, stressed or perhaps becoming fatigued.

We use combined EEG with a second, complementary method: functional near-infrared spectroscopy, or fNIRS. In this method, light in the near-infrared range is directed through the scalp into the brain. You can think of it a bit like when, as a child, you likely shone a torch through your finger and could see your blood vessels. By analysing the light absorption, we can

Eye trackers (left) are also used in the test setup to record participants' gaze direction, helping to determine how long information is viewed in the cockpit.



Assessments usually take place in flight simulators (centre and right), providing real-life conditions without any risk. The aim is to understand how humans function in the cockpit.

determine how much oxygenated and deoxygenated blood is present and how this ratio changes over time – and thus how active the brain is. The more demanding the task, the harder the brain has to work and the more energy required.

Can parameters other than brain activity also reveal something about a person's condition?

Yes, absolutely. We also observe behaviour, for example using eye trackers that show us where the participants are looking and how long they view certain information. In addition, we measure physical parameters such as heart rate, respiration and skin conductivity. Taken together, all this data combined provides as complete a picture as possible of a person's mental and physical state.

Do these experiments take place in the air?

We mostly conduct tests in flight simulators, where realistic but controllable and repeatable scenarios can be created. This allows us to examine in a targeted way how pilots respond in demanding situations – and which signals indicate that they are reaching their stress limits. This combination of modern technology and psychological observation is leading to an increasingly accurate understanding of how humans function in the cockpit.

In the future, pilots could be supported by dedicated assistance systems. What should they be able to do?

In our ideal scenario, the system would be unobtrusive and reliable, fitting comfortably on the body without interfering. Sensors would continuously transmit collected data to an assistance system which would recognise how the person is feeling and respond accordingly – for example by issuing warnings, adapting information or temporarily taking over routine tasks.

Do the design and comfort of the measuring devices affect how well participants tolerate the measurements?

Surprisingly, appearance matters very little – comfort is far more important. In the military sector in particular, the equipment is already extensive so additional sensors are barely noticeable. What really counts is that they can be easily integrated, are easy to put on and do not restrict movement. When these conditions are met, acceptance increases.

Images: DLR

Who decides what data is collected and how it is evaluated?

As a researcher, I currently decide what data is collected and evaluated. However, my scientific work always takes place under the supervision of an ethics committee. Every study is reviewed to ensure that participants are protected and research is conducted responsibly. I think it's essential that someone keeps an eye on scientific practice.

It will become particularly exciting when such systems are actually used in aircraft one day. Then, clear rules will be required. Pilots must be able to trust that the data is not accessible to everyone and is used exclusively for their benefit – for example, to improve safety or provide support during flight. Employers or third parties must not have access to personal performance data, to prevent misuse or unfair performance evaluations.

How realistic is it that such systems will become standard in civil aviation in the next 20 years?

I consider systems that can detect specific states such as stress, fatigue or overload and respond at an early stage – before a person's ability to act is impaired – to be realistic. The aim is therefore not to take over human thinking or decision making, but to provide targeted support to people in demanding situations.

Andrea Haag is an online editor in DLR Communications. She has long been fascinated by human–machine interaction and the ethical questions raised in this interview, in particular, have inspired her to write further stories on the topic.

ANNEKE HAMANN

is a scientist at the DLR Institute of Flight Guidance in Braunschweig. After studying psychology in Jena and Dresden, she joined DLR in 2018, where she initially worked on a project on remote tower operations. She completed her doctorate on the neurophysiological assessment of operator states and continues to research this topic in both civil and military projects.

Safely deployed

What at first glance looks like a specialised form of parcel delivery is actually an important step in DLR's Swarming project. The project is developing technologies and algorithms to coordinate and operate entire swarms of uncrewed aerial and ground vehicles from one central control station. In the flight test pictured here in Cochstedt, DLR researchers demonstrated that the automated deployment of a drone from a box works reliably, and that the helicopter, box and deployed drone can communicate with one another. Following this success, the technologies are now to be used in further tests to deploy and control multiple drones simultaneously. Centrally controlled uncrewed vehicles are particularly relevant in crisis situations, for example, when rescue teams cannot reach a site at all, or only at significant risk to their own lives – such as during natural disasters.

More information on the DLR Swarming project

A universe within the atom

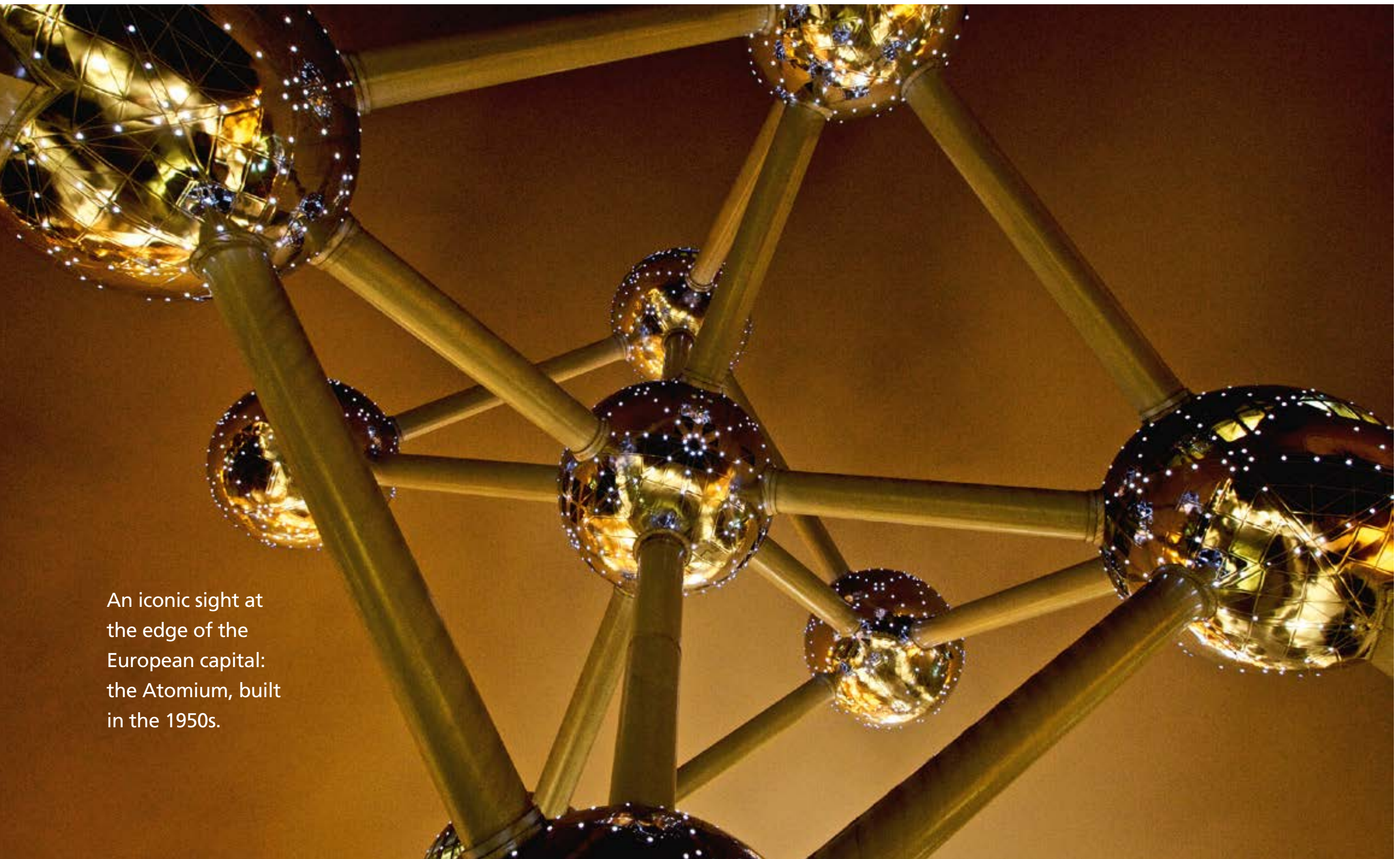
Brussels' landmark – then and now

by Michael Müller

Through a sepia-tinted window, the panoramic view falls on the iconic central building of the Brussels Expo site – originally constructed as the centrepiece of the 1958 Brussels World's Fair. A giant, silver-shimmering sphere comes into view. The setting autumn Sun does its bit to give the scene a surreal aura – as if a spaceship were about to land next to an Aztec temple. Welcome to the Atomium, an exhibition building that doubles as a work of art.

From symbol to icon

The adventure begins with a permanent exhibition spread over two levels, telling the story of the Atomium within the context of Expo 58. Like the Eiffel Tower, this Belgian exhibit was originally intended to be temporary. The Parisian landmark built for the 1889 World Expo marked the dawn of the age of electricity; almost 70 years later, the construction of the Atomium coincided with the start of the civilian use of nuclear energy – a spirit of optimism in both instances. Another similarity between the Parisian and Brussels landmarks is that, by the time the respective World Expos ended, the public had become so fond of these unique techno-futuristic creations that dismantling them was out of the question. With time, however, the Atomium's outer shell began to corrode. At the turn of the 21st century, elaborate restoration work was carried out and the cladding of the spheres was completely replaced with rustproof stainless steel – this 'makeover' is another of the topics featured in the permanent exhibition. In 2026, the Atomium celebrates 20 years since its reopening.


An iconic sight at the edge of the European capital: the Atomium, built in the 1950s.

Images: p. 50 Atomium – SOFAM – Axel Addington; p. 51 Atomium – CROSSING – Lio Photograph


A sneak peek at the popular temporary exhibition, 'Crossing'

Along winding paths

A seemingly endless escalator sets the mood for the artistic light and sound installations to follow: from fundamental particles to the Universe. Passing between the elementary particles, you're cloaked in darkness, surrounded only by spherical sounds and occasional pulsing light effects.

Since 2013, through its temporary exhibitions, the Atomium has given artists free rein to realise projects in parts of the spheres that celebrate the uniqueness of this world-famous site. Since 2023, the projects have centred on digital art, from immersive installations to live performances.

For example, the French artist collective Visual System has designed the permanent installation for the central sphere – an almost psychedelic 'mushroom of light' with changing light effects rotating around a central cylinder, surrounded by sculpted benches. This is a place to pause and relax before exploring the next exhibition spheres.

Or, you can take a completely different approach: ride the lift straight from the ground floor to the very top of the Atomium, immersing yourself in the installation 'Look up' along the way. Once at the top, visitors are rewarded with a 92-metre-high view, stretching as far as the centre of the European capital, almost ten kilometres away.

What's next?

Since 14 February this year, two new temporary exhibitions have been on show: Nimbus (by the already mentioned Visual System) and Supply Chain (by the French artist Romain Tardy).

Overall, it can be said that all of the Atomium's light and sound installations span the widest imaginable arc. If you allow yourself to engage with them, you cross an invisible threshold, embark on a journey through space and forget about time. Indifference is not an option here – hence the clear recommendation: go and see it for yourself, ideally in the early morning when visitor numbers are lower, and immerse yourself in the past and present of this oversized iron crystal.

Michael Müller, an editor in DLR's Communications department, enjoys spending time in Brussels and is happy to have now also seen the Atomium from the inside.

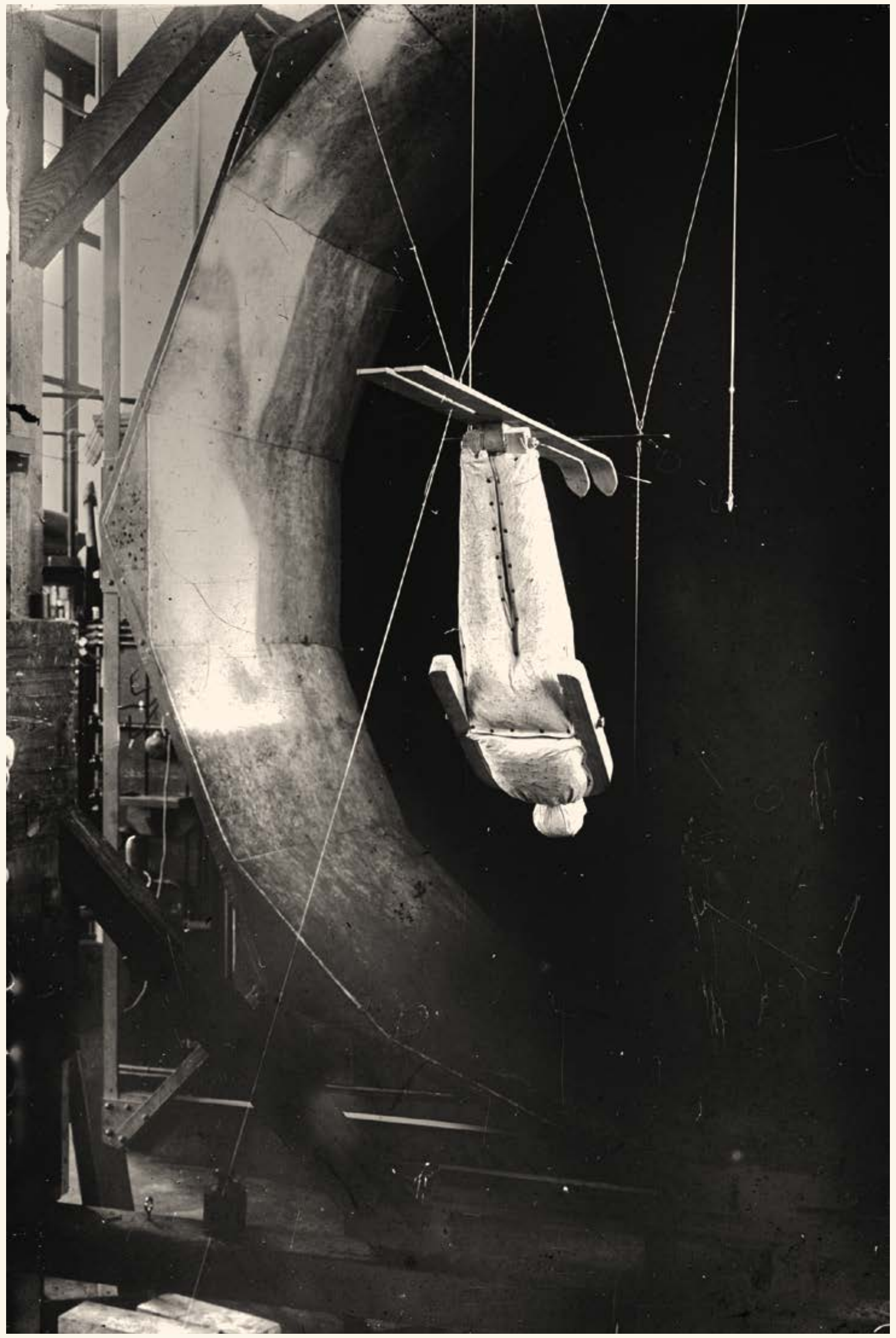
ATOMIUM BRUSSELS

Address
Place de l'Atomium 1,
Atomiumplein 1,
1020 Brussels, Belgium

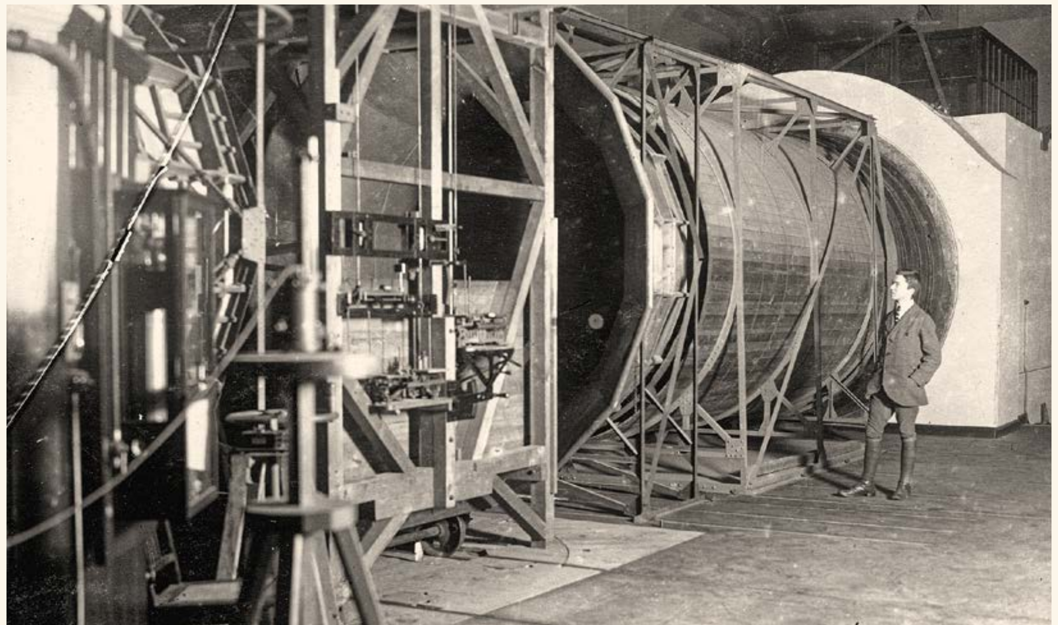
Opening times
Mon–Sun:
10 a.m.–6 p.m.
(last entry: 5:30 p.m.)
Online ticket reservation (recommended)
atomium.be/tickets

Admission
Adults: 16 euro
Under 18s and students: 8.50 euro
Children up to 115 cm: free

Atomium website



Ski jumping model in Wind Tunnel I at the Aerodynamics Research Institute (Aerodynamische Versuchsanstalt; AVA) in Göttingen, 1927



Wind Tunnel I of the AVA went into operation in 1917 and could reach speeds of up to 58 metres per second

Images: DLR

ABOUT THIS SECTION
DLR's Central Archive is home to over 50,000 documents. Here, we delve into the depths of this treasure trove of images, papers, certificates and texts. In this issue, we look at how winter sports athletes found their optimal posture in the Göttingen wind tunnel.

Posture is everything

Winter sports athletes in the Göttingen wind tunnel

by Jessika Wichner

In January 1927, the Aerodynamics Research Institute (AVA) in Göttingen – one of the predecessor organisations of today's German Aerospace Center – received an unusual request. The enquiry came from Swiss engineer Reinhard Straumann (1892–1967), who wanted to know whether the aerodynamic conditions of ski jumping could be studied under laboratory conditions to determine the optimal posture for a ski jumper and the ideal flight trajectory. The AVA responded promptly, confirming that such investigations could indeed be carried out in the wind tunnel – provided he supplied a suitable model.

Just a few weeks later, the Göttingen researchers received a package containing a wooden mannequin measuring approximately 50 centimetres in height, along with a pair of scaled model skis. The mannequin was equipped with a joint at hip level that allowed the upper body to be adjusted into various postures. To give the model the most realistic appearance possible, it was carefully padded with fabric in Göttingen – and it was ready for use.

Deep in the squat

In Wind Tunnel I – normally used to test models of aircraft, automobiles, rail vehicles and ships – the wooden mannequin was now suspended, hanging upside down for reasons of stability. Over several experiments, the Göttingen researchers meticulously measured lift and drag in different body positions and sent the results to Straumann.

The engineer carefully studied the data and published an article entitled 'Vom Skiweitsprung und seiner Mechanik' (On ski jumping and its mechanics) in the Swiss Ski Association's magazine that same year. In it, he recommended that ski jumpers crouch as low as possible during the 'inrun' – the steep track at the top of a ski jump hill where jumpers gain crucial speed. During take-off, the upper body should then be thrust quickly forwards, adopting a slightly rounded shape in flight – similar to the cross-section of an aircraft wing.

In fact, the research conducted in the Göttingen wind tunnel helped to gradually increase jump distances, and to this day the optimal upper body posture for ski jumpers identified in 1927 is still clearly recognisable.

Designing better ski jumps

Straumann's interest in ski jumping went even further. Based on the data collected in Göttingen, he subsequently developed recommendations for the construction of ski jump hills and was appointed as a technical member of the International Ski Federation. The 'Trampolino Olimpico Italia' ski jump in Cortina d'Ampezzo, built for the 1955 Winter Olympics, is based on one of Straumann's designs.

Examining a downhill skier in the three-metre wind tunnel in Göttingen in preparation for the 1976 Winter Olympic Games

Today, the German Ski Association uses the Audi Wind Tunnel Center in Ingolstadt to prepare its athletes for competitions

The ski jump is no longer used for competitions, as Italy now has two more modern facilities. Nevertheless, it remains a popular tourist destination – thanks in part to its appearance in several scenes from the well-known James Bond film 'For Your Eyes Only' (1981).

The search for the ideal posture and aerodynamic equipment to give ambitious athletes an edge over their competitors continued even after Straumann left the International Ski Federation. In 1975, the German Ski Association approached the then 'German Research and Test Institute for Aviation and Space Flight' (DFVLR) – now DLR – for assistance.

On the way to gold

In preparation for the 1976 Winter Olympic Games, the German Ski Association wanted its athletes and their equipment to undergo wind tunnel tests. The three-metre low-speed wind tunnel in Göttingen was ideal for this purpose, so the German athletes nominated for the Games travelled there for a series of intensive tests in the pre-Olympic year. The investigations paid off: the downhill skier Rosi Mittermaier won two gold medals and one silver medal in various disciplines the following year.

To this day, elite athletes use wind tunnels to optimise their posture and test new equipment for its aerodynamic performance. However, the three-metre wind tunnel in Göttingen is no longer available for this purpose. It was decommissioned many years ago to make way for a more modern low-speed wind tunnel at the DLR site in Braunschweig. Where winter sports athletes once endured the blast of air, school classes now bustle around, visiting the School_Lab Göttingen and learning how such experimental facilities work in the decommissioned wind tunnel.

Jessika Wichner prefers gliding through the roller racks of DLR's Central Archive to being on skis, and in doing so regularly uncovers surprising historical documents that remain relevant to this day.

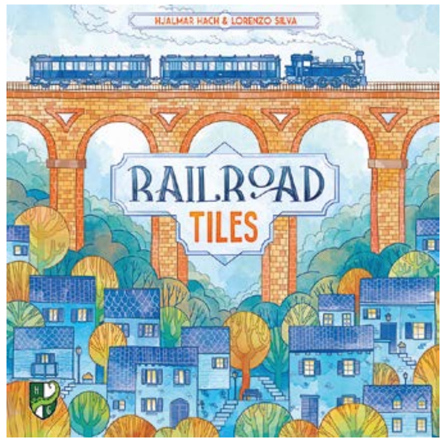
Images: (above) DLR; (below) Audi AG

A picturesque rail network

Ready for a little experiment? I'll give you two terms and you decide which sounds more appealing. Ready? First term: rail network. Got it? Second term: Belgian chocolate. Well? Which one speaks to you more? What's that? You think that's a bit unfair? You associate transport planning with something about as cosy as a waiting room in November? Then read on – because you clearly haven't encountered **Railroad Tiles**.

A world of watercolours

To be fair: the world of the tile-laying game Railroad Tiles, published by **HeidelBÄR Games**, doesn't exactly reflect the reality of Germany's local transport system. When was the last time you felt delighted watching a train pull into the station, or felt a warm glow at the sight of a railway winding through the countryside? In Railroad Tiles, these feelings are inevitable. Your eyes wander across a landscape delicately painted in watercolour, spreading across the table tile by tile. Cities, tracks, roads and trees are drawn from a soft blue cloth bag and pieced together like a puzzle – and you can't help but smile when ponds and park benches appear alongside the transport routes. Next to the individual worlds each player creates, a large station board sits in the centre of the table. Each round, scoring tiles pass through the waiting room, allowing small wooden steam locomotives, cars and passengers to be placed onto the ever-growing game board.



A feast for the eyes and the mind: the tile-laying game Railroad Tiles appeals to board-game enthusiasts of all ages.

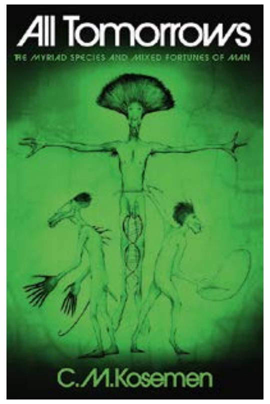
Strategy pays off

Despite its tranquillity, Railroad Tiles shouldn't be underestimated. Above all, it is a well-thought-out strategy game. Players aim to build cities and connect them as efficiently as possible, complete tasks and avoid loose ends. Placed figures earn extra points if they are connected to others by rail or road. Unlike other tile-laying games such as Carcassonne, tiles are not drawn at random; instead, several sets are laid out face up. If you choose one, your opponents get access to the others. Sets that are not chosen are gradually supplemented with bonus points, making them more attractive with each round – and whoever chooses the smallest set goes first in the next round.

Good planning is (not) everything

Railroad Tiles is as relaxing as it is exciting. It rewards clever planning without becoming overwhelming, making it an ideal game for beginners. The rules are easy to learn and it works great with children aged eight and up. There's great satisfaction when your plan comes together and you score more points than your fellow players. But even if you don't win, it's hard to feel disappointed when you look at the beautiful pastel-coloured landscape in front of you. Somehow, it feels as though you painted it yourself.

Philipp Czogalla is an institute communications manager at DLR. He knows that the golden age of railway romance is over – but he's convinced that a beautiful waiting room should still be possible today.



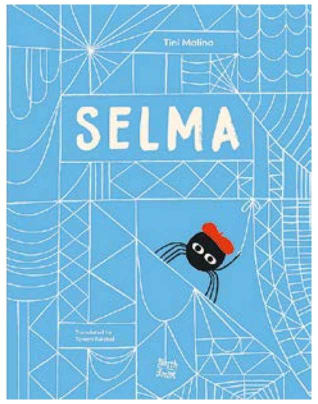
The dark future of us

If you think our future in space will be a story of progress and ingenuity, **All Tomorrows** will make you reconsider. First published in 2001 but only released as a physical English edition in November 2025 **(Wilton Square Books)**, **C. M. Kösemen's** cult classic traces the dark future of humanity over the next billion years.

Narrated by an alien observer, the book explores humanity's expansion across the galaxy – from planetary colonisation and experiments in genetic self-modification to a tragic encounter with the Qu. Angered by humankind's ambitions, the beings reshape us into bizarre creatures stripped of autonomy and dignity. Through eerie, unsettling illustrations, the book explores speculative evolution and the results of genetic engineering used as a tool of control.

The premise is compelling, but the style may divide readers. The detached narration suits the subject, but can read like an encyclopaedia, with extended descriptions of human-descendant species. For some, this is precisely its appeal. Ultimately, All Tomorrows reminds us that humanity's story is long, but not guaranteed.

Yasmin Tosta



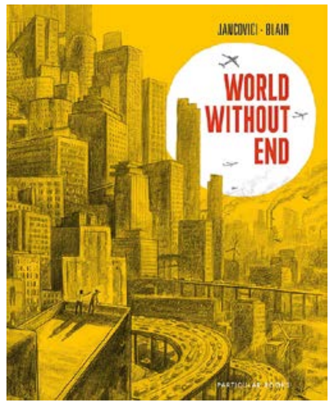
When being wrong is exactly right

Selma is no ordinary spider. While her fellow arachnids are busy catching flies, she spins her webs to capture the splendour of the Universe. And so the little protagonist of **Tini Malina's** picture book **Selma – The Story of a Stellar Spider** (**NorthSouth Books**, 2026 – German and English editions; Spanish forthcoming), repeatedly hears the same line: "Selma, you're doing it wrong!"

The language of this picture book, which received the Luchs Children's and Young Adult Book Prize, is kept simple – short, warm and sensitive; well suited to children aged four and up, and ideal for bedtime reading aloud. The illustrations are minimalist in style and, with a restrained colour palette, guide the reader's eye across double-page spreads depicting Selma's journey over large A4 pages.

Tini Malina traces Selma's path with great empathy. Through her story, she shows how valuable it is to be different and to remain true to oneself, while also making it clear that a certain degree of loneliness must sometimes be endured. The symbolic ending is likely to invite not only children, but adults too, to interpret it together and reflect on its meaning.

Philipp Burtscheidt



Drawing on energy

Would using a bike to power your home save energy? What is energy in the first place and how did we become so addicted to it? And what would it really take to decarbonise our energy system? **World Without End (Particular Books)** tackles these questions with clarity, using an unusual but effective format: adult graphic nonfiction. While common in youth publishing, this bestseller stands out for combining visual storytelling with serious scientific depth.

The book's strength lies in its collaboration: illustrator **Christophe Blain** supports the explanations of his co-author, science communicator and researcher **Jean-Marc Jancovici**, with restraint, humour and angst. A conversation between expert and learner; the book deploys Socratic dialogue, guiding readers through difficult concepts without oversimplifying.

Its main limitation is also a deliberate choice: the book presents Jancovici's perspective rather than a range of expert views. While this narrows the scope, World Without End succeeds as a focused, thought-provoking look at how energy shapes our world – and our future.

Sarah Leach

LANDING
Media tips

Techno trouble, doubled

What to do with a temptingly powerful technology deemed far too dangerous for use on Earth? Why, send it to space with a party of distant-planet colonisers, of course. In **Mickey 17** (directed by **Bong Joon Ho**), that technology is the ultimate 3D printer – a kind of reverse MRI scanner capable of producing an all-new version of a human being, complete with memories conveniently stored on a brick-sized hard drive.

Enter Mickey 17 (**Robert Pattinson**), who follows Mickey 16, 15, 14 and so on – all copies of Mickey 1, once known simply as Mickey Barnes. Mickey's troubles began when he got on the wrong side of some nasty, ultra-powerful criminals who took their pound of flesh with the unrefusable offer of a one-way trip to planet Niflheim. The colonising mission is led by a failed politician whose obsession with founding a 'pure-bred' society – and willingness to eradicate Niflheim's native, worm-like inhabitants – makes for a very modern baddy.

On Earth, the powers-that-be banned this miracle technology to avoid having 'multiples', whose existence would raise nasty – though unspecified – legal and moral issues. But in space, such 'expendable' crew members like the Mickeys would be ever-so-useful for tasks and experiments deemed too hazardous for, well, normal people. Director Bong Joon Ho, best known for his 2020 global hit Parasite, takes 40 minutes to get to the hinge point: the printing of Mickey 18, after Mickey 17 is presumed dead in an accident in an ice cave overrun by those very hungry, big-toothed giant worms. The catch? Mickey 17 didn't die. When he makes it back to base and discovers his replacement, mayhem ensues. The resulting duality pleases their girlfriend (Naomi Ackie) but proves incompatible with peace in a nascent colony threatened by worms.

Cineastes may see a film tripping over its own abundance of ideas and plot threads. Scientists, engineers and politicians, however, might take Mickey's fate as an invitation to reconsider a familiar assumption: what is technically possible must inevitably come to pass.

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DLR Institute of Space Propulsion

Launching into space

HyImpulse aims to make European spaceflight independent

The founders of HyImpulse (from left): Mario Kobald, Christian Schmierer, Ulrich Fischer and Konstantin Tomilin

HyImpulse

The idea

HyImpulse has developed a hybrid propulsion system based on paraffin and liquid oxygen – enabling launch vehicles to reach space reliably and cost-effectively. The target destination for satellites launched with this system is low Earth orbit.

The context

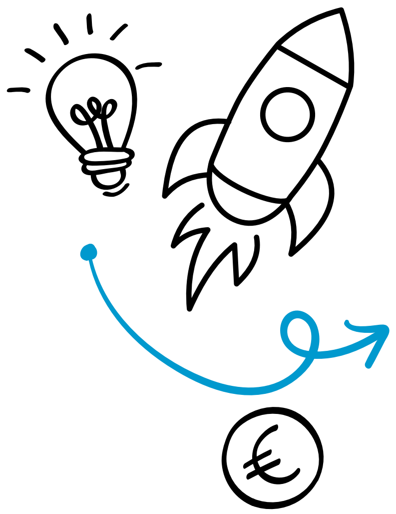
Small satellites play an important role in spaceflight – for communication, Earth observation and navigation. Europe needs autonomous and flexible launch capabilities to remain technologically independent.

HyImpulse makes the world a better place because…

…it targets small satellite operators and commercial spaceflight companies seeking reliable, flexible and affordable launch services.

The next challenge

A second launch of the SR75 suborbital rocket and the inaugural flight of the SL1 in 2027.



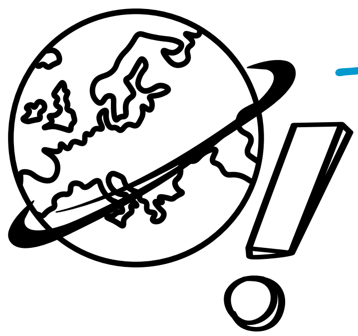
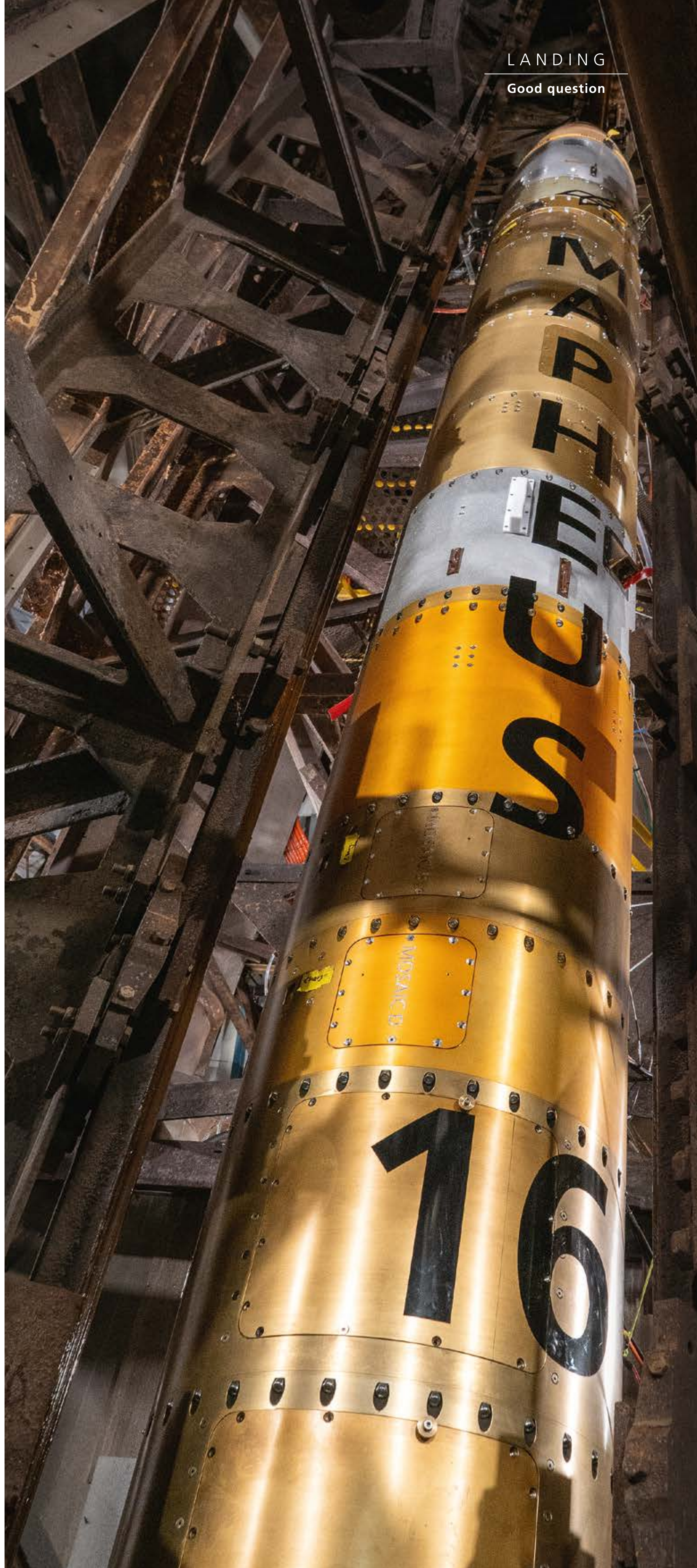


Image: HyImpulse Technologies



How do 500 kilograms of experiments reach microgravity?

Conducting experiments in weightlessness is an important part of research in engineering, materials science and medicine. In microgravity – when the effects of gravity are extremely reduced – physical, chemical and biological processes behave differently and, in some cases, faster than on Earth. For this reason, DLR has been carrying out regular research flights with sounding rockets as part of the MAPHEUS® programme for more than 15 years. On 12 November 2025 at 5:05 a.m., the MAPHEUS®-16 mission lifted off from the Swedish Space Corporation's (SSC) launch site in Esrange on its journey to weightlessness. For the first time, DLR combined two RED KITE rocket engines in one mission, setting a new payload record: the rocket carried approximately 500 kilograms of scientific cargo into microgravity for just over six minutes. The RED KITE engine is a German development from DLR in collaboration with Bayern-Chemie.

All about MAPHEUS®