FACULTY OF ENGINEERING AND COMPUTER SCIENCE | ISSUE 01.2021

HAW HAMBURG

KNOW!

MAGAZINE FOR RESEARCH AND NEW KNOWLEDGE | DRIVE

HYDROGEN

The rocky road to nearly climate-neutral aviation

ARTIFICIAL INTELLIGENCE

The mobile phone reports stress and anxiety in people with dementia

GEAR NOISE

When rippled gears dampen the driving pleasure

HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN HAMBURG
Hamburg University of Applied Sciences

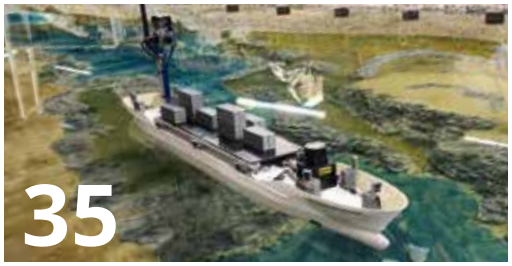
Editorial

Dear Readers!

Knowledge is the raw material from which our future is shaped. There cannot be enough of it, especially if we want to solve the many tasks on the way to a sustainable and climate-neutral future. Here at the Faculty of Engineering and Computer Science at HAW Hamburg, this raw material is increased and imparted daily, both in applied research and teaching.
With the new magazine K|NOW! – you are actually holding the first issue in your hands –, we want to give you an insight into what happens in our laboratories. We would like to tell you about the projects we are working on and the people behind them. And we want to show you how diverse and vibrant research is on our campus. Not least, how relevant it is. We do not focus on basic research. Rather, scientists from the four departments of our faculty and the four research and transfer centre (RTC) work together with partners from industry in our projects to put new research results into action. Their work is also relevant because they address the pressing issues that are important to us as a society. For example, engineering and computer science researchers help develop solutions for climate-neutral mobility, resource-saving production, and digitalisation. We create the future every day!
With this issue of our magazine and its central theme, "Drive," we can only give you a small sample of our diverse research landscape. I hope it creates an appetite for more. If you have any suggestions or feedback, I look forward to receiving an e-mail from you at KNOW-TI@haw-hamburg.de.

I hope you enjoy reading this first issue

Prof. Dr.-Ing. Anna K. Usbeck
Vice-Dean Research, Faculty of Engineering and Computer Science, HAW Hamburg



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With its research magazine K|NOW!, the Faculty of Engineering and Computer Science at HAW Hamburg provides insight into research projects and their results. Additionally, it introduces the people working on finding solutions to many pressing problems of our time.

You can request a copy of our research magazine either in print or by e-mail as a pdf. Please get in touch with Dr. Ariane Ament at the Research Office of the Faculty of Engineering and Computer Science: KNOW-TI@haw-hamburg.de.

“In our studies, we focus on three aspects: practical relevance, creativity and a passion for innovation.”

PROF. DR. HANS-JOACHIM SCHELBERG

PIONEERING DEGREE COURSE

Since the winter semester 2021/2022, bachelor students in the Mechanical Engineering and Production Management program can choose the new degree course Digital Engineering and Mobility. Students take part in both classic studies and interdisciplinary projects. They work in teams to develop innovative solutions for real-world tasks. With this new degree course, the university is picking up on significant trends of our time.
“Think of electric vehicles for transporting people and goods that are specially tailored for urban use, having low emissions and being flexibly available via digital platforms. We teach our students to develop and design such vehicles and the corresponding digital infrastructure,” explains Prof. Dr. Tankred Müller, Professor of Electrical Engineering at HAW Hamburg. ■

NEW FACES AT THE FACULTY TI

In 2021, five new professors were appointed to the Faculty of Engineering and Computer Science: Prof. Dr. Alexandra von Kameke and Prof. Dr. Martin Lauer at the Department of Mechanical Engineering and Production Management, Prof. Dr. Christian Lins at the Department of Computer Science, Prof. Dr.-Ing. Kay Kochan at the Department of Automotive and Aeronautical Engineering, and Prof. Dr. Kolja Eger at the Department of Information and Electrical Engineering. In addition, Ariane Ament, who holds a doctorate in meteorology, came on board as a new member of the research office. ■

DESY AND HAW HAMBURG STRENGTHEN HAMBURG AS A SCIENCE LOCATION

The research center DESY and HAW Hamburg have agreed on a new strategic Cooperation for Application and Innovation (KAI). The cooperation includes dual study and teaching, research and development, as well as the transfer of innovation, technology, and knowledge. Hamburg’s Science Senator Katharina Fegebank welcomed the collaboration as excellent news for researchers, students, and industry partners of both institutions, but also for Hamburg as a science location.

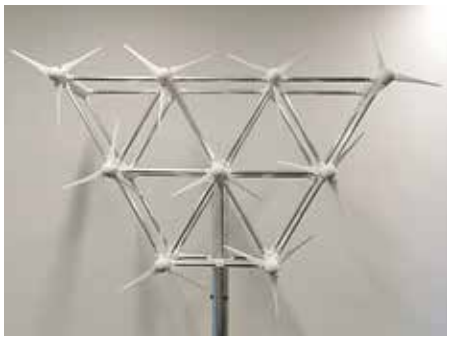
“Through KAI, we are sending a strong signal that applied research at HAW Hamburg and basic research at DESY complement each other perfectly,” said Prof. Dr. Micha Teuscher, President of HAW Hamburg. Already before, the university had participated as a partner of DESY with four professors from the Faculty of Engineering and Computer Science in the top-class education of young researchers in the graduate school DASHH (Data Science in Hamburg - Helmholtz Graduate School for the Structure of Matter).

KAI Kooperation für Anwendung und Innovation der HAW Hamburg und DESY

The list of concrete areas of cooperation ranges from real-time control technologies for highly complex accelerator facilities through visual simulation and robotics, efficient energy systems, scientific computing, intelligent sensor systems, spectroscopy and measurement data processing, embedded electronics and electronics development, all the way to scientific illustration. Likewise, a joint site is planned in the Science City Hamburg Bahrenfeld currently under construction. ■

MANY ARE BETTER THAN ONE

Wind turbines of the future could look very different from those of today. Instead of one large rotor, they could have several smaller ones. The CC4E (Competence Center for Renewable Energies and EnergyEfficiency) has commissioned a laboratory wind turbine that can be used for teaching purposes, exhibitions and wind tunnel tests. It has a fully functional pitch system for adjusting the blades and a generator control system. It will be used to research how the individual rotors of such a turbine influence each other. Research on multi-rotor turbines is a lighthouse project in wind energy research, where projects are being carried out on the service life and optimization of wind turbines and their operating concepts.



This is what the wind tower of the future could look like.

Another project in this research area is called FatWake. It uses LiDAR systems at the Curslack wind farm to investigate how wind turbines affect the loads on leeward turbines to optimize wind farm design. ■

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News

AWARD FOR BACHELOR THESIS

In theory, flying wing aircraft would be much more efficient than today's aircraft. However, many feasibility questions still need to be addressed. Moritz Herberhold, a graduate of the Aeronautical Engineering course at HAW Hamburg, has now addressed the topic of "Identification of dimensioning load cases on the level of finite elements on a flying wing structure in comparison to the cutting loads method" in his bachelor's thesis. He was honored for his work by the German Society for Aeronautics and Astronautics (DGLR) with the Hermann Köhl Award. The award is endowed by the Förderkreis Ozeanflieger Hermann Köhl e.V. to keep the memory of the aviation pioneer alive. One year after Charles Lindbergh's Atlantic crossing from west to east, Köhl succeeded in April 1928 in making the first Atlantic crossing in the opposite direction. Every year, the DGLR bestows the young scientists' award for outstanding dissertations, student research projects and diploma theses. Prof. Dr. Michael Seibel supervised Herberhold's thesis at HAW Hamburg. ■

THE BIG QUESTIONS OF HUMANITY

There was a time when People believed that the Earth was at the center of the universe. Today we know that our world is not the center and that there is not only one planet, but many. Einstein's theory of relativity and quantum mechanics have fundamentally changed our idea of space and time.
Prof. Dr. Peter Möller, professor of Physics and Mathematics in the Department of Information and Electrical Engineering, answers the questions of how the cosmos evolved, why it is the way it is, and whether there may be other universes in his book, "Warum es Leben im Universum gibt (Why there is life in the universe)". Möller also addresses U.S. physicist Lee Smolin's idea that there is some kind of cosmological heredity and that new baby universes with similar properties emerge from the massive black holes of one universe. ■

→ Warum es Leben im Universum gibt
Astrophysik auf dem Weg zu einem neuen Weltbild | Prof. Dr. Peter Möller
Verlag Dr. Köster | Softcover: 86 pages
Year of publication: 2021|ISBN: 9783968310190
(available in German only)

ROOM FOR CLEAR THOUGHTS

To offer the doctoral students optimal working conditions, the Faculty of Engineering and Computer Science has set up the Room for Research in one of its buildings. Here, doctoral students will find everything they need for successful scientific work: Workstations, laboratory space, meeting facilities, and a kitchen. And all this in an inspiring environment.

The Room for Research has two meeting rooms with space for up to ten people. Other members of HAW Hamburg can also book these. In this environment, doctoral students can engage in joint and interdisciplinary research, discuss and learn from each other. At the same time, it is a launchpad for start-ups founded out of HAW Hamburg. It is also an event space and meeting place and a communication platform for the university, politics, business, and science. ■

STUDENTS BECOME VIRTUAL CAR TESTERS

Real prototypes are expensive. To save development costs and bring vehicles to market faster, the automotive industry increasingly relies on virtualization. This applies both to the development of innovative functions and to the evaluation of driving characteristics. By using a so-called driver-in-the-loop (DiL) simulator, engineers can validate design decisions faster and more reliably.
The AUDEx project at HAW Hamburg picks up on this development while familiarizing students with the industry's actual development processes. AUDEx enables students to work on modern development tasks with realistic, remote-controlled vehicles using standard industry tools. The vehicles are equipped with a modular system of cameras, microcontrollers, and sensors and actuators for various applications. In addition, the vehicles can be controlled via a motion system so that the drivers and passengers can experience the effects on driving behavior. ■

AUDEx

"The Room for Research is a great place for me to be really productive."

DR. VALERIYA TITOVA,
RESEARCH ASSOCIATE

Aviation impacts our climate – and contrails are part of the problem. They prevent long-wave infrared radiation from being reflected back into space.

HYDROGEN INSTEAD OF KEROSENE

More than hot air

NOTHING IS SIMPLE IN AVIATION, EVEN IN NORMAL TIMES. THE ROAD TO A CLIMATE-NEUTRAL FUTURE IS THEREFORE PAVED WITH TECHNOLOGICAL CHALLENGES. HYDROGEN IS EXPECTED TO PLAY A KEY ROLE IN MAKING THE ENERGY GENERATED BY THE SUN AND WIND USABLE FOR AVIATION AS WELL. FOR THIS SHIFT TO SUCCEED, HOWEVER, RESEARCH STILL HAS TO FIND ANSWERS TO MANY QUESTIONS. →

TEXT: HEINRICH GROSSBONGARDT

No atom is smaller and none occurs more frequently in the universe. Out of 1,000 atoms, 900 are hydrogen atoms, 99 are helium, and only one is one of the other 90 elements. On Earth, hydrogen is rather rare. This is due to its volatility. But in combination with oxygen, as water, it is the basis of all life. It is also expected to play a key role on the path to a climate-neutral future.

The history of human energy consumption can also be read as a journey from fuels with a low hydrogen content to those with ever higher hydrogen content.

Hamburg has set itself the goal of becoming the center of a future hydrogen economy in Northern Europe. "The clear goal is to establish an internationally leading hydrogen economy in Hamburg," says Michael Westhagemann, Senator of Economic Affairs, formulating the vision of Hamburg's senate.

In May, Hamburg received half a billion euros in funding for a total of eight projects. The city is adding another 160 million euros out of its own pocket. Establishing a functioning hydrogen economy along the entire value chain is a mammoth task – just like the path to a climate-neutral future in general. Not least because corresponding interfaces are necessary, linking production, transport, distribution, and ultimately the consumers who have to convert their fossil processes to hydrogen at great expense.

"The clear goal is to establish an internationally leading hydrogen economy in Hamburg."

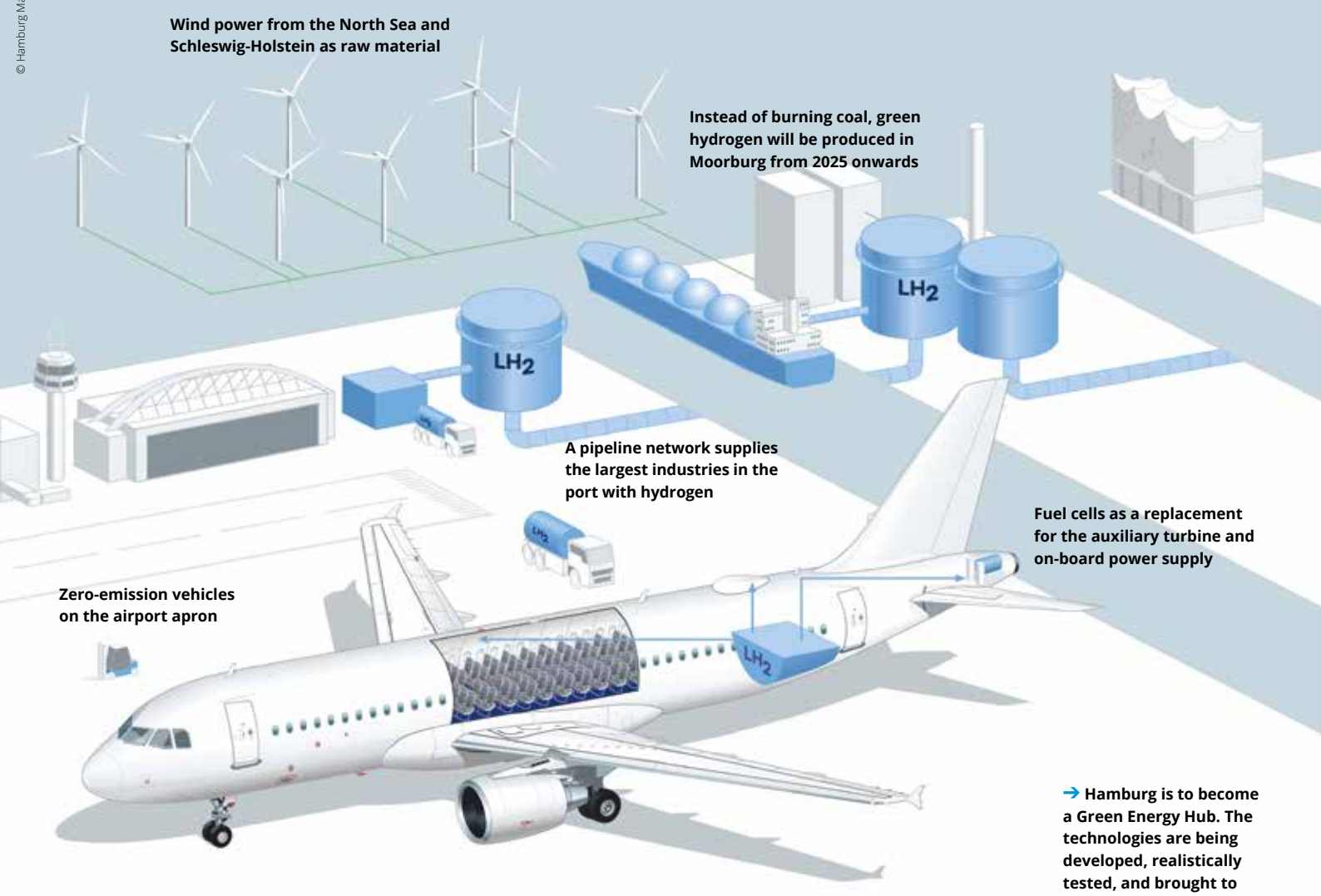
MICHAEL WESTHAGEMANN,
SENATOR FOR ECONOMIC AFFAIRS OF THE FREE AND HANSEATIC CITY OF HAMBURG

From wood to coal, from coal to oil, from oil to gas: Based on this development, building a hydrogen economy is the next logical step. In this scenario, hydrogen is not considered a primary energy source like coal or oil. Instead, it offers the potential to store the energy generated by wind and solar power, allowing it to be used when and where it is needed.

What makes the stuff our energy dreams are made of so interesting in this respect is that it is non-toxic, abundantly available, and very energy-dense. While gasoline, kerosene, and diesel have an energy density of between eleven and 13 kilowatt-hours per kilogram, hydrogen has three times that. The best lithium-ion batteries store just 0.18 kilowatt-hours per kilogram.

NOTHING HAPPENS OVERNIGHT

Hydrogen is also expected to pave the way for a more environmentally compatible future in aviation. The industry's need for action is immense. What was achieved through modern aircraft with increasingly efficient engines as well as through savings in flight operations has been more than eaten up by an almost unstoppable growth. In fact, CO_2 emissions



An Airbus A320 as H2 demonstrator for the practical research of the ground handling of hydrogen

→ Hamburg is to become a Green Energy Hub. The technologies are being developed, realistically tested, and brought to operational readiness here in Hamburg.

from aviation have increased by 3.5 percent annually – and this while emissions in the EU countries are decreasing by an average of one percent since 1990. So there is a lot of catching up to do.

The EU wants to reduce CO_2 emissions in its member states to 55 percent of the 1990 level by 2030. Describing the dilemma, Prof. Dr. Dieter Scholz, Professor of Aircraft Design, Aircraft Systems and Flight Mechanics at the Department of Automotive and Aeronautical Engineering at HAW Hamburg, says: "For aviation, this means a reduction of around nine percent per year." However, through operational fuel-saving measures and fleet modernization, the industry achieves an average of 1.5 percent per year. "Additionally, air traffic would have to shrink by 7.5 percent permanently per year," says Scholz.

In September 2020, Airbus unveiled three concept studies for hydrogen-powered aircraft under the title ZEROe (Zero Emissions) and announced plans to put the world's first zero-emission aircraft into service by 2035. In May of this year, Airbus Chief Technology Officer, Grazia Vittadini, announced that the configuration of a "green aircraft" for regional and medium-haul routes should be in place in four years.

However, even if the industry succeeds in keeping to the timetable and delivers hydrogen-powered aircraft in the middle of the next decade, it will still take several years before their share of the world fleet – and thus their contribution to reducing emissions – can reach a significant level.

Lastly, hydrogen was already high on the agenda once before. After Russian engineers successfully demonstrated the use of hydrogen fuel in 1988 with a converted triple-engine Tupolev Tu-154, the then Deutsche Airbus generated studies for a hydrogen-powered aircraft. →

"Water will be the coal of the future."

JULES VERNE,
POET AND VISIONARY, IN "THE MYSTERIOUS ISLAND", 1874

The colorful world of hydrogen

Like most gases, hydrogen is colorless and invisible. In the context of the climate debate, however, it has been assigned various color codes. They were chosen to indicate the more or less climate and environmentally friendly origin of the element.

GREEN Green hydrogen is made through water electrolysis using electricity generated by wind power or photovoltaics. Its production does not cause any greenhouse gases. The process is also known as power-to-gas.

GREY Grey hydrogen is obtained from fossil fuels. Usually, natural gas is converted into hydrogen and CO_2 under heat (steam reforming). The production of one ton of grey hydrogen generates around ten tons of CO_2.

BROWN Brown hydrogen is produced from lignite (brown coal). A respective project is in preparation in the Australian state of Victoria as the brown coal mined there can no longer be used. The production of each ton of brown hydrogen generates 20 tons of CO_2 which is to be captured and stored (Carbon Capture and Storage, CCS).

BLUE Blue hydrogen is similar to grey hydrogen, but the CO_2 is captured and stored in the ground (CCS).

TURQUOISE Turquoise hydrogen is obtained by splitting methane gas at high temperatures in the absence of air (methane pyrolysis). This does not produce CO_2 but solid carbon, which can be stored or used industrially.

RED Hydrogen produced using nuclear power.

YELLOW Hydrogen produced with the conventional electric power mix.

WIHTE White hydrogen is a by-product of certain processes in the chemical industry.

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According to calculations at the time, an Airbus A310 with 200 seats and hydrogen tanks located above the passenger cabin would have had enough range to fly travelers from Hamburg to the Mediterranean vacation island Mallorca.

The hydrogen was to be produced with hydroelectric power in Norway, and later in Canada within the framework of the Euro-Québec-Hydro-Hydrogen-Project. From there, it was planned to be shipped to Hamburg. Initially, the driving force behind this effort was the fear of another oil price shock and its economic consequences. It was only in the course of the 1990s that the increase in the CO_2 concentration in the atmosphere, and thus climate protection, gradually came into focus.

HYDROGEN FUEL AND GLOBAL WARMING

In principle, there are three ways to make solar and wind energy usable for aircraft propulsion in the form of hydrogen fuel. Firstly, synthetic kerosene (SAF) can be produced from hydrogen and from CO_2 which is extracted from the air or from exhaust gases. SAF can be mixed with other kerosene or, if sufficiently available, burned pure. Hydrogen can also be burned directly in the engine, provided that some technical modifications are made to the combustion chamber. However, both options generate nitrogen oxides that contribute to ozone depletion in the stratosphere. A third possibility comprises the generation of electricity in a fuel cell by means of so-called cold combustion, thus powering the aircraft electrically.

The program title chosen by Airbus, ZEROe, may be catchy and powerful, but is misleading: none of the methods are actually emission-free. In every case, nitrogen oxides are produced in the engine in spite of the considerable progress made in this area

“Hydrogen in fuel cells has the greatest potential for aviation.”

PROF. DR. DRAGAN KOZULOVIC, PROFESSOR FOR AIRCRAFT ENGINES

A cluster for hydrogen

Clusters are an integral part of Hamburg's industry policy. They connect business, research, and politics, and they were established for the eight economic sectors that are particularly important for the city's economic future. These include Hamburg Aviation, Logistik-Initiative Hamburg, Life Science Nord, and Erneuerbare Energien (EEHH), under whose umbrella the hydrogen economy has been operating in its own structure since February 2021.
Founded in 2010, the EEHH cluster today has almost 200 members, including HAW Hamburg. The city of Hamburg wants to use hydrogen to decarbonize the industry and chemical companies. It will also be used in aviation and shipping as well as for trucks and public transportation (HVV) buses.

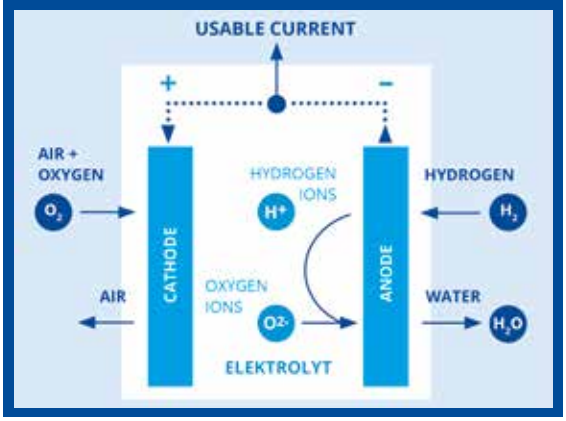
in recent years. What's more, burning hydrogen fuel produces 2.6 times more water vapor than kerosene. Under specific circumstances, water vapor forms contrails that prevent long-wave infrared radiation from being reflected back into space.

The question is still open as to how the introduction of large amounts of water vapor into the otherwise very dry air of the upper atmosphere affects cloud formation and the Earth's radiation budget.

The fuel cell is older than the internal combustion engine. It was invented in 1838 by the chemist and physicist Christian Friedrich Schönbein. For a long time, the discovery remained practically unused. Apart from its use in space flight since the 1960s, this technology has only been commercialized for about 20 years. The performance of existing systems is far below what would be needed even for a small commercial aircraft. Engine manufacturer MTU Aero Engines and the German Aerospace Center (DLR) are currently developing a hydrogen-powered fuel cell with an output of more than 500 kilowatts. It is to be flight-tested in a twin-engine Do 228 of DLR from 2026. A fuel cell that runs on green hydrogen is emission-free – except for the water vapor produced when hydrogen and oxygen react. This makes the fuel cell an ideal candidate in terms of climate protection. Prof. Dr. Dragan Kozulovic is convinced: "Hydrogen in fuel cells has the greatest potential for aviation." Kozulovic is a Professor of Aircraft Engines at HAW Hamburg and is part of the management team of the FTZ Future Air Mobility.

With today's technology, a fuel cell to power an aircraft the size of an Airbus A320 would weigh around ten tons. Including the engine electronics and the electric motor, the entire propulsion system would be two to three times heavier than a current engine. "This would account for about 20 percent of the empty mass of the aircraft. But engines from before the introduction of jet propulsion were similarly heavy, and yet people flew across the Atlantic with them," Kozulovic says. "Also, colleagues who are working on developing fuel cells tell me that they could become 30 or 40 percent lighter in the next few years. The possibilities are far from exhausted."

OPERATION OF A FUEL CELL



This flying wing is an Airbus concept for a CO_2-neutral long-haul aircraft.

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WASTE HEAT FOR AN ENTIRE SMALL TOWN

One of the unique characteristics of a fuel cell is that it generates not only electricity and steam, but also waste heat. The more its power potential is exploited, the more waste heat is produced. This is not an issue for smaller systems, such as those used to power a motorhome or even a car. With an aircraft, however, the situation is quite different. Here, we are talking about quite significant orders of magnitude. Kozulovic has scientifically researched the problem and possible solutions to the questions: Is the use of fuel cells still possible? What possible solutions are there, and how does this affect the aircraft as a whole? →

→ You can find information about the Aeronautical Engineering degree program here (German only):

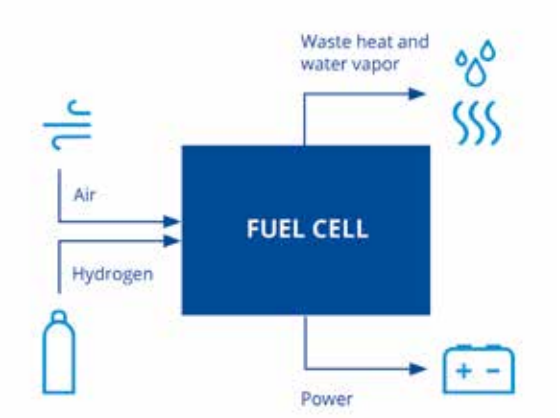
Hydrogen – the oil of tomorrow

In 2019, 2,514 terawatt-hours of final energy were consumed in Germany, 4 percent less than in 1991. However, 14 percent more oil and electricity were used for our mobility in the same time period. The transport sector has thus overtaken industry and households as the largest consumer. 45.4 percent of electricity and 19.6 percent of final energy now come from wind power and photovoltaics.

According to a Max Planck Institute for Chemical Energy Conversion forecast, Germany will have to import 45 million tons of hydrogen in 2050 – even if it consistently exploits its own possibilities for generating and storing renewable energy. Yet, as huge as this amount may sound, it is only half of today's crude oil imports.

In the dry and sunny countries of Africa, conditions are ideal for the generation of solar energy. While one square meter of solar panel in Hamburg can generate around 1,200 kilowatt-hours, this figure is up to 2,250 in Senegal, and even more than 2,500 kilowatt-hours in Namibia. Agreements are already in place between Germany and several African countries to investigate the production feasibility in the frame of initial pilot projects.

Hardly anyone doubts that the capital will be available for the necessary projects. Investments are made where they promise returns. According to BloombergNEF, an analyst corporation specializing in renewable energies, investors worldwide already spent 500 billion dollars into the decarbonization of energy generation, industry, and transportation in 2020.



The fuel cell produces water from air and hydrogen. Half of the generated energy is electricity and half is heat.

An A320 in cruise flight requires an engine output of ten megawatts. Even if the fuel cell is designed sensibly, about the same amount of energy is generated as waste heat – enough to heat 2,500 apartments, each with 80 square meters of floor space. While some of the waste heat could certainly be used for air-conditioning the cabin and for the wings' anti-icing system, this would require only a few hundred kilowatts at most.

WHERE TO WITH THE WASTE HEAT

The 100-degree Centigrade exhaust stream of today's engines generates a comparable volume of unused waste heat. However, a low-temperature fuel cell, which is most suitable for aviation, operates at less than 100 degrees itself. Therefore, it only emits a "lukewarm breeze" of just 70 or 80 degrees Centigrade. It is precisely here where the problem lies: The smaller the difference in temperature to the environment, the more difficult the cooling. This is especially true when there is as little a margin in terms of weight and space as in an aircraft.

"Storing hydrogen in pressurized tanks is more suitable for shorter-range aircraft."

PROF. DR. DRAGAN KOZULOVIC

FTZ Future Air Mobility


© Paula Markert

As an important aviation location, Hamburg faces tough international competition. Its status depends on the extent of its innovative contribution to the technological advancement of aviation. As a platform for airborne mobility, HAW Hamburg's Future Air Mobility research and transfer centre (RTC) contributes to strengthening the location. It is the youngest of the four research and transfer centres of Faculty of Engineering and Computer Science. 13 professors are members. In their research, they cover the full range of relevant topics from urban aviation (drones, air taxis, helicopters, etc.) and the use of hydrogen in aviation to weight-saving materials and construction methods as well as cabin concepts for future commercial aircraft. Issues relating to sustainability and climate neutrality are of particular importance. By transferring scientific findings, the RTC contributes to the development of new products and production processes and thus to the competitiveness of companies in the metropolitan region. This is achieved, among others, through joint projects together with leading companies from the industry.

The RTC is optimally networked. In addition to aerospace companies, cooperation partners include Hamburg Aviation, HECAS, and the Hamburg Centre for Aviation Training-Lab (HCAT+). Furthermore, universities and research institutions, including the Technical Universities of Hamburg and Braunschweig, the Centre for Applied Aviation Research (ZAL), and the German Aerospace Center (DLR). ■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A sufficiently large heat exchanger would have about the frontal area of today's engines and would increase the drag by 20 percent – thus requiring 20 percent more power in cruise flight. Kozulovic presented this effect at an international conference in 2020 – bad news for the development of aircraft powered by fuel cells. More drag means higher energy consumption and thus even higher operating costs than expected anyway from using alternative engines and fuels.

But research does not stand still. In a master's thesis that Kozulovic supervised, a student at the Technical University of Braunschweig thought things further. If you don't use water as a coolant, but one that evaporates at less than 100 degrees, then you could use the principle of the refrigerator or the heat pump and drive the temperature up to 300 degrees. "You need energy to drive the pump, but since the heat exchanger is much smaller, it has considerably less mass and generates significantly less drag."

Thinking of hydrogen for many people immediately brings to mind the Lakehurst airship disaster or the oxyhydrogen reaction from chemistry class. But hydrogen is by no means more dangerous than kerosene. On the contrary, we have learned to work with this reactive gas routinely and safely, for example in the space and chemical industries.

Unlike gasoline or kerosene, hydrogen does not spread along the ground. Because the gas is much lighter than air, it rises quickly in the event of a leak, as do flames in an ignition.

"Accident prevention will be more about protecting passengers from a blast of the cold temperatures," says Kozulovic, who expects that at least larger aircraft will have liquid hydrogen on board. Temperature: minus 252 degrees Centigrade. "Gaseous hydrogen in pressurized tanks is more suitable for shorter-range aircraft. However, when thinking of longer flights, then you have to liquify the hydrogen."

THE MOST RADICAL CHANGE IN THE HISTORY OF THE INDUSTRY

The step from the carbon age to the hydrogen age is the most radical our industrial society has ever had to take. The road ahead is paved with unresolved issues and technological challenges. This is especially true in aerospace. Here, the demands on new technologies are much higher and much more challenging to meet than in most other sectors – especially since mere decarbonization, i.e., abandoning fossil fuels alone, may not be enough to become truly carbon-neutral. Science, especially applied science, still has a lot of work to do. ■

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QUIET AIRCRAFT CABIN

Christmas ornaments for research

© Stefan Albrecht

Hannah Hoppen shows the two Christmas ball ornaments she used for the first measurements of noise insulation.

THERE IS AN AGE WHEN CHILDREN KNOW FOR SURE THAT THEY WANT TO BE A POLICE OFFICER, A TEACHER, OR A PILOT. BUT BEYOND THAT, THE QUESTION OF THEIR CAREER ASPIRATION IS DIFFICULT TO ANSWER FOR MOST YOUNG PEOPLE.

FOR HANNAH HOPPEN, A VISIT WITH HER SCHOOL'S PHYSICS CLASS AT HAW HAMBURG WAS THE DECIDING FACTOR. TODAY SHE IS EARNING HER DOCTORATE THERE ON WAYS TO MAKE AIRCRAFT QUIETER ON THE INSIDE.

TEXT: HEINRICH GROSSBONGARDT

Hannah Hoppen remembers it very clearly: "We did experiments in the wind tunnel – and I was thrilled. I didn't even know that it was possible to do experiments, determine values from them, and calculate something meaningful." And then a second passion showed up. Thanks to a teacher's initiative, she had maintained a pen pal friendship with a girl in Montivilliers, the French twin town of her hometown, Nordhorn, since elementary school. She had also been to France in the eleventh grade. "I wanted to combine these experiences: Physics, science, and France." Where better to do that than at Airbus, where she successfully applied for a dual study program in aircraft construction. "At school, I had no contact with technology at all. That's why I couldn't imagine what it would be like," she admits today.

Nevertheless, she was hooked on technology. As early as her bachelor's thesis on a test rig for an aircraft emergency power supply based on a fuel cell, it was clear to her: I want to earn a doctorate. During experiments, she met Prof. Dr. Wolfgang Gleine, who was setting up a test rig for a cabin system in another laboratory at the time.

Gleine was working on ways to make aircraft wastewater systems quieter. "That's how I got into acoustics," says Hannah Hoppen. She took a leave of absence from Airbus to complete a master's degree as the next step towards her doctorate.

At HAW Hamburg she then finds what she was missing in her job: the opportunity to get to the bottom of things. "For me, I always had the feeling that you had to deliver results before you got to the bottom of something," says the 32-year-old. Things are different in research. It is all about understanding connections, recognizing regularities, and thus creating new knowledge and the basis for fresh solutions. It takes persistence and stamina. It's not flashes of inspiration that change the world, but the persistent drilling of the proverbial "thick boards".

In Hannah Hoppen's case, a red and a green Christmas tree ball were the beginning of an tedious task on the way to her doctorate. The ornaments' role in the service of science has certainly left its mark on their shiny surface. They are no longer suitable for Christmas trees. Instead, the balls are helping the doctoral student find a way to better insulate the cabin of future aircraft against engine noise. ➔

Hannah Hoppen and her colleague prepare a measurement.

PASSENGERS WANT A QUIET CABIN

Anyone who has ever flown in an Airbus A380 will have noticed how quiet this airliner is inside. A low noise level in the cabin improves travel comfort. Long-haul flights in particular are more stressful the louder it is inside the aircraft. Finding sleep at noise levels above 60 decibels is almost impossible. Even an A380 cabin is about as noisy as a restaurant, depending on where you sit. Since passengers want a quiet cabin, airlines also place a high priority on this when selecting their aircraft.

As part of the Federal Aviation Research Programme (LuFo), HAW Hamburg had, among other things, won the contract to develop solutions for improved sound insulation in aircraft such as the A320. Third-party funded projects such as this enable HAW Hamburg to employ students for their doctoral studies, or at least for part of their time working on their doctorate.

→ Scan QR code for more information on the Mechanical Engineering and Production Management degree program (German only).

The next generation of fuel-saving engines will produce less aircraft noise, but paradoxically will be more audible inside the cabin than today's engines. The engine's fan rotor is a major contributor to a cabin's noise level. Because it will rotate slower on future engines, it will also make less noise. But, as an unavoidable consequence, other noises will become more prominent – the reason being that the sound spectrum will shift towards lower frequencies. Unfortunately, the glass wool insulation mats between the cabin paneling and the outer skin of the aircraft, which shield the interior against cold temperatures and noise, have only a poor effect on them.

Everyone with party-loving neighbors knows the problem: Because high tones are swallowed by the brickwork, it's mainly the rumble of the bass that penetrates into your own apartment. To dampen the low frequencies, you would have to make the walls either heavier or thicker. Both options do not exist in an airplane. Something else is needed.

"It can't weigh anything, it must be non-combustible and must absorb no water, and it should cost nothing," says Hannah Hoppen, laughing as she sums up the requirements for additional noise insulation in an aircraft.

However, the new insulation was allowed to be a little heavier: 100 grams per square meter, the weight of paper. In other words: practically nothing. The insulation should also be easy to install and require little maintenance.

A PATENTED SOLUTION

The Christmas tree balls came into play after an attempt to endow glass wool with the necessary properties failed because it was to heavy. Removing the ornaments' caps with which they are attached to the tree, they become so-called Helmholtz resonators. A vibrating system is thus created at a specific frequency comprising the air in the neck and the air in the sphere (which acts like a spring). The insulating effect depends on the length of the neck and the size of the sphere.

In the process, a particularly large amount of energy is converted into heat through friction. Measurements in the state-of-the-art acoustics laboratory at HAW Hamburg confirmed that the idea works in principle. Using table tennis balls and spheres made of glass-fiber reinforced plastic with several necks, the scientist ended up working on a solution for which she, her former colleague Felix Langfeldt and Professor Gleine, head of RTC Technical Acoustics, have since been granted a patent.

"I could well imagine becoming a professor. There you always have both: teaching and research."

HANNAH HOPPEN, DOCTORAL STUDENT

RTC Technical Acoustics

Acoustics play a unique role in many areas of life – both positive and negative. It determines our quality of life as well as the competitiveness of products. That is why it is essential to understand how and where the noise originates, how it propagates and how it can be attenuated and weakened as effectively as possible where it is undesirable. In 2019, the acoustics laboratory of the RTC Technical Acoustics was inaugurated. It was designed by Prof. Dr. Wolfgang Gleine, the initiator and founder of the RTC, and closely overseen during construction.

The laboratory's core on the HAW Hamburg campus at Berliner Tor in downtown Hamburg consists of various acoustic measurement rooms: a reverberation room and, next to it, four anechoic chambers of different sizes and characteristics. The building also houses offices, a workshop, a materials room, and a measurement and evaluation room. Research is conducted here on aviation topics but also, for example, on the acoustic effects of electromobility.

The ZAL (Center for Applied Aeronautical Research) houses a globally unique technology demonstrator for cabin acoustics. It was designed and built by Prof. Gleine together with Airbus. The demonstrator can be used, for example, to measure the basic acoustic properties of an aircraft fuselage and its cabin furnishings. The RTC Technical Acoustics also features an air-conditioning acoustic chamber with an original A320 fuselage section, the I²AudioLab for research into virtual acoustics, and a high-performance sound laboratory. In addition, the equipment includes an acoustic camera and a weatherproof, portable monitoring station geared toward environmental measurements. ■

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The acoustics laboratory is equipped with state-of-the-art measuring rooms.

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This consists of small, hollow cuboids made of a particularly light but sufficiently hard foam with closed pores. A U-shaped slot is milled into the surface, acting like a Helmholtz resonator. At the same time, the narrow tongue of the U is designed to vibrate in response to the noise and also absorbs some of the energy. Using a model measuring over one square meter and comprising 252 of these elements, Hannah Hoppen was able to show that this new type of sound insulation helps to reduce the part of the noise that escapes from the glass wool.

It remains to be seen whether it will be installed in an aircraft. It's a long way from the university lab to the ready-to-use product. The fact that the results of her work will not be visible and that only trained ears will be able to hear a difference is not a problem for the young scientist:

"You need the drive to figure things out, but also the serenity to know that you're only contributing one piece of the puzzle to the big picture."

Hoppen is currently on parental leave. She became a mother at the beginning of the year, which does not leave her much time to work on her PhD. It is hardly possible for her to dive into complex topics, even though her husband is currently working in the home office, saving time on the commute and taking care of their son as much as possible.

DETOURS CAN BE PATHWAYS

Hoppen still has two years to go before she receives her doctorate. What's next? "I could well imagine staying at the university and becoming a professor. There you always have both: teaching and research." She is already giving lectures in mathematics, in a bridging course that is designed to make it easier for students who have come to HAW Hamburg through second chance education, after vocational training or who have taken a break after graduating from high school.

The knowledge she passes on and the feedback are a strong motivation for her. And that doesn't just apply in terms of the subject matter. The step from guided learning at school to independent knowledge acquisition at university is a big one.

"I can pass on so much in my lectures to first-year students that helped me in my studies myself." Whether teaching and research will work out in the end remains to be seen. Even if motivation and qualifications are right, the right opportunity has to present itself. But Hoppen doesn't think that's a bad thing. She tries to teach students in her math lecture that it's not a problem if they take detours when solving problems. In her opinion, that also applies to the career path one takes. ■

A fascinating country: Vietnam

Vietnam is one of the most interesting countries in Southeast Asia, not only for travelers but also for investors. The country is one of the fastest growing economies in the region. The transition from a centrally managed economy to a socialist market economy has resulted in a per capita income that is now seven times higher than it was 20 years ago. Vietnam is not only a popular tourist destination, but also an increasingly attractive production location.

INTERNATIONAL PARTNERSHIP

Research full of HaMoNee

VIETNAM IS BECOMING INCREASINGLY ATTRACTIVE FOR INVESTORS. ITS INDUSTRY IS GROWING FAST, ALSO BECAUSE A GROWING NUMBER OF COMPANIES SEE THE COUNTRY AS AN ALTERNATIVE LOCATION TO CHINA. HAW HAMBURG COOPERATES WITH FOUR VIETNAMESE UNIVERSITIES TO PROMOTE THE INTERNATIONAL MOBILITY OF STUDENTS AND TEACHERS IN THE ENGINEERING SCIENCES OF BOTH COUNTRIES. ALWAYS IN VIEW: ENVIRONMENTALLY FRIENDLY SOLUTIONS FOR INDIVIDUAL TRANSPORTATION. →

Thanks to the opening and modernization of the economy, the urban population is growing by about one million people every year.

TEXT: MARGARITA ILIEVA

The international exchange of knowledge and skills moves our world forward and helps us solve humanity's problems. HAW Hamburg is therefore determined to further strengthen its profile in this respect. HaMoNee is one of 14 cooperation projects at universities of applied sciences throughout Germany that the German Academic Exchange Service (DAAD) is funding from 2021 to 2024 as part of the HAW.International program.

HaMoNee (pronounced very much like "harmony") stands for Hamburg/Hanoi Mobile Engineers. HAW Hamburg cooperates with a number of industry partners, and with four renowned Vietnamese universities: Hanoi University of Science and Technology (HUST), University of Transport Technology (UTT), Phenikaa University in Hanoi, and Ho Chi Minh City University of Technology (HCMUT). In addition, new application-oriented, English-language study programs are to promote the international mobility of students and teachers in the engineering sciences in both countries. For HAW Hamburg, this is the start of a sustainable strategic partnership in Asia.

The aim is to intensify contacts not only with Vietnamese universities but also with local industry partners. In addition to Beiersdorf affiliate Tesa, these include the two Vietnamese car manufacturers, VinFast and Thaco. Tesa is currently building a new plant in the port city of Haiphong. From 2023, the company plans to move production to this location for the entire Asian region.

In addition to teaching and practical semesters in cooperation with industry partners, digital, internationally oriented courses are to be devised and implemented in hybrid learning and teaching spaces. Teaching (in English) is to take place synchronously in German and Vietnamese real-time. In the context of summer schools and short courses, even more insights into teaching and practice are to be offered to give students from both regions the opportunity for professional and intercultural exchange.

HaMoNee

→ Further information on the project:

Vietnam:
- **Population: 96.4 million**
- **Capital: Hanoi**
- **Largest city: Ho Chi Minh City**
- **Population of Ho Chi Minh City: 8.9 million**
- **Coastline: 3,444 km**
- **Area: 331,120 km²**
- **Universities: 237**
- **Students: 1.7 million**
- **Currency: đồng (1€ ≈ 27.000 đồng)**

The initiator of the cooperation is Prof. Dr. Dirk Engel. A Professor of Mechatronic Systems in Chassis Technology in the Department of Automotive and Aeronautical Engineering, he is the one who successfully submitted the DAAD application for the project with the support of the International Office.

He sees a particular success for HAW Hamburg in the fact that the project is being promoted with a country as a cooperation partner and not, as is usually the case, with an entire region. For Engel, the Shanghai-Hamburg College, which was founded jointly by HAW Hamburg and the University of Shanghai for Science and Technology (USST) in 1998, is a role model. "I see the partnership stabilizing to the point where either an equivalent of the Shanghai-Hamburg College is established or some kind of 'Asia structure' is created to intensify cooperation with North and South Asia. This would also provide the opportunity to support this industrial Southeast Asia aspect," he says, explaining the long-term perspective.

ST. PAULI OR HSV?

The project started with a personal contact, which Engel established in 2005 and has since intensified. In 2016, the idea of long-term cooperation between Vietnamese and German teaching was born. When he met the local partners in 2019, Engel was surprised to be greeted with a friendly "Moin!" in Ho Chi Minh City and was asked whether he was a fan of St. Pauli or HSV, referring to the notorious rivalry between the two Hamburg soccer clubs.

The German-Vietnamese partnership has a long tradition. Even in the days of the GDR, there was a lively exchange of labor and knowledge under various programs." At that time, many Vietnamese came to the GDR. They learned German and worked there. That's why there is a high level of attachment, especially among the slightly older generation," Engel says. Even today, a German university degree opens the doors to their dream jobs for many Vietnamese. HAW Hamburg is extremely popular among Vietnamese students. There is hardly any other country from which so many international students come.

Hoang Long Nguyen is studying automotive engineering and is about to start his master's degree at HAW Hamburg. "We don't have many companies in this field in

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Vietnam. That's why it's often difficult for Vietnamese engineering students to find a good internship," he says. Hoang Nguyen has already completed an internship at the Fraunhofer Institute in Berlin while enrolled at HAW Hamburg. "There are things students can't learn in Vietnam. For engineers, practical experience is essential. With more practical experience, you can improve your knowledge and find a good job more easily," says Nguyen about his hopes to participate in the HaMoNee project.

For Engel, the reason for HAW Hamburg's popularity with Vietnamese students is apparent: "The structure of our university offers something different from what is known in Vietnam. We offer a strong practical component. We are application-oriented and not as theory-loaded as a traditional university. That is something that appeals to many in Germany as well."

Prof. Dr. Thomas Clemen, Vice-Dean for International Affairs at the Faculty of Engineering and Computer Science, confirms this experience. In addition to the attractive location of Hamburg, he sees the strength of the university in its long-standing international positioning through summer schools, English-language lectures, the project-based approach, and the internationally networked research groups. Of all the universities in Hamburg, HAW Hamburg is, in his opinion, the one that lives internationalization the most. "Notwithstanding the corona restrictions, one could hear up to 90 languages on campus. That's fascinating," says Thomas Clemen.

VERY GOAL-ORIENTED IN EDUCATION

Stefan Hase-Bergen is head of the DAAD field office in Hanoi. He sees another reason for the attractiveness of German universities of applied sciences in Vietnam's culture and high economic growth, which has been between five and seven percent for 20 years: "A rapidly growing middle class is emerging here, in which Confucian ethics provide for a very high educational ideal." Entire families are willing to invest large sums in education. "The family bonds together so that one day the children can do better and learn something worthwhile. It makes the Vietnamese very goal-oriented in education."

The government and the Communist Party of Vietnam, which controls everything in the one-party state, always emphasize the importance of education and research for the country's socio-economic progress. But there is a lot of unmet demand for application orientation and practical relevance in →

"We offer a strong practical component. We are application-oriented and not as theory-loaded as a traditional university."

PROF. DR. DIRK ENGEL

Hoang Long Nguyen is studying automotive engineering at HAW Hamburg. He is one of over 7,600 Vietnamese who have chosen to study in Germany.

degree programs so that the content can be adapted to the needs of the labor market. "There's truly a gap there, and that's where German universities can play a very important role," he adds on the background of the HAW.International project.

EFFICIENT, BUT INFLEXIBLE

As different as the countries may be, the challenge is the same: transitioning to sustainable mobility. In many cities in Southeast Asia, scooters and motorcycles dominate the street scene. In Hanoi, as in Bangkok, Jakarta, or Kuala Lumpur, two-wheelers are essential for millions of people. "The streets are bustling, it's noisy and stuffy, and they burn fossil fuels. So if you can solve the mobility problem there, you can solve it here, for sure," Engel describes his experience.

A shift to renewable energy and electric mobility could help solve the metropolitan environmental problems in this region, reduce the resulting health problems, and improve people's quality of life. In projects such as HaMoNee, such solutions are to be jointly designed and developed by combining German and Vietnamese know-how.

The COVID 19 pandemic and the recent flood disaster show that this is not a one-way street. "What we were able to learn in Germany, especially with the pandemic, is first and foremost how to deal with such situations in a relatively flexible way. The lack of flexibility is also something the Vietnamese complain about when they are in Germany, as much as they love the country. So, there's certainly something to that," says Hase-Bergen. Adaptability is crucial in a time of rapid change, he says. Vietnam has long been affected by similar severe weather disasters caused by climate change, and according to Hase-Bergen, "It's not even just about fighting the effects of climate change, but developing and adapting to the changes that are coming."

Many Vietnamese students associate qualities such as reliability and discipline with Germany. The high value placed on education at German universities is also reflected in a recent DAAD publication. It was published in 2020 on the occasion of the 45th anniversary of diplomatic relations between the two countries. It is entitled "Alumni careers – made in Germany" and profiles 14 Vietnamese who talk about their experiences in Germany and what they learned and brought back to Vietnam. What one often reads there are terms like efficiency, reality, transparency, goal orientation, intrinsic motivation, and critical faculty.

"These are partly typical Western values that don't exist here to the same extent. Intrinsic motivation, for example, is something that is sometimes less common here. When collaborations arise, people often first ask where their personal advantage is," explains Stefan Hase-Bergen.

It is precisely the combination of the strengths of the two regions' cultures that makes cooperation under the HaMoNee project so promising. According to Clemen, it is Vietnam's increasing attractiveness and its potential as an investment location of the future that will benefit all project partners. In addition, "Vietnam's role as a moderating partner in dealing with China is very relevant in terms of security policy. That also plays a role in research and teaching. So I'm pretty sure that our faculty will be much more involved in Vietnam in the future." ■

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→ You can find information on the Automotive Engineering course here:

→ Two-wheelers dominate the street scene. In Vietnam, for every 1,000 residents there are 450 motorcycles, but only seven cars. The potential to improve the air and quality of life in cities through electromobility is significant.

International Office

The HAW Hamburg International Office team supports the internationalisation of the university, both internally and externally. We provide assistance to degree-seeking international students and visiting exchange students (incomings) as well as to HAW Hamburg students and professors who want to study or teach abroad (outgoings).

Interview

PROF. DR. THOMAS CLEMEN ON THE IMPORTANCE OF INTERNATIONALIZATION FOR THE FACULTY OF ENGINEERING AND COMPUTER SCIENCE AND ITS STUDENTS.

How would you define the benefits of international cooperation for HAW Hamburg?

Thomas Clemen: In turbulent times like these, it is essential for students and teachers to maintain an international exchange. It is a precious experience to realize that there are people on the other side, no matter where they come from. The photos and testimonials on the HAW-International Facebook page are touching. It's wonderful to see how friendships are forming through international exchange. That is something that promotes tolerance. The exchange can change society. That should be our goal at the university. It's not just about imparting knowledge to individual students but also about actually taking on social responsibility.

> "It's about actually taking on social responsibility."
>
> PROF. DR. THOMAS CLEMEN

Is there a specific strategy that the Faculty of Engineering and Computer Science follows concerning internationalization, and how is it implemented?

A few years ago, the German government and its federal states conveyed that 50 percent of students should gain experience abroad. Dr. Thomas Flower, as dean, and I then decided that students abroad would have to deal with the country's everyday life for a longer period – for example, when looking for an apartment or shopping. For us, the sole transfer of expertise and competence in the technical realm stands alongside intercultural exchange – soft skills, sustainability, responsibility, social responsibility, and everything that goes along with it. "This is what will be needed in the future," we hear from internationally operating companies. At our faculty, we are therefore implementing a new strategy. We are committed to adopting sustainability and social responsibility in our degree programs.

To achieve the 50 percent target, we need a great deal of personal commitment. If we succeed in inspiring teachers and researchers to visit certain countries and universities, this will have a multiplier effect. For example, I have almost always taken colleagues with me on recent trips in the hope that they will "taste blood," so to speak, and see for themselves how valuable these personal contacts are. In order to meet the federal government's 50-percent goal, we need to focus on partnerships where there is a genuine interest on both sides to live and breathe this partnership and send and host many students.

That is certainly not always easy. Has there been a pitfall or two in your experience?

I'll take Vietnam as an example, although, of course, you can't generalize all Vietnamese. In Vietnamese culture, you generally don't say "No". Otherwise, you lose face and express, "that wasn't good". Hence, you don't get a clear statement. Only when talking privately, partners tell you how they really feel about something: "That's not going to work because the basis isn't there." If you then ask why they didn't say it in the first place, the answer will most likely be, "Then I would lose face."

Of course, these cultural differences exist in all countries. If I were to write e-mails to somebody in South Africa with a somewhat American attitude, my colleagues there would never reply to me. In the USA, people write: "I need this and that by this afternoon" – without salutation, without anything else. And no one takes offense to that. But in Africa, for example, it's very impolite to get straight to the point. They always ask first: "How is the family?", "How are the children?" Even at the supermarket cash register, with people waiting behind in line, it's quite normal to chat first. In the U.S., when people ask "How are you?" they don't really want an answer, certainly nothing like "Not so well." You can learn this in intercultural training. But of course, it's much more sustainable and personally rewarding to experience the little jabs and funny things for yourself.

They then create a kind of bandwagon effect themselves – like my colleague Dirk Engel, who is himself interested in Vietnam and international cooperation. With his personal commitment, he pulls such a system along. I myself do research in systems theory, and we know from this field of research that there is a "critical mass" – a so-called "tipping point" – at which a system tips completely to the other side. If we have a critical mass of faculty, researchers and students who feel like engaging internationally, we suddenly are an international university without needing a big strategy. ■

MARSMISSION

3.5 windmills per electric kettle

A STORM ON MARS DOESN'T KNOCK ANYONE OVER. THE AIR IS TOO THIN. NEVERTHELESS, WIND POWER WOULD BE A CONCEIVABLE ALTERNATIVE TO NUCLEAR POWER ON THE RED PLANET.

TEXT: HEINRICH GROSSBONGARDT

"Houston, we have a power problem". Should mankind step on Mars in the next 15 or 20 years, this modified version of Apollo 13's famous emergency call would be precisely the kind of message that mission control on Earth would not want to receive. An energy crisis on Mars would be a terrifying scenario. Without electrical power, there is no survival on our neighboring planet. How else could the artificial atmosphere be maintained to enable the Mars astronauts to survive the year and a half that their stay would inevitably have to last until Earth and Mars again reached a constellation in their orbits that would permit a return?

Photovoltaics are used to generate electric power in space, whether satellites or the International Space Station. Similarly, a small solar farm would probably be the means of choice for powering a Mars station. However, it would have to be larger than such an installation on Earth to achieve the same output. There is only slightly less than half as much sunlight per square meter on Mars as on Earth.

Around 80 kilowatts of electrical power are needed to supply life support systems, communications, research equipment, and whatever else belongs to a small Mars station. "That's about 40 electric kettles, so it's very manageable," says Prof. Dr. Vera Schorbach, professor of Wind Energy and Virtual Product Development at HAW Hamburg. She is investigating possible solutions for a particular problem of a Mars mission: dust storms.

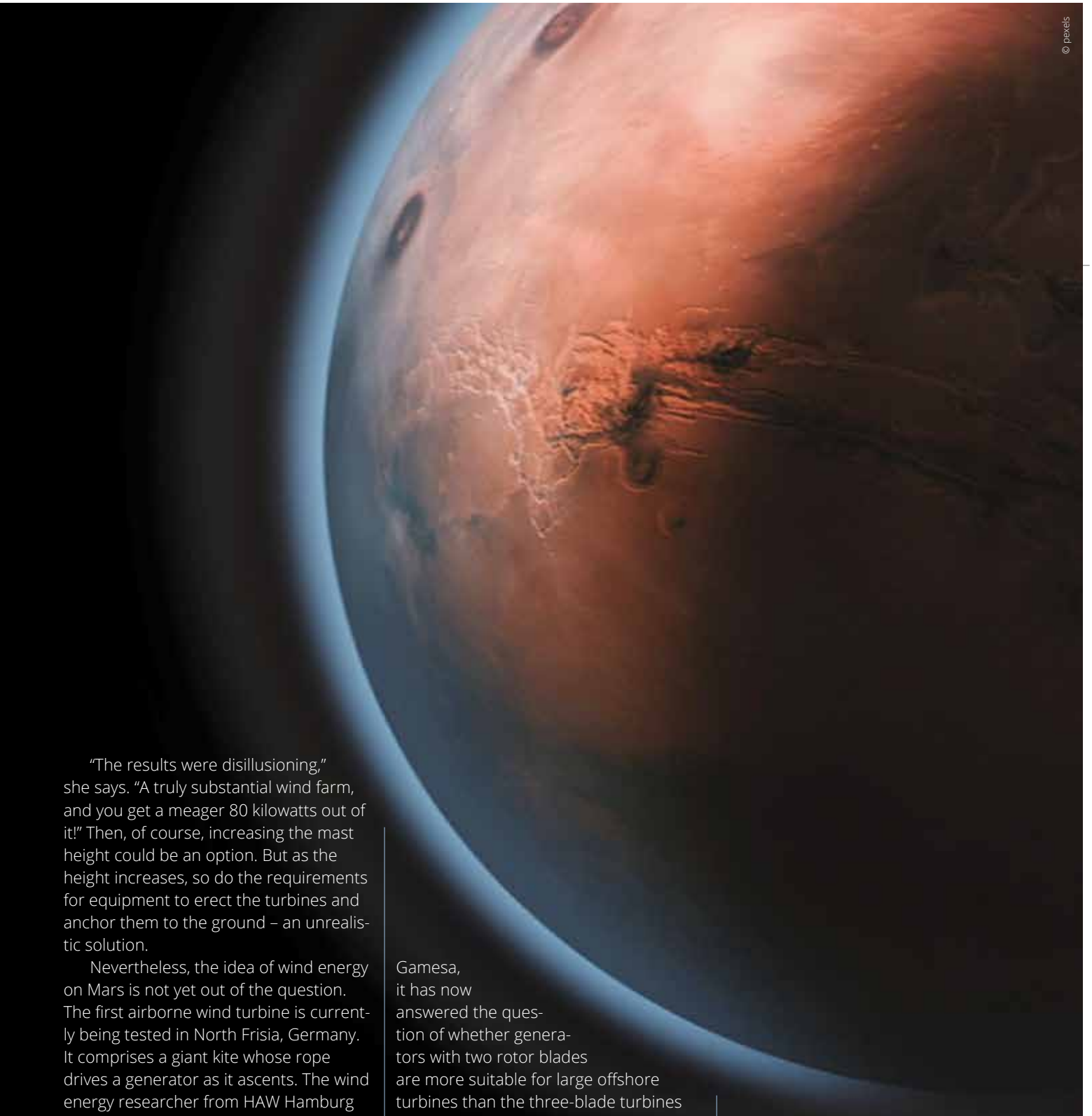
From time to time, massive storms occur on Mars, stirring up so much fine red dust that it covers the whole planet. The dust storms can even be seen from Earth. "You can't even see the polar caps with a telescope when this happens," she says, describing the phenomenon. However, the dust settling on the solar cells is not the problem. The crew of a Mars station would then simply have to go out and dust off the panels. But, more seriously, the dust would block out the sun, so the output of a solar farm on Mars would go down drastically, not just for a few hours or days, but for several weeks – and therefore longer than a battery lasts.

In search of a solution, the professor raised the question of whether this could be bridged with wind power. NASA has developed a small nuclear reactor with up to ten kilowatts of power as part of the Kilopower project. But it would be much better, of course, if the power problem could be solved in other ways. After all, even today, rocket launches involve considerable risk. If something goes wrong, the nuclear payload does not lift off into orbit as planned but crashes on Earth.

DISILLUSIONING RESULT

At first glance, the wind on Mars certainly blows strongly enough to generate electricity. Wind speeds reach up to ten meters per second in the fall and even triple that during dust storms. But even the fiercest storm would not be strong enough to knock over a Martian astronaut. The atmosphere is very thin. The air pressure is only about six millibars, about the same as the pressure in Earth's atmosphere at an altitude of 35 kilometers.

As a result, air density is 70 times lower than on Earth. The energy yield of a wind turbine would be correspondingly meager. Schorbach computed turbines of various sizes. Assuming a hub height of ten meters, 142 wind turbines are needed to close the energy gap during a dust storm.



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"The results were disillusioning," she says. "A truly substantial wind farm, and you get a meager 80 kilowatts out of it!" Then, of course, increasing the mast height could be an option. But as the height increases, so do the requirements for equipment to erect the turbines and anchor them to the ground – an unrealistic solution.

Nevertheless, the idea of wind energy on Mars is not yet out of the question. The first airborne wind turbine is currently being tested in North Frisia, Germany. It comprises a giant kite whose rope drives a generator as it ascents. The wind energy researcher from HAW Hamburg believes that something similar is also conceivable on Mars. "This is a promising technology. It can save 90 to 95 percent of the weight, which would be ideal for a Mars mission," says Schorbach. After all, NASA's current Mars mission with the helicopter "Ingenuity" even proved that flying on the Red Planet is possible.

As exciting as the topic is, the core of Vera Schorbach's research work is very earthly. She is part of the CC4E (Competence Center for Renewable Energies and Energy Efficiency) at HAW Hamburg, which researches and works on the energy transition. As part of an extensive research project with its partner Siemens Gamesa, it has now answered the question of whether generators with two rotor blades are more suitable for large offshore turbines than the three-blade turbines used today: They are indeed.

Since she was nine years old, the 41-year-old professor has been interested in climate change. Back then, she read that CO_2 is a greenhouse gas. Her reading had significant consequences: "I studied mechanical engineering to save the world."

As a young graduate engineer, she joined the Daimler Group and was involved in developing the first Mercedes B-Class car with fuel cell and hydrogen drive. This put her more than a decade ahead of her time. And who knows, maybe she is too with her thoughts on using wind energy on Mars. ■

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GERMANY

Straight to the point

WE GERMANS ARE CONSIDERED TO BE PUNCTUAL, RELIABLE, AND FACTUAL. ALSO, THAT WE USUALLY EXPRESS OUR CRITICISM WITHOUT BEATING AROUND THE BUSH. THIS TAKES SOME GETTING USED TO FOR STUDENTS WHO HAVE GROWN UP IN A CULTURE THAT PLACES MORE VALUE ON COURTESY. AND THEN, THERE'S THE MATTER OF THE LANGUAGE.

TEXT: TIZIANA HILLER

José Alamos and Leandro Lanzieri Rodriguez come from South America and work as PhD students at HAW Hamburg. They are part of the RAPstore project at the Department of Computer Science, where they are engaged in further developing the open-source operating system RIOT-OS for the Internet of Things.

José Alamos first came to Germany for an internship in 2016. He was studying Electrical Engineering at the Pontificia Universidad Católica de Chile in Santiago de Chile. "The concept of an internship as part of your studies does not exist in Chile. So for that, I put my studies on hold for a few months," he says. He had his first contact with RIOT, the operating system for the Internet of Things, during his internship at Freie Universität Berlin and the Inria Saclay research center south of Paris. There and at HAW Hamburg, the project was primarily developed by an international team of scientists. Since 2018, Alamos has been a permanent member of the Internet Technologies Research Group (INET) led by Prof. Dr. Thomas C. Schmidt. The group is vigorous and internationally visible: six scientific assistants and as many students work together in the RIOT team.

Leandro Lanzieri Rodriguez graduated in Electrical Engineering from the Universidad de Buenos Aires and – like Alamos – joined the INET Group in 2018 as a scientific assistant. "I had no connection to Germany whatsoever before," Lanzieri says. "But the job appealed to me so much that I moved here without further ado."

JOSÉ ALAMOS

LEANDRO LANZIERI RODRIGUEZ

Both started as research assistants and are now pursuing doctoral degrees at HAW Hamburg as part of a cooperative dissertation program with Freie Universität Berlin.

Both Alamos and Lanzieri were surprised to find that speaking English doesn't get you very far outside of an academic context. "I currently have handymen in my apartment – if I didn't speak German, I'd be lost," Lanzieri says. That's why the two of them made sure to learn a new language from the start: German.

RESEARCH POWER FOR MINIPOWER

At HAW Hamburg, they work on an open-source operating system for Internet of Things (IoT) devices. IoT refers to a network of objects, devices and systems that are connected to each other and exchange data. An example of this is an automated heating system that automatically lowers the temperature when nobody is home.

But the problem is that each company is creating its own Internet of Things. This makes users dependent on manufacturers, Alamos explains. With RIOT, on the other hand, Alamos and Lanzieri are trying to find a kind of common language that is freely accessible to all. RIOT implements standard protocols, for instance. With them, battery-powered sensor nodes can communicate directly with the Internet. "Our implementations are open-source software," Lanzieri explains. "They are even used in the development of the Internet Engineering Task Force's standardization process. This organization takes care of the technical improvement of the Internet. Such open-source solutions are particularly valuable for start-ups or educational institutions without a significant financial backing, as they can be deployed directly, quickly and free of charge.

Alamos and Lanzieri focus on so-called low-end IoT devices. Unlike cell phones or smart TVs, these devices are limited in terms of connectivity or computer capacity. But, on the other hand, they can run for years on a battery. Therefore, they are suitable for use in places without electricity, such as in the mountains, or in places where powerful devices would simply be too big, for example, in smart clothing.

"At the end of the day, it's about respect. One can be friendly and straightforward at the same time."

LEANDRO LANZIERI, DOCTORAL STUDENT

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→ The Internet Technologies Research Group researches technologies and applications for the next-generation internet with a focus on mobility, security and knowledge-based systems. inet.haw-hamburg.de

→ Information on the Applied Computer Science course (German only):

While Lanzieri is working on ensuring that the various components function optimally on their own and, for example, recognize and reach other devices, Alamos specializes in wireless communication over long distances: How can a computer communicate with a device 15 kilometers away on a mountain? And most importantly, how does it work without WLAN? To this end, he is looking into LPWAN (Low Power Wide Area Network). This allows devices to be connected to a server with minimal energy consumption, even over long distances.

GERMAN STRAIGHTFORWARDNESS

The two researchers have been living in the Hanseatic city for three years and have already acquired German habits. "I communicate much more efficiently than before," says Lanzieri. At first, the German directness threw him for a loop, he says. "In South America, we wrap up criticism in softening phrases – in Germany, when something is not going well, one addresses it directly. Meanwhile, I really appreciate it, and I am much more direct myself," he says. "At the end of the day, it's about respect. One can be friendly and straightforward at the same time."

Neither of them knows yet whether they will leave their beloved new home after completing their doctorates: "This decision ultimately depends on the career prospects, which are simply better here. But I don't rule out returning home. I do miss my family and friends," says Lanzieri. José Alamos feels similar: "Leaving Hamburg would be tough for me. I would like to continue working in the IoT context – if not as a scientist, then perhaps in a political setting. You can start great projects with the Internet of Things. For example, we could use multiple networked sensors to measure air quality and ensure that the air in cities gets better in the long term." ■

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ARTIFICIAL INTELLIGENCE

Now it's getting emotional!

THE FOUNDING TEAM OF BEYOND EMOTION HAS A MISSION: THE HAW HAMBURG SPIN-OFF WANTS TO USE AI-BASED SOFTWARE TO READ EMOTIONS AND TO DO SO BETTER THAN HAS BEEN POSSIBLE BEFORE. THEIR VISION: MAKING LIFE EASIER FOR PEOPLE TENDING TO DEMENTIA PATIENTS.

“We want to contribute and add value to our society.”

HANNE BUTTING,
CO-FOUNDER OF BEYOND EMOTION

TEXT: MARIA ZEITLER

Anja is worried. She can’t concentrate on her work because her mother, who has dementia, lives at home. Anja constantly wonders if her mother is doing well. How can she go about her work with a sense of calm and still let her mother live longer in her familiar surroundings? “Emotion recognition solves all these problems,” is the message of a video on the website of Beyond Emotion. HAW Hamburg launched the company as a spin-off in 2020.

TACKLING THE DRAWBACKS OF EXISTING EMOTION RECOGNITION

It all started with a bicycle: Sobin Ghose and Arne Bernin, two of the three founders of Beyond Emotion, met in 2015 in the university project EmotionBike. They discovered that existing systems for recognizing emotions had drawbacks. The project involved test subjects moving through a virtual world on a stationary bike trainer called the EmotionBike. In doing so, a 3D camera captured and analyzed their facial expressions. One of the tasks involved bouncing the bike from one island to the next.
“We set up the system in such a way that this was not possible. Frustrated people usually start laughing. However, while a human recognizes that the person is laughing out of frustration, the existing software stated: This person is happy,” says Sobin Ghose, who studied and wrote his master’s thesis at HAW Hamburg.

Co-founder Arne Bernin then continued researching the topic in his doctoral thesis, analyzing existing facial expression recognition systems. “It was not our goal to create our own emotion recognition system,” says Bernin. But the team’s ambition was sparked: There had to be something better than working with the inadequate psychological models that only know a handful of emotions. “Our AI software now does it the other way around: it groups all the similar facial expressions we feed in, and it’s us, humans who name them according to what we see on them,” explains Arne Bernin.

SOLUTION SEEKS APPLICATION

In 2019, the research project and the doctoral thesis were completed. Then, the question arose: What to do with the idea? “Not so easy, if you approach this from the technological side and not from the problem angle,” says Sobin Ghose. Emotion recognition is already used in the automotive industry and in marketing. Improving them with the new solution would have been one option. But the founding team opted for an application that, at first glance, could hardly be further from the realm of artificial intelligence: the care sector. ➔

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Hanne Butting and Sobin Ghose founded Beyond Emotion with Arne Bernin (not pictured here).

Interview

PROF. DR. KAI VON LUCK ASSISTS STUDENTS WHO WANT TO FOUND A START-UP.

> **“Interacting with young, dedicated people is a lot of fun.”**
>
> PROF. DR. KAI VON LUCK,
> PROFESSOR OF COMPUTER SCIENCE

What is your motivation for supporting young scientists in starting a business?
Kai von Luck: My understanding of who I am as an employee of a university – especially a university of applied sciences – is to support young people on their way to founding a company.
I understand the practical relevance of my work in the exchange with existing companies and in contributing through our training to students or employees of our university putting their own ideas and companies into practice. And: I have a lot of fun exchanging ideas with young, committed people.

Why do you think it is vital to support university spin-offs?
Large companies often have problems piled up, and Corona has intensified that. Corporations can be rather heavy tankers, and it’s not so easy to turn the tables and initiate transformation processes yourself. Sometimes it’s just good when innovative ideas come forth just like that – as a speedboat – and are bought up by the tankers. Here lies a great opportunity for founders.

How do you support young entrepreneurs?
This is not really my official function; it has simply developed that way. My support is more of a very informal nature. First and foremost, I help students develop the necessary professional maturity through their master’s or doctoral theses and also as research associates. My door is always open to discuss their ideas. Furthermore, I help them with the application for funding, such as the EXIST start-up grant, for example. I’m there when I’m needed.

What factors are decisive for a spin-off to be successful?
Naturally, a solid technical foundation is essential. That can be good if you mainly want to sit in the basement and accomplish tasks. But it’s not enough to drive a start-up forward. You also have to have the qualities of a “stage hog” to present your project or product.

What are the potential pitfalls that young start-ups can trip over?
Sometimes the team no longer has a shared understanding and breaks apart. Or there are disagreements over issues such as funding, strategy, collaborations, or decisions about public or private money. It’s essential to always have a close look: What was originally planned? Is the project successful now, and is it worthwhile to develop it further? When the shared dream crumbles, sometimes the team spirit is gone, too.

Do you have an advice for founders in the field of computer science?
Especially when it comes to a tangible product, it’s also about sales and market entry. Then considerations come into play that have much more to do with business administration than computer science. In this case, the start-up is well advised to take specialized people from this area on board.

The Beyond Emotion team has done it this way. So how do you rate the success of the young company?
In any case, they are a perfect team. Arne Bernin and Sobin Ghose are technologically skilled computer scientists: One is of a calmer nature, the other has more of the aforementioned “stage hog” qualities. And then, of course, they’ve brought Hanne Butting on board as a business psychologist. I can’t speak for the market, but the technical brilliance of the idea is undeniable. ■

EXIST start-up grant

The program of the Federal Ministry for Economic Affairs and Energy (BMWi) supports students, graduates, and scientists who want to start a business. The scholarship runs for twelve months: students receive up to 1,000 euros, doctoral students 3,000 euros per month. Material costs are funded with up to 10,000 euros (30,000 euros for teams) and coaching with up to 5,000 euros. The prerequisite for the grant is an innovative technology-oriented or knowledge-based product with clear unique selling points and good prospects of commercial success.

“There’s not much data from dementia patients available to test the software.”

ARNE BERNIN, FOUNDER OF BEYOND EMOTION

➔ The step from the university into the market meant an encounter with a different world. “After years of research and programming, we had to learn a new language. We had to go to the customers and ask them what their problems were,” Ghose admits. Learning this new language is what Hanne Butting helps them do. As a business psychologist with a master’s degree in business consulting, she rounds out the Beyond Emotion team. Hanne Butting contributes her expertise in consulting, process optimization, and project management, and she takes on all tasks that require economic background knowledge.

WORRY IS A CONSTANT COMPANION

For her master's thesis, Hanne Butting conducted interviews with family caregivers of dementia patients: “It turned out that family members are stressed when they are working and have to worry constantly about whether, for example, a father with dementia has fallen and how he’s doing. That’s the main stress factor,” says Hanne Butting. A kind of “mood notification system” would help: The software reads the face to see how the dementia patient is feeling. It sends a message to the caregiver if it detects pain, fear, anger, confusion, or similar emotions. “Feeling better informed means less stress for family members,” says Hanne Butting.

She joined the company because she believes the idea can make a difference: “We want to make a contribution and add value to society. Using the software for market analysis tools so that a fashion label sells five more T-shirts would not motivate us. But our messages could really help people with dementia live at home longer,” Butting says.

Just as little as they are afraid of the bureaucratic hurdles in the healthcare system, the three young founders don’t shy away from direct involvement in the difficult living situation of people with dementia and their relatives. They are convinced that they can make a difference, especially since Beyond Emotion offers both, data protection and anonymization. ➔

➔ HAW’s Foundation Service helps to apply for funding or scholarships. Contact:
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Facial expressions are a powerful language. Beyond Emotion teaches the computer to understand them using artificial intelligence.

➔ Information on the Computer Science Master’s degree program (German only:

RTC Smart Systems

The Smart Systems research and transfer centre (RTC Smart Systems) of the Faculty of Engineering and Computer Science at HAW Hamburg engages in the (inter-)disciplinary, methodological and reflexive support of the digital transformation in a selected range of topics. Starting from computer science, an interdisciplinary team of professors, scientific associates, doctoral students, and undergraduates works on such issues as Interactive Virtual/Augmented Reality; Ubiquitous and Tangible Interaction; Machine Learning & Data Mining; Science &Technology Studies.

In the Living Place Lab, a 140-square-meter, fully equipped apartment, the interaction between humans and machines in a smart home is studied under realistic conditions.

Another RTC laboratory is the Creative Space for Technical Innovations (CSTI). It is the central platform for interdisciplinary projects, collaborations, research studies, doctoral studies and student projects. Initially based in computer science, the lab collaborates with numerous other areas such as mechatronics, design and art, as well as social and cultural sciences. Collaborative projects include the model ship nHAWigatora (see page 35).

In the autosys research laboratory, interdisciplinary work is being carried out on intelligent robot systems. These include robotics for a sustainable circular economy, autonomous diving robots for observing biodiversity in the oceans, and robots for implementing mobility concepts in urban districts. ■

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➔ That's crucial in emotion recognition, but even more so in healthcare and for people with dementia. The system is not as vulnerable to attacks because the data is not streamed to the cloud like other apps do, but computed locally on a device. In addition, emotion recognition works in such a way that facial expressions are transferred to an anonymized face and only then evaluated.

The team is currently trying to find out what features those affected need and how the seniors' emotions could be identified. This could be accomplished, for example, through a kind of digital picture frame. Beyond Emotions has applied for funding from the German Federal Ministry of Education and Research (BMBF) jointly with the Hospital zum Heiligen Geist nursing home in Hamburg. There, the start-up can also conduct further research: "While we have generally available images of faces, there is not that much data from dementia patients to test the software," says Arne Bernin. The start-up is always looking for test subjects who are interested.

EXTENSIVE SUPPORT FROM THE RTC

One of them could be Susanne Draheim. She has relatives with dementia and knew about the founders' early on: Draheim has known Sobin Ghose and Arne Bernin from their time as research assistants. In the Department of Computer Science, Susanne Draheim heads the Smart Systems research and transfer centre in the area of human-machine systems. In addition to individual consulting, the founders have also received support from the RTC in the form of a server farm for machine learning, equipment, infrastructure, or relevant contacts. "Beyond Emotion has also used the Room for Research at HAW Hamburg: The rooms are well equipped for meetings and workshops, allowing the young founders to welcome business partners there," says Susanne Draheim. She is currently consulting with the three on how the collaboration with HAW Hamburg can continue after the EXIST start-up grant expires.

➔ Dr. Susanne Draheim heads the RTC Smart Systems with Prof. Kai von Luck. susanne.draheim@haw-hamburg.de

➔ The Beyond Emotion team is looking for test subjects. Are you interested? Tel +49.40.239 697 43 or e-mail kontakt@beyond-emotion.de (German only)

AN APP FOR CAREGIVERS

Computer science professor Kai von Luck was also a key advisor: "He is an extremely dedicated professor who invests a lot of time in mentoring his students. We have really enjoyed having him as an experienced mentor at our side over the years," says Sobin Ghose.

The first customers for the pilot phase could be in as early as mid-2022. The three founders' greatest wish is for the start-up to become an app that long-term care insurances accept based on its proven benefits for caregivers – similar to the "app on prescription". They want to score with their unique selling points of data protection and anonymization. Since these are probably nowhere as important as in healthcare, this could ensure the start-up's success. ■

Driven by curiosity

WHEN JUTTA ABULAWI STARTED STUDYING MECHANICAL ENGINEERING, SHE WAS ONE OF ONLY THREE WOMEN AND LATER THE ONLY ONE. ENGINEERING WAS A MALE DOMAIN. FORTUNATELY, THIS HAS CHANGED SINCE.

INTERVIEW: SILKE UMBACH

Ms. Abulawi, the distinctive architecture of HAW Hamburg's campus at Berliner Tor has shaped your life. How did it come about?

Jutta Abulawi: To be honest, our campus combines almost bizarre extremes of architectural styles in a small space. I am a professor at HAW Hamburg, but I am also a graduate; I studied mechanical engineering here. So when I came here as a high school graduate to look at the university, the electrical engineering building that now also houses the dean's office and computer science already existed. This high-rise building will certainly not win any beauty contests. But there was also the brick building of the mechanical engineering department from 1911.

On the way back, I walked through this beautiful building. As I came home, I said to my father that I could well imagine studying there, I will try it. If it's going to be technology, it should be mechanical engineering.

The requirement for studying mechanical engineering at that time was a six-month internship. You had to get through that first.

My father was an electrical engineer, and mechanical engineering was a man's world back then. He knew that, of course. So he thought that if he sent his daughter somewhere where the prejudices were too prevailing, she would follow her alternative plan and study Chinese in Heidelberg.

So he advised me to do a basic internship at Rotring, the ink fountain pen manufacturer. The idea was: they were open to women's talents, and they valued the skills of precision mechanics. Besides, the company employed women primarily.

> **"If it's going to be technology, it should be mechanical engineering."**
>
> JUTTA ABULAWI

But of course, as a prospective mechanical engineer, I didn't end up in production assembly but in toolmaking. And there were only men there, men in gray coats. So it was all about turning, milling, grinding, hardening, eroding, welding, and soldering.

Was that very hard back then?

Not at all, I was received extremely friendly. I was really able to learn and do a lot there, even though I had no prior background. But when I actually wanted to start my studies, this was suddenly no longer enough. The professor said that metal casting was also one of the necessary prerequisites. So I took on this challenge as well. Within two weeks, →

→ I managed to cast an object that was entirely useless for me, namely an ashtray, out of aluminum flawlessly. But nevertheless, I began my university studies with the idea that it would be difficult. Not so much because we were three young women at the beginning and I was even alone at the end, but because I assumed that it was easy to fail at many things. But that was not the case. Everything went well. But the gender thing just can't be explained away; when you're the only woman, it's just always obvious when you're absent or not having a good day. There's nowhere to hide.

Your subsequent career path is fascinating because it is so diverse.

As a university of applied sciences graduate, I had the opportunity to have a completely new cultural experience. Thanks to a DAAD scholarship, I went to Cambridge for a year as a postgraduate. There, it's natural to do university sports, learn a language – in my case Arabic, my husband's mother tongue – and strive for a broader horizon. It would have been no problem for me to earn a doctorate with my technical college degree in Cambridge. It just wasn't financially feasible for me. After working in the industry, I did my doctorate at Helmut Schmidt University here in Hamburg. Our children had long since been born. In that respect, it was an effort, but it was worth it.

What were typical barriers you had to overcome?

It is a true story that as a woman in the aerospace industry – in my case MBB, now Airbus – it could happen to you that the new head of department said: "Nobody asked me, I don't want you." And this after a successful application. Just as real was how, with small children on your resume, you sometimes got an application back faster than you sent it. But I also experienced the exact opposite: When the going got tough, I came across a job ad from Rotring, the company where it all began. A subsidiary hired me for something completely different than expected: Robotics

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applications and DC drives. So I started all over again and stayed for twelve years. The managing director thought it was perfectly normal to start a family and have children, and indeed that everyone had the right to do so. So, parental leave and returning to work were no problems for me. There you go, it works!

It seems your wealth of experience is also because you never intended to plot out an ideal career on the drawing board.

That's right; there were advances, retreats, detours, and zigzags. I owe the reason I became a professor because there was an advertisement that fit my profile exactly, without anyone having thought of me. I accepted this opportunity because it fit what has always driven me, namely the extreme curiosity to understand things, but also people and what drives them.

How does your journey shape your view of students today?

Some things are easier today. Many of the rights that are taken for granted have become a reality; you can be who you are and love who you want. These are promising developments. A lot has changed. For example, in the aircraft industry, there are many more female graduates. In environmental engineering and process engineering, there are a lot. I want all students to be able to achieve what they want. Likewise, I understand when their generation critically questions our generation: "What have you done to the world? It can't go on like this." So we hope to train them in a way that they can create the better, more sustainable technologies of the future. ■

Research vessel in Wunderland. The nHAWigatora is full of sensors and intelligence.

The "Elphi" concert hall and HafenCity in miniature format are visible proof of high-tech and great attention to detail.

AUTONOMOUS SHIP

Small models on a big trip

FOR HAMBURG AS A TOURIST DESTINATION, MINIATUR WUNDERLAND IS A STROKE OF LUCK. FOR HAMBURG AS A RESEARCH LOCATION AS WELL. IT IS AN IDEAL PLAYGROUND FOR SCIENTISTS TO DEVELOP TECHNOLOGIES ON A SMALL SCALE THAT WILL CHANGE OUR MOBILITY ON A MUCH LARGER ONE. →

TEXT: SILKE UMBACH

© H. Burau, F. Stark, T. Schnirpel/HAW Hamburg

Even in the most incredible adventures you can find tiny heroes. And in times when machines can learn and act on their own, their protagonists no longer necessarily have to be humans or heroic mythical creatures. One vision that Prof. Dr. Tim Tiedemann, a specialist in Intelligent Sensing at HAW Hamburg, and his team have of a little heroic action is landing an air taxi drone on a moving ship. But doesn't that already exist today? Not when the drone is without remote control and on its own, and when the ship also finds its way by itself. And certainly not if the model ship has a scale of 1:100, and the air cab is smaller than a toy drone. The artist's piece will be put on a stage known far beyond Germany's borders: the Miniatur Wunderland in the Speicherstadt warehouse district in the Port of Hamburg.

finders and a color camera installed on a mast at the stern. The ship is electrically powered and, like its real-life counterparts, has a stern propeller and transverse thrusters. Student groups, whose projects pass their "water test" here in the Wunderland, have played a major role in its further development: "They use our exhibit like a playground to run their autonomous vehicles on. At first, it was just the ship, then cars came along and finally the airborne drone," says Daniel Wolf, miniature software developer at Miniatur Wunderland. His team has a lot to offer: A 30,000-liter real-water basin with tidal range, harbor facilities, a rocky island, and lots of marine traffic. The whole operation is embedded in a Scandinavian fjord landscape. For example, to create the tides, 2,500 liters of water are circulated by pumps within eight minutes.

researchers aim to integrate intelligent electronics and drive and energy sources into vehicles that are as small as possible – thus following the concept of miniature autonomy.

The Wunderland "nerds," on the other hand, control their fleet centrally; their vehicles are designed for low energy consumption and maximum endurance. Both concepts will emerge in the big, real traffic world of the future: full coordination of rail traffic, for example, with central monitoring, but also autonomous vehicle traffic of all kinds.

"They use our exhibit like a playground to run their autonomous vehicles on."

DANIEL WOLF, MINIATUR WUNDERLAND

The "miniature wonderland" is not only one of the city's biggest tourist attractions but also an experimental field entirely to the liking of Tim Tiedemann and his colleague Stephan Pareigis. The two professors from HAW Hamburg are researching aspects of autonomous mobility.

Here, at the world's largest model railroad layout, with its own network of roads and waterways, the HAW Hamburg's miniature cargo ship has already made many a grand voyage.

The model ship nHAWigatora is about one meter long and controlled by two Raspberry Pi computers. The small vessel uses a lidar laser scanner to map its surroundings. It also features infrared range-

The experimental model ship thus discovers a fascinating test environment for itself. At the same time, it moves in a "world" in which two technological philosophies meet: On the one hand, the

Much of the momentum for miniaturization comes from years of experience with land vehicles. Over time, cars have become smaller and smaller, electronics and sensors have become ever tinier and lighter, and self-driving miniature cars have long been available for which a two-euro coin is sufficient for size comparison.

The HAW Hamburg fleet has also proven itself in competition, much to the delight of the many students involved: "A regular highlight is the Carolo Cup, which the TU Braunschweig organizes every

year," says Stephan Pareigis. "This is where our vehicles compete against the concepts of the other teams." The contest for the trophies requires autonomous course driving, obstacle avoidance, and parking, but not such radical miniaturization as in the nHAWigatora (1:100) or the Wunderland H0 Standard (1:87): The Carolo competitors are "merely" ten times smaller than a real car.

Today, everyone can experience how powerful miniaturized technology already is in everyday life: Current smartphones contain cameras and microphones, GPS localization, proximity, acceleration, ambient light and rotation sensors, electromagnetic probes, and a digital compass. Sensor technology in its smallest state is already prevalent in the marketplace – but when incorporated into the systems of miniature vehicles, they can be experimented with to the extreme. As with the ship, the drone or the microcar, they move in the real, physical world.

FROM SIMULATION TO REALITY

Stephan Pareigis explains why this approach is so fruitful for research: "Algorithms and concepts can be tested well in computer simulations, with millions of calculations per second. But there remains a gap, the so-called sim-to-reality gap – the gap between simulation and reality. It's an everyday experience for us: if you have simulated something, it often does not work as expected in reality for unforeseeable reasons. That's why research still works best by repeatedly testing our approaches in small lab experiments and analyzing the results." Whether on land, sea or air, the big questions are always: Does everything work as it was to be expected? Surprises are part of experimentation and can be an inspiration as well. Miniature autonomy offers researchers real-world experiences at low cost, and thanks to small moving masses, the risk for accidents is small. Moreover, working on the subject provides a delightful intellectual dimension. After all, making something smaller and smaller adds knowledge and enjoyment to the research. ➔

Interview

POWER FROM THE HUB: PROF. DR. TANKRED MÜLLER AND HIS TEAM DEVELOP INNOVATIVE ELECTRIC MOTORS.

In some corridors of HAW Hamburg, you occasionally see a robot vehicle driving around. It has various sensors, orients itself independently, and opens doors with a gripper arm. What's going on there?

Tankred Müller: Husky is a commercial vehicle platform. It was upgraded with these capabilities by our colleagues in the TIQ project (Test Area Intelligent Quartier Mobility), which focuses on so-called "quartier mobility" (see the question on the right). Vehicles of this type are also of interest to our working group. We are developing new electric drives for them.

"Husky" can open doors.

What makes your drives unique?

A good example is the miniaturized wheel hub motor: The wheel is taken out of the rim, and a special rim that drives the wheel directly at the hub is installed in the vehicle. This concept eliminates the need for space-consuming engine compartments, power transmission shafts, and the differentials needed to drive wheels at different speeds when turning. Instead, we convert the components that are no longer needed into electronic systems that control the powertrain. We want to make the drive very quiet and precisely controllable. It should work without gears and not require any mechanical parts other than the bearings.

What is "quartier mobility" all about?

Quartier mobility refers to mobility in urban residential areas, i.e., transporting people and goods within public spaces with distances of less than 3 km. A car is still needed there today: Most of us would use it for a typical shopping trip, although it is probably oversized. A big advantage of the hub drive is that we can use it to turn any box into a vehicle, so to speak. You install two wheel hub drives and the appropriate control system, and then the load becomes mobile.

So, I would expect to see autonomous beer crates in the future?

Of course, this was just a simplification. In reality, it could solve urban transport tasks in many ways. For example, imagine you are riding your bike, and your groceries are following you.

Many skeptics of electric drives are constantly worried about battery capacity. Will they have to do the same here?

I don't see this as a problem today with applications in the city and with small vehicles that don't have to go very far. An autonomous small vehicle with a wheel hub drive would get through the day very well with just one battery charge. ■

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© Yara Birkeland | Knut Brevik Andersen

The Norwegian freighter Yara Birkeland is the world's first autonomously operated cargo ship.

This also applies in the light of the specific challenges. "We've learned that autonomous operations in miniature format require a great deal of entirely new thinking," says Tim Tiedemann. "We have to break a lot of new ground, find new algorithms and approaches to solving problems that you don't need in a normal car on the road. Because in the real world, you can put in big, powerful computers that solve the problems. And if you have to, you can even add five cameras if need be."

Such luxuries don't exist in matchbox format. Instead, there are challenges such as maximum energy efficiency and the elegance of lean solutions: "The idea is to find solutions that allow our ship to move safely from one position to the next. At the same time, the systems need to be simpler, more reliable, and more robust than those using ten large computers and five cameras." The nHAWigatora is a hundred times smaller than a real freight ship but still offers a generous amount of space.

"We've learned that autonomous operations in miniature format require a great deal of entirely new thinking."

PROF. DR. TIM TIEDEMANN

"We'd also like to build an autonomous bus or a truck in the Wunderland format. That would be the smallest system that we currently believe can operate autonomously," says Tiedemann.

NO CAPTAIN ON BOARD

In the real world of commercial shipping, intelligent ship automation is a hot topic. Autonomous or at least semi-autonomous ships are expected to be able to make highly efficient use of innovative electric drives, among other things. In Scandinavia, for example, such a fleet could replace inefficient road connections along the long and winding coasts with safer and more environmentally friendly maritime transport or operate in convoys on long-distance routes. Experimental ships, the nHAWigatora's big cousins, so to speak, already exist.

The Yara Birkeland, built in Norway, was launched in February 2020. At 80 meters long, it is almost a hundred times larger than nHAWigatora. Just like the model ship in Hamburg, it is also equipped with sensors and control systems for autonomous driving. The Birkeland is expected to transport fertilizer from the plant to deep-sea ports in the future.

Deployed on routes of up to 30 nautical miles, this type of commercial operation is expected to save around 40,000 truck trips per year.

This example shows that it is worthwhile to explore the water in an experimental setting for a research-oriented university such as HAW Hamburg, and even more so in one of Europe's most important port cities.

The small ship in Miniatur Wunderland and its larger relative in Norway still share a fate: Both projects suffered restrictions due to the Corona pandemic. The development of the Birkeland came to a standstill for several months. And for the students of HAW Hamburg, it is hardly possible to mingle with the Wunderland visitors and integrate into the regular operation of the tourist attraction, given the severely limited number of visitors. Nevertheless, Wunderland technician Daniel Wolf recounts, the researchers sometimes came at the crack of dawn.

IN THE DRY DOCK

Currently, the ship is in "dry dock" at the university. Here, the model can be equipped with new capabilities. For the miniature autonomy researchers' road vehicles, test tracks and facilities are available at HAW Hamburg itself. Research into algorithms, drives, and automation strategies thus continues to progress. With the return of normality, many a vehicle flying the flag of HAW Hamburg will once again be on the road amidst a large crowd of visitors in the exhibit of Hamburg's Speicherstadt warehouse district. On the water, on land, and in the air. ■

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→ Scan QR code for more information on Computer Science for Technical Systems (German only)

© Yara Birkeland

The control system for the Yara Birkeland was also developed on a model.

What is technology allowed to do?

WHY ETHICS MATTERS IN APPLIED SCIENCES

Ethics is a branch of philosophy. But anyone who thinks that this means it is not represented at a university of applied sciences is mistaken: Many decisions concerning the design and performance of technical systems require ethical considerations. In the case of vehicles, for example, the safety of occupants and other traffic participants must be considered in a balanced way. The ethics of autonomous technology seem to pose a particular challenge: If a machine evolves its own behavior, it would also have to abide by the rules of society autonomously.

AUTONOMOUS AND SAFE

At HAW Hamburg, such questions will be addressed by a university-wide 14-member ethics committee in the future. The committee was constituted in the summer and is under the responsibility of Prof. Dr. Peter Wulf, Vice President for Research, Transfer and International Affairs. The chairman is Prof. Joachim Westenhöfer, who has already chaired the Ethics Committee of the Competence Center Health (CCG). Professors Stephan Pareigis and Tim Tiedemann are committee members as representatives of the Faculty of Engineering and Computer Science.

"It will be important to clarify which potential hazards in general are realistically conceivable," says Tiedemann. So far, the public debate has often been dominated by rather theoretical examples from seminars, such as vehicles that have to decide whom to give way to in an extreme situation and whom not to: "However, useful autonomy doesn't have to go as far or be as complex as in utopias. Simple autonomy, ships navigating by GPS positions and preventing the crew from accidentally steering onto a reef, or choosing optimal routes, would already be a big win."

His colleague Pareigis agrees: "Even with today's vehicle assistance systems, they already react much more defensively than many drivers. I'm sometimes amazed at how careful my car is, so to speak, when the brake assist intervenes." Still, both professors are sure that many profound questions can be discussed across disciplines in the commission. After all, even with micro-autonomy using miniature vehicles, safety is paramount: "If a microdrone flies in Miniatur Wunderland, everything must be done to ensure that it cannot endanger the public in any way," says Tiedemann. In addition to the implemented safety in the control logic, nets and safety lines, for example, ensure that dangerous human-machine encounters cannot occur. ■

GEAR NOISE

The art of hunting ghosts tooth by tooth

DEVELOPING NEW ENGINES CAN BE A MYSTERIOUS BUSINESS. UNEXPLAINED SECONDARY NOISES CAN GET ON THE NERVES OF THE VEHICLE DEVELOPERS. MECHANICAL ENGINEERING PROFESSOR GÜNTHER KIES IS ON THE TRAIL OF THE RUMBLING GHOSTS. BALLS OF BLOOD-RED RUBY HELP HIM. BUT DON'T WORRY: THIS IS NOT A MYSTERY REPORT – BUT A STORY ABOUT SENSITIVE TECHNOLOGY AND THE ART OF UNVEILING ITS SECRETS TOOTH BY TOOTH.

TEXT: ANDREAS BEERLAGE

When the professor pulls up in the morning, you can hear him from afar: on the seat of his bright red, voluminously humming Laverda 750 SF, a sporty motorcycle classic from the 1970s, he is quite close to the subject of his research. One can both hear and feel the vibrations of the 47 horsepower combustion engine.

Such "signs of life" may be desirable in motorcycles. However, the research focus of Prof. Dr. Günther Gravel from the Department of Mechanical Engineering and Production Management is quite different: He is on the trail of unwanted engine noises. These are caused by a specific, seemingly mundane object that – usually hidden – actually moves and drives so much in our world.

"Hang on, I'll get one!" he says, having meanwhile arrived on the second floor of House F at the university's Berliner Tor campus. A short time later, he is back and places on the conference table what his research is mainly about: a palm-sized gear wheel. It is polished to a high gloss and shows its teeth in a silvery shine. It is the mechanical engineering version of a Hollywood smile.

A CONCERT OF WHISTLING AND HUMMING

But even what looks so smooth and perfect can hide defects. And these can cause major problems in the automotive industry. For example, when an engine transmission undergoes end-of-line (EoL) testing at the end of a production line. Secondary noises, which are not part of the normal engine sound, especially occur during pre-series development and testing of new transmissions: "It's usually a whistling noise. While it doesn't have to be loud, it's nerve-racking nonetheless," says Günther Gravel.

The cause of the whistling noise is to be found in the surface of a gear's teeth. "During the manufacture of gears, which subcontractors usually carry out, grinding patterns sometimes occur on the teeth, forming waves in the hardened metal." These patterns repeat from tooth to tooth, and the ripples on the surface become sound and pressure waves as a tooth and its opposing tooth mesh together. They hum their own song at the exact frequency at which they are milled into their surface: "60 waves per revolution of the gear, at a speed of 6,000 revolutions – we quickly reach a high frequency there."

In other words, the noise originates inside the gearbox. And if it stayed there, it wouldn't be a problem. "But there are two developments that favor its transmission: First, less and less insulating material is being installed these days to save weight. Secondly, the lightweight materials used are increasingly stiff and dense. As a result, they transmit sounds better." The noise then travels until it finds an "output": a surface that acts as a "loudspeaker cone". At that point, the sound is in the vehicle, "and that is no longer tolerated by customers today."

In case the EoL check reveals suspicious noises – usually by visual representations of the soundscape – then part one of the detective work follows: One gear after the other is changed, and the transmission is rerun until the culprit is found."A transmission has quite a few gears, as Günther Gravel is now demonstrating on a modern dual-clutch gearbox from a German manufacturer that was made available to him for training. ➔

Tooth of time

➔ The oldest known predecessor is a so-called Göpel wheel (aka whim drive), into the edge of which pegs are inserted as teeth: It typically transferred the muscle power of animals or humans to grinding stones. This type of gear is known from illustrations in ancient Egypt.

➔ At the same time, i.e. around 300 BC, a legendary war machine was moving in China. It was able to maintain an exactly straight course with the help of a control circuit of gears. However, the Chinese machine's maker named Ma Jun referred to a much older model whose plans are lost.

➔ About 200 years later, the "Mechanism of Antikythera" was built. The exact function of this wondrous work for calculating the position of the planets, dated to about 100 BC, is still not clear.

➔ The principle of drive via gears really caught on in the operation of water mills and later also in windmills.

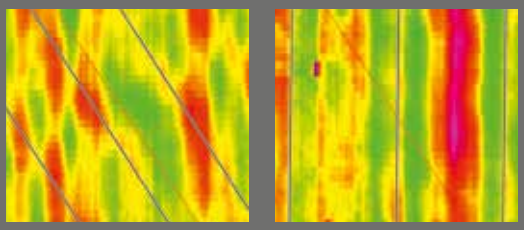
© pixabay

Wooden gears transferred power from the blades to the grinder in windmills.

➔ The optimum shape of the tooth was developed around 1674 by the Danish astronomer Ole Rømer. A blend of straight and rounded surfaces – the epicycloid shape – guarantees uniform frictional resistance and thus reduces uneven wear.

➔ Then came the steam engine. It marked the beginning of the industrial age, which would be inconceivable without metal gears. Finally, in 1820, the hour of helical teeth and herringbone gearing arrived. Shortly thereafter, the first differential gear was developed. Since the mid-19th century, the tools for grinding the teeth became more and more precise, while at the same time, the requirements for accuracy increased.

SURFACE PATTERN OF A LOUD AND A QUIET GEAR



loud **quiet**

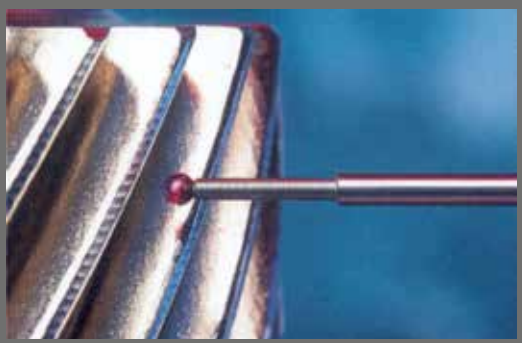
His students took it apart once and put it back together, creating a blueprint for the lecture. Gravel stays with the object for a moment, moving small levers to operate the clutch and shift gears: "I can't find reverse right now!" A motorcyclist might be forgiven for that.

Part two of the detective work follows when a defective transmission is discovered. This takes us to the catacombs of House F, two floors below. Here, Professor Günther Gravel goes on a "ghost hunt" – the disturbing noises are actually categorized in "ghost orders," and their respecitve number indicates the measured waves per revolution of the gearwheel: "The gearwheel may appear perfectly pristine. However, this drives the engine developers almost crazy." But then the "magic ruby" comes into play.

GEMSTONE WITH 0.7 MM DIAMETER

The professor points to the gear measuring device. It is about as high and wide as a bookcase and a computer workstation is attached to it. The gearwheel is pushed on an axis that stands vertically on the measuring table. From the side, a metal pin then scans the tooth surfaces of the gear. The pin is like a "finger"; a ruby sphere 0.7 millimeters in diameter acts as the "fingertip" – the gemstone measures with an accuracy of ten nanometers.

MEASUREMENT OF A TOOTH



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RTC 3i | intelligent industrial innovations

The digitalization and automation of all industrial processes create a new scope of efficiency and resource conservation. HAW Hamburg's RTC 3i (intelligent industrial innovations) is conducting research in this context. The center's equipment includes a six-axis industrial robot with a payload of 125 kilograms. It is housed in a laser cell designed and built by students as part of a project. The cell complies with all safety regulations, thus allowing laser-based welding.

As part of the Smart Production @ HAW.X0 research project, which the university's "Zukunftsfonds" finances, it looks at the automation of joining processes, additive manufacturing, and the digitalisation of teaching.

RTC 3i is the home of the Shared Guide Dog 4.0 project aimed at developing a technical assistance system for blind and visually impaired people. Safe and autonomous navigation in an urban environment is extremely demanding. Shared Guide Dog 4.0 not only has to overcome the same challenges as driverless cars, but also find its way around sparsely marked park paths, for example. It has to safely avoid water puddles, poles, playing children, and running dogs.

Training and continuing education is an essential pillar of RTC 3i's activities. The center offers an internationally recognized qualification with the Welding Specialist Engineer (SFI). Engineers with this additional qualification are in great demand in many industry sectors. Training for this qualification can already be started during studies at HAW Hamburg. ■

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(German only)

That's one millimeter divided by 10,000, or about two-thousandths of the thickness of a hair. "We can't yet measure using optical methods with this precision; we can only do it through 'tactile' means."
A complete scan of all teeth – the entire "dentition" – can take an hour. That's why Gravel and his small team are constantly working on simplifying the scanning process: What is the minimum number of scan points required to calculate the damage pattern with sufficient accuracy?
The first step in the reduction was to scan the tooth surface in a cross shape with two strokes. "Now we are testing the calculation with increasingly fewer individual points," says Gravel. The goal is a software that provides engine developers with a fast-working analysis tool: "Because typically, noise problems come into focus not only when automobile production moves from pre-series to large-scale production, but also during normal production." →

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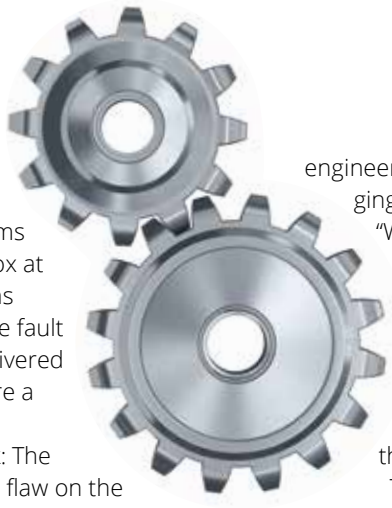
"We are not in an ivory tower here but are researching real applications as a partner to the industry."

PROF. DR. GÜNTHER GRAVEL



➔ At this point, every noisy gearbox means a financial loss. Consequently, the goal is to identify potential problems before installation: Removing a gearbox at the factory is about a hundred times as expensive as the gear itself. Should the fault first appear after the car has been delivered to the customer, replacement costs are a thousand times higher.

Let's get back to the detective work: The defective gear has been identified, the flaw on the surface has been discovered and is now localized. The only thing missing is the actual cause. Three different factors are involved in manufacturing a gear: the machine, the tool (the grinding wheel), and the workpiece (the gear blank). Transitions from one to the other are prone to error. "For example, the grinding wheel can wobble, causing ripples. Sometimes even the floor of the production facility vibrates." Gravel and his team are now employing artificial intelligence and pattern recognition to teach the new software to detect errors automatically.

TOOTH PROBLEMS WITH ELECTRIC MOTORS

Gears have been around for over 2,000 years and internal combustion engines since the last third of the 19th century. And yet, the "notched discs", so to speak, continue to pose new challenges to engineers. "That's also true for the emerging electric mobility," Gravel says. "With electric motors for cars, after all, we're then talking about rotational speeds that are three to four times higher. And that means very different ripples are causing new problems." The HAW Hamburg team can help if there are problems in this respect.

The problem with electric vehicles is different in another aspect: Here, the combustion noises are missing, which sometimes hide gear noises. Tooth problems can thus become apparent more quickly. And even bicycles with assisting e-drives are not immune to the noise problem. "On e-bikes, gear ripples make themselves heard as grinding noises because of the much lower speeds."

It is precisely this kind of joint effort that is so important to Professor Gravel: "We are not in an ivory tower here but are researching real applications as a partner to the industry." He also believes his mechanical engineering department is at the forefront of tackling one of the most critical challenges of our future: climate change. "Electric vehicles need smooth-running gearboxes, just like wind turbines," he says. "There are many reasons to study with us if you want to contribute something positive to the future!" ■

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Research projects

MECHANICAL ENGINEERING AND PRODUCTION MANAGEMENT

IsoSens Development of an AI-based sensor to determine the isotopological composition of greenhouse gases for research into climatic processes
LEAD: Prof. Dr. Marcus Wolff
FUNDING: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
DURATION: 01.01.2021 – 31.12.2023

MamoGE Microservices for automated mobile devices for processing large areas
LEAD: Prof. Dr. Stephan Schulz
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.10.2020 – 30.09.2022

Multirotor-DfM Maintenance-friendly design with high system availability and minimized operating costs for multirotor wind turbines
LEAD: Prof. Peter Dalhoff (CC4E)
FUNDING: Federal Ministry of Education and Research; Industry
DURATION: 01.05.2021 – 31.01.2025

Optimal measurement strategy for waviness Economically optimal measurement strategy for the detection of noise-causing waviness
LEAD: Prof. Dr. Günther Gravel
FUNDING: Forschungsvereinigung Antriebstechnik e.V. (FVA)
DURATION: 01.11.2019 – 30.04.2022

StaTur Prototype of a stack of tubular redox flow battery cells. Subproject: Development and system integration of components, cells and stack
LEAD: Prof. Dr. Thorsten Struckmann
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.12.2018 – 31.05.2022

Tubulyze Design fundamentals of a tubular electrolytic cell fabricated by additive methods and extrusion. Subproject: Cell development, system integration and characterization
LEAD: Prof. Dr. Thorsten Struckmann
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.01.2019 – 30.12.2022

VAMOS Development of an online vanadium monitoring system to determine the state of charge of vanadium redox flow batteries
LEAD: Prof. Dr. Thorsten Struckmann
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.04.2021 – 30.09.2023

VORAUS PV Development of prediction algorithms for failures in complex power electronic systems based in photovoltaics
LEAD: Prof. Dr. Sarah Hallerberg
FUNDING: Federal Ministry of Education and Research
DURATION: 01.12.2019 – 30.11.2022

X-Rotor Research into alternative wind turbine designs in the form of two-blade and multirotor turbines for renewable energy generation and integration
LEAD: Prof. Dr. Vera Schorbach, Prof. Peter Dalhoff (CC4E)
FUNDING: Federal Ministry of Education and Research; Industry
DURATION: 01.11.2017 – 30.06.2022

HY-TO-FLY Design and construction of an ultralight aircraft with hydrogen propulsion, including teaching
LEAD: Prof. Dr. Felix Kruse
FUNDING: Claussen-Simon-Foundation
DURATION: 01.01.2019 – 30.06.2022

LD-SODA Learning-based Data analysis – Stochastics, Optimization, Dynamics and Approximation
LEAD: Prof. Dr. Sarah Hallerberg
FUNDING: Hamburg – Ministry for Science, Research, Equality and Districts
DURATION: 01.07.2020 – 31.12.2023

PRAMECO
Practicing Mechanical Engineering Online
LEAD: Prof. Dr. Shahram Sheikhi (RTC 3i)
FUNDING: European Commission
DURATION: 01.06.2021 – 31.01.2023

COMPUTER SCIENCE

AuTag BeoFisch Autonomous diving robot-assisted observation of fish shoals
LEAD: Prof. Dr. Tim Tiedemann
FUNDING: Hamburg – Ministry of Science, Research, Equality and Districts
DURATION: 01.04.2020 – 30.09.2023

DERECKA The Development of Doctoral Education and Research Capacities of Kyrgyzstani Academia
LEAD: Prof. Dr. Marina Tropmann-Frick
FUNDING: European Commission
DURATION: 15.01.2020 – 14.01.2023

DIGECO Digital, creativity and smart education as added value of economic development in Ukraine and Tajikistan
LEAD: Prof. Dr. Marina Tropmann-Frick
FUNDING: European Commission
DURATION: 15.11.2020 – 14.11.2022

i-Elfe Innovations in university teaching
LEAD: Prof. Dr. Markus Linke,
Prof. Dr. Tim Tiedemann
FUNDING: Stifterverband
DURATION: 01.01.2019 – 30.06.2023

PIVOT Privacy-Integrated design and Validation in the constrained IoT. Subproject: Embedded security for content projects
LEAD: Prof. Dr. Thomas Schmidt
FUNDING: Federal Ministry of Education and Research
DURATION: 01.04.2021 – 31.03.2024

RoLand Robotics in Agriculture
LEAD: Prof. Dr. Tim Tiedemann (RTC SMSY)
FUNDING: Federal Ministry of Education and Research
DURATION: 01.10.2021 – 30.09.2024

VALIDAS_at_WP Integration of visual analytics and data science methods into auditing processes
LEAD: Prof. Dr. Marina Tropmann-Frick (RTC SMSY)
FUNDING: Federal Ministry of Education and Research
DURATION: 01.02.2021 – 31.01.2025

X-Eptance Explore Mobile mixed-reality system for 3D visualization of wind power stations
LEAD: Prof. Dr. Birgit Wendholt
FUNDING: Federal Ministry of Education and Research
DURATION: 01.09.2019 – 28.02.2022

AUTOMOTIVE AND AERONAUTICAL ENGINEERING

AvaTur Aerodynamics of low-loss turbine profiles
LEAD: Prof. Dr. Dragan Kozulovic
FUNDING: Federal Ministry of Education and Research; companies
DURATION: 01.04.2019 – 31.03.2023

ePAXFLOW Development and use of an intelligent digital passenger flow measurement system from airport entrance to the passenger seat
LEAD: Prof. Dr. Gordon Konieczny (RTC FAM)
FUNDING: Hamburgische Investitions- und Förderbank (IFB)
DURATION: 15.08.2021 – 14.08.2023

i-LUM Innovative airborne urban mobility
LEAD: Prof. Dr. Dragan Kozulovic,
Prof. Dr. Tim Tiedemann (RTC Future Air Mobility)
FUNDING: Hamburg – Ministry for Science, Research, Equality and Districts
DURATION: 01.10.2020 – 31.12.2023

JoinDT Joining with predictable Damage Tolerance. Subproject: CrackJump – Improved damage tolerance of bonded joints by predicting the influence of intralaminar fatigue crack growth in CFRP joining pieces
LEAD: Prof. Dr. Markus Linke
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.03.2020 – 31.08.2023

KoWiKa Concept studies for a virtual design consultant for the additive manufacturing of aircraft structural components
LEAD: Prof. Dr. Jutta Abulawi (RTC 3i)
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.10.2018 – 30.09.2022

MULTIKABIN Multifunctional cabin wall structure for aircraft cabins with aerogel components for efficient sound, heat and moisture insulation
LEAD: Prof. Dr. Wolfgang Gleine
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.09.2020 – 31.08.2023

INFORMATION AND ELECTRICAL ENGINEERING

LImeS Lithium-ion cells for integration with advanced sensor technology.
Subproject: Sensor communication, impedance spectroscopy, and optical sensor technology.
LEAD: Prof. Dr. Karl-Ragmar Riemschneider
FUNDING: Federal Ministry for Economic Affairs and Climate Action
DURATION: 01.06.2019 – 31.05.2022

INSTITUTE FOR PRODUCTION ENGINEERING

CleanGrind Ecological grinding with minimum quantity lubrication
LEAD: Prof. Dr. Dietmar Pähler
FUNDING: Hamburg – Ministry of Science, Research, Equality and Districts
DURATION: 01.07.2021 – 30.06.2022

VibraDrill Vibratory drilling of difficult-to-machine lightweight materials
LEAD: Prof. Dr. Dietmar Pähler
FUNDING: Hamburg – Ministry of Science, Research, Equality and Districts
DURATION: 01.07.2021 – 30.06.2022

MINUTES: *SILKE UMBACH*

A

A classic nerd? I never was one of them. I never wanted to fly to Mars either; I'm an experimental physicist. I'm 39 years old, and the typical scenes you imagine actually play out in everyday life, such as the question, "Student?" And my answer, "No, I'm a professor." But that happens quite a bit to some people. There's nothing wrong with being mistaken for being young. My path to technology? I didn't follow a one-sided passion for technology. Instead, it was a fascination that grew on me.

I felt early on that physics came easily to me! And there were encouraging influences. My grandfather studied electrical engineering at HAW Hamburg's predecessor. As a farmer's son, he went into an apprenticeship as a blacksmith and completed it with "very good".

So he was allowed to study, which was something special at his time. My aunt studied mathematics, which influenced me just as my physics teacher. To have a woman as a physics teacher was hardly ever the case back then – and is still rare today. I chose the advanced physics course, and as a young woman, there were three of us. Today, one of us is a civil engineer, and the other is a banking consultant. Physics is obviously not a bad choice. Why did I choose this path? Because I really wanted to know how the world works, what makes atoms stay together, and also what's between them.

I studied in Heidelberg and, without even speaking Spanish, I went to Spain as an Erasmus student. It was there that I discovered that programming was fun. I found it easy – just like learning Spanish –, so I returned there to complete my PhD. I spent a total of five years living in Santiago de Compostela, and that's where my interest in fluid dynamics was sparked. In the end, earning my doctorate was both a pleasure and a scientific success.

Am I researching fascinating questions? I think so. Turbulence in flows, for example, is one of the last big problems. Exploring this problem opens up a wide range of possible applications. They range from meteorology and climate research to biology and medicine and far into the engineering sciences. They have significance for vehicle construction, civil engineering, or chemistry; and they concern the wind that flows around buildings as much as the optimal flow of reagents in production processes.

Turbulent flows have unique properties – a cyclone is enormous, but its smallest vortices are microscopic. In addition, the large and small scales intertwine: When you stir on large scales, similar structures form on small scales. Then again, there are systems in which energy is transferred from small to large structures, thereby creating order. This happens in highly confined systems, for example, in two-dimensional turbulence as found near boundary surfaces. I have my own DFG (German Research Foundation) project on this topic. The complexity of this research is high, but much of it is pretty close to the basics. Yet, even if it is not possible to build a car immediately based on a new finding, one can be pretty sure that applications will emerge.

"Turbulence in flows is one of the last really big problems."

I am familiar with applied research. After my doctorate, I thought I should first try something tangible. At Swiss company Sensirion AG, I integrated sensors into cell phones, experimented with it, and developed an algorithm. It was the first time humidity and temperature sensors were integrated into a cell phone. Later, I returned to flow research at the German Aerospace Center (DLR). Here, I worked with Airbus to research the ventilation of aircraft.

I came to HAW Hamburg "on the fly", as you might say. I have been living here in my hometown with my husband and our children, born in 2013 and 2016, for quite some time now – thanks to another exciting position at the Hamburg University of Technology in Harburg. There, the focus shifted again to fluid flow research with sensor technology also playing a role.

I'm looking forward to the interdisciplinary work and the exchange here. I believe that the future also depends in large part on sharing results. and working together productively. I find the atmosphere at the Heinrich Blasius Institute very supportive of this approach. ■

→ **Prof. Dr. Alexandra von Kameke, Heinrich Blasius Institute of the Department of Mechanical Engineering and Production Management. alexandra.vonkameke @haw-hamburg.de**

One of us

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“I believe that the future also depends in large part on sharing results.”

HAW HAMBURG

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