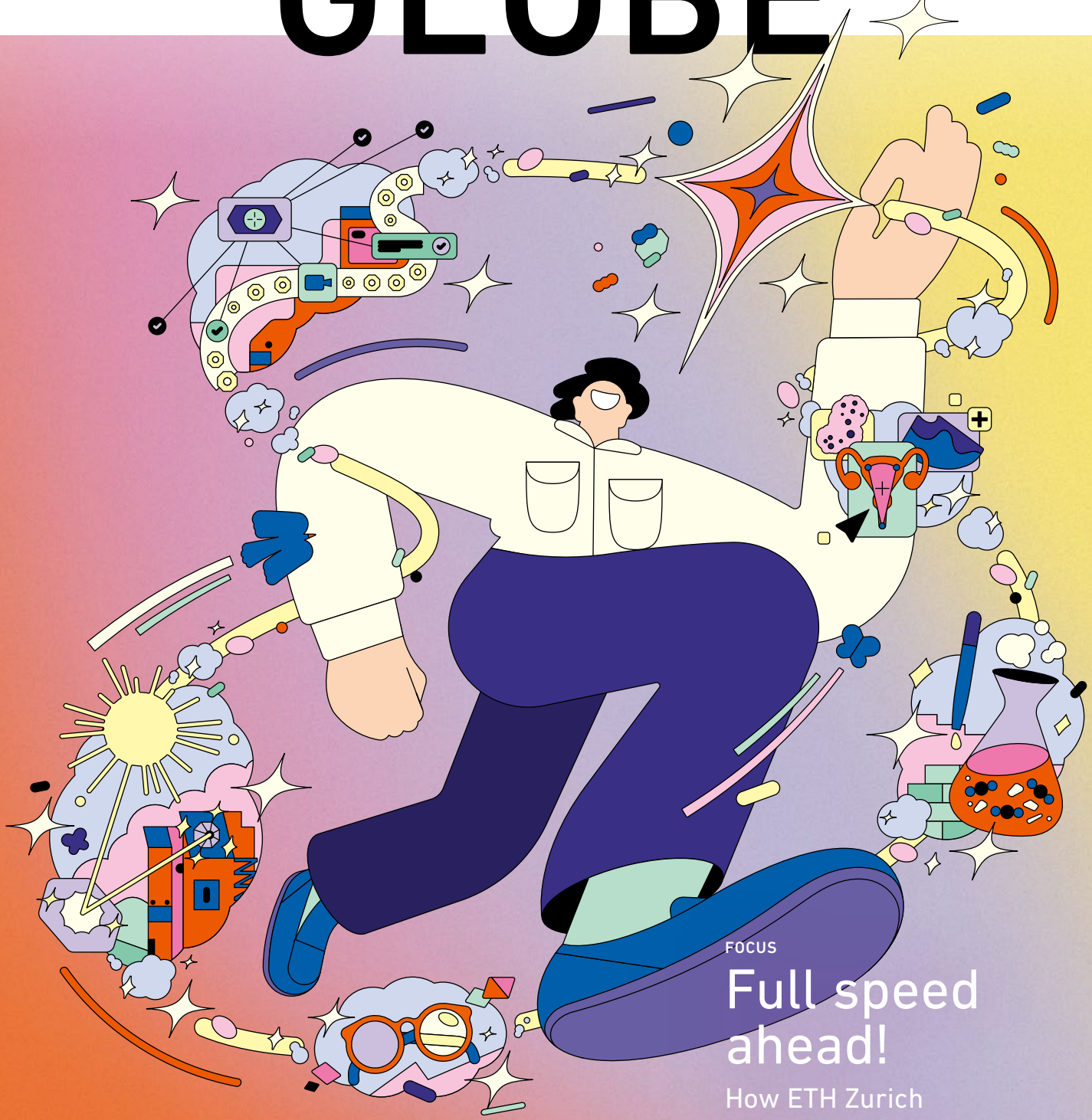
Jeannine Pilloud on the future of the ETH Alumni Association 38
Research on the Jungfraujoch 42 Sandals from a 3D printer 50

GLOBE

NO. 2/2024



FOCUS

Full speed ahead!

How ETH Zurich drives innovation in Switzerland

ETH zürich

Dear readers,

Knowledge is Switzerland's most important resource and the cornerstone of its success. It's therefore no surprise to discover that Switzerland is one of the world's most innovative countries. With its highly qualified graduates, state-of-the-art teaching and continuous transfer of knowledge to the private and public sectors, ETH Zurich plays a major role in driving this culture of innovation. Time and again, it harnesses its technological expertise to solve problems and bring about change. This makes it a valuable partner to international companies, Swiss SMEs and the Federal Administration in Bern.

Getting to this point hasn't been easy. Switzerland's strong competitive position on the world stage is the result of hard work and far-sighted policy. In parallel, ETH Zurich has always sought to serve society – from its pioneering work on electrification and bridge building to its collaboration with global organisations such as the UN and the ICRC. Yet only if the right conditions are in place can we achieve our mission of attracting the best and brightest and continuing to drive innovation. That is why I very much hope that parliament chooses to amend the drastic budget cuts in its review of the Federal Council Dispatch on the Promotion of Education, Research and Innovation. For every Swiss franc of tax invested, ETH generates five to six more in added value – the very definition of money well spent. This issue of *Globe* features numerous examples of how the members and alumni of ETH add value to society.

I hope you find it an inspiring read.

Joël Mesot,
President of ETH Zurich

Globe – the magazine for ETH Zurich and ETH Alumni

Images: Bratislav Milenković (cover); Alexandra Compain-Tissier (editorial)

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NEW + NOTED

FOCUS

Images: Daniel Winkler; courtesy of anonymous

COMMUNITY

REPORT

NEW + NOTED

Image: ETH Zurich / Alan Kovacevic

Three chunks of gold obtained from computer motherboards. The largest is some five millimetres across.

Turning electronic waste into gold

In a remarkable feat, researchers from the Department of Health Sciences and Technology at ETH Zurich have managed to recover gold from electronic waste using a by-product of the cheesemaking process. Electronic waste contains valuable metals such as copper, cobalt and significant amounts of gold. As demand for gold surges, recovering this precious metal from discarded smartphones and computers is an increasingly attractive proposition. The problem is that current recovery methods are energy-intensive and often involve the use of toxic chemicals. Professor Raffaele Mezzenga's research group has now trialled a new method that uses a sponge made from a protein matrix to extract gold from electronic waste. In addition to being more sustainable, this method is highly efficient and cost-effective.

To manufacture the sponge, the researchers used whey proteins, which were denatured under acidic, high temperature conditions so that they aggregated into a gel of protein nanofibrils. This gel was then dried to create a sponge from the protein fibrils. In the experiment to recover the gold, the team dissolved the motherboards in acid and placed the protein fibre sponge in the metal ion solution. Gold ions adhered to the protein fibres much better than other metal ions. The gold ions were crystallised into flakes, which were then melted down to form a gold nugget. From 20 computer circuit boards, the researchers obtained a nugget weighing around 450 milligrams. The nugget was 91 percent gold, equivalent to 22 carats. This shows the new technology is commercially viable, says Mezzenga: "And what I like most of all is that we're using a food industry by-product to obtain gold from electronic waste!" His next goal is to bring the technology to market. ○

AI can detect heart defects in newborns

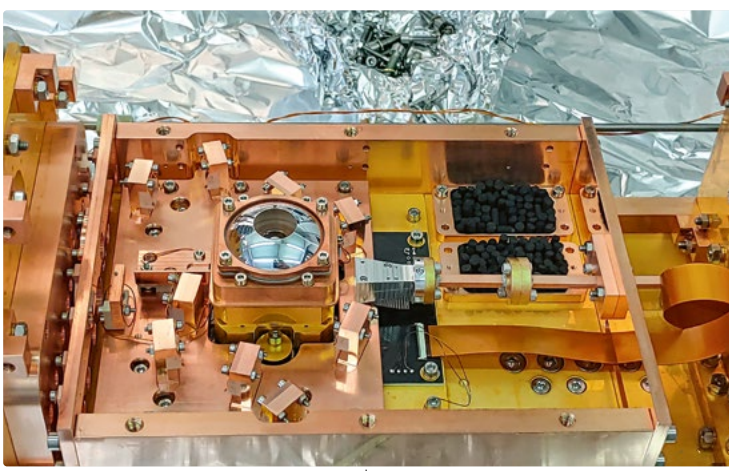
Preterm or very sick infants may suffer from pulmonary hypertension, a serious disorder in which the arteries to the lungs remain constricted after delivery or become narrow or blocked in the first few days or weeks after birth. This hinders the flow of blood to the lungs and reduces the amount of oxygen in the blood. Severe cases of pulmonary hypertension need to be detected and treated as rapidly as possible, a task that requires specific expertise. Researchers from the group led by Professor Julia Vogt, who runs the Medical Data Science Group at ETH Zurich, recently teamed up with neonatologists at KUNO Klinik St. Hedwig to develop a computer model that offers reliable support in diagnosing this condition.

The ETH researchers began by training an algorithm with video recordings from cardiac ultrasound examinations of 192 newborns. This dataset also included moving images of the beating heart taken from different angles as well as diagnoses by experienced paediatric cardiologists and an evaluation of disease severity. To determine the algorithm's success at interpreting the images, the scientists used the original dataset along with a second one unknown to the model. The model delivered the correct diagnosis in 80 to 90 percent of cases and was able to determine the severity of the condition in 65 to 85 percent of cases. The system also highlights the areas of the ultrasound image on which its diagnosis is based. This allows doctors to see exactly which areas or characteristics of the heart and blood vessels the model considers to be abnormal. ○

A path toward larger quantum computers?

When oscillating electromagnetic fields are used to create ion traps for quantum computers, this limits the number of qubits that can be processed to around 30. Conventional techniques do not offer a straightforward path toward building much larger quantum computers: the use of oscillating fields makes it difficult to combine several such traps on a single chip and also causes the traps to heat up – a problem that grows as systems get larger. An ETH research team led by Jonathan Home has now demonstrated that ion traps suitable for use in quantum computers can also be built using static magnetic fields instead of oscillating fields. Known as Penning traps, these static traps could be key to building much larger quantum computers. ○

Image: ETH Zurich / Pavel Hrmo



The ETH researchers' experimental set-up.

Image: Marco Rosasco Photography

Better stroke treatment

Strokes are the second most common cause of death and a leading cause of permanent disability worldwide. The faster a clot is removed and blood flow restored to the brain, the less likely the patient is to suffer any permanent damage. Given the challenges involved in navigating a catheter through narrow blood vessels, however, this is no easy task. To optimise endovascular procedures of this kind, a research group led by ETH professor Brad Nelson is working on microrobotic catheters that are guided by a magnetic field. The flexible catheter has a diameter of less than one millimetre and a soft magnetic tip. This can be steered in all directions using software and is therefore easier to control than a manually guided wire. A new study published by the research team shows how an enhanced version of the magnetically guided microrobot is steered through blood vessels even more efficiently: the surface of this robot features a helical structure that engages with the inner wall of the vessel, converting rotary movement into forward motion. ○

Multi-Scale Robotics Lab
→ msrl.ethz.ch

Pesticide-free offers a third way

It is possible to make the switch to pesticide-free agriculture without converting to organic methods. Robert Finger outlines the benefits and challenges.

ROBERT FINGER is Professor of Agricultural Economics and Policy and Chair of the World Food System Center at ETH Zurich.

A new approach is gaining momentum in European agriculture: a "third way" between conventional and organic farming. It requires farmers to forgo synthetic pesticides but nothing else – which is simpler to implement than a switch to organic farming. Since pesticide use is associated with significant risks to the environment, biodiversity and human health, this approach offers a way for Switzerland and Europe to achieve their ambitious targets for more sustainable methods of crop protection.

An increasing number of pesticide-free production systems have recently been introduced in Europe through public and private initiatives. Since 2023, for example, Switzerland and Germany have run agri-environmental schemes to compensate farmers who forgo synthetic pesticides.

In 2019, IP-Suisse launched a scheme that pays farmers a premium for grain grown without pesticides. Recent years have seen the emergence of similar initiatives in Europe, as well as pesticide-free labels, such as the French "cultivé sans pesticides" for tomatoes. These schemes enable farmers to send a clear "no pesticides" message to consumers and policymakers alike.

COMBINED APPROACHES We conducted a study to examine these various European schemes and initiatives. Our findings show that farmers substitute pesticides with a combination of various pest-management strategies, such as choosing resistant crop varieties, controlling weeds by mechanical means and tailoring crop rotation strategies. Despite these efforts, pesticide-free cultivation still produces lower yields than conventional farming, albeit higher than those achieved in organic farming, thanks in part to the use of mineral fertilisers.

In many cases, conversion to pesticide-free cultivation is not economically viable without subsidies. However, price premiums and area-based payments from public and private programmes can make it a financially attractive option for many farms. Surveys of Swiss farmers have highlighted the importance of ensuring that the switch to pesticide-free agriculture does not have a negative impact on a farm's bottom line. Farmers also tend to perceive pesticide-free production systems as riskier, which may deter them from adopting these new practices.

GRADUAL EXPANSION When given targeted support, pesticide-free farming systems have the potential to be implemented on a broad scale and to complement existing cultivation systems. They offer farmers greater flexibility when choosing appropriate sites for production and can be extended step-by-step to other aspects of crop rotation. As

such, they can provide a viable pathway between conventional and organic farming – one that creates added value for the environment and farmers.

The quest to expand pesticide-free production systems is not without its obstacles, however. There is currently no broadly accepted definition of what exactly counts as a pesticide-free production system. In addition, the labelling of pesticide-free production poses logistical challenges, as all the transportation and processing steps must be separated. There is also the question of whether price premiums and area-based payments can be maintained over the long term to ensure that a large proportion of the population is fed with pesticide-free produce. Finally, steps must be taken to close the yield gap between pesticide-free and conventional farming. To achieve this, researchers must now join forces with farmers and industry to increase the effectiveness of pesticide-free approaches and reduce the associated costs. ○

This article was written by Robert Finger in collaboration with Niklas Möhring, a professor at the University of Bonn.

Read more blog posts at:
⟶ ethz.ch/zukunftsblog-en

Some of the bread grain marketed under the IP-Suisse label is grown without pesticides.

Image: ETH Zurich / Robert Finger

Detecting forged documents

Image: ETH Zurich

The Thenti app allows users to authenticate physical documents using a smartphone.

The Information Security group, led by David Basin, has developed a smartphone app designed to thwart forgers. To use the new system, organisations provide each document they issue with a QR code, save the original in encrypted form on a server, and send a printed copy to the recipient. Anyone wishing to check the authenticity of the printed document can simply open the organisation's verification app, scan the QR code and film the document. It takes just seconds for the app to compare the individual images of the film sequence with the original. Any deviations – however small – are immediately displayed onscreen. The researchers' goal was to apply the technology for authenticating digital documents – which is already highly advanced – to the physical world. This led to the founding of thenti, an ETH spin-off. In March 2024, the city of Zurich rolled out thenti's app solution for its debt collection offices. If the pilot proves successful, the system could be deployed for other uses in the city. In future, the app will also be able to detect forgeries of physical objects. Luxury watch manufacturers, for example, could register their products in the system so that customers are able to check their watch against a database of registered timepieces. ○

Did cosmic dust kick-start life on Earth?

Researchers in a group led by NOMIS-ETH Fellow Craig Walton believe it is likely that critical biological elements such as sulphur, phosphorus, nitrogen and carbon first came to Earth primarily as cosmic dust. This dust is created in space – for example, when asteroids collide. To find out whether cosmic dust could possibly be the source that kick-started prebiotic chemistry, Walton developed a model in collaboration with colleagues at the University of Cambridge. Their simulations show that there could have been places on the early Earth with an extremely high concentration of cosmic dust. "This study will certainly stir controversy in the scientific community," Walton admits. "But it will also spark new theories on the origin of life." He now intends to test his theory in the lab. ○

Image: Kertu Liis Krigul / CC BY-SA 4.0

Sediment and cosmic dust accumulate in melt holes on the surface of glaciers.

Image: Courtesy of anonymous

A team from the ETH Zurich student initiative Swissloop Tunneling has won the 2024 Not-a-Boring Competition in Texas.

Swissloop takes top spot in Texas

A team from ETH Zurich's Swissloop Tunneling student initiative has won the 2024 Not-a-Boring Competition in Texas. The team's tunnel-boring machine placed first overall and received the prestigious Champion Award. This follows on from their success in the two previous editions of the competition, which saw the team win the Innovation Award and take second place overall. Since last year, the team has further harmonised the complex mix of hydraulics, electronics, cables and many other elements. The latest and most successful version of their boring machine is called Groundhog Beta. The team attribute their success not only to the performance of the machine itself but also to their members' own passion for advancing technological innovation. The initiative, which got underway in 2020, now involves over 60 students. ○

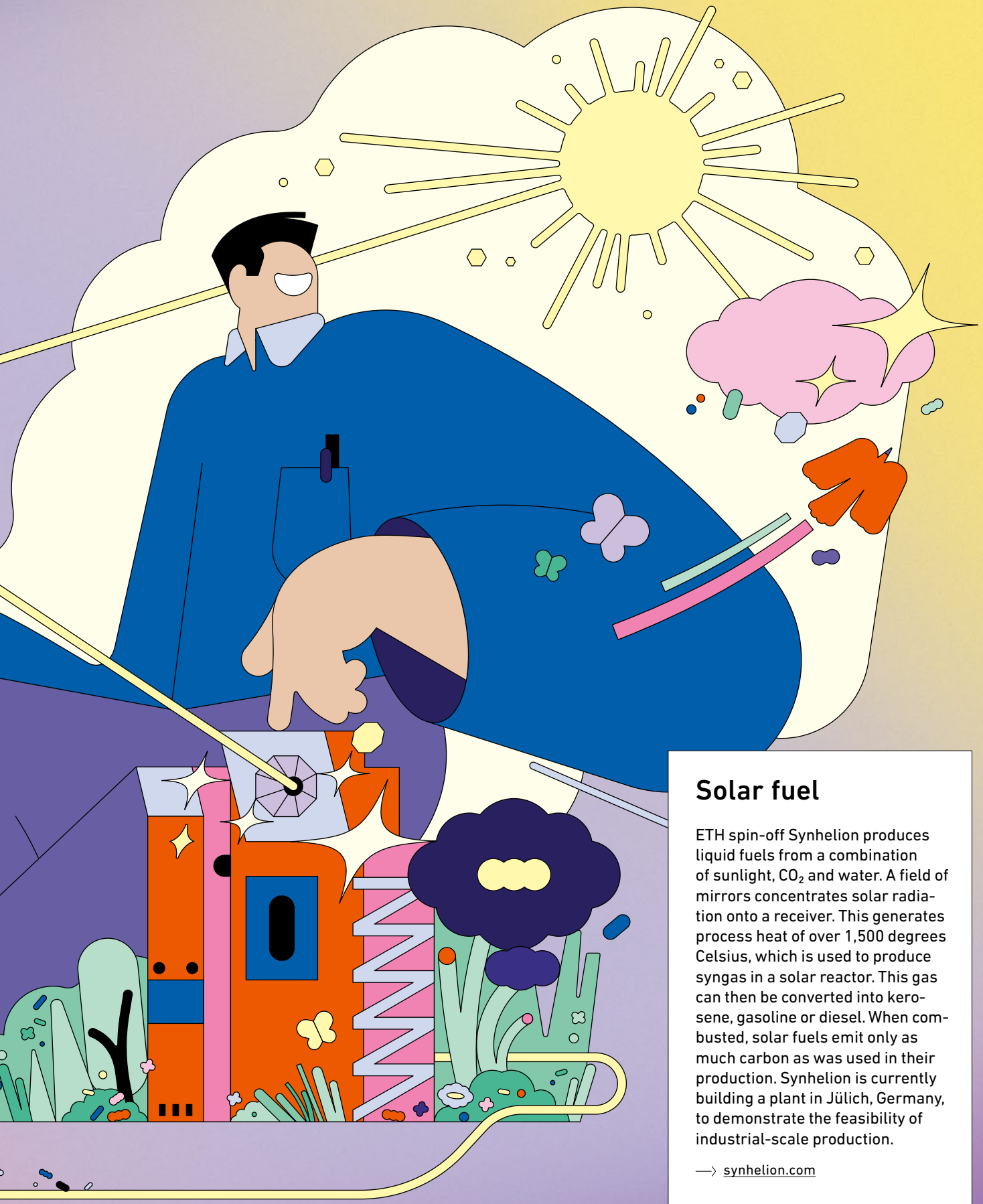
High cost of removing CO_2 from the air

The Intergovernmental Panel on Climate Change (IPCC) estimates that up to 13 billion tonnes of CO_2 will need to be removed from the atmosphere every year from 2050 if long term global climate goals are to be met. This will be hard to achieve unless ways can be found to reduce the cost of direct air capture (DAC) technologies. Now, a team of ETH researchers led by Bjarne Steffen, Professor of Climate Finance and Policy, and Tobias Schmidt, Professor of Energy and Technology Policy, has developed a new method that provides a more accurate estimate of the future cost of various DAC technologies. The researchers compared the potential costs of three technologies that are already in use. According to their calculations, the method used by ETH spin-off Climeworks, in which a solid filter with a large surface area captures CO_2, could cost between 280 and 580 US dollars per tonne by 2050. Currently, the cost per tonne lies between 1,000 and 1,300 dollars. The estimated costs of the other two DAC technologies fall within a similar range: the team calculated a price per tonne of between 230 and 540 dollars for the capture of CO_2 using an aqueous solution of potassium hydroxide, while the cost of carbon capture using calcium oxide derived from limestone was estimated at between 230 and 835 dollars. ○

STRONG INNOVATION DRIVER

FOCUS | ETH Zurich is one of Switzerland's key generators of innovative research and development. *Globe* took a closer look to find out what makes this engine tick.

ILLUSTRATIONS Bratislav Milenković



Solar fuel

ETH spin-off Synhelion produces liquid fuels from a combination of sunlight, CO_2 and water. A field of mirrors concentrates solar radiation onto a receiver. This generates process heat of over 1,500 degrees Celsius, which is used to produce syngas in a solar reactor. This gas can then be converted into kerosene, gasoline or diesel. When combusted, solar fuels emit only as much carbon as was used in their production. Synhelion is currently building a plant in Jülich, Germany, to demonstrate the feasibility of industrial-scale production.

—〉 synhelion.com

Cutting-edge research for Switzerland

ETH's outstanding reputation attracts top-flight researchers from all over the world. This pool of talent makes Zurich a major draw for global companies such as Microsoft.

TEXT Corinne Landolt

Young people wearing futuristic glasses are striding around the lobby of the ETH Main Building. It looks like some kind of game, but this group of students is actually part of a scientific project set up to scan this physical space using mixed-reality headsets. Once this task is complete, the lobby can be overlaid with holographic content, blurring the line between the real and the virtual. As the students pace around, cameras on their headsets scan specific features of the space around them. These will subsequently serve as fixed reference points that can be identified from anywhere in the hall.

Marc Pollefeys, Professor of Computer Science at ETH Zurich, is very much at home in this futuristic world. He is confident that this "mixed reality" realm will play an integral role in many people's lives just a few years from now, and his research focuses on how these two worlds – the real and virtual – can be combined as seamlessly as possible.

It was thanks to this Belgian computer scientist that Microsoft opted to set up a lab in Zurich to study augmented reality and artificial intelligence (AI). During a two-year stint in the US, Pollefeys helped the technology company develop the HoloLens 2 mixed-reality headset. When he returned to his professorship in Zurich, Microsoft was keen to keep him on board. It achieved this by establishing the Microsoft Mixed Reality & AI Lab in Zurich in 2018, with ETH as a partner. Pollefeys now runs this lab alongside his teaching and research commitments at ETH.

A FOCUS ON COMPUTER VISION Pollefeys spent three years as an assistant professor at the University of North Carolina before making what he calls a simple decision to head to Zurich in 2007. "ETH has some truly outstanding people working in all fields of research, not just in mine," he explains. "I realised

how important that was not just for future collaboration, but also to attract other talented colleagues," says Pollefeys. And he wasn't disappointed: "ETH gives me the opportunity to carry out all sorts of exciting joint projects on an equal footing with other top-flight researchers."

From the outset, Pollefeys focused his attention on computer vision, a sub-domain of AI. Computer vision specialists train computers to capture and interpret information from image and video data. With the help of machine-learning models, the goal is to create digital systems that are capable of processing, analysing and understanding visual data at a human-like level.

A system that is trained to monitor production facilities, for example, can inspect thousands of products or processes a minute, spotting defects and problems that humans would most likely miss. Computer vision is already employed across a range of sectors, including utilities, manufacturing companies and automakers.

NEW AREAS OF APPLICATION Combining computer vision with mixed reality – where natural perception is enriched with computer-generated content – creates entirely new user experiences, paving the way for applications that are both innovative and safe.

This combination is offered by mixed-reality headsets such as the HoloLens. Equipped with a variety of sensors and cameras, this device has numerous features, including the ability to track eye movements, recognise gestures and objects, and understand speech. It is also able to map a physical space in three dimensions and then calculate the position and orientation of objects within this environment. Armed with this information, the HoloLens can then generate digital 3D objects.

Such headsets can be used to display circuit diagrams, for example, or plans of an object or a building. "By superimposing a virtual plan on what the user actually sees of the real building, we enable them to perform tasks without ever having seen the plan before," Pollefeys explains. Mixed reality offers many other potential uses: helping train medical staff to perform complex surgery is one example; another is the ability to use robots to perform hazardous tasks, remotely controlling them through the HoloLens by means of simple hand gestures. ⟶

ALUMNI help drive innovation

TEXT Vinzenz Greiner / Corinne Johannssen
ILLUSTRATIONS Blagovesta Bakardjieva

When it comes to innovation, Switzerland's greatest capital is its highly qualified workforce. But what makes an innovation successful? And what makes an idea innovative in the first place? Twelve ETH Zurich alumni share their thoughts and experiences.

Image: ETH Zurich / Microsoft

Students kitted out with mixed-reality headsets and mobile phones paced around the Main Hall as part of a joint research project by ETH Zurich and Microsoft.

REAL-TIME INSTRUCTIONS Faced with automation, the Internet of Things (IoT) and a general shortage of skilled workers, industry is having to rethink its approach, says Pollefeys: "What companies need now is people who are flexible enough to perform a whole range of tasks."

When equipment is mishandled, improperly operated or poorly maintained, that can end up being expensive for an employer and also put employees at risk. Mixed reality provides users of such equipment with digital instructions when and where they need them.

When a machine operator has to carry out a new or complex task, for example, arrows and other symbols can be displayed to guide them through the process step by step. Similarly, data from IoT sensors can be displayed in a headset wearer's field of view to update them on the live status of a machine. Unlike virtual reality, where you are completely immersed in a synthetic environment, mixed reality overlays the real world – which remains visible – with computer-generated 3D holograms.

RESEARCH, EDUCATION, APPLICATION In his role as Director of the Mixed Reality and AI Lab in Zurich and Director of Science at Microsoft, Pollefeys manages a team of 25 engineers and scientists in Switzerland. He also has one team member in Prague and 15 others at Microsoft's headquarters in Redmond, Washington. "I'm proud to have assembled a team from such a fantastic mix of people," says Pollefeys. "Their outstanding talent and expertise are crucial to our work on this pioneering technology – especially since we can't be sure exactly what we need and how we should go about building it." With technology evolving at such a rapid pace, he says, the team has to be incredibly flexible.

Pollefeys divides his time equally between ETH and Microsoft. He works, researches and teaches at two different locations, with a separate office at each site, following a schedule that is broken down into individual days or even half-days. "That makes it easier for me to organise my various tasks in a more structured way," he says.

There are times when finding a solution for a specific mixed-reality application is so complex that he works exclusively with his Microsoft team. But, he adds, there are actually very few cases where it makes sense to draw a strict line between Microsoft and the university. "If we're working on a fundamental kind of problem that requires a general solution, then we put our heads together with both ETH and Microsoft at the same time," says Pollefeys. Sometimes, Pollefeys encounters a problem at Microsoft that he can channel directly into his teaching and research at ETH. "The students tend to find that very exciting and motivating, because they understand it's a real-world issue," he says.

But regardless of whether he's wearing his Microsoft or ETH Zurich hat, he always does his best to publish research results and share code. Collaboration with other companies is also integral to his work, says Pollefeys: "It's important for researchers like me to maintain a neutral stance." One example of the fruits of his professorship is a key algorithm that provided the basis for the Google Live View navigation tool, which is now in use worldwide.

A WIN-WIN SITUATION Microsoft's collaboration with ETH gives it a deeper insight into this area of research and helps spur innovation at the company. Finding the time to try out new things can be challenging within the confines of a corporate product team, says Pollefeys. But by collaborating with ETH, Microsoft gains an edge when it comes to exploring new perspectives and finding new solutions.

Marc Holitscher, National Technology Officer at Microsoft Switzerland, has seen the benefits of

this approach first hand. "Our collaboration with ETH, and Marc Pollefeys in particular, has already yielded tremendous results, driving innovation across various sectors and contributing to Switzerland's position as a global technology leader," he says. "Together, we continue to push the boundaries of what is possible, leveraging cutting-edge research, talent and technology to address some of the world's most pressing challenges."

Pollefeys is quick to point out that working with the private sector is equally beneficial for university teaching: "Students get to hear about the latest ideas and challenges not just from professors like me, but also from Microsoft engineers. That gives them the opportunity to work on exciting topics, put their own ideas to the test and learn about new applied technologies."

The collaboration between the university and the international technology giant is clearly a win-win situation, he says: "When we work on a problem with our students and ask them to explore how a new technology might be applied to a specific situation, both they and the product developers gain interesting new insights. The students are supervised by an expert who has enough experience and in-depth product knowledge to know when a certain step might be relevant."

And there are benefits for ETH too, says Pollefeys, when professors gain a better understanding of how industry works: "My job with Microsoft gives me valuable insight into how decisions are made and how processes are run at big companies. That helps me see the whole process of technological development within a wider context."

An additional benefit of joint projects is that they encourage networking within ETH itself – just as Pollefeys envisaged when he first took up his professorship in Zurich. He is currently collaborating with a colleague, Siyu Tang, to develop a new method of generating data using autonomous avatars. "Kitting out these virtual figures with a HoloLens turns out to be a great way of obtaining the data we need to train and test algorithms – it's much easier than using the HoloLens ourselves to walk through a physical space and scan its features." ○

MARC POLLEFEYS is a professor in the Department of Computer Science at ETH Zurich. He also heads the Microsoft Mixed Reality & AI Lab in Zurich.
⟶ cvg.ethz.ch

DOMINIK BLUNSCHY
Member of the National Council (Centre Party) and lead engineer at ti&m

"The Federal Institutes of Technology play a vital role in Switzerland. They are one of the reasons why we're among the most innovative countries in the world. Alongside leading institutions such as ETH, Switzerland also boasts a dual and flexible education and training system that guarantees a steady stream of highly qualified young talent. The country's business-friendly environment is another key driver of innovation. To ensure these strengths are maintained, universities must remain committed to the pursuit of science, free of ideology. At the same time, we must dismantle bureaucratic hurdles for business that reduce innovation." ○

TILLA THEUS Owner and managing director of architects Tilla Theus und Partner

"Innovation is a state of mind. On the one hand, it means never being satisfied until something is perfect – an attitude that could well be described as quintessentially Swiss and one with which I'm all too familiar. On the other hand, it's the freedom from fear. As the composer John Cage once said, 'I can't understand why people are frightened of new ideas. I'm frightened of the old ones.' ETH has always understood the importance of recruiting people who are unafraid of new ideas. At the same time, it has come to recognise that it's not enough to conduct research and register patents. The key question is whether a new idea can be turned into a commercial success." ○

Less cement

Neustark has developed a technology that binds CO_2 on the surface and in the pores of demolished concrete. This process permanently locks in carbon that would otherwise escape into the atmosphere. If granules of this concrete are used in place of sand and gravel for fresh concrete, the same properties can be achieved with the addition of less cement. This further reduces carbon emissions.
The ETH spin-off currently operates 14 carbon capture and storage plants at concrete recyclers, mainly in Switzerland.

—〉 neustark.com

Early diagnosis

A new method from ETH spin-off Scanvio is helping to speed up diagnosis of the disease endometriosis. The company founders have developed an AI algorithm that can scan ultrasound images of the uterus to detect this benign but painful growth of the inner uterine layer, the endometrium. This kind of tissue growth often remains invisible to the human eye. This means that patients currently wait an average of eight to twelve years for a diagnosis and generally have to undergo a laparoscopic procedure as well.

—〉 scanvio.com

Support for federal government

From devising new forecasting models for the federal budget to describing the latest trends in civil protection, ETH researchers provide vital support to the Swiss state and help drive innovation in the public sphere.

TEXT Christoph Elhardt

Researchers from ETH Zurich routinely supply Switzerland's government and public administration with expert input. Their know-how helps the public sector to craft new responses to the challenges facing society. In regular contributions to commissioned studies, hearings and consultations, ETH researchers present data, outline new trends, model scenarios, explain correlations and warn of emerging threats to the social fabric. And since the government generally lacks the time to get up to speed with new methodologies and the latest technology, ETH's contribution also helps drive innovation in the public sector.

At the same time, ETH offers a wide range of continuing education programmes that help maintain a continuous flow of knowledge into this sphere. Each year, these courses – over 85 in total – attract a steady stream of employees from public administration, allowing them to keep abreast of the latest advances in fields ranging from artificial intelligence to digital healthcare. This article examines how ETH researchers are assisting the Swiss state and driving innovation in civil protection, financial planning, energy provision and cybersecurity.

NEW TRENDS IN CIVIL PROTECTION

In Switzerland, it is the responsibility of the cantons to protect the population in the event of an emergency – be that a power cut, mobile phone outage or even the next pandemic. Support and coordination at the national level is provided by the Federal Office for Civil Protection (FOCP). Its responsibilities include the development of a civil protection strategy capable of addressing emerging threats and exploiting new opportunities. The Center for Security Studies (CSS) at ETH Zurich has been lending its support in this area since 2015. "Our trend analyses give the FOCP advanced warning of critical developments," says Andrin Hauri from the CSS.

The CSS report focuses on 12 key trends that are likely to have a major impact on Swiss civil protection over the next 5 to 10 years. In addition to well-known issues such as the growing urgency of climate change mitigation and increasing geopolitical polarisation, the authors also describe two technological changes that are destined to play an increasingly important role in civil protection.

For a start, they discuss the growing impact of unmanned robotic vehicles. Researchers are al-

ready working with the public sector on the use of this technology in disaster relief, as part of the Advanced Robotic Capabilities for Hazardous Environments (ARCHE) project. ETH developments in this area include Tethys, a diving robot, Anymal, a four-legged robot, and Gravis, an unmanned excavator. The report also highlights how satellites are offering new ways to monitor the environment and to provide advance warning of natural disasters. For example, ETH researchers recently demonstrated how GPS data can be used to improve the forecasting of extreme weather events such as thunderstorms with heavy rainfall.

FORECASTS FOR THE FEDERAL BUDGET

How much money is in the federal coffers at any one time? This is a question that routinely preoccupies Switzerland's Federal Finance Administration (FFA), the body responsible for compiling budgetary statistics and generating forecasts of future income and expenditure. To better anticipate how budgetary constraints might shift over the course of the year, the FFA has teamed up with the KOF Swiss Economic Institute at ETH Zurich. Over the past two years, ETH researchers have created a forecasting model that provides a sound statistical basis for planning the federal government's finances and have helped get the new system up and running.

The FFA receives a steady stream of data on the Swiss economy, including figures on gross domestic product, unemployment, inflation, exchange rates, tax revenue and public expenditure. Using the new model, it can produce federal budget forecasts more quickly and more accurately. At the same time, the model makes it easier to handle volatile variables and calculate different budget scenarios. "It gives the FFA a more powerful tool to analyse how income and expenditure are affected by factors such as lower growth," explains KOF project lead Samad Sarferaz. "That makes the state more agile when predicting how public finances will develop and determining what scope they have within the framework of the debt brake mechanism."

E-CARS FOR GREATER GRID FLEXIBILITY

Switzerland aims to replace fossil fuels such as gas and oil with electricity from solar and wind power by 2050 at the latest. In addition to replacing fossil fuel heating with electric heat pumps, another ⟶

LUCA DI TIZIO
CTO Microcaps

"For me, innovation is about solving problems in new and creative ways. Our country's small size and our focus on continuing education give us an edge in Europe in terms of innovation. And compared to other countries, our economic policy offers strong incentives for people to be inventive and set up their own company. That's something we need to defend with all our might. Where we can still improve as a society, however, is in our attitude towards failure. We can all do our bit here by celebrating entrepreneurship and by accepting that failed projects and unsuccessful ventures are all part of that journey. We need to be more open to taking risks!" ○

BEATRIX RAUCH SCHMID
Innovation manager
at MUVON Therapeutics

"What is innovation? And what is just hype or a false dawn? It's often hard to tell the difference. What we need to remember is that the purpose of innovative products, methods and solutions is to offer a response to a concrete need. Understanding those needs, some of which are only just emerging, requires education and the curiosity to question the status quo. ETH provides its students with both these tools. Furthermore, incubators such as Wyss Zurich, a joint accelerator for translational research at ETH and the University of Zurich, help create a thriving ecosystem – and that makes it simpler to transform a vision into an innovation." ○

BIGNA SALZMANN
Sustainability and circularity lead at Freitag

"Innovation is all about shaping the future and creating something that didn't exist before. This takes vision and the courage to think outside the box. It also requires role models and inspiration. In my own work, I try to inspire others by rethinking existing structures and the systems behind them and then sharing that knowledge. I bring people together so that we can shape the future together. And that's exactly what ETH Zurich does. It attracts people from all around the world – people who have grown up in different environments and have diverse stories to tell. This diversity is vital for innovation." ○

DENNIZ DÖNMEZ Owner of enabling structures and director of agile transformation for data, analytics and AI

"ETH understands that radical innovation requires basic research plus plenty of staying power. But that's only part of the story. You also need the ability to deal with frustration, because the search for something new and of value will most likely not turn out the way you anticipated. My contribution to making Switzerland an innovative place is to bring people together and to act as a 'catalyst for ideas'. For a team to be innovative, it must have a high level of diversity but, at the same time, not be too diverse. It must be creative but also understand markets and people's needs. Creativity alone is not enough." ○

key element of this strategy will be the switch from petrol and diesel to electric cars. By 2025 – according to the government target – half of all cars newly registered in Switzerland will be powered by battery. In 2023, this proportion was around 20 percent. Given that all these new e-cars will need recharging on a regular basis, this will require not only the appropriate infrastructure but also the provision of more power.

To investigate what this will mean for the country's electricity system, the ETH Energy Science Center (ESC) is currently running a project as part of a consortium commissioned by the Swiss Federal Office of Energy (SFOE). ESC researchers point out that all these electric cars will not necessarily increase the load on the power grid, provided they are charged primarily at times when electricity is plentiful. Conversely, if electric cars are able to feed electricity back into the grid when power is in short supply, they can also help make the grid more flexible and resilient. At present, researchers are still unsure whether the benefits of this process, known as bidirectional charging, will outweigh the still-high costs of installing the infrastructure.

"The question of whether electric cars will relieve the Swiss power grid or merely create an extra burden depends largely on how and when their owners recharge them," explains Jonas Savelsberg from the ESC. "Floating electricity prices can play a major role in delivering the right incentives and exploiting the full potential of electric cars to increase grid flexibility." With insights like these, the ESC is helping to improve our understanding of how the electricity grid will function in the future. At the same time, it is giving government and public administration the tools they need to steer power pricing to the maximum benefit.

ARMED AGAINST CYBERATTACKS

The Federal Administration is a regular target of cyberattacks. In January of this year, for example, hackers disrupted access to a number of federal websites. In the worst case, such attacks can compromise critical administrative and military capabilities. Sound technical infrastructure is one line of defence; the other is ensuring that staff are properly educated as to the dangers. A dubious USB stick or one click in a phishing mail is all it takes to jeopardise a department's entire IT system and operational capabilities, potentially leading to the loss of

Image: Tethys Robotics

Researchers are working with the Federal Administration to examine the role of new technologies in disaster relief. This diving robot was developed by ETH spin-off Tethys Robotics for use in search-and-rescue missions.

valuable data and damage to the reputation of the Federal Administration.

To counter this threat, Céline Herren from the Federal Department of Defence, Civil Protection and Sport (DDPS) is helping raise staff awareness of common cybersecurity risks. She holds lectures and workshops, designs e-learning modules and works on the department's information campaigns. A psychologist by training, with no background in IT, she enrolled for the ETH Certificate of Advanced Studies in Cyber Security in autumn 2023. The course gave her a technical grounding in cybersecurity and thereby sharpened her ability to assess new threats in this arena.

"It gave me deeper understanding of the latest issues and trends in cybersecurity, and that means I can now provide our staff with more detailed information and develop better teaching materials," she explains. "Some of the modules were technically demanding. But if the knowledge I've gained can help the DDPS improve the way it deals with cyberattacks, then it will have been worth the effort!" ○

FIND OUT MORE:

CAS ETH in Cyber Security
—〉 ethz.ch/cas-cybersecurity-en

Center for Security Studies
—〉 css.ethz.ch/en/

Energy Science Center
—〉 esc.ethz.ch

KOF Swiss Economic Institute
—〉 kof.ethz.ch/en/

Solid foundations

In 2023, a record-breaking 43 spin-offs were founded at ETH. While cutting-edge research lays the groundwork for the technologies they bring to market, this success story is also fuelled by the entrepreneurial spirit that ETH instils in its students from day one.

TEXT Michael Walther

01

Learning to focus on solutions

For ETH students, the first years at university are all about learning the basics: mathematics, theory, technical know-how. This is what sets them apart from other students and lays solid foundations for a future entrepreneurial career. Project work is introduced as soon as they finish their first year; on many degree programmes, it is a core part of the curriculum. Whether it's building electric cars, hydrogen-powered planes or tunnel-boring machines, students learn to run their own projects and develop a steady stream of creative solutions. This builds their confidence and helps foster an entrepreneurial spirit.

02

Testing, discarding, reworking

ETH actively encourages students to pursue their ideas – and to dare to fail. At the Student Project House, students can safely explore new ideas without worrying about grades. All the projects are conducted in interdisciplinary teams, and the Student Project House gets students talking to people from industry right from the start. What better way to test their ideas and discover whether their vision meets a genuine need?

05

Support in getting started

Students looking to found a company can get advice and support from the ETH Entrepreneurship group. This helps young researchers find suitable funding programmes, grants and contacts in the founder ecosystem. It also has a dedicated team that can assist with questions on intellectual property, licences and patents. In addition, the team assesses the accreditation of start-ups as official ETH spin-offs. For a limited time, companies with this seal of approval can rent laboratory or office space at ETH and hire equipment at a reduced rate.

06

And then?

In the make-or-break years after their founding, accredited ETH spin-offs receive support in the form of consulting, the licensing of ETH technologies and networking opportunities. Examples of this include the Investor Summit, a new investor event organised by ETH in collaboration with Swiss bank UBS. A detailed analysis conducted in 2020 by the University of St. Gallen revealed that ETH spin-offs perform better, create more jobs and are more likely to be an M&A target than the average Swiss start-up.

04

From research to product

Young researchers looking to commercialise the results of their Master's or doctoral project can also apply for a Pioneer Fellowship. Each year, between 12 and 15 researchers receive 150,000 Swiss francs and 18 months of coaching, business training and access to ETH infrastructure – from labs and workshops to computing capacity and office space. Funding is provided by donors to the ETH Foundation.

03

A thriving ecosystem

ETH cultivates a network and an ecosystem that sets the stage for founders to succeed. This includes the nationwide Talent Kick initiative, which helps students find co-founders and gain business experience before they even complete their course. Other examples include ESA BIC – a business incubation programme for space-related start-ups, which is run by ETH and the European Space Agency (ESA) – and Wyss Zurich, an initiative that provides funding to around a dozen young founders from ETH and the University of Zurich in the fields of medicine and robotics.

Mutual support

Founded and run by students, the Entrepreneur Club organises pitching competitions, offers inspiring stories of resilience at its "FuckUp Nights", and holds events to help students network with start-ups and industry representatives.

ETH professor Mirko Meboldt helps Swiss SMEs find the right technology to tackle the challenges they face. His early prototypes give companies a solid basis for decision-making – and the confidence to take things further.

TEXT Christoph Elhardt

A source of innovation for Swiss SMEs

Small and medium-sized enterprises (SMEs) are the backbone of the Swiss economy: 99 percent of Swiss companies employ fewer than 250 people, and SMEs employ two-thirds of the Swiss workforce. Innovations are essential to the survival of many SMEs, especially those that compete on the international stage. The only way to maintain their edge in a competitive global environment and to safeguard Swiss jobs is by responding promptly to the latest technological trends with a steady stream of new products, services and production methods. Yet, unlike larger companies, SMEs often struggle to dedicate enough resources to innovation. "Running an innovation project requires a significant investment of time, money and people," says Mirko Meboldt, Professor of Product Development and Engineering Design at ETH Zurich. "At SMEs, these resources are in short supply: most of them lack a dedicated research and development department, and their employees often have their hands full just focusing on the operating business. And you can never be sure whether the effort will pay off."

Meboldt has plenty of experience in this field. Since completing his doctorate, he has focused much of his attention on how innovation is born and how ideas evolve into products. He has collaborated with numerous SMEs during his 13-year stint at ETH Zurich, and the same issues tend to crop up again and again. "It's tough for SMEs to decide whether and when a new technology is mature enough to go to market," he explains. "They have to weigh whether to opt for long-term innovation projects with high uncertainty or stick with projects that improve the performance, speed or cost of

something that's already working." This debate even extends to publicly funded projects such as those supported by Innosuisse, the Swiss Innovation Agency, in which researchers and businesses spend several years working together to put novel ideas into practice. In recent years, Meboldt has been involved in a number of successful projects of this type. But before an SME can apply for state funding, it must identify which new technology will be of benefit – and this can be hard to pin down.

PROTOTYPES BUILD TRUST This is where Professor Meboldt and his Feasibility Lab come into the equation. "We aim to build a bridge between SMEs and research," he says. Together with his researchers and students, he helps companies get to grips with new technologies and discover whether these could help them create value. "Companies often come to us because they want to keep their competitive edge but aren't sure whether they could profit from new technologies such as artificial intelligence," says Meboldt.

Most of these exploratory projects have no fixed goal and are designed to run for a maximum of six months. The first step is to establish a sound basis for deciding which technologies are the best choice for the company concerned. Only when these have been identified and the company is confident they will be profitable does it make sense to start applying for an Innosuisse innovation project.

This can be a rocky road, and Meboldt and his team see prototypes as the key to navigating it successfully – hence his lab's motto "From crazy ideas to a first prototype". As a general rule, Meboldt only embarks on a fully fledged project once he has demonstrated on a smaller scale that a technology actually works. Yet putting the technology into practice is only part of the goal. "It's also about showing potential partners how we work and building a relationship with them," he says. "That establishes the trust and foundation you need to tackle the inevitable ups and downs of a years-long project."

DIGITAL FEEDBACK FOR BUDDING SURGEONS The first time Heinz Hügli set eyes on the prototype of a camera-based training assistant for trainee surgeons built by Meboldt and his team, he knew he had come to the right place. The CEO of Swiss medtech SME Synbone has long been on the hunt ⟶

MANUEL SUTER
Deputy director, National Cyber Security Centre

"In cybersecurity, what drives innovation is the emergence of a new threat. Each new challenge that we face has to be met by new solutions. But innovation only happens when stakeholders with different mindsets engage with the arguments of others and then work to refine their own answers. That's what we do here in Switzerland when we engage in direct democracy. But this open dialogue has to be based on established facts. One role of the scientific community is to continually check that these facts stand up to scrutiny. As one of the world's leading universities, ETH is therefore vital to this dialogue and to our country's capacity to innovate." ○

MYKE NÄF Co-founder and managing partner of Übermorgen Ventures

"Innovation is a key driver of economic growth and social progress. It's often equated with invention, but I prefer a more rounded view: successful innovation equals invention plus implementation plus diffusion. In other words, it's about inventing something but also about putting it into practice and achieving commercial success. Switzerland has considerable strengths in many of the areas that help drive innovation, not least in research, education and funding. But where I still see plenty of room for improvement is in having the courage to try things out and in accepting the occasional failure as part of that process." ○

ORIANA KRAFT
Founder of the Fem Technology Summit

"There's no recipe for patents, no 'one size fits all' approach to successful innovation. But what always drives innovation is people questioning the status quo, along with optimism and a belief that things can get better than they are right now. Innovation is never passive. It always involves action and interaction. Friction is therefore a key part of this process, be it in the form of irritation or annoyance, or in a creative form when different disciplines interact with one another and introduce different perspectives. This interdisciplinarity is part of the DNA at ETH Zurich – and part of what makes it such an innovative place." ○

GARIF YALAK
Country digital transformation lead at Cisco Systems, Switzerland

"An innovation must offer significant added value or address existing problems in a novel and more effective or efficient way. In my work, I strive to support projects that will propel Switzerland towards greater innovation and digitalisation, by providing direct financial investment or material support. Switzerland already boasts a robust framework, with stable political structures, ample funding opportunities and dynamic knowledge transfer. In addition, the country attracts talented individuals from around the globe, drawn by its exceptional education and training opportunities. ETH Zurich plays a pivotal role in this ecosystem and shows a real commitment to developing future leaders in science and the private sector who can drive innovative solutions." ○

for an innovative business line to supplement the company's existing activities. Headquartered in Zizers and with production facilities in Malaysia, Synbone sells bone models worldwide to help train orthopaedic surgeons. As an experienced manager, Hügli knows how vulnerable businesses can be in times of crisis, such as the recent coronavirus pandemic. Surely, he thought, it must be possible to improve surgical training – which still largely involves looking over the shoulder of experienced colleagues – by incorporating digital technologies, thereby adding another string to the company's bow.

Meboldt was already using Synbone products in other projects, and this led to a chance meeting with Hügli. The two got talking, and Hügli set out his vision of digital training for surgeons based on his firm's bone models. Back then, Hügli still had no clear plan of how to make this vision a reality. His staff of ten in Switzerland didn't have the resources to track down suitable technologies, let alone to actually put them into practice. So he could hardly contain his delight when Meboldt offered to build him a prototype within just two weeks.

"We already had experience from other research projects in how to digitalise surgical procedures using cameras," says Meboldt. More than anything, this requires expertise in the fields of image recognition and machine learning. On the day of the prototype presentation, one of Meboldt's doctoral students attempted to reconstruct a Synbone model of a broken bone while a camera filmed his movements. These appeared on a screen in real time and were evaluated and recorded. "I knew then that it really was possible to digitalise training using our bone models," says Hügli. "And I was really impressed with what Mirko and his team had achieved in such a short space of time."

This demonstration convinced Hügli that it was worth applying for an Innosuisse innovation grant. With Meboldt's help, he submitted an application and received funding for a two-and-a-half-year project. Half of that time has now passed, and his vision of a digital training platform is steadily taking shape. In the meantime, Meboldt and his team have developed a simulator for orthopaedic surgery. Using Synbone bone models, surgical instruments and a camera, trainee surgeons can now practice performing real surgical interventions and then receive feedback from the software.

Image: ETH Zurich

Using a camera to digitalise and evaluate a trainee's performance.

The camera digitalises everything the trainee surgeon does – for example, how they screw together a broken bone, the angle at which they place the drill and how deep they make the hole. An algorithm registers each individual movement and step in the process and evaluates it. Once the procedure is complete, the trainee receives feedback on their performance. For instance, the camera is able to determine whether tissue would have been damaged, or whether an implant was placed in the correct position and at the correct angle relative to the bone. The current system can even simulate X-rays during the training session. Heinz Hügli is now much closer to achieving his vision for his SME, in large part thanks to the technological expertise of ETH researchers.

HELMET TO TREAT ALZHEIMER'S Back in autumn 2022, Bekim Osmani was wrestling with the problem of how to develop a digital process ⟶

CONTINUING EDUCATION DRIVES INNOVATION
ETH Zurich's continuing education and training programmes help specialists and managers gain a solid foundation in areas of future importance. Andreas Ruflin, Chief Digital Officer at Zurich-based company BX Digital, has experienced the benefits firsthand. Founded in 2023, BX Digital is developing a platform that enables banks to trade and transfer digital assets using blockchain technology. Keen to deepen his understanding of the technology behind blockchain and to learn new software development methods, Ruflin completed two programmes at ETH: the CAS ETH in Applied Information Technology and the CAS ETH in AI and Software Development. "Both programmes helped me channel technology-driven innovation into product development," says Ruflin.

chain that could produce a highly personalised product as quickly and cost-effectively as possible. The CEO and co-founder of Basel-based company Bottneuro works with a seven-strong team to improve the treatment of degenerative brain diseases such as Alzheimer's through electrical stimulation of certain areas of the brain. To determine where the electrodes should be placed on an individual patient's head, a neurologist consults an MRI scan of their brain. Bottneuro has developed a personalised treatment helmet to ensure that precisely the same areas of the brain are stimulated during each treatment session. This helmet will eventually enable patients to perform the treatment at home.

"Each helmet is uniquely tailored to the patient's head and brain. Currently, it takes around 100 hours of manual work to produce, which is very expensive," says Osmani, who studied at ETH Zurich before completing his doctorate at the University of Basel. He knew that his SME would have a greater chance of long-term success if he could reduce these production costs. The answer was to digitalise and automate the design and manufacturing process, but this called for a level of technical expertise that Bottneuro simply didn't have. Deciding which technology to use proved an uphill struggle for Osmani and his team.

The first time Meboldt heard about Bottneuro, he immediately saw the potential for collaboration. But there were still too many questions that needed answering on both sides before they could consider submitting a joint project application to Innosuisse. The ETH professor and his team therefore decided to produce a prototype. The goal was to provide an example of how Bottneuro's process chain could be digitalised – from the shape of the helmet and the position of the electrodes right through to the

Image: Bottneuro

Bottneuro's personalised helmet also enables patients to receive treatment at home.

3D-printing process used for fabrication. The researchers were able to prepare each individual patient's MRI data in such a way that a 3D printer could then automatically fabricate the helmet, leaving holes for the electrodes in exactly the right places.

The prototype ticked all the boxes, and the CEO of Bottneuro was impressed. "We immediately saw the benefits of the new process, and it was clear that Mirko was the right partner for the Innosuisse innovation project," he says. Osmani and Meboldt eventually received state funding for a three-year period, half of which has now passed. Thanks to the support of ETH researchers, Bottneuro will be launching a faster and more cost-effective digital production process for its treatment helmets in 2025. Meboldt is still keen to go one step further by finding a way to print the helmet and electrodes as a single piece, but this will require a lot more research.

The Synbone and Bottneuro projects are good examples of how SMEs can benefit from working with ETH Zurich. In the early stages, however, the ball often lies in the researchers' court: they have to prove that their research findings and the new technology genuinely have the potential to take a company to the next level. But once this initial step is complete, their technological expertise can be an invaluable source of innovation for Swiss SMEs. ○

MIRKO MEBOLDT is Professor of Product Development and Engineering Design in the Department of Mechanical and Process Engineering at ETH Zurich.

⟶ pdz.ethz.ch

LUKAS AMBÜHL
Co-founder and joint CEO of Transcality

"Promoting innovation means encouraging people and institutions to be more daring. That's a process that begins with research and extends into the practical realm. ETH Zurich played a key role in my career by giving me a certain freedom in my research and by providing financial support through the ETH Foundation to set up a spin-off company. I'm immensely grateful for that. This kind of support not only fosters entrepreneurship; it also strengthens the innovation ecosystem as a whole by enabling me to connect with other researchers and company founders. That's the only way for bold ideas to attract the right support – and for a daring venture to produce concrete innovation." ○

REA SODERO
Co-founder and CEO of Planlabs

"Innovation can only thrive in the right environment. With all its initiatives and its programmes to promote entrepreneurship – such as ETH Juniors, the Student Project House and the Entrepreneur Club – ETH Zurich creates the perfect ecosystem for innovation and those first steps into the start-up world. As a former ETH Junior, I'm part of a huge network of inspirational people who have offered me support at many moments of my career. Trust and unity are essential ingredients of a successful team – along with open-mindedness, joint decision-making and absolute transparency." ○

Clear view

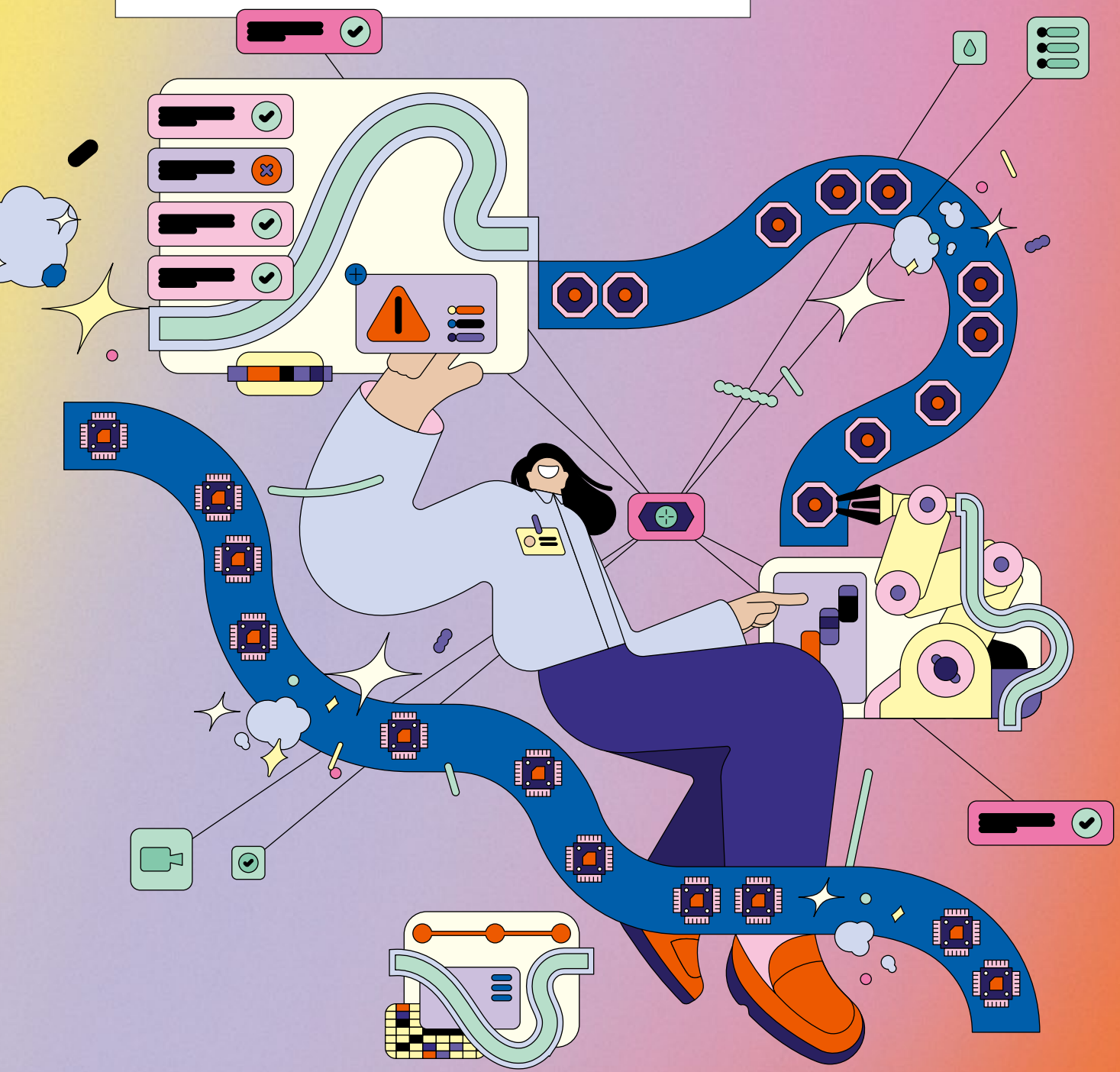
ETH researchers have developed and patented a simple and effective method to prevent glasses, mirrors and car windows from fogging. A wafer-thin, transparent nanocoating of gold, applied to glass or other surfaces, absorbs a large portion of the infrared radiation emitted by the sun. This warms up the coating to a temperature of eight degrees Celsius, ensuring a clear view even in humid conditions – without requiring additional energy.

→ ltnt.ethz.ch

Better quality

Poor quality drives up manufacturing costs and can quickly damage a brand's reputation and harm the environment. A software platform from ETH spin-off EthonAI uses machine learning to detect, monitor and prevent quality problems in production. EthonAI's software compares images from cameras on the production line and generates heat maps to highlight potential flaws. Use of this technology has already helped manufacturers such as Siemens, Roche and Lindt & Sprüngli to substantially increase productivity and reduce quality issues by over 50 percent.

→ ethon.ai



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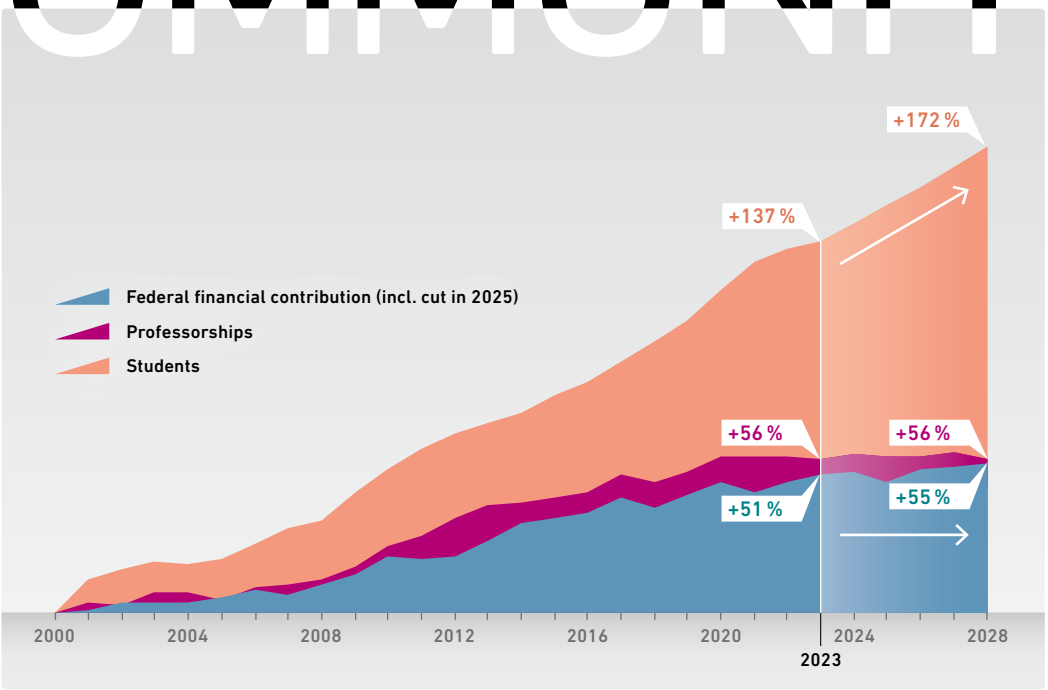


Graphic: null-oder-eins.ch

A widening gap between student numbers and the federal financial contribution

Top position jeopardised

With a total of 6,050 graduates, top rankings in international university league tables and 43 new spin-offs, ETH Zurich's annual report 2023 looks back on a very successful year. A total of 31 new professors were appointed in the reporting period, 58 percent of whom were women – the first time that women have outnumbered men. In addition to fulfilling its basic mandate in teaching, research and knowledge transfer, ETH Zurich also launched two new national research initiatives. The Coalition for Green Energy & Storage is tasked with developing solutions for the storage and transport of renewable energies, while the Swiss AI Initiative aims to establish Switzerland as a leading global hub for the development and use of transparent and trustworthy artificial intelligence.

FREE RESERVES SOON EXHAUSTED ETH Zurich faced significant financial challenges in 2023 due to a rise in student numbers, a real fall in funding for the ETH Domain after adjustment for inflation, and additional pressures caused by budget cuts in federal government. Nevertheless, ETH Zurich still managed to generate a consolidated surplus of 50 million Swiss francs in 2023, thanks to a combination of internal cost discipline, increased donations and positive net finance income – in marked contrast to the previous year's loss of 73 million Swiss francs. Despite this encouraging result, ETH Zurich's liquidity has been steadily declining since 2020. This means that ETH is no longer able to fully meet its liquidity requirements for investment and operations from the federal financial contribution and third-party funding alone. "We are currently living from our freely available reserves, but these will be completely exhausted by the end of 2025,"

explains Stefan Spiegel, Vice President for Finance and Controlling. "ETH Zurich urgently needs additional reserves in order to fund major future investments and offset any fluctuations in expenditure."

At the same time, student numbers continue to grow strongly. At the end of 2023, there were over 25,000 people studying at ETH Zurich. The number of students has therefore more than doubled over the past 20 years, while the federal financial contribution has increased only by around 50 percent. ETH Zurich expects this gap to widen further. "In the past, we have been able to offset this trend through improvements in efficiency, the postponement of major construction projects and a slower growth in professorships," says ETH President Joël Mesot. "But we have now reached the point where, without compromising the quality of teaching and research, we can no longer accommodate this continuing growth in student numbers and a budget that is stagnant in real terms."

DRASTIC SAVINGS UNDER REVIEW ETH Zurich is aware of federal financial constraints and is prepared to play its part in combatting the deficit. However, in the light of the ERI Dispatch for 2025 – 2028 and a proposed annual budget increase of 1.2 percent, it has now become necessary to consider drastic cost-cutting measures. These include a restriction in student numbers, a targeted freeze of new appointments, a discontinuation of entire research areas and study programmes, and the reduction of services to federal government or charging for them at market rates – e.g., the Swiss Seismological Service, the Swiss National Supercomputing Centre and the Swiss Support Center for Cybersecurity. "In view of the challenges currently facing society, such as the acute shortage of skills, I believe that implementing such drastic measures as these to achieve short-term savings would be too high a price to pay," Mesot underlines. In order to maintain the quality and scope of services currently offered, even as student numbers continue to grow, ETH Zurich estimates that an annual budget increase of 2.5 percent in real terms is required. ○

For more information on ETH Zurich's annual report 2023:

—〉 ethz.ch/annualreport

PHILANTHROPY

DONALD TILLMAN
Managing Director of the ETH Foundation

A bond stretching over 60 years

For many people, university is a formative experience that has a lasting influence on their life. Take alumnus Jacobus Kann. Having graduated from ETH Zurich in 1962 with a degree in chemistry, he promptly returned home to the Netherlands. As things turned out, the former ETH student would only come back to Switzerland on a few occasions – to enjoy the odd skiing holiday, for example. All in all, he spent 38 years working for the oil company Exxon, now ExxonMobil. Yet he never forgot his "fantastic time" at ETH, with daily exercise at the Polytechnic Rowing Club, his brilliant professors and the social buzz of Hollandia, the Dutch student association. Back in the Netherlands, he became a longstanding member of the Nederlandse Vereniging van Zürichse Ingenieurs, a Dutch association for engineers with a connection to Zurich. Now, at the age of 88, Jacobus Kann has chosen to commemorate his time at ETH with a generous donation to the Excellence Scholarship Programme. That way, his fond memories of ETH will be reciprocated by ETH's profound gratitude to him.

—〉 ethz-foundation.ch/en

Image: Hannes Heinzer

“We’re at the start of a major transformation”

Jeannine Pilloud, president of the ETH Alumni Association, explains how she hopes to double its membership in the years ahead.

TEXT Roland Baumann

Ms Pilloud, what do you enjoy about being a member of the ETH Alumni Association?

I love the wide range of events it offers – things like the Global Lectures, which might feature a topic unrelated to my day-to-day work. I particularly like the mix of guests these lectures attract, from students and distinguished alumni to public figures. And everyone has their own perspective to offer.

Which event or occasion has impressed you most?

At this year’s World Economic Forum (WEF), we invited our members to an event at AI House that was organised in collaboration with the AI Center. We expected around 30 people, but in the end over 100 alumni turned up. The place was absolutely packed, which was fantastic! We also had a live stream so that members could join in from all over the world.

You became president of the ETH Alumni Association in May 2023. What motivated you to take on this role?

I was originally invited to join the board and provide an outsider’s perspective on the Alumni Association, based on my years of management experience. The association wanted to strengthen ties to ETH, and during those discussions, a number of people, including ETH President Joël Mesot, suggested I should take on the role of president.

When you took up the post, you announced your intention to double the number of members. How do you hope to achieve that?

The real question is when we hope to achieve that by! The point I was trying to make is that “ETH alumni” covers all of the 90,000 people who have graduated from the university, yet only 35,000 of those graduates are actually members of the association. Following a survey, we realised that many people assume they automatically become a member of the association when they graduate. We think we can give the association a major boost by tapping all that potential.

Why does ETH need its alumni so much right now?

Our by-laws state that alumni should support ETH Zurich by raising awareness – in the business sector and the public domain – of the issues that are important to the university. Remember, 1,800 members of the Alumni Association are CEOs. That’s a powerful network, not least abroad.

Closer to home, ETH is concerned about the difficult financial situation. I imagine this issue is also very much on the association's radar?

Absolutely. This is exactly the kind of thing we can help with. And I don't mean by simply rustling up two or three more donors, but rather by identifying influential alumni and getting them firmly on ETH's side. Education is the most important resource our country has. Cut corners here, and we risk jeopardising our prosperity. Student numbers at ETH continue to surge, which is good news for the economy. But if we wish to maintain the quality of research-oriented education, then we also need to increase teaching staff and expand infrastructure. ETH alumni understand how this all ties together, so they can put forward credible arguments.

What does the association offer its members?

We're at the start of a major transformation. Towards the end of last year, we launched the Knowledge Network, a flagship project that enables members of the Alumni Association to ask questions and get answers from experts. The project started as a pilot with around 2,000 members and has since evolved into a really active community. Over the next few years, we'll be expanding it further. Young members, in particular, appreciate the opportunity to share information across generations. And they're just as enthusiastic about our job platform and mentoring programme, as well as all the different activities offered by local groups and clubs.

You're keen to strengthen ties to ETH. How do you plan to achieve this?

Firstly, through events. ETH offers all sorts of exciting events, and we would like to make these more accessible to alumni. I already mentioned the successful WEF event, and another good example is this year's Industry Day, which is being run in collaboration with Swiss media conglomerate NZZ under the heading of Open-i. Everyone who signs up through the ETH platform gets a 50 percent discount. Continuing education and training programmes are another area in which we could envisage our members benefiting from discounts.

What services are available to alumni who are living abroad?

We have some 3,500 members outside Switzerland, who are organised into chapters that hold their own local events. We're currently drawing up a blueprint in the US that will provide guidance and support in setting up new chapters. Other plans include a worldwide Alumni Community Day to strengthen the bonds between our members. And we're also seeking synergies with ETH in the area of communications: we want to give our members better access to articles and audiovisual content produced by ETH by linking to them in our newsletter and on our website. ○

Image: Courtesy of anonymous

JEANNINE PILLOUD graduated from ETH Zurich with a degree in architecture and went on to pursue a successful career in a number of industries. She came to public attention with her appointment as head of passenger transport at Swiss railway operator SBB. In May 2023, Pilloud was elected president of the ETH Alumni Association on an honorary basis. In July of the same year, she joined the Office of the Vice President for Knowledge Transfer and Corporate Relations, where she is responsible for partnerships with industry and institutions.

New hub for greater animal welfare in science

In its approach to animal experimentation, ETH Zurich has long been guided by the three Rs: replacement, reduction and refinement. In March, the university set up a hub for all activities in this field. By creating a single point of contact, it aims to establish and disseminate effective, rapidly implementable 3R methods across ETH. This includes training for researchers as well as developing new 3R methods. All measures and activities carried out by the 3R Hub will focus on improvements in animal welfare. The new hub is headed by Oliver Sturman from the Institute for Neuroscience. ○

Prize for young water researchers

Established to inspire young researchers to get involved in improving the state of our waters, the Otto Jaag Water Protection Prize is awarded in recognition of outstanding doctoral theses and Master's dissertations completed at ETH Zurich in the field of hydrology. The fund for the prize was endowed at ETH Zurich in 1980 in honour of Otto Jaag (1900–1978). An internationally recognised pioneer in the field of water protection, Jaag played a significant role in drafting the Swiss Federal Water Protection Act and was Director of the Swiss Federal Institute of Aquatic Science and Technology (Eawag) from 1952 to 1970. At the beginning of this year, the original endowment was topped up by former Director of Eawag Janet Hering. As a result, prize money has now increased to 5,000 Swiss francs. ○

Commitment to ETH Zurich

Last year, a great many individuals, foundations and companies contributed to ETH Zurich with over 3,500 donations, bequests and legacies totalling more than 130 million Swiss francs. In its latest annual report, the ETH Foundation highlights how this generous support from over 2,700 donors and partners has been put to good use – in helping to shape the digital transformation, empowering brilliant young talent and boosting medical research. Newly appointed to the ETH Foundation's Board of Trustees are Michael Rechsteiner, Chairman of the Board of Directors of Swisscom, and Fabrizio Petrillo, CEO of AXA Switzerland. ○

New on the ETH Foundation Board of Trustees: Michael Rechsteiner (left) and Fabrizio Petrillo.

Images: Courtesy of anonymous

IN PERSON

Hedan Bai would like to use soft materials to develop robots that help people. She is also working on creating robots that are recyclable or compostable.

HEDAN BAI is Assistant Professor of Robotic Materials at the Department of Materials, ETH Zurich.

→ robotic.mat.ethz.ch

Are fantasy and science fiction a source of inspiration for your research?

Yes, as a child I was fascinated by all the amazing abilities of the Pokémon figures. My favourite right now is Baymax from the Big Hero 6 series. I see my research heading towards creating robots that help people in some way or other.

What are the benefits for robotics of working with soft materials?

Today's robots are composed mostly of hard materials – unlike living organisms. By exploring the use of soft materials, we are taking a bottom-up approach to increasing a machine's bodily intelligence. We want to develop robots that can act intelligently and carry out tasks autonomously in dynamic environments with the same ease as biological organisms.

Are your robots inspired by animals or plants?

Mainly by animals and humans. For example, our autonomous, self-healing optical sensor is inspired by the mechanoreceptors in our skin. This sensor will help with the development of intelligent and resilient robots.

One of your research areas is sustainable robots. Will future robots be recyclable or compostable?

Both! And a lot more besides. We are looking at the different stages of a robot's life cycle with the aim of making these more sustainable. For starters, a robot can be made from raw materials taken directly from natural sources or from industrial waste. We can prolong its service life by giving it self-healing capabilities. At the end of its life, it can be recycled or biodegraded.

Where do you anticipate seeing the first applications of your research in everyday life?

Flexible bioelectronics equipped with soft robotic functions offer exciting potential for clinical applications – such as in vivo monitoring of fetuses during fetoscopic surgery. ○

TEXT Samuel Schlaefli

Image: Daniel Winkler

GLACIER ON THE RADAR

TEXT Peter Rüegg
IMAGES Daniel Winkler

REPORT | ETH researchers are using radar to scan the snow and ice on the Jungfraujoch. Sometimes, scaling an icy peak is the only way for scientists to fully understand satellite data.

With mist obscuring the sun, and powerful gusts of wind whipping up flurries of snow, everything merges into a white blur. The sun may be hidden, but its harsh glare still forces the eyes into a squint. Without sunglasses, it's almost impossible to see.

Eager to exploit a sudden lull in the wind, ETH researchers Marcel Štefko and Esther Mas i Sanz hurriedly help their professor, Irena Hajnsek, to set up two radar antennas. The spots they have chosen are three stories above their lodgings in the High Altitude Research Station Jungfraujoch, one on the upper terrace, and one on the lower terrace. The researchers have spent the whole morning waiting for the weather to clear up – and now there's no time to lose.

Somewhere in the white glare below is the Aletsch Glacier, though not a trace of it is visible. "Fortunately, that's not a problem for radar! It can see the glacier through any amount of mist or clouds," says Štefko. As he talks, he hooks up the radar antenna to a computer, which is safely stowed in a yellow plastic box to protect it from the snow and ice. "Strong winds are bad news, though," he adds. "They make the antennas wobble, which can reduce the accuracy of our measurements."

MEASURING ICE LOSS For several years, ETH researchers have made their way up to the High Altitude Research Station Jungfraujoch to study the upper part of the Aletsch Glacier using a variety of radar technologies and systems. These visits also serve to develop new methods and to gather reference data for satellite radar systems.

The researchers use this data for various purposes, including the creation of topographic maps known as digital elevation models. Based on these representations of the Earth's surface, the researchers can determine the thickness of the Aletsch Glacier and calculate the shrinkage of the glacier over time.

"The radar data clearly shows a huge drop in the glacier's thickness over recent years, at an average rate of 2.5 metres a year," says Hajnsek, who specialises in remote sensing.

Even if the ice only shifted a few millimetres, the ETH radar systems would still be sensitive enough to detect it. "Our measurements show that the glacier is moving at a rate of 8 to 12 millimetres an hour, which is somewhere between 20 and 30 centimetres a day," says Mas i Sanz, a doctoral student who is currently on her third Jungfraujoch measurement campaign. But this figure varies significantly from one location to the next: up here at the top of the glacier, the ice is still moving relatively slowly, but in other parts not covered by the ⟶

1
The researchers position the radar – and its horn antennas – on a sturdy base.

2
Professor Irena Hajnsek lends a hand setting up the antenna.

3

4

3
The second radar, equipped with narrow beam antennas, has a clear view over the Aletsch Glacier.

4
Many metres of cable are required to connect the radar antennas to the computer.

radar, the Aletsch Glacier is slipping towards the valley at an average rate of 80 centimetres a day.

Glacier melt is just one of the topics the researchers are here to study. They are also developing new radar methods to directly measure the thickness of the snow cover. This has traditionally been a manual task: the most reliable means of calculating snow depth is to climb the glacier and drive a long probe into the snow. But with so many crevasses in the upper reaches of the ice flow, this can be a risky undertaking.

IMPROVED REMOTE SENSING Back in their improvised control room, Hajnsek and Mas i Sanz look over Štefko's shoulder as he opens the laptop. He is eager to find out whether the incoming data is usable. Massaging his frozen fingers, he types in a few commands and opens what looks like a medical ultrasound image.

The screen shows patches of black and white as well as fuzzy areas with isolated coloured pixels. "That's a crevasse in the glacier," says Štefko, pointing to a furrow. "The black area is the radar shadow,

and the white area is where the beam is strongly reflected, which is why it's so bright." The grey zones indicate where the snow, in line with its specific characteristics, is reflecting the radar beams.

Performing a detailed study of the cryosphere around the Jungfraujoch is not the only goal of this radar project. The scientists also hope the data they collect on the ground will support and improve radar remote sensing from satellites.

It was Hajnsek who forged this connection to satellite remote sensing. She is currently helping to design and plan a number of European radar missions and, before joining ETH Zurich, was responsible for scientific coordination of the TanDEM-X mission, operated by the German Aerospace Center (DLR). The objective of this mission was to generate a high-resolution topographic map of all of Earth's land surface using radar measurements. The DLR launched the first mission satellite in 2007, and the second three years later.

The twin satellites – each of which is equipped with a radar system – fly in a helix-like formation as they orbit the Earth. Experts refer to this as bistatic radar configuration, and the data it provides has enabled DLR researchers to create three-dimensional digital elevation models in high resolution.

Although TanDEM-X has long since achieved its objective, the mission is still operational. The twin satellites continue to orbit the Earth, detecting changes in land use, such as deforestation. Once every 11 days, TanDEM-X also passes over the Jungfrau region, which features on the DLR's list of "super test sites". The aim is to take regular measurements over the course of several years and thereby record the development of these rapidly evolving areas.

Over the past few years, Hajnsek and her colleagues have developed a ground-based radar system called KAPRI, which simulates the bistatic radar configuration of TanDEM-X and provides new data that will help scientists prepare for future bistatic missions.

"The ground-based radar is a quick method of gathering a lot of data on a specific area and can be set up almost anywhere, just as long as the location is elevated," she explains. One downside, she acknowledges, is that the radar system can only cover a small area, while satellite radars span the entire Earth. "But because we know exactly what we're looking for with our radar systems, it's easier for us to interpret the data we collect and to assign it ⟶

5
Esther Mas i Sanz (l.), Irena Hajnsek and Marcel Štefko check the incoming data.

5

accurately to a specific part of the Earth's surface. That, in turn, helps us do a better job of interpreting the data we get from space," she says.

PERFECT TEST SITE It's taken the three researchers over an hour to set up the two radar systems on each terrace. Hajnsek is standing next to the radar system on the lower terrace, protected from the elements by glacier goggles, thick gloves and sheepskin-lined winter boots. Stretching out her arms, she marks out 60 degrees of a circle: "This is the section of terrain the radar will capture," she says.

The view from here encompasses much of the upper part of the Aletsch Glacier and continues far beyond Konkordiaplatz, where four fingers of the glacier meet. Conducting research here would be impossible without access to the superb infrastructure of the High Altitude Research Station. It provides everything the scientists need, including a reliable power supply from Jungfrau Railways, Wi-Fi, comfortable lodgings with a fully equipped kitchen and an unobstructed view of the glacier. The researchers also have direct access to the glacier through a tunnel, which allows them to collect snow and ice samples and to set up corner reflectors, which are used to calibrate the radar systems.

"The Jungfraujoch is the perfect test environment for our project – we're very lucky to have all this infrastructure at our disposal," says Hajnsek, clearly grateful for all the support she and her colleagues have received here.

MOBILE GROUND-BASED RADAR The sun has finally broken through and dispelled most of the clouds; the thermometer, however, remains stubbornly at minus 12 degrees Celsius, and the icy wind blows unabated. Štefko has dismantled one of the beam antennas and is now carrying it carefully back to the storeroom next to the control room. "The rule is that we dismantle the radar antennas 40 minutes before sunset," he says. Undoing the delicate retaining screws requires him to remove his gloves, so there's no escaping cold fingers.

Štefko and Mas i Sanz will stay up here for another ten days to take further measurements before the spring campaign comes to an end in mid-March. The next campaign is scheduled to start in the summer. Štefko has developed a new system that he hopes to work on further, which involves one of the two radars moving slowly along a rail from right to left. This simulates the relative motion of the two TanDEM-X satellites. As they move along their orbits, the varying distance between them has a major influence on the radar signals received. The researchers hope their rail-based radar will reveal how significant this effect is.

During the March measurement campaign, they assembled and tested the system on several occasions. But the snow and cold posed some unexpected challenges. "The equipment we're using isn't designed for such harsh conditions. We had to carry out some technical modifications to get it working up here," says Štefko. "We're steadily improving the technology, and our next task is to process and analyse the data to find out which direction our next measurements should take." The ETH researchers are determined to unravel the secrets of the cryosphere that have so far eluded the radar's view – and they will continue to scale these icy peaks until they do so. ○

6
Esther Mas i Sanz checks that the cables are securely connected.

7
Muffled up against the wind and cold, Marcel Štefko carries the horn antennas and their metal frame up the steps.

6

○ ETH app

New design and new features

The official ETH smartphone app has been reworked with a new design and enhanced features. It's the perfect tool to look up the contact details of ETH staff members, find your way around campus or check out the latest ETH news and events. The new version of the ETH app is now available in app stores.

Find out more:
⟶ ethz.ch/new-design-eth-app

○ Public tours

Globi's forest lab

An educational nature trail for children aged 7 to 12

Image: ETH Zurich / Nicolas Zonvi

Globi heads into the woods to search for tracks. What animals live here? What makes up the soft forest floor? And how long do trees live? At Waldlabor Zurich, a forest laboratory near the Hönggerberg campus, children get to explore a remarkable corner of nature. In parallel, accompanying adults can enjoy the public tour of Waldlabor Zurich, which offers a fascinating insight into Switzerland's first forest lab.

2 July 2024, 6.15 – 7.15 p.m.
ETH Zurich, Hönggerberg campus

Browse more public tours and book your place:
⟶ tours.ethz.ch/en

Image: ETH Zurich / Julia Ecker

○ Public tours

The chemistry of happiness

Throughout history, people of all cultures have sought to achieve a sense of happiness or well-being. Often, they have found it in natural stimulants such as tea, coffee and cocoa. These three delicacies have a long and chequered history, at times celebrated and at others forbidden on pain of death. To this day, they are enjoyed in myriad forms around the world – and Switzerland is no exception. But what exactly is the chemistry behind this feeling of well-being? Can it be steered or influenced? Can we even get too much of it? Join us on a self-indulgent tasting tour of chocolate, tea and coffee to find the answers to these and other questions. Together, we will unlock their molecular secrets!

18 June 2024, 6.15 – 7.15 p.m., in German
ETH Zurich, Hönggerberg campus

Find out more and book your place:
⟶ ethz.ch/chemie-des-gluecks

○ Themed tours

Innovation Park in Dübendorf

This new tour takes us to Switzerland Innovation Park Zurich at Dübendorf airfield to explore the ETH hangar. It includes an introduction to four student teams working on the development of electric aircraft, space technologies, a race car and hyper-loop pods. Visitors will also gain insight into research projects run by the Centre for Immersive Wave Experimentation, a group that is pioneering a new approach to seismic wave experimentation with three different experimental set-ups.

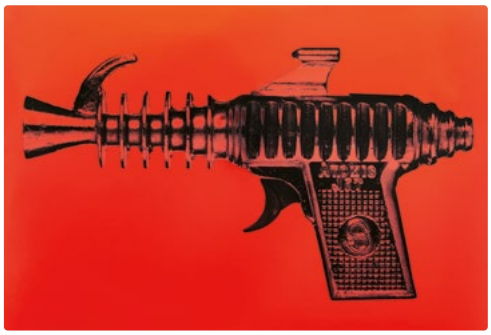
Check available dates and book your place:
—〉 tours.ethz.ch/en

○ Exhibition

Intoxicating objects: fetishism in art

This exhibition explores aspects of fetish-ism in art from the Middle Ages to the Romantic period and through to the present day. Focusing on ostentatious gestures and poses, it also highlights grandiose, exaggerated and bizarre portrayals of everyday objects – all in terms of the artist's quest to find new encodings of gender and new forms of allegory.

Until 7 July 2024
ETH Zurich, Zentrum campus,
Graphische Sammlung



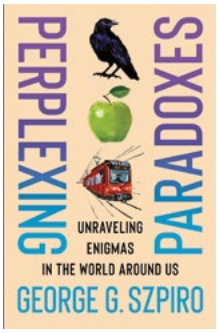
Sylvie Fleury (*1961), **Raygun**, from a series of the same name, 2004, silk screen, 50.0 x 69.8 cm, inv. no. 2011.121.4, Graphische Sammlung ETH Zurich / © Sylvie Fleury

○ Recommended reading

Perplexing Paradoxes

Unraveling enigmas in the world around us

George G. Szpiro guides readers through the puzzling world of paradoxes, presenting sixty counter-intuitive conundrums drawn from diverse areas of thought. Szpiro offers a lively history of each paradox, unpacks its inner workings and explores where it might be encountered in daily life.



Light-hearted, witty and entertaining, *Perplexing Paradoxes* delivers sophisticated material in an accessible manner for anyone intrigued by the world's boundless possibilities – and impossibilities.

Columbia University Press
ISBN: 978-0-231-21376-9

○ Recommended reading

From startup to unicorn

An essential guide to building, scaling and sustaining value for platform and tech startups

This book by Anil Sethi helps fledgling entrepreneurs to spot the factors that can sustain growth at tech start-ups, to make timely decisions and to limit risk. By highlighting examples of both successful and failed start-ups, Sethi offers a rounded view of entrepreneurship.

Springer Verlag, ISBN: 978-3-031-53893-3

Image: Columbia University Press

Image and video: ETH Zurich / Nicole Davidson

From left to right: Linda Wang, Philipp Kronenberg (doctoral student, D-MTEC), Roman Wyss and Kristýna Hrabánková from the start-up URBNC 3, pictured in the Student Project House at ETH Zurich.

Snug sandals from a 3D printer

TEXT Samuel Schlaefli

Just like fingerprints, no two feet are alike. For the founders of the start-up URBNC 3, such a unique challenge calls for a unique solution. Their answer is personalised sandals that not only look cool but are also suitable for people with problem feet or feet of different sizes. The customised footwear is produced on a 3D printer based on data from an app. Customers select a model online and receive an order code. Using this code, they activate their smartphone to take a 3D scan of each foot. On the basis of this virtual model, URBNC 3 then fabricates an individual footbed that is perfectly tailored to the customer's foot. URBNC 3 is also committed to sustainability, using vegan and naturally degradable materials for its sandals. "We have close ties to the sustainable fashion scene in Switzerland and regularly seek input from experts to make our products even better," says co-founder Roman Wyss. ○

STUDENT PROJECT HOUSE This creative thinkspace and makerspace provides ETH students with support in developing and implementing their own project ideas.

⟶ sph.ethz.ch

Video: URBNC3
⟶ youtu.be/630BJcPB3g8

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