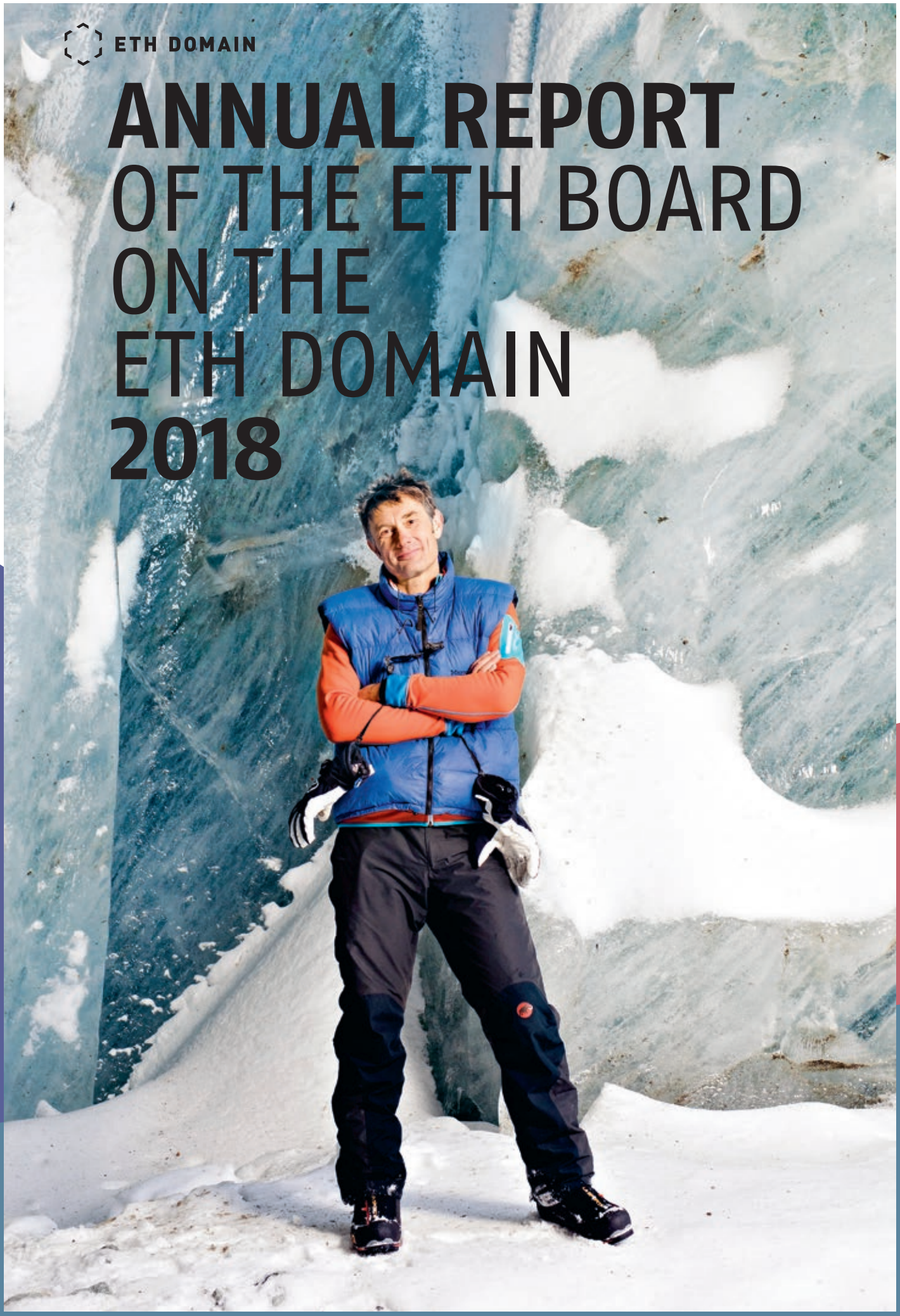
ETH DOMAIN

ANNUAL REPORT OF THE ETH BOARD ON THE ETH DOMAIN 2018



ETH Domain

FACTS & FIGURES

ETH BOARD

The ETH Domain consists of the two Federal Institutes of Technology ETH Zurich and EPFL as well as the four federal research institutes, the Paul Scherrer Institute (PSI), WSL, Empa and Eawag. Appointed by the Federal Council, the ETH Board is the strategic governing and supervisory body of the ETH Domain.
www.ethboard.ch

The Institutions of the ETH Domain

ETH Zurich Page 15

ETH zürich

At ETH Zurich, around 500 professors educate over 21,000 students and doctoral students from over 120 countries. Together they are engaged in research in the fields of natural science, engineering, architecture, mathematics, system-oriented sciences, as well as in management studies and the social sciences. The findings and innovations of the ETH researchers flow into the most forward-looking sectors of Swiss industry, from informatics to micro- and nanotechnology, and high-tech medical equipment.
www.ethz.ch

EPFL Page 19

EPFL

11,100 students and doctoral students from 116 countries and more than 350 laboratories conduct leading research in areas such as renewable energy, medical technology, materials science and information technology. On average, EPFL produces more than one spin-off per month and maintains close economic relations. In 2018, EPFL opened the LEARN Centre, dedicated to educational sciences. It promotes educational innovation to meet the challenges of digital transformation, just as the Center for Digital Trust does.
www.epfl.ch

PSI Page 23

PAUL SCHERRER INSTITUT PSI

The Paul Scherrer Institute (PSI) develops, builds and operates large-scale and complex research facilities which it makes available for use by the national and international research community. All of these large-scale research facilities are unique in Switzerland, and in some cases the PSI is the only place in the world to have them. The institute's own research focuses on the fields of matter and materials, energy and the environment, as well as humanity and health.
www.psi.ch

WSL Page 26

WSL Swiss Federal Institute for Forest, Snow and Landscape Research WSL

The WSL investigates changes to the terrestrial environment, and the use and protection of natural habitats and cultural landscapes. It monitors the condition and progress of forests, landscape, biodiversity, natural hazards and snow and ice, and develops sustainable solutions for socially relevant problems. WSL also includes the WSL Institute for Snow and Avalanche Research SLF Davos.
www.wsl.ch

Empa Page 29

Empa Materials Science and Technology

Empa is the interdisciplinary research institute of the "ETH Domain" for materials science and technology. On the basis of its research, it develops solutions to meet the biggest challenges currently facing industry and society, and therefore plays a significant role in reinforcing the innovative capacity and competitiveness of Swiss industry in an increasingly competitive environment.
www.empa.ch

Eawag Page 32

eawag aquatic research

Eawag is one of the world's leading water research institutes. Its strength and success are based on the combination of research, teaching and continuing education that it has provided for over 80 years, along with consultancy and the transfer of knowledge. The combination of natural sciences, engineering and social sciences enables comprehensive research into water in relatively untouched rivers and lakes, right through to waste water management systems.
www.eawag.ch

Total federal contribution[1]

CHF millions

2,531m

2017: CHF 2,531m

Expenses

CHF millions

3,349m

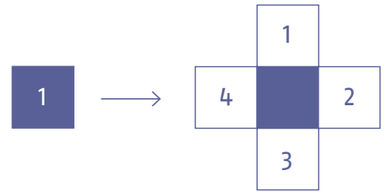
2017: CHF 3,307m

Value-added study[2]

Investments in the ETH Domain | Value-added in Switzerland

Approx. CHF 2.5bn from the state | Approx. CHF 13.3bn cross value-added

1 job in the ETH Domain | creates 4 jobs in Switzerland



Approx. 21,000 employees | Approx. 80,000 jobs in Switzerland

Personnel

Employment contracts

22,349

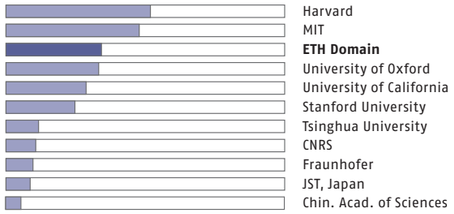
Proportion of women: 34% Apprentices: 462

Students and doctoral students

32,531

Proportion of women: 31%

World-class patents[3]



In comparison with some of the world's most renowned research institutions the ETH Domain has the third-highest share of world-class patents.

Spin-offs from the ETH Domain

55

University rankings

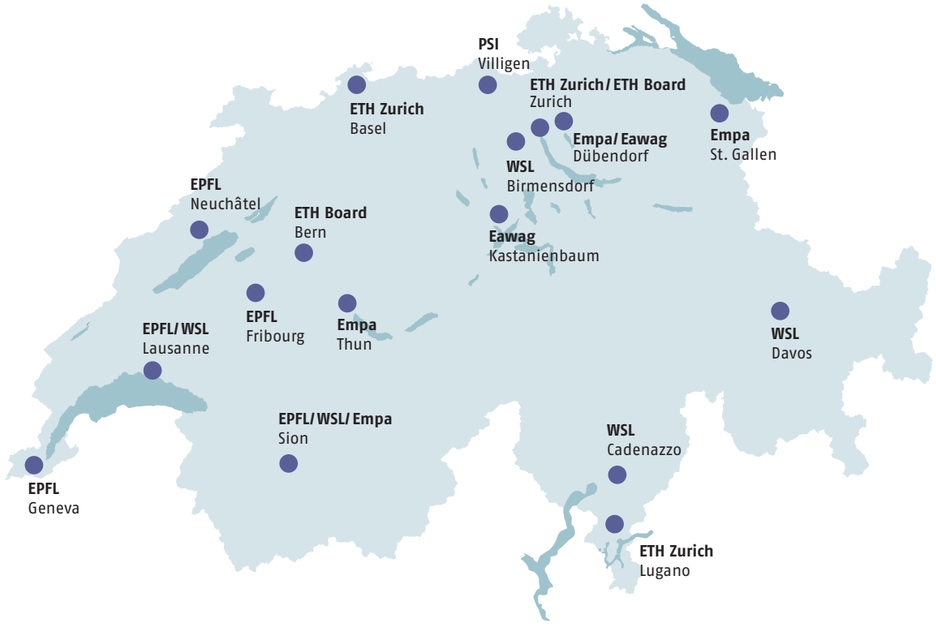
THE World	THE Europe	QS World	QS Europe
Ranking	Ranking	Ranking	Ranking
11	4	7	3
35	9	22	7

ETH Zurich EPFL

[1] Credits taking into account the budgetary framework
[2] BiGGAR Economics, November 2017
[3] BAK Economics AG, 2018

VISION

The ETH Domain strives to strengthen the competitiveness of Switzerland in the long-term and contributes to the development of society through excellence in research, teaching and knowledge and technology transfer. It endeavours to serve as an exemplary beacon by assuming its share of responsibility for the management of urgent social challenges, the enhancement of the quality of life, and the long-term maintenance of our natural resources.



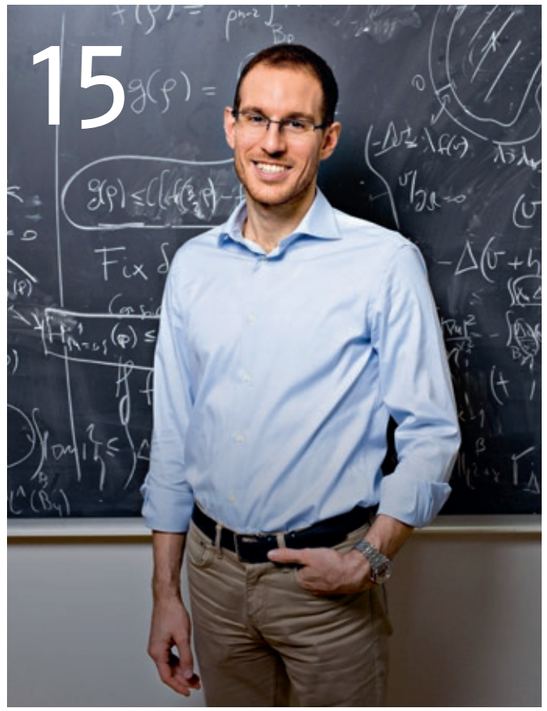
The ETH Domain and its institutions
Higher education, research and innovation of the highest standard: the ETH Domain provides these services with more than 22,000 employees, more than 32,000 students and doctoral students and a pool of around 850 professors.

The ETH Domain consists of the two Swiss Federal Institutes of Technology ETH Zurich and EPFL as well as the four federal research institutes the PSI, WSL, Empa and Eawag. The strategic leadership and supervisory body of the ETH Domain is the ETH Board.
www.ethdomain.ch I www.ethboard.ch

2018 Annual Report of the ETH Board on the ETH Domain

Financial Report:
www.ethboard.ch/financialreport2018

Table of contents



ETH Zurich: 2019 Fields Medal

Profile of Alessio Figalli

He won it. The most prestigious prize in mathematics in the world, the Fields Medal. And this has turned Figalli, a professor in mathematics at ETH Zurich, into a role model. Twice as many young people enrolled to study mathematics in his native city of Rome in Italy in autumn 2018.

21

EPFL: 2018 Latsis Prize

Winner Andrea Ablasser

Andrea Ablasser, assistant professor at EPFL, was awarded the 2018 National Latsis Prize for her ground-breaking research on innate immunity.

Federal Councillor Guy Parmelin with the Presidents and the Directors of the institutions of the ETH Domain.

WEF 2019

Switzerland as a global player

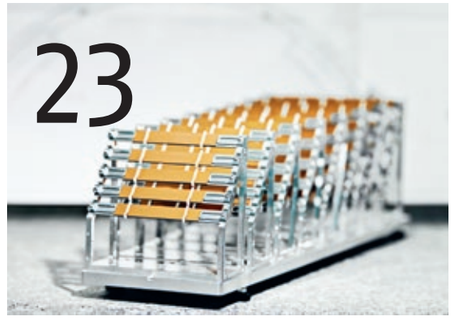
For the third time, ETH Zurich exhibited at the WEF with its own pavilion in Davos. The ETH Board and the institutions of the ETH Domain invited delegates to events on cutting-edge research in Switzerland. The networking events brought together national and international scientists, policy-makers and the business community.

› Markus Mallaun / ETH Board

EPFL

Disappearing glaciers and ecosystems

A team of researchers from EPFL is planning a major expedition to around 200 glaciers around the world to gain a better understanding of microbial life in those disappearing ecosystems.



PSI

Successful expansion of research infrastructure

The ETH Domain maintains numerous research infrastructures such as the research and innovation building NEST or the neutron source SINQ, which is at the disposal of national and international researchers. The latter is currently being refurbished and will then be the source with the best lens in the world.

Empa

Actuators instead of motors

CTsystems, a spin-off company from Empa, has already unveiled the first prototype of electromechanical polymer converters in a stacked configuration: as an actuator, it converts electrical energy into mechanical work with an "integrated" sensor function. Thanks to the collaboration with the Swiss specialist Dätwyler, the degree of industrial production reached a new level.

Eawag

The wastewater goldmine

Millions of people around the world have no access to sanitation that offers a "clean" solution. Therefore, Eawag is researching technical possibilities for treating wastewater and recovering resources from it.

WSL

Mounting extremes

In an interview, WSL experts Andreas Rigling and Manfred Stähli explain what effect dry summers like the one in 2018 will have on nature in Switzerland.

FOREWORD

Dr Fritz Schiesser, President of the ETH Board

Fritz Schiesser has held the office of President of the ETH Board and of the Executive Committee of the ETH Domain since 2008. With a doctorate in law, he is also a solicitor and notary public in the Canton of Glarus. Schiesser was a member of the Swiss Council of States from 1990 to 2007, where he served as President from 2003 to 2004, and he was President of the Foundation Board of the Swiss National Science Foundation (SNSF) from 1999 to 2007.

Dear readers,

ETH Zurich is on a mission to Mars, EPFL is getting paralysed people back on their feet, and Empa is investigating the collapse of the bridge in Genoa. These are just a few of the thousands of media reports from the past year that illustrate the areas of expertise and diversity of the ETH Domain. Year in year out, rankings and studies confirm the high quality of teaching and research, as well as the knowledge and technology transfer of the institutions of the ETH Domain. An analysis of the quality of patents, for example, shows that one third of the patents analysed from the ETH Domain are regarded as world-class. This puts it in third place worldwide and at the very top in Switzerland. These successes are only possible because our country's prevailing conditions are excellent. Policy-makers, the business community and the Swiss public are working together to ensure that the ETH Domain has sound financing and sufficient autonomy, and that Switzerland remains an open country.

Leading-edge research, like top-level football, is international. Both rely equally on home-grown and foreign talent to be among the best. The ETH Domain would not be where it is today without students and staff from abroad and without the opportunity to develop international collaborations. The ETH Domain is proud of the many spin-offs that are founded here every year, generating innovations and jobs. More than half of the founders come from abroad. And two thirds of the professors who train our next generation of academics, promote projects with industry and make new discoveries in medicine, nanotechnology or energy are not Swiss passport-holders. Most of the research is based on international cooperation. Obstructing this has adverse consequences. As a result of the temporary exclusion from Horizon 2020, Swiss research institutions were involved in significantly fewer EU projects, received less funding and had fewer opportunities to coordinate projects.

Decisions on Switzerland's relationship with Europe, freedom of research and debates on the budget will continue in the future. Policy-makers, the business community and the Swiss public are therefore required to defend the good prevailing conditions time and time again. For its part, the ETH Domain will continue to make every effort to use its expertise to the greatest possible benefit of our country and to share responsibility worldwide for tackling urgent social challenges.

Zurich / Bern, February 2019

ETH Domain

AN INTERNATIONAL SUCCESS STORY

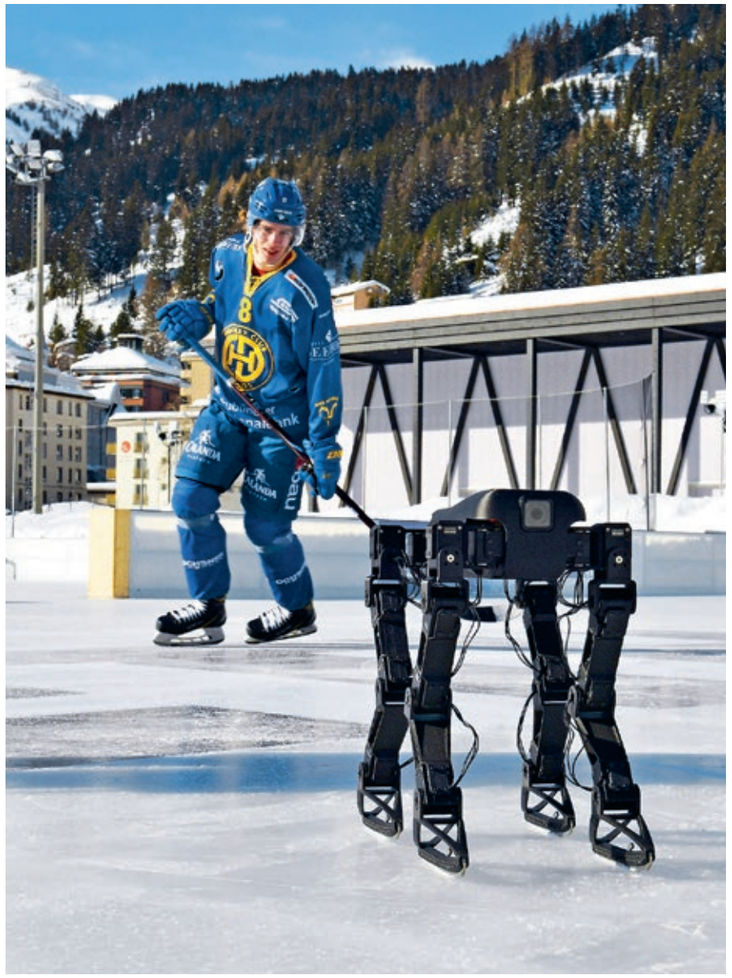
There are close links between academic excellence, international networking and openness. Thanks to the strong cooperation between the institutions of the ETH Domain and partners at home and abroad, they are able to hold their own internationally and attract the world's top talent as outstanding teaching and research institutions. This also has a positive impact on the Swiss economy with its demand for specialists in STEM fields. Maintaining stable international relations – especially with the European Union – is key to ensuring that excellent research and innovation policy conditions are guaranteed in the future as well.

1/3

One third of the ETH Domain patents analysed are among the 10% of the world's most important patents in their respective technologies.

There are many ways and means of measuring the quality of universities and research institutions. The comparison with other academic institutions all over the world is an essential part of this. The ETH Domain performs impressively in this contest. Year on year, the two universities in Zurich and Lausanne occupy top positions in the rankings, which are compiled by different organisations applying different methods and benchmarks (see Fig. 16 and 17, p. 91). ETH Zurich came 11th in the THE World Ranking in 2018 and EPFL 35th. While the THE uses indicators for teaching, research and citations, the QS World Ranking focuses on the reputation of academic institutions and graduates among their employers. ETH Zurich achieved as high as seventh place in 2018, and the EPFL was ranked 22nd.

The excellent performance of the ETH Domain is also confirmed by other benchmarks. The results of the study on "Analysis of the patent portfolio of the ETH Domain" published at the end of 2018 are particularly encouraging. Commissioned by the ETH Board, BAK Economics AG analysed the portfolio of patents within the ETH Domain. Deviating from a purely quantitative method of counting, a Big Data approach was applied and the significance of the individual patents for 17 different technologies was weighted and compared, among other things, against the figures for ten of the world's leading universities and research institutions. The analysis shows that about one third of the ETH Domain patents analysed are among the 10% of the world's most important patents in the respective technologies. Only the two private American universities Harvard and MIT have higher figures. A close look at the distribution of patents reveals that the ETH Domain leads the international comparison in more than one third of the technologies analysed.



The Computational Robotics Lab at ETH Zurich has built the first robot with the ability to skate.
› Andreas Eggenberger/ ETH Zurich

2/3

About two thirds of the publications from the ETH Domain are the product of international cooperation. This type of work has the most important impact.

Great importance of international networking in research

If quality and performance are measured by international comparison, this global element is a key aspect of academic activity and of central importance for top academic results. This is illustrated by the bibliometric analysis commissioned by the ETH Board with a view towards the intermediate evaluation of the ETH Domain in 2019. The study, prepared by the Centre for Science and Technology Studies (CWTS) at Leiden University, analyses the number of articles and reviews written by researchers from the six institutions of the ETH Domain between 2007 and 2016 and quantifies their impact on the basis of the number of citations up to and including 2017. The collaboration between scientists from the ETH Domain and specialist colleagues from research institutions all over the world is crucially important.

The bibliometric analysis shows that about two thirds of all publications were the result of international cooperation. This type of study has the greatest impact, it was therefore cited very frequently. Without exception, all the institutions of the ETH Domain achieve scores in the analysis of their scientific output that are well above the global average in some cases.

The European research framework programmes should also be mentioned in connection with the distinctly international cooperation culture that exists within the ETH Domain. Collaborative Horizon 2020 projects often involve universities, colleges and industrial partners from different countries working together. The institutions of the ETH Domain can not only point to an above-average success rate for the project proposals they have worked on, they also often take the lead in the multinational working groups.

WEF 2019:
EPFL President Martin Vetterli in discussion with moderator Patrizia Laeri, Marianne Janik, Country Manager Microsoft Switzerland and Olivier Bousquet, Head of Google AI Research in Europe (from left to right).
› Andreas Eggenberger / ETH Zurich

The EPFL researchers Jenifer Miehlbradt (left) and Carine Rognon with the fly jacket. A sensorised exoskeleton with artificial intelligence software for intuitive control of drones. The technology is patent pending.
› Markus Mallaun / ETH Board

Worldwide appeal – specialists for Switzerland

The high quality of teaching and research in the ETH Domain enables the institutions to be successful in bidding to attract the "best minds". Scientists often come from abroad to work in Switzerland's outstanding research environment. Two thirds of the professors at ETH Zurich and EPFL are researchers from abroad. At the same time, the international make-up of staff is the result of the excellent standing of the teaching and research institutions compared to other institutions worldwide, and an essential basis for future academic excellence.

It is not only Switzerland as a research centre that benefits directly from the global appeal of the ETH Domain. One year after graduating from ETH Zurich or EPFL, some 60% of foreign students are employed in Switzerland. These STEM specialists are not only highly sought-after, they also make a significant contribution to keeping the innovative potential of the Swiss economy high. Former employees of the ETH Domain remain very active when employed as researchers in Swiss industry. According to the BAK study, 3,800 company patents list at least one researcher who used to work for the ETH Domain and previously filed patents there.

Education policy – securing international openness through agreements

The fact that Switzerland has held the top ranking in the "Global Innovation Index" for many years, thanks in part to its domestic and foreign graduates from the ETH Domain, should not disguise the fact that international competition for research and innovation-friendly framework conditions is tough. A study published this summer by the Swiss Academy of Engineering Sciences (SATW) showed that larger companies in Switzerland are increasingly outsourcing their research and development to countries offering more and more state incentives to do so.

The study commissioned by SERI on "Research and Innovation: Comparing Switzerland With Other Innovation Regions" (Centre for European Economic Research, May 2018) shows that other regions of the world are continually making up ground. The study concludes that Switzerland can only compensate for its structural disadvantages as a small state by opening itself up accordingly.

Maintaining this openness is of the utmost importance to the ETH Board. The success of the ETH Domain is essentially based on strong international cooperation and direct competition with the world's leading research institutions. Stable and reliable relations, especially with the European Union, are vital for this. The report recently published by SERI on Switzerland's participation in the European research framework programmes makes it clear that, as a result of the partial exclusion from Horizon 2020 following the adoption of the mass immigration initiative, our country was involved in significantly fewer projects overall and also saw a drop in project coordination. In order to ensure intensive academic exchange across national borders, it is very much hoped that Switzerland will be able to be involved in the next EU research framework programme as a fully associated country once again.

FASCINATION ETH DOMAIN

ETH Domain

CYBERSECURITY, THE SWISS WAY

There's more to the Internet than just the likes of Google, Facebook and Twitter. There's a whole infrastructure constructed behind it. If Swiss values could be injected into it, perhaps confidence in the Internet might be restored. While all the talk is about cybersecurity, there is still a great deal of uncertainty. That's what experts from the ETH Domain have to say about this issue.

Launched in 2018 by the EPFL, the Center for Digital Trust (C4DT) is a partnership between research, industry, the public sector and wider society to develop and implement a common vision for digital trust.
c4dt.org

Cybersecurity. Or security in the digital realm, which is frequently no longer even called cyberspace because it has long since become part of our everyday lives. And that's precisely where the problem lies too. Some people still haven't developed a sense of this space, especially of its dark corners and pitfalls. The German Chancellor Angela Merkel called it "uncharted territory" a few years ago and was criticised on the Internet for that comment. But she wasn't altogether wrong. Society is taking this "uncharted territory" – and everything that makes it work – too much for granted. It has become clear to every Internet user since the US whistle-blower Edward Snowden made his revelations, if not before, that ambiguities and dangers lurk pretty much everywhere on the Internet. And new stories keep cropping up: it was recently reported that Asian hardware companies had been incorporating discreet back doors into the electronic infrastructure we use every day.

Symbolic image
› Shutterstock

Nothing seems safe any more. You are left with a sense of unease and many questions. Where's the threat actually coming from? What everyday digital activities and, more especially, which careless actions make you vulnerable? Are private Internet surfers even being targeted? Would society collapse in the event of a targeted attack on digital infrastructure? Are there problems residing within the structure of the Internet? Or should we be most afraid of malicious disruptive acts?

The digital world has infrastructure and "engineers" who build it. Switzerland has some of the best engineers in the world and, above all, engineering with a reputation for being highly reliable. Both Federal Institutes of Technology train engineers. Wouldn't Switzerland have a lot to offer in order to build the digital realm to be both elegant and robust? A digital engineering paradigm based on bridges, tunnels and building statics.

"The current Internet has so many problems that you have to redesign and build it from scratch if you want to make it more secure."

– Professor Adrian Perrig, Head of the Network Security Group at ETH Zurich

"Switzerland is precisely the right place to restore confidence in these systems."

– Professor Edouard Bugnion, Vice President for Information Systems at EPFL

The research activities of the Center for Security Studies (CSS) focus on central questions of security policy around the changing threat situation in which nation states and their societies find themselves.
css.ethz.ch

C4DT: Interdisciplinary cybersecurity

Engineers have to know what stresses their system will face. For the safety of a bridge, this means that it has to be stable enough to withstand the ravages of time and the expected volume of traffic. And extreme peak loads, of course. But would it also have to be able to withstand an earthquake? If so, up to what magnitude? Therefore, the question of safety is always a question about the likely danger too.

Professor Edouard Bugnion, Vice President for Information Systems at EPFL and one of the initiators of the recently launched "Center for Digital Trust" (C4DT), believes that computer networks should not have to withstand natural hazards, but rather targeted attacks by perpetrators whose motivation he has no hesitation in calling "perverse". "The enemy is not nature, but private or state attackers." Therefore, the question of the security of a system, its resilience, is very different from the question of building physical structures. And as far as defence against cyber attacks is concerned, Switzerland clearly lacks the means and thus the expertise compared with other countries, such as the major players as well as specialists such as Israel. Nevertheless, Switzerland is precisely the right place to restore confidence in these systems.

In addition to engineering, Bugnion also sees a second great Swiss tradition, one that is just as important in developing identity and trust: reliability. For centuries, Switzerland has specialised in areas which are based on reliability and, thus, on trust between people, be it luxury watches, banks or insurance companies. This is an attribute that can also be put to good use in the digital realm. C4DT, which is an umbrella organisation for the research activities of more than 30 groups, is trying to combine ethical issues and political feasibility, adopting an interdisciplinary approach, for example in relation to encryption technologies. Security is understood here in a broader sense, as a kind of culture to be fostered.

Myriam Dunn Cavelty is in complete agreement with this. "Cybersecurity has long since ceased to be just a technical problem." The researcher at the Center for Security Studies (CSS) at ETH Zurich firmly believes that we will not have secure cyberspace unless there is a socio-political agreement to protect this territory. There are some initiatives to change that, and occasionally they come from surprising quarters. Dunn Cavelty mentions the idea recently proposed by Microsoft President Brad Smith for a new Geneva Convention for digital space. This did not necessarily meet with widespread approval, "because countries do not like to be guided by private enterprise". Nevertheless, she believes that Switzerland and Geneva, in particular, could play a special role in international efforts to stem attacks on digital infrastructure. On the other hand, she considers attempts to establish digital sovereignty in the national context as "humbug". Bugnion feels the same way: "You have to be more European in your thinking." In particular, he bemoans the absence of a European initiative for a different digital culture, focusing strongly on data protection and a secure Internet.

SCION – new Internet architecture

Adrian Perrig thinks global. The professor at ETH Zurich and head of the Network Security Group has perhaps taken on one of the most ground-breaking cybersecurity projects in the ETH Domain; he wants to rebuild the entire Internet. The network specialist realised at some point that "the current Internet has so many problems that you have to redesign and build it from scratch if you want to make it more secure." Perrig and his group have invested a good ten years of research into this topic. Specifically, the aim has been to find out how much security can be achieved at all. Not as a theoretical ideal, but in everyday computing practice. "Achieving absolute security for the use of computers is very difficult," Perrig cautions. However, in the case of networks, he is very optimistic after many years of testing. The new Internet architecture is not only more secure, but also more efficient.

Another important contribution is the work done in the research groups led by Professors David Basin and Peter Müller at ETH Zurich. They are working on mathematical proof that the Internet protocols and the code are actually secure. "Due to the complexity of today's Internet, this so-called formal verification is extremely difficult," says Basin, adding, "but it is the structure of our new network architecture that makes verification possible in the first place. Professor Müller's group is working on the verification of the source code. He observes that "in recent years, we have done intensive research to improve our methods in order to provide evidence." Thanks to a breakthrough, it was possible to use the methods of evidence developed by the Basin and Müller groups so that the entire system, from protocol to code, is verifiably secure.

This new network is called SCION (Scalability, Control, and Isolation on Next-Generation Networks), and Perrig promises that users will not notice any difference between it and the "old" Internet; and if they do, they'll find surfing more enjoyable. One of the ways in which the SCION team achieves this is by specifically influencing the paths of the data packets and using several different paths for a single transmission, for example one with a short delay for the audio signal and one with more bandwidth for the video signal. There is no need to completely rebuild everything for this. "Imagine if you could choose to go along a road either on a bicycle or in an electric car." While this may still be a vision for the future, it is not too far off; intensive negotiations are under way with Internet providers. So, does this mean that you will soon have several options for how you want to surf, as you do with electricity providers? At low cost and insecure or in the fast lane, with network architecture from the 21st century? That doesn't sound all that far-fetched; it's actually perfectly reasonable from an engineering perspective.

The "enemy" in my laptop

But what if the problem is in your own computer? Professor Gabriel Aeppli, member of the directorate and Head of the Photon Research Division at the Paul Scherrer Institute (PSI) can well imagine that the hardware has already been manipulated. While the software that keeps the western digital world turning was probably written in America or Europe, the hardware in most computers is produced in Asia. If it were possible to corrupt the computer components during manufacture, then normal defence strategies or new network architectures wouldn't be much use. Therefore, Aeppli believes that it will soon be standard practice to conduct spot checks on hardware deliveries down to individual circuit level.

So far, this has only been possible with great effort, which makes reasonable monitoring impossible, which opens the door to suspicious activities, of course. This is precisely where new X-ray technology co-developed by Aeppli could help. It can X-ray entire chips within a matter of minutes without destroying them. The 3D method perfected at the PSI has caused quite a stir in technology circles, as it allows the routing of the internal, nanometer size components to be shown in detail and without any distortion for the very first time. The deliverables can then be compared with the goods ordered. It is good for trust, and monitoring will be better in the future.

It begs a key question at the psychological level. Who can you even trust? The story about the corrupted hardware did nothing to improve trust, not least of all since the companies affected denied everything and sought injunctions against the reporters. Then again, this reaction is hardly surprising when you consider how damaging this sort of loss of trust would be to business. Dunn Cavelty's view is that "trust is crucial, not least of all for the economy."

"As if things aren't complex enough at software level, I can well imagine that the hardware has already been manipulated."

– Professor Gabriel Aeppli, member of the Directorate and Head of the Photon Research Division at the PSI

"Mathematics is everywhere. A discipline for modelling the world."

– Alessio Figalli,
professor of mathematics

Alessio Figalli won the most important mathematics prize in the world, the Fields Medal, in 2018. This put him in the spotlight and made him a role model, especially for the next generation: matriculation figures for mathematics in his native Italy surged.

Alessio Figalli hurries into his office in the main building of ETH Zurich and apologises in a heartfelt Italian way for being two minutes late. His shirt freshly ironed; on his desk a few piles of papers, which he quickly straightens up. The autumn sun shines in, he pulls the blinds and apologises for the mess, which is hardly worth mentioning – ticking the boxes for "light-shy" and "likes things to be tidy". Otherwise, however, Figalli does not strike you as being eccentric. He comes across as the sort of sociable young man you would trust with your financial affairs. In fact, he couldn't be any less like the stereotype of a mathematician. And that stereotype actually gets on Figalli's nerves. "Why do we believe that mathematicians always have to be a little unworldly or quirky?" Most of them don't fit that image. He first decided to go to a grammar school specialising in humanities, including Greek and Latin, before being drawn to the legendary Scuola Normale Superiore in Pisa via the Mathematics Olympiad.

Figalli has been working on the Monge-Ampère equation for over ten years. He is now using them to characterise the path of individual drops of water in a cloud, for example, and thus to improve the mathematical models for weather forecasting.

The office still fits the cliché, however with the stereotypical board, scribbled all over with formulas and diagrams. Yes, sometimes he likes to get stuck into his work on there. It can be rather liberating to wipe the board clean and rearrange your thoughts. Figalli says, however, that he simply works best with a pen and paper – and whenever possible, the computer stays switched off. He sometimes wonders whether the rhythm of today's society is healthy and whether we should not take it down a few gears. Mathematics, he says, moves along at a rather slow pace. Every single line of thought has to be carefully examined and proven. That takes time.

The Fields Medal put Figalli in the spotlight – and made him a role model, especially for the next generation. Twice as many young people enrolled to study mathematics in his native Rome in autumn 2018.

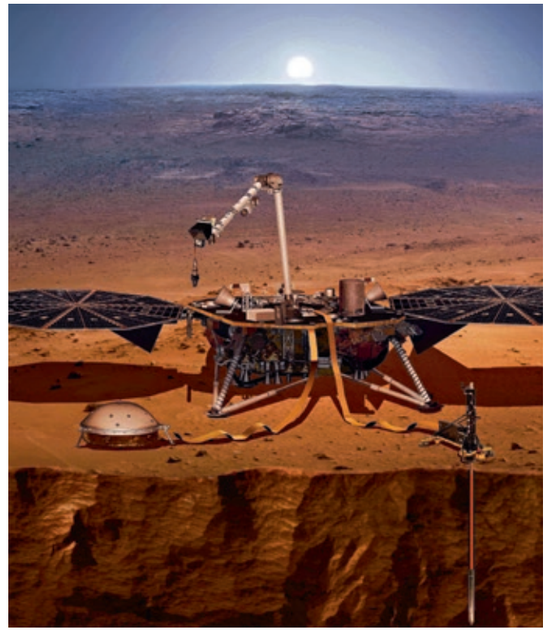
And what if the computer did some of the work in the background? Figalli's brow becomes furrowed. He is "anxious" at the prospect that artificial intelligence might soon learn to draw and link logical conclusions. While there is not much to be said against automated systems acquiring this skill in theory, he cannot (or does not want to) imagine that they could also achieve the creative ability to do so. And he refers to chess; all the fun has gone by the wayside since the best computers can now beat any human player without any bother.

He chose mathematics because of its logic and order, because it was "clean" and not a matter of faith. However, he chose this field of research precisely because of the "fun" that rich mathematical problems offer. He was awarded the Fields Medal because he was able to demonstrate how questions about the optimum distribution of resources intertwine with the geometry of space. The findings can be applied in economics, probability theory or fluid mechanics. So, is he contributing towards the unstoppable drive to increase efficiency, with the ever-more, ever-faster culture? No, he doesn't like to see it that way, because efficiency can also enable us to save time to do other things. In essence, however, it is good to know that our discoveries can also be beneficial. "The closer you get to the application, the better." But he wouldn't let the application steer him in his work. The mathematics would ultimately have to stand on its own merits. Figalli mentions the Fourier transform. Without that, it is inconceivable that today's electronics would function, although Fourier could not have foreseen that.

He regards communication among researchers, be they physicists or biologists, as a fundamental stumbling block in linking basic mathematical research to scientific applications: "We just don't understand one another." Mediators who are familiar with both fields can help, but the approaches will always remain essentially different. "There's still no sound theory for the phenomenon of how planes fly; it's a very difficult field mathematically." And it sums up the difference between mathematics and physics neatly. Of course, the absence of any rock-solid evidence does not stop the engineer from building aircraft. Nor does it stop us from boarding them.

View of the InSight lander: electronics from ETH are well protected inside the lander.
› Courtesy NASA/JPL-Caltech

ETH electronics on a mission to Mars



At the start of May 2018, a rocket carrying NASA's InSight lander took off for Mars from California. Inside the lander was an electronic control and data acquisition system developed at ETH Zurich, which is used in the seismometer of the lander. Scientists hope to use it to record seismic activities and meteorite impacts on Mars in order to investigate the inner structure of the Red Planet. From spring 2019, earth scientists at ETH Zurich will routinely receive seismic data from Mars to evaluate and interpret. The researchers also hope that the InSight mission will provide them with a new understanding of the origin and development of other planets in our solar system.

Research on a banknote

The Swiss National Bank (SNB) unveiled the new 200 franc banknote at the end of August 2018. It shows a particle collision and the history of the universe. Günther Dissertori, Professor at the Institute for Particle Physics and Astrophysics at ETH Zurich, acted as consultant. The project ran for several years and was strictly confidential. Dissertori advised the SNB graphics team on how to illustrate a particle collision, a particle detector and the most important moments in the history of the universe. The fact that fundamental research is featured prominently on a banknote illustrates its importance in Switzerland.

Stack of 200 franc banknotes: there is a particle collision illustrated on the back, among other things.
› Swiss National Bank 2017

An outstanding life's work

The European Patent Office has been awarding the European Inventor Award since 2006 in recognition of the achievements of people whose ideas and creativity have made a significant contribution to the development of innovative products. In 2018, Ursula Keller, ETH Professor of Ultrafast Laser Physics, was among the winners. She was recognised by the jury in the Lifetime Achievement category for her developments in the field of ultrafast lasers. The lasers developed by Keller are widely used in industry today. At the same time, they also enabled important breakthroughs in basic research. For example, Keller was able to demonstrate quantum physical phenomena with high precision with her laser-operated attoclock.

Ursula Keller has received the European Inventor Award in the Lifetime Achievement category.
› European Patent Office

Golden Lion for the Swiss Pavilion

At the invitation of the Pro Helvetia Cultural Foundation, four young architects from ETH designed the Swiss Pavilion at the 16th Architecture Biennale in Venice. The project was impressive: "Svizzera 240: House Tour" was awarded the Golden Lion. This is the first time that this highest award in the National Contributions category has gone to Switzerland. The team, consisting of Alessandro Bosshard, Li Tavor, Matthew van der Ploeg and Ani Vihervaara, created the idea of a tour which takes visitors through unfurnished rooms that are reminiscent of a conventional apartment, but at the same time confronts them with oversized kitchens and warped doors. The aim is to focus their awareness on the architectural shell that surrounds us day in, day out.

The winners of the Golden Lion – Alessandro Bosshard, Li Tavor, Matthew van der Ploeg and Ani Vihervaara (left to right) – in the oversized kitchen of the Swiss Pavilion. › Christian Beutler / KEYSTONE

School for Continuing Education

Technological change has a major impact on the skills required in business and society. The half-life of knowledge is decreasing, and there is a need for lifelong learning. Against this background, ETH Zurich founded the "School for Continuing Education" and grouped the existing continuing education programmes into four areas: "Environment, Infrastructure & Architecture", "Technology, Management & Innovation", "Public Policy & Governance" and "Health, Life & Natural Science". All told, the courses on offer comprise 17 MAS (Master of Advanced Studies), 9 DAS (Diploma of Advanced Studies) and 20 CAS (Certificates of Advanced Studies) courses, as well as around 20 other programmes.

Botnar finances research for children

The University of Basel and ETH Zurich founded the Botnar Research Centre for Child Health (BRCCH) in Basel on 19 September 2018. They bring together outstanding science and clinical research from different disciplines to develop new methods and digital innovations for worldwide use in paediatrics. The focus is on countries with limited resources. However, the solutions developed should be applicable everywhere. This approach enables sustainable research and development with a direct benefit for the health of children and adolescents. The BRCCH is financed by the Basel Botnar Foundation through a contribution of 100 million Swiss francs over ten years.

Peter Lenz, Chairman of the Board of Trustees of the Botnar Foundation, Andrea Schenker-Wicki, Rector of the University of Basel and the then ETH Zurich President Lino Guzzella (left to right). › Peter Hauck

Compete against the best: ETH Zurich is using its most well-known alumnus to promote its range of continuing education courses. › ETH Zurich

"This research is of global importance and fits in perfectly with the new Centre for Alpine and Polar Environmental Change at EPFL Valais."

– Martin Vetterli, President of EPFL

Why is a natural scientist interested in glaciers? Because it is teeming with life up there. And the absence of research into this life is astonishing. It can perhaps tell us a great deal about times when the whole earth was iced and glaciated. A team from EPFL is planning a major expedition to around 200 glaciers around the world to bridge this research gap.

"We owe it to future generations to gain a better understanding of microbial life in these disappearing ecosystems."
– Professor Tom Battin, research director of the NOMIS project (photo)

It's cold up here at 2,300 meters, but fortunately the sun is shining. The first snow of this year is already lying on the Corbassière glacier in mid-November. While the team is setting up at the stream just below the glacier snout, unpacking the experiment kit they have brought with them from their cases, Tom Battin and Hannes Peter are beside themselves with excitement; they take stones from the stream and pass them around. What can there possibly be to see at these inhospitable, very wintry altitudes? A great deal as it happens, and you don't have to be an expert to soon realise that. Some of the stones are covered with a greenish coating of slime, and in some places in the stream it grows like Gandalf's beard. And what is the temperature of the water? 0.01 degrees. Is there any other life around? There's not much to see: a few lichens on the stones, a few hardy plants in sheltered spots on the slopes. The stream may hardly flush many nutrients out of the glacier bed, but it's enough for these microorganisms. Hannes Peter specialises in river ecosystems, and he knows that this is the best time for biofilms. Not too much current, but there is plenty of light. The conditions couldn't be any better.

What are biofilms? This has nothing to do with wildlife documentaries, they are communities of microorganisms. Most people are aware of them from medicine, where biofilms are often problematic because they prove to be very resistant. It is estimated that some 80 percent of chronic infections are caused by biofilms. They are also resistant up here, on the glacier, where they have found a perfect niche. "Biofilms have been around for three and a half billion years and are a very original and successful form of life on Earth," explains Tom Battin, professor at EPFL and head of the Stream Biofilm and Ecosystem Research Laboratory.

Perhaps they were the beginning of life as we know it: more complex life forms with organs that share tasks. Microorganisms became "sedentary" at some point. They began to form a slimy substrate, into which other species subsequently also settled. Higher life must have started as a microbial commune. The communities soon became megacities, with thousands of taxa, which survived, for example, in metabolic processes and in defence against enemies. Battin calls it "sociomicrobiology".

The biofilms up here are the basis of stream ecosystems and, to a certain extent, the start of the food chain. "The microorganisms orchestrate essential biochemical processes in streams and rivers, and they are the least researched." Especially up here where the water emerges. "We know more nowadays about microbial life in the depths of the ocean than we do about the water in the streams that drain the roof of our planet," says Battin.

He wants to change that. This is why he has recruited Michael Styllas, who normally leads expeditions into the high mountains and who is now using a shovel to fetch sediment from the stream. In the next few years, a team led by Styllas will travel the globe, investigating around 200 glacial streams in various geographical environments.

Battin believes that there are remains of ancient ecosystems up here in the snow and ice. It is possible that they have hardly changed. Battin and Peter are hoping to find a core microbiome, the lowest common denominator of biofilm life. "We want to know what genetic repertoire these communities need. That way, we can understand how they manage to survive under these conditions." And that is all the more important as these conditions are changing rapidly at the moment. How are stable communities formed in an environment that is extremely unstable, especially now? To understand this, we need to take a look into the past, and at the same time, one into the future. How are these biofilms adapting to climate change?

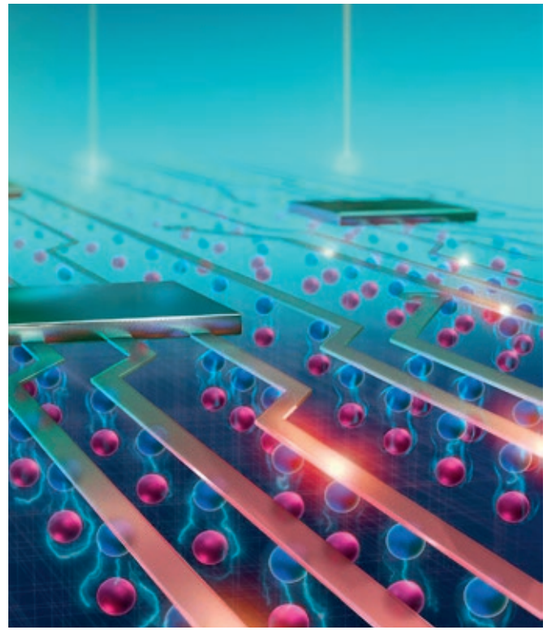
On the Corbassière glacier, it's a matter of learning what to do and testing the materials. Who to position where along the stream and how to coordinate the experiments? Everything runs according to a precise plan and has to function reliably, whether the sun is shining, or whether it is cloudy and windy. Some experiments are carried out in situ at the stream, while more complex analyses follow later in the laboratory. The precise sequencing takes place there, because the researchers are particularly interested in the metagenomics and metatranscriptomics of the microbes in the biofilms.

The project is funded by the NOMIS Foundation and is the first research programme for the Alpine and Polar Environment Research Center (Alpole) of the EPFL Valais Wallis Campus in Sion.

An excitonic shift.
› LANES/EPFL

The electronics of the future

The exciton could revolutionise electronics. A team of EPFL researchers has developed a transistor, one of the most important components of electronic circuits, based on excitons instead of electrons. And above all, they have been able to demonstrate how excitons perform at room temperature, something which was not possible previously, and so solve the main problem associated with those devices. This success is particularly due to the choice of two 2D materials as semiconductors. This discovery could lead to more economical, faster and more compact devices and pave the way for a variety of new possibilities in the exciton field, a sector that is proving to be highly promising alongside photonics and spintronics.



Opening of a Center for Educational Sciences

EPFL has developed a unique ecosystem of services, research laboratories and business enterprise in the field of education. The LEARN Center, run by Francesco Mondada, professor at the Robotic Systems Laboratory and inventor of the Thymio robot, brings together all those involved in educational research and the development of new training tools. "To keep pace with the major advances in digital technologies, we need to adapt both the learning content and the learning methodology," explains Pierre Vandergheynst, Vice President for Education at EPFL. The center is seeking to promote innovation in education and to respond to the challenges of the digital transformation.

Winner of the 2018 Latsis Prize, Andrea Ablasser

Immunologist and EPFL professor Andrea Ablasser is investigating how cells defend themselves against attacks by viruses and bacteria. She was awarded the 2018 National Latsis Prize for her ground-breaking research on innate immunity. In contrast to acquired immunity, which produces antibodies against certain pathogens in a targeted but gradual manner, innate immunity reacts immediately and triggers a defence reaction. Ablasser conducts research into how this innate immune response is regulated and has come across a promising therapeutic approach to gaining a better understanding of autoimmune diseases.

The Thymio robot allows children to try their hand at programming and to discover the fundamentals of robotics.
› EPFL

Revolutionary neurotechnology for the treatment of spinal paralysis

The STIMO study, led by EPFL and CHUV (Centre hospitalier universitaire vaudois), creates a new therapeutic framework to improve rehabilitation after spinal cord injury. Three patients with chronic spinal paralysis were able to stand and walk much better thanks to precise electrical stimulation of the spinal cord by a wireless implant. The scientists Grégoire Courtine (EPFL/CHUV) and Jocelyne Bloch (CHUV) have demonstrated that after a few months of training, patients were able to control their paralysed leg muscles without electrical stimulation. Thanks to a new rehabilitation programme that combines targeted epidural electrostimulation of the spinal cord and a body weight support system, they can now walk short distances with the help of walking aids.

Bloch and Courtine (standing, middle and right) with patients.
› Laurianne Aeby / EPFL

EPFL students on the Hyperloop podium

The EPFLoop team finished third in the Hyperloop Pod Competition final in Hawthorne, California last July. A success for the students who were taking part in the competition for the first time and who were one of only two teams that had not taken part in any of the previous editions. The EPFLoop team that qualified for the final reached a pod speed of 85 km/h in the 1.5 km long tube. Communication problems prevented the EPFL pod from reaching its top speed. Nevertheless, the team managed to secure a strong third place in the presence of Elon Musk, the founder of SpaceX, who launched the competition.

Official opening of the Center for Artificial Muscles in Neuchâtel

Collaborating with the University Hospital of Bern and later with the University Hospital of Zurich, EPFL has stepped into the interface between technology and medicine. The first project aims to develop a less invasive cardiac support system to help where only a donor organ or a complex support system can save patients. The prosthesis developed at EPFL, a ring around the aorta, does not come into contact with the blood and, in particular, prevents bleeding and thrombosis problems. The second project, the reconstruction of facial muscles, is intended to restore facial expressions. This is to be followed by the development of an artificial sphincter using the same technology as for the heart.

The movements of the ring around the aorta are reinforced by a high-precision titanium spring.
› EPFL

PSI

SHARP VISION WITH NEUTRONS

"Once everything has been refurbished, we'll have the source with the best lens in the world."

– Professor Christian Rüegg, member of the Directorate and Head of the Neutrons and Muons Division

pictured with his team Christian Kägi, Mechanics, Roman Bürge, Electronics, and Dieter Graf, Design, left to right

The PSI has one of the best neutron sources in the world, which is currently being upgraded to the latest standards. Christian Rüegg, Head of Neutrons and Myons Research, explains on site what is so special about the neutron process.

We all know about X-rays or photon beams. Researchers at the PSI also experiment with X-rays. However, Christian Rüegg, Head of the Neutrons and Myons Research Department, is responsible for another fluoroscopy method that works with neutrons. SINQ – the Swiss Spallation Neutron Source – which turned 20 in 2017, delivers these neutrons for this. Typical neutron sources are research reactors because free neutrons are also produced during nuclear fission. Obtaining neutrons with the help of a particle accelerator, such as at the PSI, is more complex. SINQ was the first facility to use spallation to produce a continuous neutron flow and is still the most powerful of its kind.

The investigation of samples with neutrons is not in itself different to using X-rays: you can also "illuminate" objects with a neutron source in order to look inside. Or you can measure how the neutrons change direction as they penetrate a sample. This, in turn, allows conclusions to be drawn about the finest regular structures down to individual atom level. "The art to this is in producing the neutrons in a very controlled way, decelerating them to the required energy and focusing them," explains Rüegg. This is because neutron technology has to manage on fewer particles than X-ray technology. "We shouldn't be too choosy when it comes to selecting them; otherwise, we will end up with too few particles and will not have the necessary intensity. The information gained is therefore unique and particularly valuable". A state-of-the-art lens and sensitive and efficient detectors are therefore needed to capture as many generated and scattered particles as possible.

Many systems are built in-house. The PSI is a powerhouse in this regard, boasting not only the best scientists, but also outstanding technicians.

Neutron lenses – neutron guides that transport the particles from the source to the instruments – and several instruments are currently being upgraded at SINQ. A new instrument, the CAMEA (Continuous Angle Multiple Energy Analysis) neutron spectrometer, which the PSI built together with EPFL, is already finished and designed for optimum yield. The detection is described as "super efficient". Rüegg is enthusiastic about it. "Once everything has been modified, we'll have the source with the best lens, and our instruments such as the CAMEA will be among the most innovative in the world." With this in mind, use is being made of the expertise of the PSI spin-off SwissNeutronics, which is making neutron optics future-safe with special focusing units and mirrors optimised for neutron beams. Some of these mirrors have up to 10,000 metal coatings. Innovative and much more accurate measurements will be possible from 2020. Rüegg says that not only the scientific expertise but more especially the technical know-how available at the PSI is crucial for this. The research institute is considered a powerhouse in this respect, with the best scientists and outstanding technicians. Many systems are built in-house in order to guarantee that the high technical requirements are met, and that the most innovative ideas for new instruments are implemented.

Researchers from the ETH Domain, Swiss universities and industry worldwide have unique opportunities to conduct experiments at PSI's large-scale research facilities. Neutron scattering is often used to complement X-ray diffraction, for example to determine the position of hydrogen or lithium atoms, which are difficult to see in X-rays. This creates opportunities for a whole range of specific analytical applications, from basic research in physics and chemistry to applications in material and energy research or in medicine.

The technology is highly efficient, for example, in battery research and in the in-situ observation of chemical processes. What makes neutrons even more interesting is their magnetic moment. Neutron scattering is, therefore, an important method for the investigation of magnetic structures and phenomena. It is possible to visualise layer structures in electronic modules and virtually to watch them during switching.

The rather weak interaction between neutrons and the sample being analysed is both a blessing and a curse. It makes it impossible to build detectors with an even finer resolution at present. But little interaction also means a great depth of penetration and non-destructive analysis, and they are invaluable advantages, for example, when examining large industrial metal parts or pieces of art.

Chemical analyst Martin Béhé takes the radioactive nuclide Lutetium-177 from a lead container to couple it with a target molecule.
› Markus Fischer/PSI

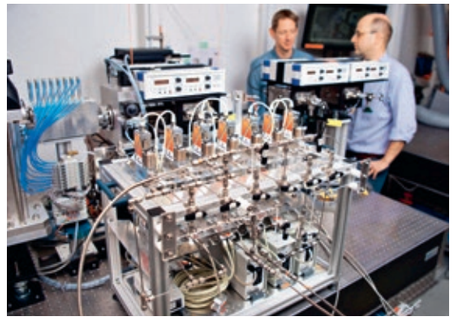
New cancer drug

A radioactive agent developed at the PSI against a particularly malignant form of thyroid cancer has the potential to become a blockbuster drug. Its structure means that it may be able to dock onto cells of other tumours and destroy them with its radiation – provided they carry the appropriate receptors on their surface. One such tumour is small cell lung carcinoma. As there is no really effective treatment for either type of cancer, a biopharmaceutical company from Lausanne, Debiopharm, intends to develop the PSI substance further as a drug until it becomes licensed. Debiopharm and the PSI established the contractual basis for this in October 2018.

Clean diesel fumes

Harmful nitrogen oxides (NOx) are produced when diesel engines burn fuel. Therefore, the automotive industry has developed a process that reduces emissions: gaseous ammonia is added to the exhaust fumes and converts the nitrogen oxides into harmless nitrogen and water with the aid of a catalyst. However, this process does not work perfectly at low temperatures. Scientists at the PSI have now demonstrated for the first time what can be done to help the engine at molecular level. The exact amount of ammonia added must be varied depending on the temperature. Manufacturers can use this knowledge to improve the efficiency of their catalytic converters for diesel vehicles.

The right gas mixture combats diesel nitrogen oxides.
› Markus Fischer/PSI



New power transistors

An innovative power transistor made of gallium nitride is expected to offer the electronics industry considerable advantages over the high-frequency transistors that are currently in use. However, many of the basic properties of the material are still unknown. Researchers at the PSI, together with colleagues from Russia and Romania, have now watched the electrons in one such transistor flow for the first time. They used one of the world's best sources of soft X-ray light at the PSI's Swiss Light Source (SLS). They discovered that if the gallium nitride transistor is examined in high-voltage mode, the electrons move more efficiently in certain directions. This finding will enable faster and more powerful transistors to be developed, which is a prerequisite for upgrading our communications networks to the upcoming 5G standard.

WSL

MOUNTING EXTREMES

Andreas Rigling (left), WSL member of the directorate and professor in the Department of Environmental System Sciences at ETH Zurich, heads the Forest Dynamics research unit.

Manfred Stähli, Head of the Mountain Hydrology and Mass Movements research unit, also studies the impact of climate change on water resources.

What effect will dry summers like the one in 2018 have on nature in Switzerland? Experts at the WSL focus on the water balance and on the forest as a resource and place for recreation. It looks as if there could well be major changes, but not at all levels. Manfred Stähli (S) and Andreas Rigling (R) in conversation with Roland Fischer.

Mr Stähli, Mr Rigling, summer 2018. How did you find it from a technical point of view?
S – For a start, we should mention the winter, which was very snowy. That actually created the perfect conditions as there was a lot of water in the ground.
R – But then April came along, which was decisive for the vegetation. The weather was constantly dry from then on. In terms of summer heat, 2018 is actually comparable to 2003, which was previously used as a yardstick for everything.
S – That's true; it matched the summer heat of 2003, which had been unparalleled up until then. But this summer had some elements that were even more extreme than then. For example, the runoff in watercourses in 2018 was lower in many places than it had been in 2003. There had also been a sharp decline in groundwater, for example in the Thur area.

And fifteen years later, we have had another extreme. Is it fair to say that the extremes are mounting up?
S – Yes, things are heading that way. We have now had four very dry years within a short time.

What impact has this had on woodland?
R – I have been studying the damage caused by drought on woodland for over 20 years. We keep observing what are known as mortality peaks. But these don't necessarily come directly after extreme years. We have found that they occur more often when several dry years follow each other. The forest can cope with one dry year, but when the next one is dry again, it can become critical.

Why is that?
R – The trees take emergency steps in those sorts of dry seasons. They close their stomata to protect themselves from excessive transpiration and reduce their entire metabolism. It's a good strategy, but not for too long: a tree produces much less sugar in years like that. This can be seen in the narrow annual rings, for example. It lives off the reserves, but eventually they become depleted.
S – It is similar for the water balance as a whole to some extent. There are also so-called memory effects. The groundwater table has not recovered completely yet, for example, and this will take some time. However, this is not a problem in the medium term, as the groundwater is replenished again and again over several years.

How do you envisage that? Is there a big lake below Switzerland?
S – No, the underground topology is complex. The groundwater is not evenly distributed everywhere, it depends largely on the geology. This means that localised shortages can occur.
R – Groundwater is not crucial for woodland. It is more a matter of the ratio of precipitation, sunlight and water storage in the topsoil.

What do we know about it, are there any trends?
S – Yes, water availability is changing. There are likely to be wetter winters and drier summers. We also expect to see more heavy rainfall.
R – The history of the founding of WSL has a lot to do with extreme events such as floods. And that's what is increasingly engaging us on many different levels.
S – It has become a common issue.

How dramatic is this going to be for woodland?
R – That depends on your perspective. While woods will not disappear, we will see a shift in species to a greater or lesser extent. Oaks, for example, cope much better with drought, but spruce and beech may find it difficult to hold their own on the Central Plateau. While oak forests can also be used for recreation, the timber sector is also facing a major shift.

And what are the prospects on the water balance side?
S – The NRP 61 on sustainable water use, which was recently completed, came to the following conclusion: there will be more shortages locally, but overall we will have enough precipitation, even for the extreme climate scenarios.

So, this won't be a problem for agriculture?
S – It will certainly be a challenge. Farmers will have to water more, that is foreseeable, and possibly adapt their crops.
R – Yes, there is also a crucial difference in this adaptation. The agricultural sector adapts quickly and can change from one year to the next. However, woodland operates over much longer periods of time, from decades to centuries. And the timber industry is geared towards the spruce and will be forced to rethink. The early leaf fall from beech trees and massive infestation by bark beetles in some areas in 2018 was probably an eye-opener, even for the foresters.

What role does the WSL play, and what response is needed to such extreme years with specific research projects?
S – Together with MeteoSwiss, we have developed a hydrological 30-day forecast for Switzerland. Preventative measures can be taken with a monthly outlook, even if they are only forecasts.
R – These years always present us with a unique opportunity. We learn a lot about the processes on the basis of climatic extreme years. We have stepped up our monitoring and selected 1000 trees throughout Switzerland. We can now see how affected trees will "digest" the extreme event of 2018. We investigate the fundamental relationships between the reactivity and adaptability of our trees in order to answer pressing practical questions. Do trees that lose their leaves early have to be felled or can they recover? There is simply a lack of empirical information because those sorts of summers have been so rare so far. We can provide support in this respect.

Fifty years on the trail of water

Metal baskets trap stones, boulders and pieces of timber which are carried by the Erlenbach during floods.
› WSL

Small streams in the foothills of the Alps can turn into thundering torrents when it rains heavily, leading to flooding. For this reason, WSL has been studying the catchment areas of these sorts of streams in the Alptal valley (Canton Schwyz) for fifty years. Many years spent measuring the debris – i.e. stones, boulders and timber pieces that the torrent carries down into the valley – have improved models for estimating possible floods, which is important for accurate hazard maps. To mark the 50th anniversary, WSL not only organised a scientific workshop, it also upgraded the runoff and climate stations in the Alptal valley and made the long-term data series available in the WSL data portal EnviDat.

The search for healthy ash trees

Almost all ash trees in Switzerland are affected by ash dieback, a dangerous fungal disease introduced from Asia. It is causing the deaths of more and more trees. As ash is an ecologically and economically important species of tree, WSL is looking for ways to conserve it in a project financed by the Federal Office for the Environment (FOEN). And there are reasons to be hopeful: some trees seem to be healthy or tolerant. The Forestry Service reported 397 specimens to WSL, which are now being closely studied. This not only includes how healthy they are, but also other important environmental parameters such as exposure and the woodland community. A sufficiently large selection of promising ash trees are to be preserved for future research and possible population recovery in the long term.

Three women with an ERC grant

In spring 2018, one of the prestigious ERC grants was awarded to a third woman from WSL, Catherine Graham. Following on from Anna Hersperger (SNSF Consolidator Grant, 2015) and Francesca Pellicciotti (ERC Consolidator Grant, 2017), the EU is now supporting the research of the renowned ecologist with EUR 2.5 million in the form of an ERC Advanced Grant. Graham is exploring one of the central puzzles of ecology – why biodiversity and the nature of plant-animal interactions change over time and space. She will be studying hummingbirds and plants at different altitudes in three biogeographic regions with different evolutionary histories.

Three women with ERC grants at WSL: Catherine Graham, Anna Hersperger, Francesca Pellicciotti (left to right)
› WSL

"Electroactive polymers have the potential to revolutionise electronic controls."

– Pierangelo Gröning, member of the directorate and Head of the "Modern Materials and Surfaces" department

Various materials are being researched at Empa, some of them with surprising properties. For example, there are elastomers that react to current and that contract or expand depending on the voltage applied. Two decades ago, a few researchers wondered what you could do with something like this. The result is almost ready to be marketed now – and could revolutionise electronic control elements.

Does something have to be set in motion? Nature relies on muscles, technology on motors; nature deforms, technology turns and screws. That could all be about to change, because researchers from Empa are in the process of bringing low-cost, mass-produced actuators to market maturity. They are based on technology that is basically simple, but rather secretive. Dielectric elastomers belong to the group of electroactive polymers and are materials that deform when electrical voltage is applied. Why they do this is still being researched at molecular level. In the last 20 years, scientists have learned how to "rein in" these materials in such a way that the deformation is very precise and can be finely manipulated. "It's not that easy to create a linear movement," says Pierangelo Gröning, member of the directorate and Head of the "Modern Materials and Surfaces" department. However, Empa has steadily progressed towards this goal over the years and been able to do so at comparatively deep or low voltages thanks to its know-how. Thus, the actuators developed by Gabor Kovacs have the potential to make the leap from a research laboratory to a large-scale industrial application.

The test actuators are like a soft stack of plastic in your hand, consisting of many thin plates. It might look unspectacular, but a lot of research work has gone into the ten-centimetre high stack. Kovacs recalls that a research programme was launched at Empa in 2000 with the aim of deforming mechanical structures with electrical signals. However, the materials known at that time could hardly be used for specific applications. They did too little and were too expensive. However, believing firmly in the technology's potential, they decided to move forward and set up the Functional Polymers department to develop these materials themselves. This makes actuators a "classic Empa case," says Gröning, since they have their origins in materials research. What sets Empa apart is that the idea will then be refined "in this way in two different laboratories". The engineering challenge was compounded by the optimisation of the material.

Dorina Opris is involved in the development of more suitable polymer films tailored to specific needs. The breakthrough was achieved thanks to her expertise. She modifies the elastomers that make up the films with dipoles, which makes them more "sensitive". After modification, they become deformed at much lower voltages. She has also made the films "fit" for the special manufacturing process, in which they are applied to one another like in a 3D printer. This wet stack process also makes the Empa technology unique – automation has already been incorporated.

There are two manufacturing robots in the Kovacs research laboratory. One of the machines prints the finest film layers including stretchable electrodes, one on top of the other, so that a plastic plate about 0.5 millimetres thick slowly grows. This is then cut into small pieces in the other machine and stacked. As soon as electrical voltage is applied, each individual film is deformed marginally, and its thickness changes as well. The result would hardly be noticeable with a single layer, but there are more than 1000 foil layers in a stack. The effect is multiplied accordingly, and the actuators achieve movements from millimetres to centimetres that are even visible to the naked eye. The movement is completely silent, and the actuators compact and light. And reliable. The "artificial muscles" perform their movements thousands and millions of times without complaint. The principle can also be reversed: if the foils change thickness under pressure, this appears as an electrical signal.

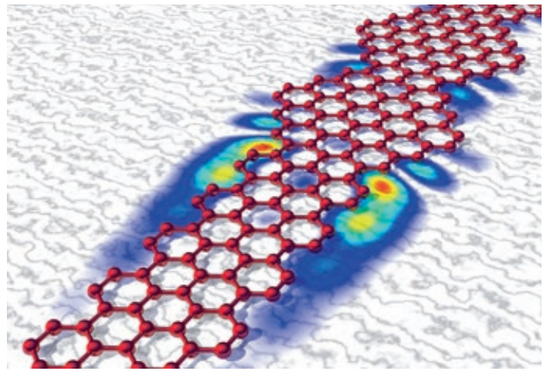
On the one hand, Kovacs envisages that they can be used in the human body as "auxiliary muscles". However, he also sees great potential in the consumer goods industry. Human-machine interaction could be completely transformed by actuators. Imagine a flat user interface that reacts by tactile rather than visual means. Buttons are created as required, and a relief is constantly changing. This is of interest to the car industry, for example. "Morphing cockpits will be standard in cars in ten years," predicts Kovacs. CTsystems, a business which grew out of his tenacious research work, will put this into practice and bring it onto the market.

The actuators developed by Gabor Kovacs (photo, left) have the potential to make the leap from a research laboratory to a large-scale industrial application.

Dorina Opris (photo, right) from the department of Functional Polymers comes to the fore when the polymer films have to be tailored to meet specific needs.

Thanks to the collaboration with the Swiss specialist Datwyler Holding SA, the degree of industrial production reached a new level.

On the way to nanoelectronics and quantum computers



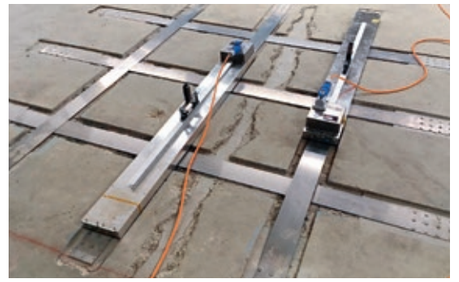
If graphene nanoribbons contain sections of different widths, robust new quantum states can emerge at the transitions, which may possibly be used in quantum computers.
› Empa

Nanoribbons of graphene – layers of carbon only a few atoms wide and one atom thin – are regarded as materials of the future, for example for the further miniaturisation of electronic components. Depending on shape and width, the ribbons behave as conductors, semiconductors or insulators. Empa researchers have succeeded in adjusting the properties of the ribbons precisely by varying their shape and creating special local quantum states. This could make it possible to manufacture nanotransistors in the future with a channel cross-section that is 1000 times smaller than is normal today. And the quantum states can be used as elements of qubits, as the complex, crossed states in a quantum computer are called.

"Smart" plasters with many talents

Not every medication works in tablet form or can be injected. The skin, on the other hand, offers a large, permeable surface to absorb active ingredients painlessly and efficiently, for example via active ingredient plasters. Researchers at Empa have developed nanocontainers for drugs and special polymer fibres that can be controlled by external stimuli such as light, pressure or pH in order to control the dosage precisely. However, patches can also be made "smart" to monitor how wounds are healing, with a sensor that warns early of problems. If critical levels of glucose are exceeded in the wound, which is indicative of poor healing, the sensor begins to fluoresce. This makes it easier to monitor complex skin injuries, such as burns.

A new type of wound dressing uses fluorescent sensors to warn nursing staff when a wound is healing poorly.
› Empa



Reinforcement of a suspended ceiling with "memory-steel", a new type of shape-memory alloy.
› Empa

How to make fragile structures fit again

Countless bridges and other structures in Switzerland, but also abroad, are ageing. Empa researchers have developed various technologies to strengthen them retrospectively so that they can continue to withstand increased stress loads safely. Firstly, carbon fibre plaster for steel bridges that are becoming brittle; this has already been used successfully to reinforce a Swiss railway bridge and a road bridge in Australia. Secondly, a new type of building material with shape memory: the memory-steel tensions itself by heating itself and, thus, reinforces concrete structures. After around 15 years in research, the innovative material is now about to be brought onto the market via the Empa spin-off "re-fer" and another industrial partner.

Eawag

THE WASTEWATER GOLDMINE

"The economic prospects for pellets that can be used as fuel are excellent."

– Linda Strande, Department of Sanitation and Water for Development at Eawag

Millions of people around the world have no access to sanitation that offers a "clean" solution. Therefore, Eawag is researching technical possibilities for treating wastewater and recovering resources from it. The main focus is on sustainable solutions for the southern hemisphere.

"Only solutions based on a market analysis have the opportunity to become established on a broad scale." – Christoph Lüthi, Head of the Department of Sanitation and Water for Development at Eawag

This story can be told in two ways. First, there's the market story. What a waste! All the valuable stuff in human excrement just poured down the sewers. Out of sight, out of mind. Money just thrown away… flushed away. But the public health story sounds very different. Housing developments need a fully functioning sewage system, otherwise hygiene emergencies are inevitable. Western countries have developed centralised sewage systems over time, which work in this country but which also create costs. This approach doesn't really work for cities in the southern hemisphere; the plants usually fail sooner or later, and the money invested goes down the drain. Decentralised systems are much better suited to collecting and treating sewage locally. But then the most important question arises: what to do with it? Not simply dumping it in the next stream, that's for sure, but treating and burning would be the more hygienic solution, for example.

It gets really interesting when you bring the two stories together. This is the goal of research conducted by Linda Strande and Christoph Lüthi from Eawag. Both work in the Department of Sanitation and Water for Development (Sandec) and develop scenarios to establish wastewater management worthy of the name in the southern hemisphere. The focus is on people's health, while resource recovery and "management" are the economic driving forces. Lüthi says that previous attempts to improve the wastewater situation in the southern hemisphere have largely ignored the economic aspects. This is the decisive factor when it comes to a sustainable and financially viable solution. Because the sewage system is not subsidised – there are simply no funds available for this – solutions must be sought that pay for themselves.

After years of research, the specialists from Dübendorf have indeed put together a series of economically impressive solutions: energy, nutrients for fertilisers and even animal feed can be obtained from waste water and faecal sludge. Almost all the nutrients come from the urine. A high-tech plant is in operation at Eawag itself, which separates the urine in the toilets and then processes it into valuable liquid fertiliser. Researchers are proud to report that Switzerland has recently even officially permitted the use of this fertiliser for food crops. However, less complex and more robust solutions for faecal sludge may prove to be much more interesting for cities in developing countries. That's Strande's area of specialisation. She has overseen various projects, for example in Uganda, which have demonstrated the practicability of the procedures. For example, faecal sludge can be dried and pressed into odourless pellets that can be burned like wood pellets, thus solving the problem of possible pathogens. The economic prospects are excellent, says Strande, and local industries have also shown great interest in the cheap pellets, provided they are produced in sufficient quantities.

The latest trick of the researchers is even more amazing: transforming animal or human waste into valuable protein. They use the larvae of the Black Soldier Fly (or BSF for short), which clean up pretty much all organic waste, be it salad leftovers, meat or food already digested by us. If this food mash is properly treated, hardly anything remains after the feast apart from fat larvae, which can be processed into food for farm animals or used in fish farming, for example.

The potential is huge. On the one hand, there is the growing demand for these sorts of feed materials, economic pellets or nutrient-rich fertilisers. On the other hand, there is the appalling reality for about one third of the world's population: sanitation for around 2.7 billion people is still provided decentrally without a sewer system or regulated wastewater disposal. Lüthi stresses once again that only solutions based on a market analysis will be viable on a broad scale. He doesn't want to see any more "white elephants" – he'd prefer to see lots of black soldier flies.

Interdisciplinary and practical: research project on “Bed-load and Habitat Dynamics”

What lives in and along streams with strong bed-load dynamics? And how do rivers with too little replenishment of gravel work? The results of an interdisciplinary research project conducted by the Federal Office for the Environment (FOEN), Eawag and WSL, as well as the hydraulic engineering laboratories of ETH Zurich and EPFL in the field of “Bed-load and Habitat Dynamics” answer these questions. Documented in the new set of leaflets from the FOEN “Environmental Knowledge” series, which is part of the “Hydraulic Engineering and Ecology” programme, the eight leaflets describe findings from practice relating to bed-load management and the restoration of bed-load dynamics with structural and operational measures (such as diversion tunnels, fills).

Many insects spend their larval stage in the water. The caddisfly species *Alloamus auricollis* builds its cases from sediment particles. The hatching insects are an important source of food for many creatures on land.
› Roland Riederer/Eawag

SQUIDs – Searching for traces in the sewer system

The sewage system not only channels wastewater, it is also a large biological reactor. Variables that influence the “power” of this reactor are only measured at a few points, if at all, and with great effort. Whether and to what extent substances are transformed in the sewage system is of particular interest in wastewater-based epidemiology. Eawag researchers have therefore developed the SQUID, a small sensor platform as part of the TransDrugS project. Floating in the wastewater stream, SQUID automatically measures pH, temperature, redox potential and electrical conductivity. High spatial resolution of the measurement parameters, of a level previously unattained, is thus achieved through repeated use. The collected data are used for the calibration of water quality models and can be of relevance to practice in connection with the identification of special dischargers or the problem of foreign water. A more detailed “trace search” is being implemented in the unique MS2field project with industrial partners: a high-end mass spectrometer measures organic micropollutants such as drug residue or pesticides in real time directly in the field.

Development and testing of a small series of new SQUIDs for international cooperation with eleven partner institutions.
› Andri Bryner/Eawag

Ugly rubber ducks

Warm, humid bathrooms offer the ideal growing conditions for biofilms of bacteria and fungi. Lush carpets grow in rubber ducks and other bathing toys in particular. A group of researchers from Eawag, ETH Zurich and the University of Illinois has investigated which factors promote growth and which types of microorganisms are present. The results don’t sound appetising. Between 5 and 75 million cells per square centimetre thronged on the plastic surfaces. The researchers found potentially pathogenic bacteria in 80 percent of all rubber ducks. The reason for the abundant biofilms lies in the soft plastic material that many ducks are made of and from which a lot of organic carbon is released, which serves as a nutrient. Other important nutrients such as nitrogen and phosphorus, as well as additional bacteria, end up in the bath during bathing.

Not exactly appetising. This inside of a rubber duck. In addition to the plastic material, the people in the bathing area also add to the bacteria cultures.
› Andri Bryner/Eawag

GOVERNANCE

Structure and leadership of the ETH Domain

The Federal Government operates the Federal Institutes of Technology in accordance with the Federal Constitution (Art. 63a Para. 1). As this is the law governing the ETH Domain, the ETH Act defines this mission. It also forms the legal foundation for operating the four research institutes of the ETH Domain.

The ETH Domain: Legal basis
The Federal Act on the Federal Institutes of Technology of 4 October 1991 (ETH Act) defines the status, structure and mission of the ETH Domain. The ETH Domain is autonomous within the framework of the law and it is affiliated to the responsible government department pursuant to the ETH Act. This has been the Federal Department of Economic Affairs, Education and Research (EAER) since the beginning of 2013. The ETH Act defines the autonomy of the two Federal Institutes of Technology and the four research institutes. The ETH Board is the strategic leadership and supervisory body of the ETH Domain.

The consultation process for the partial revision of the ETH Act was opened in November 2018. In addition to the Corporate Governance guidelines that have not yet been implemented (restrictions on voting rights and the absence of institutional members of the ETH Board), the new regulations under discussion concern various personnel policy changes, the creation of a legal framework for certain data processing activities and the sale of surplus energy generated or purchased for the ETH Domain's own use, as well as the implementation of recommendations of the Swiss Federal Audit Office (SFAO). Motions for the legislative amendments are to be submitted to parliament together with the next ERI Dispatch 2021–2024 and are expected to enter into force at the beginning of 2021.

Tasks and leadership
According to the objectives set out in Art. 2 of the ETH Act, the two Federal Institutes of Technology and the four research institutes (institutions of the ETH Domain) must:
- educate students and specialists in scientific and technical fields and ensure continuing education;
- expand scientific knowledge through research;
- foster the development of junior scientific staff;
- provide scientific and technical services;
- perform public relations work, and
- make use of their research results.

The institutions of the ETH Domain discharge their mission in observance of internationally recognised standards. They take account of Switzerland's needs and promote international cooperation.

ETH Domain structure

*Employment contracts including doctoral students as of 31 December 2018

ETH Domain

ETH Board
11 members
Staff: 53 employees*

Federal Institutes of Technology

ETH Zurich
over 21,000 students and doctoral students
12,151 employees*

EPFL
over 11,000 students and doctoral students
6,053 employees*

Research institutes

PSI
2,080
employees*

WSL
508
employees*

Empa
994
employees*

Eawag
510
employees*

Strategic objectives and budgetary framework
The ETH Domain is managed according to an effect-oriented model. The political authorities specify performance standards to be met and key financial parameters, whereas the ETH Domain is the service provider, and the ETH Board is responsible for implementing the specifications.

The political leadership rests with the Federal Council and the Federal Parliament. The central leadership tools are the Dispatch on the Promotion of Education, Research and Innovation (ERI Dispatch), the associated strategic objectives set by the Federal Council for the ETH Domain and the annual credit allocation from Parliament. The political tools are supplemented by financial controlling, which provides information on financial reporting and mission fulfilment. The common principles for management of companies and entities with close links to the Swiss Federation are set down in the corporate government reports of the Federal Council.

The ETH Act has been revised within the scope of ERI Dispatch 2017–2020. The Federal Council has passed the strategic objectives of the ETH Domain since then in lieu of the performance mandate. Parliament will continue to exercise parliamentary oversight and can instruct the Federal Council to define or change strategic goals. With this change, guiding principles 16 and 17 of the corporate government report of the Federal Council of 13 September 2006 and of 25 March 2009 (Supplementary Report) were implemented in the ETH Domain. In addition, the dispatch is geared towards the Federal Act of 17 December 2010 on the Participation of the Federal Assembly in the Management of Autonomous Units.

Reporting
The ETH Board reports on its activities in various ways: it reports to the Federal Council every year on the fulfilment of the strategic objectives and illustrates how the ETH Domain has used the annual total federal financial contribution. Based on the ETH Board's report, the Federal Council informs Parliament within the scope of its modular reporting with a summary report and a detailed report. In a self-evaluation report in each half of the performance period, the ETH Board indicates the extent to which the strategic objectives of the Federal Council have already been met. This self-evaluation report serves as the basis for the evaluation of the ETH Domain by outside experts (peer review) which is to be carried out by the EAER.

Along with the application for funding for the next performance period, the EAER informs Parliament on the status of the achievement of goals in an interim report (Art. 34a ETH Act) produced half-way through the performance period. The ETH Board is responsible for the strategic leadership of the ETH Domain (see next section). The Executive Boards of both Federal Institutes and the Directorates of the four research institutes are responsible for the operational leadership of the individual institutions of the ETH Domain. In accordance with Art. 4(3) of the ETH Act, the institutions of the ETH Domain assume all responsibilities which are not assigned to the ETH Board by the ETH Act.

ETH Board: mission and operating principles
The ETH Board defines the strategy of the ETH Domain within the framework of the strategic objectives of the Federal Council, represents the ETH Domain when dealing with policy-makers and government authorities at federal level, issues directives about financial controlling, and carries out strategic controlling. It also approves the development plans of the institutions of the ETH Domain, oversees their implementation and supervises the ETH Domain. It agrees targets with the institutions and allocates federal funds on the basis of the institutions' budget requests. It submits requests to the Federal Council for the selection of the Presidents of the two Federal Institutes of Technology and of the Directors of the four research institutes. It also appoints the other members of the Executive Boards of the two Federal Institutes of Technology and of the Directorates of the four research institutes. Finally, the ETH Board appoints professors at the request of the Presidents of both Federal Institutes of Technology.

The ETH Board performs its supervisory function through the use of the following tools: periodic reporting by the institutions on resources (finances, human resources, real estate), annual reporting by the institutions on the extent to which they have fulfilled their duties with regard to target agreements, annual discussions (known as dialogues) between the ETH Board and the institutions of the ETH Domain within the scope of strategic controlling, handling supervisory complaints addressed to it while observing subsidiarity and institutional autonomy, as well as reports by the institutions within the scope of their risk-management systems. Moreover, the ETH Board's "Internal Audit" staff evaluate the risk management processes, internal control system and governance processes of the institutions and report on them to the ETH Board, in particular the ETH Board's Audit Committee. The rules of procedure of the ETH Board are published in the compilation of Federal law. The ETH Board usually meets five times a year for two days at a time, and arranges additional meeting days for dialogues with the institutions of the ETH Domain. The President of the ETH Board is responsible for holding periodic individual discussions with the Presidents of the two Federal Institutes of Technology and with the Directors of the research institutes.

Discussions are held twice a year between the proprietor, represented by the EAER and the Federal Department of Finance (FDF), and the ETH Board, represented by its President.

Management bodies of the ETH Domain

Presidency and Members of the ETH Board
- Fritz Schiesser [1], President (until the end of April 2019)
- Beth Krasna [2], Vice President (from May 2019 President ad interim)
- Prof. Dr Lino Guzzella [1] (until the end of 2018)
- Prof. Dr Martin Vetterli [1]
- Prof. Dr Joël Mesot [1]
- Dr Kristin Becker van Slooten [1]
- Marc Bürki [2]
- Beatrice Fasana
- Prof. Dr sc. nat., Dr h. c. mult. Susan Gasser
- Prof. Dr Dr h. c. Barbara Haering [2]
- Christiane Leister

[1] Member of the Executive Committee
[2] Member of the Audit Committee

Fritz Schiesser will step down at the end of April 2019 as he reaches retirement age.

Prof. Dr Lino Guzzella resigned as President of ETH Zurich at the end of 2018. He was replaced on 1 January 2019 by Prof. Dr Joël Mesot, who will continue to serve in this capacity on the ETH Board.

Prof. Dr Gian-Luca Bona, Director of Empa, has been a new member of the ETH Board since January 2019 and is a representative of the research institutes on the ETH Board.

Executive Board of ETH Zurich
- Prof. Dr Lino Guzzella, President (until the end of 2018)
- Prof. Dr Joël Mesot, President (since January 2019)
- Prof. Dr Sarah Springman, Rector
- Prof. Dr Detlef Günther, Vice President for Research and Corporate Relations
- Dr Robert Perich, Vice President for Finance and Controlling
- Prof. Dr Ulrich Weidmann, Vice President for Personnel and Resources

Executive Board of EPFL
- Prof. Dr Martin Vetterli, President
- Prof. Dr Pierre Vandergheynst, Vice President for Teaching
- Prof. Dr Andreas Mortensen, Vice President for Research
- Prof. Dr Marc Gruber, Vice President for Innovation
- Caroline Kuyper, Vice President for Finance
- Dr Etienne Marclay, Vice President for Personnel and Operations
- Prof. Dr Edouard Bugnion, Acting Vice President for Information Systems

Directorate of the PSI
- Prof. Dr Joël Mesot, Director (until the end of 2018)
- Dr Thierry Strässle, interim Director (since January 2019)[3]
- Prof. Dr Leonid Rivkin, Deputy Director
- Prof. Dr Gabriel Aeppli, Member
- Dr Peter Allenspach, Member
- Prof. Dr Andreas Pautz, Member
- Prof. Dr Christian Rüegg, Member (since May 2018)
- Prof. Dr Gebhard F. X. Schertler, Member
-

Directorate of WSL
- Prof. Dr Konrad Steffen, Director
- Dr Christoph Hegg, Deputy Director
- Prof. Dr Rolf Holderegger, Member
- Prof. Dr Andreas Rigling, Member
- Dr Jürg Schweizer, Member
- Prof. Dr Niklaus Zimmermann, Member

Directorate of Empa
- Prof. Dr Gian-Luca Bona, Director
- Dr Peter Richner, Deputy Director
- Dr Brigitte Buchmann, Member
- Dr Alex Dommann, Member
- Dr Pierangelo Gröning, Member
- Dr Urs Leemann, Member
- Dr Tanja Zimmermann, Member (since September 2018)

Directorate of Eawag
- Prof. Dr Janet Hering, Director
- Prof. Dr Rik Eggen, Deputy Director
- Prof. Dr Jukka Jokela, Member
- Dr Tove Larsen, Member
- Gabriele Mayer, Member
- Prof. Dr Alfred Johny Wüest, Member
- Dr Christian Zurbrügg, Member

[3] As of January 2019, Dr Thierry Strässle took over as interim Director of the PSI in place of the Director of the PSI who resigned at the end of 2018, until a new Director is found.

Status as at 31 December 2018
(reference is also made to changes agreed in 2018 which will become effective in 2019).

Audit and Executive Committees
The Audit Committee assists the ETH Board in financial supervision and in the monitoring of risk management, of the internal control system and of financial auditing activities. It is generally composed of three ETH Board members who are independent of the executive leadership, but may also involve additional people in a consultative capacity. The President of the ETH Board, the head of the Internal Audit department and the head of the Finance section of the ETH Board's staff attend the meetings in an advisory capacity.

The Executive Committee assists the ETH Board in preparing for and following up on meetings, in appointing the heads of the institutions of the ETH Domain, and in fulfilling its duties as an employer. It also liaises with the social partners. It is composed of the President of the ETH Board (chair), the Presidents of both Federal Institutes of Technology, the representative of the research institutes and the delegates of the University Assemblies. The Executive Director and, if necessary, other members of the ETH Board's staff attend the meetings.

Remuneration of the ETH Board
In 2018, the President of the ETH Board received a salary of CHF 287,306 (the employer also paid social security contributions amounting to CHF 84,660) for his 80% FTE position. In addition, he received an entertainment allowance of CHF 5,000. The President is insured by the Swiss Federal Pension Fund, the rules of which determine the employer's contribution. The Vice-President, who like the other five members of the ETH Board has no employment relationship with any institution of the ETH Domain, received a lump sum of CHF 26,000 in 2018. The other five members of the ETH Board each received a lump sum of CHF 20,000 in 2018. In addition, they were paid a total of CHF 42,000 for dialogue meetings and Audit Committee meetings (including a lump sum of CHF 6,000 for chairing the Audit Committee by the Vice-President of the ETH Board and the audit of the annual financial statements). Their expenses were refunded on the basis of the ETH Board Ordinance of 11 April 2002 concerning the reimbursement of expenses in the ETH Domain. Those members of the ETH Board who are employees of one of the institutions of the ETH Domain do not receive additional fees for their activities on the ETH Board. For the 70% FTE position, the ETH Board covered 40% of the wage and social costs (including compensation for expenses) incurred by EPFL for the delegates of the University Assemblies of both Federal Institutes of Technology, in order to guarantee the delegates' independence from either institution.

Monitoring and audit

Internal control system
The institutions of the ETH Domain have an internal control system (ICS). It was introduced using the template provided by the Federal Government. Its objectives are to protect the assets of the ETH Domain, to prevent errors and irregularities in accounting, and to ensure proper accounting and reliable reporting. It is an integral part of the audit by the Swiss Federal Audit Office (SFAO) or the auditors appointed by it. The focus is on financially relevant business processes.

Internal audit
The Internal Audit department conducts internal audits for the institutions of the ETH Domain (Art. 35a[ter] Para. 1 of the ETH Act and Art. 11 of the Federal Audit Office Act). This department reports directly to the President of the ETH Board and its activities are supervised by the Audit Committee. The Internal Audit department provides independent, objective auditing services and supports the ETH Domain in achieving its aims. It is also responsible for coordinating and supporting the external audits of the ETH Domain.

Auditors
The SFAO performs external auditing duties for the ETH Domain (Art. 35a[ter] Para. 3 of the ETH Act). In 2018, it audited the consolidated financial statements of both Federal Institutes of Technology, the consolidated financial statements of the ETH Domain and it conducted interim audits. The SFAO performs the audits of the research institutes jointly with PricewaterhouseCoopers (PwC). The SFAO's audit report on the consolidated financial statements of the ETH Domain comprises an audit report and a comprehensive report. These reports are discussed with representatives of the SFAO in the Audit Committee every year. In 2018, the SFAO invoiced the ETH Board for the total amount of CHF 548,837 (CHF 344,601 for the 2017 annual review and CHF 204,236 for the interim audit of the 2018 annual financial statement).

Information policy
Its statutory role makes the ETH Board an interface between academia, policy-makers and society. Within its rules of procedure, the ETH Board undertakes to ensure honest, appropriate and transparent communication for the benefit of society and aims to explain its decisions and reinforce the role and reputation of the ETH Domain. Responsibility for this rests with the President. The key communication tools are the ETH Board's annual report to the Federal Government, the website www.ethboard.ch, targeted media relations work and the case-by-case illumination of relevant facts and positions, particularly regarding policies on education, research and innovation.

Appeals body

ETH Internal Appeals Commission
The ETH Internal Appeals Commission decides on appeals against rulings made by bodies of the institutions of the ETH Domain. It is an independent judicial authority based in Bern, which is administratively assigned to the ETH Board, to which it reports. Appeals mainly relate to matters arising from legislation on human resources and higher education. Appeals against the rulings of the ETH Internal Appeals Commission can be made to the Federal Administrative Court.

- Prof. Dr Hansjörg Peter, President
- Dr Esther Tophinke, Vice President (since March 2018)
- Consuelo Antille, Member
- Jonas Philippe, Member
- Dr Dieter Ramseier, Member
- Prof. em. Rodolphe Schlaepfer, Member
- Yolanda Schärli, Member

ETH Board support

Staff of the ETH Board
The ETH Board's staff support the ETH Board in fulfilling its legal mandate, particularly regarding strategic leadership, supervision, promotion of cooperation in the ETH Domain and liaising with the Federal authorities.

Executive Team
- Dr Michael Käppeli, Executive Director
- Dr Kurt Baltensperger, Science
- Gian-Andri Casutt, Communication
- Dr Dieter Künzli, Finance and Human Resources
- Dr Monique Weber-Mandrin, Legal Services
- Michael Quetting, Real Estate
- Barbara Schär, Board Secretarial Office

Internal audit
The ETH Board employs Internal Audit staff, as per Art. 35a[ter] of the ETH Act. It conducts the internal audits of the institutions of the ETH Domain.
- Patrick Graber, Head

Fritz Schiesser
* 1954, Swiss citizen
Dr iur.

President of the ETH Board (80%) and Chairman of the Executive Committee since 2008. Lawyer at "RHS & Partner Rechtsanwälte und Urkundspersonen" since 1998 (part-time).

Fritz Schiesser gained a doctorate in law at the University of Zurich and has been a lawyer and notary in the Canton of Glarus since 1998. From 1990 to 2007, he was a member of the Swiss Council of States, where he served as President from 2003 to 2004, and he was President of the Foundation Board of the Swiss National Science Foundation (SNSF) from 1999 to 2007. Today, Fritz Schiesser is a member of the Foundation Council of the SNSF, and member of the board at the Sandoz Family Foundation, the Development Foundation of Glarus Süd, Proto Chemicals, Schweizerische Mobiliar and Hefti AG. He is also a member of the Foundation Board of the think-tank Avenir Suisse and of the Swiss Innovation Park. Fritz Schiesser will resign at the end of April 2019 as he reaches retirement age.

Beth Krasna
* 1953, Swiss/US citizen
Dipl. Ing.

Vice President of the ETH Board since 2018, Member of the ETH Board since 2003, as well as President of the Audit Committee since 2008. Independent board member.

Beth Krasna has a degree in chemical engineering from ETH Zurich and a Master's degree in management from the Massachusetts Institute of Technology (Cambridge, USA). She is a member of the Board of Directors of Coop and of Symbiotics SA, as well as President of the Board of Directors of Ethos Services AG and of Xsensio SA. Additionally, Beth Krasna is Vice-President of the Foundation Board of the Graduate Institute of International and Development Studies in Geneva, and member of the Swiss Academy of Engineering Sciences. Beth Krasna will take over the office of President ad interim from May 2019 until a successor is found.

Lino Guzzella
* 1957, Swiss citizen
Prof. Dr sc. techn.

Member of the ETH Board and of the Executive Committee since 2015. President of ETH Zurich since 2015.

Lino Guzzella obtained a doctorate in mechanical engineering at ETH Zurich. After gaining industrial experience in research and development at Sulzer in Winterthur and Hilti in Schaan (Liechtenstein), in 1993 he was appointed assistant professor at ETH Zurich. Since 1999, he has been a full professor of Thermotronics. From 2003 to 2004, he was the Honda Visiting Professor at Ohio State University in Columbus (USA). From mid-2012 until the end of 2014, he served as Rector of the ETH Zurich. Lino Guzzella is a member of the Board of Directors of Kistler Holding AG and a shareholder of the Robert Bosch Industrietreuhand KG (RBIK). He is a Fellow of the IEEE and IFAC, a member of the Advisory Council on Digital Transformation of the Federal Council and a member of the Foundation Board of the Swiss Innovation Park.
(Photo: Markus Bertschi/ETH Zurich)

Marc Bürki
* 1961, Swiss citizen
Dipl. El.-Ing.

Member of the ETH Board since 2017 and of the Audit Committee since 2018. CEO of Swissquote Holding Ltd and Swissquote Bank Ltd since 1999 and 2002 respectively.

Marc Bürki obtained a degree in Electrical Engineering from EPFL. After gaining his initial professional experience with the European Space Agency in the Netherlands, he formed Marvel Communications S.A. in Gland in 1990, a company that specialised in the development of financial information software. Swissquote Group Holding Ltd, which specialises in online trading, was formed in 1999 and was floated on the stock market in 2000. In the same year, Swissquote Bank Ltd received a banking licence. Marc Bürki is the CEO of both companies.
(Photo: Swissquote)

Beatrice Fasana
* 1969, Swiss citizen
Dipl. Ing. Lm

Member of the ETH Board since 2012. Managing Director of Sandro Vanini SA since 2013.

Beatrice Fasana studied food sciences at ETH Zurich. After a traineeship at the 'Nestlé Research and Development Center' in New Milford (Connecticut, USA), she worked in various leadership roles for several large food and beverage production companies in Switzerland, including Chocolat Frey and Coca-Cola. Until the end of 2012, she ran her own company BeFood Consulting SA. Since 2013 she has held the position of Managing Director at Sandro Vanini SA, a company of the Haecky Group. Beatrice Fasana is also a member of the Board and Chair of the Management Committee of the University of Applied Sciences and Arts of Southern Switzerland (SUPSI, Scuola universitaria professionale della Svizzera italiana) and has been a member of the Board of Directors of Raiffeisen Bank del Basso Mendrisiotto since 2018.

Susan Gasser
* 1955, Swiss citizen
Prof. Dr sc. nat., Dr h. c. mult.

Member of the ETH Board since 2018. Director of the Friedrich Miescher Institute for Biomedical Research and a professor of Molecular Biology at the University of Basel since 2004 and 2005 respectively.

Susan Gasser studied biology and biophysics at the University of Chicago and obtained a doctorate at the University of Basel. She was group leader at the Swiss Institute for Experimental Cancer Research (ISREC) at EPFL from 1986 until she was appointed full professor at the University of Geneva in 2001. She was selected as a director of the Friedrich Miescher Institute for Biomedical Research at the end of 2004 and has also been a full professor of Molecular Biology at the University of Basel since 2005. Susan Gasser is a member of the scientific advisory board of the Max Planck Institute for Biophysical Chemistry, of the Institute for Advanced Study (Wiko) Berlin and of the European Molecular Biology Laboratory (EMBL) in Heidelberg. She chairs the Equal Opportunities Commission of the Swiss National Science Foundation (SNSF). (Photo: Nestlé Nutrition Council)

Martin Vetterli
* 1957, Swiss citizen
Prof. Dr sc.

Member of the ETH Board and of the Executive Committee since 2017. President of EPFL since 2017.

Martin Vetterli received his degree in Electrical Engineering from ETH Zurich, before then completing his Master's in Science at Stanford University and finally obtaining his doctorate at EPFL. Following professorships at Columbia University and at the University of California, Berkeley, he returned to EPFL as full professor of Communication Systems in 1995. From 2000 to 2003, he was a member of the Swiss Science and Innovation Council (SSIC). From 2004 to 2011, he was Vice President of EPFL, Dean of the Faculty of Computer and Communication Sciences at EPFL from 2011 to 2012. From 2013 to 2016, he was President of the Research Council of the Swiss National Science Foundation (SNSF).
(Photo: Nik Hunger/EPFL)

Joël Mesot
* 1964, Swiss citizen
Prof. Dr sc. nat.

Member of the ETH Board and of the Executive Committee since 2010 (representative of the research institutes). Director of the PSI (until end 2018) and dual professor at ETH Zurich/EPFL since 2008.[1]

Joël Mesot studied physics at ETH Zurich, obtaining a doctorate in solid-state physics in 1992. He was awarded the ETH Zurich Latsis Prize in 2002 and the Swiss Physical Society (SPG) IBM Prize in 1995. After residing in France and the USA, he came to ETH Zurich and joined the PSI, where he became Head of the Laboratory for Neutron Scattering in 2004. He was elected Director of the PSI in 2007. Joël Mesot is a senator of the Helmholtz Association of German Research Centres and member of various non-European committees of experts. He is Second Vice President of the Marcel-Benoist Foundation Board, member of the Foundation Board of the Swiss Science Center Technorama Winterthur, the Technopark Aargau Foundation, and the Swiss Innovation Park, as well as member of the Board of Directors of PARK INNOVAARE.

Kristin Becker van Slooten
* 1962, Swiss/German citizen
Dr

Member of the ETH Board and of the Executive Committee since 2017. Project manager for equal opportunities at EPFL since 2017. Maître d'enseignement et de recherche (MER).

The environmental scientist Kristin Becker van Slooten studied Biology at the University of Geneva and obtained her doctorate in Environmental Chemistry and Ecotoxicology at EPFL. From 1995 to 2002, she was employed as a scientist at the Laboratory for Environmental Chemistry and Ecotoxicology, where she headed up the Experimental Ecotoxicology research group from 2002, obtaining the title of MER in 2005. From 2006 to 2016, she was an advisor to the President and General Secretary of EPFL. Kristin Becker has been the project manager for equal opportunities at EPFL since 2017 and has reprised her role as a delegate on the ETH Board, representing the university assemblies of ETH Zurich and of EPFL as she did from 2004 to 2006.

Barbara Haering
* 1953, Swiss/Canadian citizen
Prof. Dr sc. nat., Dr h. c. sc. pol.

Member of the ETH Board and of the Audit Committee since 2008. President of the Board of Directors of econcept AG since 2015.

Barbara Haering studied natural sciences and obtained a doctorate in spatial planning at ETH Zurich in 1996. She is President of the Board of Directors of econcept AG and member of the Board of Directors of Ernst Schweizer AG, Metallbau (metal construction). In addition, she chairs the Conseil d'orientation stratégique at the University of Geneva and the Council of Foundation of the Geneva International Centre for Humanitarian Demining. Moreover, Barbara Haering is a member of the Foundation Council of the Swiss National Science Foundation (SNSF) and the University Council of Dresden University of Technology. In addition, she has worked as an adjunct professor at the University of Lausanne since August 2016.

[1] Joël Mesot took up the post of President of ETH Zurich on 1 January 2019 and will continue to sit on the ETH Board in that role.
(Photo: Markus Bertschi/ETH Zurich)

Christiane Leister
* 1955, Swiss/German citizen
Dipl.-Vw.

Member of the ETH Board since 2017. Owner and President of the Board of Directors of the Leister Group since 1993.

After graduating from Christian Albrecht University of Kiel with a degree in Economics, Christiane Leister started her career at Jungheinrich (floor-level conveyors and warehousing systems). She then headed the Controlling and Finance departments of Vereinigte Papierwerke AG and Milupa AG. She took over strategic and operational duties within the Leister family business in 1989. She has been the owner of the Leister companies since 1993, where she also acted as operations manager until 2014. During that time, she diversified the companies with new technologies and expanded them internationally to create the Leister Group.
(Photo: Leister AG)

New member of the ETH Board

Gian-Luca Bona (* 1957) has been Director of Empa and professor of Photonics at ETH Zurich and EPFL since 2009. Under his leadership, Empa has developed into a leading international research institute for material research and innovative technologies. Bona is a member of various committees for knowledge and technology transfer, among other things in the Commission for Technology and Innovation, in the Zurich Technopark and in the glaTec development centre for start-ups and innovation processes. As a representative of the research institutes, Bona has been a member of the ETH Board since 1 January 2019, succeeding Joël Mesot, who is to take on the post of President of ETH Zurich.

A complete overview of the vested interests of the members of the ETH Board can be found at www.ethboard.ch/vestedinterests.

Personnel matters

Personnel matters of the Federal Council

The Federal Council was duly informed on 19 December 2018 that Fritz Schiesser is to hand over the presidency of the ETH Board at the end of April 2019, as he reaches retirement age. Fritz Schiesser took over the presidency in 2008 when the ETH Domain was in a difficult phase. In the following years, he succeeded in setting the ETH Domain on a successful course in association with the strategy and regulatory body, the ETH Board.

On 24 October 2018, the Federal Council appointed Prof. Dr Joël Mesot as the new President of ETH Zurich. The appointment was requested by the then Director of the Federal Department of Economic Affairs, Education and Research (EAER), Federal Councillor Johann Schneider-Ammann and unanimously recommended by the ETH Board. Joël Mesot has been director of the Paul Scherrer Institute (PSI) since 2008 and held a dual professorship at the two universities, ETH Zurich and EPFL. He took up his post on 1 January 2019 and succeeded Prof. Dr Lino Guzzella.

Lino Guzzella, who served as President of ETH Zurich from 2015 to 2018, took the decision in May 2018 not to put himself forward for the next term as President in order to return to the post of Professor of Thermotronics at the Department of Mechanical and Process Engineering at ETH Zurich.

On 14 December 2018, the Federal Council elected Prof. Dr Gian-Luca Bona as a new member of the ETH Board, where he has been the representative of the research institutes since 1 January 2019. Gian-Luca Bona studied physics at ETH Zurich, where he completed his doctorate in 1987. He has been head of Empa since 2009 and professor of Photonics at ETH Zurich and EPFL. Under his leadership, Empa has developed into a leading international research institution for materials research and innovative technologies.

On 14 December 2018, the Federal Council also elected Dr Thierry Strässle as interim Director of the PSI, which he has headed since January 2019 until a successor for the post of Director has been found. Thierry Strässle has been Chief of Staff of the PSI since December 2012. In 2005, the qualified physicist joined the PSI as instrument manager of the laboratory for neutron scattering. From 2010 he worked as scientific assistant to the director and from 2011 took over as head of the Science Department.

Beth Krasna, who was selected as the Vice President of the ETH Board by the Federal Council on 5 July 2017, took up her post on 1 January 2018. As did Prof. Dr Susan Gasser, who was selected as a new member of the ETH Board.

At the request of the ETH Board, the Federal Council confirmed on 4 July 2018 that Prof. Dr Janet Hering is to serve as Director of Eawag for a further four years. Since 2007, when Janet Hering took up her first term at the head of Eawag, it has confirmed its position as a research institute of global renown. In Switzerland, Hering forged closer ties between Eawag and stakeholders in waterway protection from government and associations.

Personnel matters of the ETH Board

Appointment to the Directorate of the PSI
At the request of the then Director of the PSI, Prof. Dr Joël Mesot, the ETH Board appointed Prof. Dr Christian Rüegg as a new member of the Directorate in May 2018. Christian Rüegg has been head of the Neutrons and Muons (NUM) research area at the PSI since 2017 and, in his capacity as a solid-state physicist, investigates the behaviour of quantum magnets. In addition, he has been an honorary professor at UCL since 2011 and a professor at the University of Geneva since 2012.

Appointment to the Directorate of Empa
In September 2018, the ETH Board appointed Dr Tanja Zimmermann as a new member of the directorate of Empa at the request of the director of Empa, Prof. Dr Gian-Luca Bona. Having studied wood science, she became head of a research group at Empa in 2001. She headed the Applied Wood Research department from 2011. She succeeded in creating an international reputation for a research field that had previously attracted little attention, demonstrating curiosity, creativity and scientific competence. Tanja Zimmermann has headed the new Functional Materials department since September 2017.

Professorial matters

Appointment of professors
In 2018, the ETH Board dealt with 170 professorial matters. It appointed a total of 74 professors, 54 of whom were new members of staff and 20 were internal promotions. A total of 16 women and 32 men were appointed at ETH Zurich, as well as 7 women and 19 men at EPFL.

7 of the 25 full professor appointments were promotions of associate professors. 13 of the 21 associate professor appointments were promotions of assistant professors.

Women accounted for 31.1% of all appointments of new professors in 2018.

In 2018, the ETH Board appointed an affiliated professor for the first time. Affiliated professors mainly work at a research institution in Switzerland or abroad and are only employed at a Federal Institute of Technology on a reduced employment level. They have the status of a full professor and count as that in the statistics.

In addition, the ETH Board awarded the title of professor (adjunct professor) to 4 female and 7 male scientists.

Retirements and resignations
In 2018, the ETH Board was informed about 26 retirements: 18 from ETH Zurich and 8 from EPFL. In addition, ETH Zurich and EPFL advised the ETH Board of a total of 6 resignations for other reasons.

Appointments

74

professors, 16 of whom were women and 32 men at ETH Zurich, as well as 7 women and 19 men at EPFL

Proportion of women

31%

of all appointments of new professors

The total of 74 appointments comprised:

Full professorships*

25

3 of whom were women

Associate professorships

21

9 of whom were women

Assistant professorships with tenure track

23

9 of whom were women

Assistant professorships without tenure track

5

2 of whom were women

* 1 of whom was an affiliated professor

Risk situation and risk management

As the managing and supervisory body, the ETH Board sets out the risk policy for the ETH Domain. In this capacity, it sets targets for the two Federal Institutes of Technology and the research institutes. On the one hand, this serves to ensure that the tasks can be performed effectively, cost-efficiently and with foresight, and that functional and innovative capability can be maintained. On the other hand, this is intended to guarantee personal safety and the security of property and other assets to the greatest possible extent. The leadership of the institutions of the ETH Domain is intended to be by comprehensive, transparent and up-to-date risk information and risk awareness among students and staff, and the good reputation of the ETH Domain is to be safeguarded.

All the institutions of the ETH Domains have their own procedures for risk management, which serve to identify and evaluate the individual risks, as well as strategies for coping with them and for monitoring them appropriately. The risk management activities and supervision of risk management procedures are coordinated in each institution by a risk manager and/or a risk committee. Each institution keeps its own risk catalogue in which the identified risks are described in detail with an assessment on the basis of probability of occurrence and the extent of the potential damage. In addition, consideration is given to the possible effect a risk could have on reputation. The risk catalogues are updated at least once a year.

As part of their annual reporting to the ETH Board, the institutions provide information about their core risks, in particular their current status, extent and possible consequences. Core risks are those risks with potentially significant financial consequences and that have an above-average probability of occurring. They directly endanger the fulfilment of legal duties. The reports on the core risks are then submitted to the department responsible for the ETH Domain. Moreover, the ETH Board must be informed directly by the institutions about any extraordinary changes in risk or damaging events. The individual profile, specific focus and size of each institution are reflected in its risk catalogue. Thus, the two Federal Institutes of Technology have different core risks to the four research institutes, and the assessment of the same risks can vary.

Uncertainty regarding the development of financing and the effects of an obstructive political and legal environment (relationship between Switzerland and the EU) remain two of the ETH Domain's most important core risks in 2018. Taking on excessive obligations, the risk of a lack of oversight of long-term financial obligations and the consequences of such, as well as the loss of management and control due to the creation of external structures represent further core risks as do potential infringements of business secrets (data loss and publication of confidential data), possible infringements of scientific integrity and good academic practice, as well as violence and/or threatening behaviour towards people.

Despite careful risk management, it cannot be ruled out that an institution may be affected by a damaging event which endangers the fulfilment of its duties enshrined in law. In this type of case, the ETH Board would submit a request to the EAER, for the attention of the Federal Council, to adapt the strategic targets or increase the federal financial contribution in accordance with Art. 30(2) of the Ordinance on Finance and Accounting of the ETH Domain following consultation with the FFA.

The insurance policies taken out by the institutions are of great importance. The institutions must take out insurance against possible losses, subsidiary to other measures, where such insurance is feasible and the funding is sufficient for it. Each institution is responsible for taking out insurance cover and administering its own insurance portfolio. When doing this, they have to take into account their specific risk situation, strive for an appropriate cost/benefit ratio and ensure compliance with the federal regulations governing public sector procurement. The insurance cover must meet the standards which are customary in the Swiss insurance market and be concluded with an insurance institution that is licensed in Switzerland. The institutions have taken out property and employers' liability insurance policies, as well as smaller insurance policies for specific risks. The real estate owned by the Federal Government is not insured, because the Confederation follows a strategy of self-insurance.

STRATEGIC OBJECTIVES

Strategic objective

TEACHING

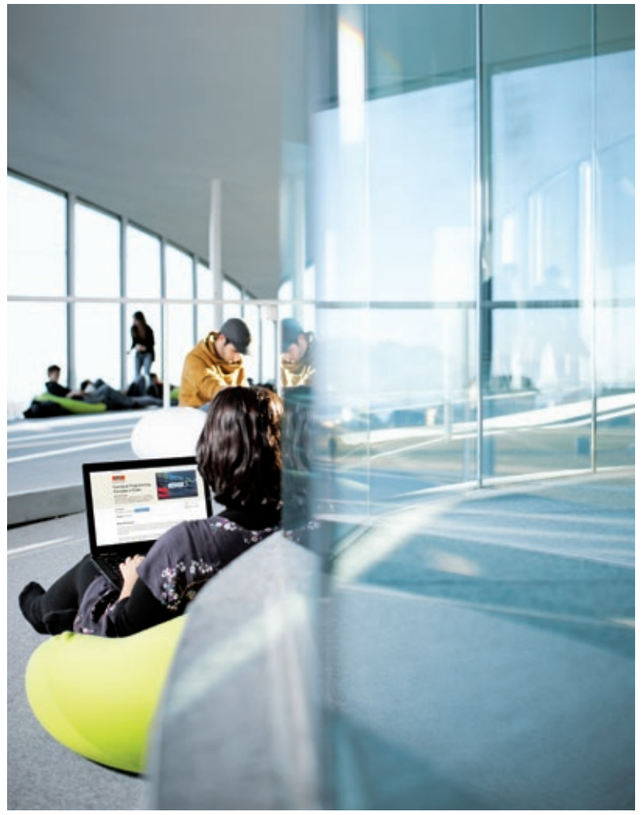
32,531 students and doctoral students were enrolled at the two Federal Institutes of Technology in 2018, corresponding to growth of 4% on the previous year. The increasing attractiveness of the ETH Domain is indicative of the excellent quality of teaching. The programme on offer was further enhanced in 2018 with a focus on innovation, digitisation and critical thinking.

Excellence in research and competence-oriented education

Education in the ETH Domain is excellent and attractive by international standards. In 2018, the total number of students and doctoral students at ETH Zurich rose to 21,397 and at EPFL to 11,134 (+4% each compared to 2017). For the second year in succession, information and communications technology recorded the highest growth (+11.9%). In view of the increasing interest in society and the business community in promoting the next generation of scientists in this area, this development is very welcome. The international nature of the students and doctoral students is further proof of the attractiveness of the ETH Domain. The percentage of foreign nationals among students and doctoral students in 2018 was 46.6% (2017: 45.7%). It should be noted that their proportion is much higher at doctoral level than at Master's level and especially than at Bachelor's level, where 69.6% of the students are Swiss nationals. The two Federal Institutes of Technology have been making great efforts to increase the proportion of women at all academic levels. In 2018, 31.3% of students and doctoral students were women, an increase on previous years (2017: 30.6%) (for detailed statistics on students and doctoral students, refer to the Monitoring Table and Academic Achievement Report, p. 82 ff.).

The two Federal Institutes of Technology regularly develop their curricula with a view towards reflecting strategically important areas of activity and the needs of society, incorporating the latest developments in research. In this spirit, ETH Zurich and EPFL have decided to launch a joint Master's degree in Cybersecurity, which is due to start in 2019. EPFL has further developed its Master's programmes and introduced a Robotics programme which attracted 69 students in its first year. 84 of the 100 students in the first year of the Bachelor's degree in Human Medicine at ETH Zurich, which was introduced in 2017, successfully completed the two first-year examination blocks (also refer to objective 5, p. 58). ETH Zurich and EPFL have each been offering a Master's degree in Data Science since the autumn semester of 2017. These courses are very successful and recorded a total of 124 new students at the two Federal Institutes of Technology in 2018 (37 up on 2017). EPFL has reformed its basic courses substantially in order to integrate computer-based thinking early on. It has also introduced a new doctoral programme in computational and quantitative biology.

The staff from the PSI, WSL, Empa and Eawag offer lectures, seminars and practical work as well as other educational opportunities in various fields. In 2018, this commitment corresponded to 18,659 teaching hours at a university in Switzerland or abroad (see Fig. 13, p. 88). In the current period, 1,477 students and doctoral candidates also accomplished their Bachelor's, Master's or doctoral theses at one of the research institutes. The year was marked by the appointment of several researchers from one of the research institutes as professors. In the year under review a researcher



Inspirational learning environment: students in the multifunctional Rolex Learning Center at EPFL.
› Michael Sieber / ETH Board

was jointly appointed as a professor at the "Institute of Chemical Science and Engineering" at EPFL and as head of the "Femtochemistry" laboratory at PSI. The Head of the "Biointerfaces" laboratory at Empa has been appointed as professor at ETH Zurich; other Empa researchers have been awarded professorships at the Universities of Fribourg and Basel; a head of an Eawag research group has been appointed associate professor of inorganic environmental geochemistry at ETH Zurich, and another Eawag group leader has been appointed associate professor of aquatic ecology at the University of Zurich. Both are still employed at Eawag. A professorship in ecotoxicology, jointly advertised by Eawag and the University of Applied Sciences and Arts Northwestern Switzerland FHNW, was successfully filled in 2018. This is the first time that Eawag has created a joint professorship with a university of applied sciences. In addition, a joint position between PSI (as laboratory head) and the University of Bern (as professor of "Nonlinear Optics") has been advertised in 2018. And in summer 2018, WSL and EPFL announced a joint full professorship.

The institutions of the ETH Domain encourage exchange between the MINT subjects and the social sciences and humanities so that students can develop their skills further. The "Science-in-Perspective" (SiP) programme at ETH Zurich, for example, which opens up new perspectives on the natural and engineering sciences and fosters critical thinking, has been firmly embedded in the various courses for many years. Two "SiP Talks" took place in 2018 as part of this programme. One of them explored the possibilities and limitations of computer-aided technologies in life sciences, the other focused on the collection of students' personal data during their studies at ETH Zurich. In addition, ETH Zurich has developed specific modules for various engineering courses that provide a basic understanding of business administration and economics. EPFL offers various activities to build social science and humanities knowledge into its courses. The "Global Challenges" course is compulsory for all departments in the first academic year. From year two, there is a selection of lectures available in the social sciences and humanities. The WSL has launched a MOOC (Massive Open Online Course) on landscape ecology that brings together the natural and social sciences. This MOOC is the result of cooperation between six universities and research institutes and is jointly financed by WSL and ETH Zurich. In collaboration with EPFL, Eawag has four MOOCs on the subject of "Sanitation, Water and Solid Waste for Development" and has been participating in an additional online course entitled "Introduction to Public Health Engineering in Humanitarian Contexts" since the end of 2017.

Innovation and quality assurance in teaching

In addition to standard courses, the institutions of the ETH Domain develop and promote new forms of teaching and learning. The ETH Zurich KITE Award, which recognises innovative teaching concepts, was presented in 2018 to three lecturers from the Department of Computer Science for their "e-tutorials", which enable students from various courses to learn and apply programming. The e-tutorials are geared towards the content of the students' own subject areas and allow personal supervision, even on large courses. ETH Zurich also offers a large number of online examinations. They are particularly suitable for testing competencies. A new testing room in Zurich-Oerlikon was put into operation and the "Testing with mobile devices" project launched.

Mixed Reality, which makes it possible for different people to interact physically with computer-generated simulations in classrooms, has also grown in significance in ETH Zurich's range of courses. A number of Mixed Reality projects were financed in 2018 by the Innovedum Fund of ETH Zurich, which supports innovative teaching projects. In addition, ETH Zurich and WSL, in collaboration with a private company, have developed an app for HoloLens eyewear with which students can learn more about lichens.

EPFL launched new teaching initiatives based on the three pillars "CORE", "MAKE" and "LEARN" in 2018. The CORE initiative is concerned with the further development of basic polytechnical courses through the introduction of new teaching methods such as the flipped classroom, distance or virtual experiences or the MOOC-supported classroom. The MAKE initiative supports work in laboratories, interdisciplinary projects with students from different faculties and the development of innovative infrastructures through Discovery Learning Labs. The focus of the LEARN initiative is on translational pedagogical research (see p. 66). The PSI is also continuing to develop its online teaching programme and has launched the MOOC "SYNCHROTRONx" in cooperation with EPFL and the University of Zurich as an introduction to synchrotrons and X-ray lasers. Over 4,000 students have already completed this course.

ETH Zurich and EPFL regularly carry out evaluations and accreditations to ensure the quality of their courses and programmes. The results of the evaluations influence how training programmes are optimised. In addition to the option for students to evaluate courses, ETH Zurich has also been offering the possibility of evaluating written examinations for some years now. 497 examinations were evaluated in the 2018 spring semester. The average response rate was 47.6 %, and overall satisfaction was rated at 3.6 (on a scale of 1 to 5).

EPFL has launched a pilot project to evaluate all Bachelor's and Master's programmes. The Master's students were asked about their Bachelor's courses, and alumni about their Master's courses. It is also planned to use the data of the online teaching programme for the purposes of refining the analysis of teaching and teaching materials.

Promotion of national and international exchanges
ETH Zurich and EPFL support student mobility in order to promote the exchange of experience and ideas. In the 2017/2018 academic year, 350 ETH Zurich students spent one or two semesters at another university in Switzerland or abroad. 326 students from EPFL opted for an exchange with another university in the spring semester, as did 385 in the autumn semester. There are also numerous exchange students from other Swiss or foreign universities who come to ETH Zurich or EPFL for an exchange. 480 exchange students attended Bachelor's and Master's degree courses at ETH Zurich in 2018. The corresponding figure at EPFL was 524 (see Fig. 7, p. 85).

The ETH Domain also has an exchange programme which is intended to promote exchange between the institutions of the ETH Domain. In 2018, more than 150 students benefited from participating in a summer school and 86 from an exchange with another institution of the ETH Domain. The introduction of the Master's degree in Cybersecurity by ETH Zurich and EPFL in 2019 will increase student exchanges further, as the course includes an exchange semester between the two Federal Institutes of Technology.

Strategic objective

RESEARCH

The ETH Domain's excellence in research is once again confirmed by the high standard of the work of its scientists and their publications. The top positions of the two Federal Institutes of Technology in the international rankings and the numerous awards and scholarships that researchers from the ETH Domain have received are also testimony to their outstanding performance.

Internationally leading position in research
The ETH Domain recorded many different research activities in 2018. The most important cooperation projects include the European Commission's FET flagship projects. Of the 140 project proposals submitted throughout Europe for the FET Quantum Flagship project, 20 were selected, including six projects involving researchers from ETH Zurich. Two EPFL projects, "Health EU" and "Time Machine", made it through to the second selection round for the next FET flagship. Other major projects are also implemented with international partners or with various Swiss stakeholders. For instance, ETH Zurich joined up with SBB to launch the interdisciplinary "ETH Mobility Initiative" to strengthen research into innovative solutions for mobility in the future and to promote cooperation with industry. In collaboration with the CHUV (*Centre hospitalier universitaire vaudois*) and the University of Lausanne, EPFL achieved a decisive breakthrough in the treatment of paraplegia (see p. 22). WSL researchers are taking part in the international G-TREE (Global Treeline Range Expansion Experiment) initiative, which is seeking to investigate the influence of various factors on the shift of the tree line to higher altitudes due to global warming. WSL's research delivers important information about the germination and growth conditions of tree seeds and trees above today's tree line.

Numerous research projects are based on high-performing and highly-specialised research infrastructure, and this allows the boundaries of research to be pushed back. This is the case, for example, with the projects at PSI's SwissFEL (also refer to objective 3, p. 52). The first pilot experiments on the SwissFEL's ARAMIS beamline successfully demonstrated the special performance capability of the X-ray laser for the investigation of proteins or protein complexes. The pilot experiments made it possible not only to analyse the structure of the proteins, but also to observe their movements and shape changes.

Other important research successes include those of scientists at Empa who made a decisive breakthrough in the field of graphene nanoribbons (see p. 31). Other Empa researchers succeeded in artificially generating the so-called superfluorescence effect, in a collaboration with ETH Zurich and IBM Research – Zurich. This discovery could lead to further developments in LED lighting, quantum sensors, quantum communication, and even future quantum computers. Researchers at Eawag have been working on the diversification of cichlids, which are ideal models for studying species development, as they develop extremely rapidly and are constantly producing new species. The Eawag researchers were able to observe the cichlids more or less evolve in a lake in Tanzania, where these fish had been introduced about 50 years ago.

The excellence of the ETH Domain's researchers is also reflected in the numerous awards and research grants they received in 2018. Alessio Figalli, Mathematics professor at ETH Zurich, was awarded the prestigious Fields

Medal (see p. 15); ETH professor Lars-Erik Cederman was the Swiss Prix Marcel Benoist laureate, and professor Ursula Keller, who is also from ETH Zurich, received the European Inventor Award (see p.17). At ETH Zurich, Professor Reto Knutti was awarded the Dr J.E. Brandenberger Foundation Prize and Professor Antonio Lanzavecchia the Louis-Jeantet Prize for Medicine. The National Latsis Prize 2018 went to EPFL Professor Andrea Ablasser (see p. 21). At EPFL, Professor Maryna Viazovska received the Mathematics Breakthrough Prize, Professor Michael Grätzel the August Wilhelm von Hofmann Medal, Professor Paul Dysen the European Sustainable Chemistry Award, and Professor Jacques Lévy the Vautrin Lud Prize for Geography. Ayodhya Tiwari, laboratory manager at Empa, received an honorary doctorate from Hasselt University in Belgium, and Empa researcher Maria Muñoz received the Swiss Aerosol Award. Professor Janet Hering, Director of Eawag, received the Clarke Prize from the American National Water Research Institute and was awarded the Geochemical Fellow by the Geochemical Society and the European Association of Geochemistry.

In 2018, the institutions of the ETH Domain received numerous ERC Grants: seven Starting Grants, 16 Advanced Grants, 14 Consolidator Grants and two Proof of Concept Grants. In addition, an ERC Synergy Grant was awarded to the HERO (Hidden Entangled and Resonating Orders) project which is being implemented under the leadership of the PSI in collaboration with ETH Zurich, EPFL and Stockholm University.

The researchers of the ETH Domain participate actively in national calls for proposals such as the National Centres of Competence in Research (NCCRs) and the National Research Programmes (NRP) of the Swiss Nat-ional Science Foundation (SNSF). The institutions of the ETH Domain are currently involved as leading houses or co-leading houses in several proposals for new NCCRs, which scored A or B in the first evaluation phase. The SNSF has confirmed the extension of the funding of the NCCRs on Robotics from 2018 to 2022, which is led by EPFL and co-led by ETH Zurich. The institutions of the ETH Domain are leading on 13 of the 25 NRP 73 "Sustainable Economy" projects, which were launched in 2018.

The bibliometric analysis of the ETH Domain carried out in 2018 confirmed the excellent performance of the institutions of the ETH Domain in publication activities. The study carried out by the CWTS (Centre for Science and Technology Studies, Leiden, Netherlands) revealed that all the institutions of the ETH Domain are high performing by international standards.

The average result of the impact of their publications, as well as the proportion of their publications that are ranked in the international top 10, is – sometimes even substantially – higher than the global average (also refer to objective 6, p. 61 ff.). The two Federal Institutes of Technology also continue to hold top positions in the international rankings of the best universities in the world (see p. 91).

Disappearing glaciers, biofilms and microbial life: the first research programme for the Alpine and Polar Environment Research Center (Alpole) of the EPFL Campus in Sion was launched in February 2019. A team of researchers practised the necessary techniques on the Corbassière glacier (see p. 19 f.).

Research priorities
Numerous research activities took place within the scope of the four strategic focus areas defined by the ETH Board for the period from 2017 to 2020.

In line with the implementation of the Swiss Government's 2050 Energy Strategy, energy research is of particular importance to the ETH Domain. The institutions of the ETH Domain head up seven of the eight SCCERs (Swiss Competence Centers for Energy Research). In addition, both ETH Zurich and EPFL created two additional professorships in this strategic area in 2018. ETH Zurich, the PSI and Empa are working together to develop ReMaP, an interdisciplinary development platform for modelling the future energy supply of urban areas. In collaboration with ETH Zurich, EPFL and the Universities of Lausanne, Fribourg and Zurich, a WSL study for the first time provided figures on the effects of glacial retreat on hydropower generation. In a project funded by the Federal Office for the Environment, Eawag researchers have been investigating the potential of certain lakes as heat sources or sinks. Empa's "ehub" energy research platform is also running various projects, such as the installation of a battery based on a molten salt or the development of various computer models to improve predictions of energy demand, for example.

Data sciences are also one of the ETH Domain's strategic focus areas. Three new professors were appointed in this field at ETH Zurich and one at EPFL in 2018. Four ETH Zurich Initiative ETH+ projects, which were approved in 2018, are directly linked to digitalisation and envisage the creation of six additional professorships in the near future. The Swiss Data Science Center has also launched the first interdisciplinary projects in the field of data sciences and open science, which are supported by new data analysis software. PSI's large-scale research facilities serve as a test environment for the development of new technologies and concepts for data processing and management. Within the framework of pilot applications, they offer partners from science and industry the opportunity to test applications, such as in the area of cyber security or machine learning.

As regards the strategic focus area on "Advanced Manufacturing", the people heading the first seven projects funded by this programme presented the results that were available in November 2018. Four new projects were launched in 2018. The network of technology transfer centres in the area of Advanced Manufacturing, which is currently being set up, is explored in greater depth in objective 4 (see p. 55 ff.). An international conference on the theme of "Digital Concrete" was also held at ETH Zurich as part of the NCCR on "Digital Fabrication" in collaboration with RILEM (Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages – International Union of Laboratories and Experts in Construction Materials, Systems and Structures). The DFAB HOUSE was also created in 2018 as part of this NCCR (also refer to objective 3, p. 52 ff.).

The highlights from the strategic focus area on "Personalized Health and Related Technologies" are described in detail in objective 5 (see p. 58 ff.) which explains in detail the contribution of institutions in the field of medicine and medical technology.

Academic integrity
Academic integrity and ethical responsibility are core values of the ETH Domain. All the institutions of the Domain have taken measures to foster a culture in which special attention is paid to academic integrity. In addition, the new generation of researchers in particular has access to numerous training and information programmes. To encourage academic integrity, the senior management of ETH Zurich has established a new Commission for Good Scientific Practice. It consists of 16 members (one per department) and has the particular task of coordinating work on the theme throughout the institution, promoting awareness of correct research work, recommending appropriate teaching content and courses, and providing expert support to the senior management in this area.

EPFL has revised its Compliance Guide and published a new version in 2018. Academic ethics have an important place in this, and a separate chapter is devoted to them. The PSI has made modifications to the Academic Integrity training programme for emerging scientists. In addition to the existing courses, a new online course module on ethics in research has been launched. WSL organised a "World Café" on academic integrity for researchers at all levels in 2018. As every year, Empa organised two welcome events for the new doctoral students to introduce them to the basic principles of academic integrity. Ultimately, the institutions have established procedures to be followed in the event of suspected fraud. Investigations were recently carried out at ETH Zurich and at the PSI, and the results of the investigations were publicly communicated by the institutions in both cases.

Strategic objective

RESEARCH INFRASTRUCTURES

The expansion of the ETH Domain's research infrastructure was successfully continued in 2018. Numerous infrastructures are not only used by researchers from the ETH Domain, but are also made available to researchers from other institutions and industry at home and abroad.

Operation, further development and provision of large research infrastructure

Various research infrastructure operated by the ETH Domain was further developed and expanded in 2018. The PSI develops, builds and operates several large items of research infrastructure on behalf of the Swiss Government which it makes available to domestic and foreign researchers. They include the Swiss Light Source (SLS), the Swiss Spallation Neutron Source (SINQ), the Swiss Muon Source SμS and the latest installation, the SwissFEL X-ray Free Electron Laser. A first call for testing time slots at SwissFEL was launched in autumn 2018. This means that the installation will be made available to the national and international scientific community from 2019. Comprehensive upgrade projects, such as those currently being implemented or prepared at SINQ and SLS (see p. 54), are intended to ensure the sustained competitiveness of the installations, as well as the benefits of the facility for Swiss scientists and industry. There were 2,595 users of the PSI's large-scale research facilities in 2018, up on the average from previous years. About 45% of the testing time slots were used by Swiss groups, about 85% of which came from the ETH Domain (including the PSI). The large-scale research facilities are overbooked by a factor of two on average. Industrial use of the SLS is about 10%, compared to 5–7% for the other synchrotron light sources around the world. Around 800 publications are brought out by researchers every year, resulting from access to this infrastructure.

Two new units were opened in 2018 at the NEST research and innovation building at Empa and Eawag: UMAR (Urban Mining & Recycling Unit), which is devoted to recycling in the construction industry, and-SolAce, an EPFL research unit dedicated to the energy management of a combined residential/office building. For the DFAB HOUSE unit, which explores digitalisation in the construction industry, wooden modules were designed and prefabricated in 2018 by robots developed at ETH Zurich. The Solar Fitness & Wellness unit received the "Norman Foster Solar Award", the "Award for Marketing and Architecture" and a "Watt d'Or" from the Swiss Federal Office of Energy (SFOE). And the Vision Wood unit received the Cadre d'Or in 2018. These different units are integrated into the NEST in the form of modules. However, research is also being carried out on the support structure, in particular in the ehub – Empa's energy research platform – and in Eawag's Water Hub, the experimental site that enables Eawag researchers to collect wastewater separately and to develop and demonstrate technologies for its treatment. The researchers from the Water Hub have developed "Aurin", a fertiliser made from the nutrients of human urine. This fertiliser was approved by the Federal Office for Agriculture in 2018 for use on all plant species, including edible ones (also refer to p. 33). Another important research infrastructure at Empa is the "move" demonstration platform for sustainable mobility. During the second phase of this infrastructure, which began in 2018, the focus will be on the conversion of hydrogen and carbon dioxide from the atmosphere into synthetic methane for operating gas vehicles, in what is known as power-to-gas technology.

Switzerland remains at the leading edge of nuclear fusion research with the Swiss Plasma Center (SPC) at EPFL. In 2018, the SPC continued its efforts to upgrade the TCV (Tokamak à configuration variable) and to study extended plasma applications, for example in the areas of water treatment, sterilisation and medicine. Switzerland's continued involvement in ITER/Euratom is central to the continuation of these activities. The CMi (Center of Micronanotechnology) is further research infrastructure at EPFL that can meet the increasing demands of researchers through regular investments in clean-room equipment and consistent, cost-conscious adaptation to reflect the latest technological developments. The number of CMi users, both from industry and from EPFL or other institutions, continued to rise in 2018. The infrastructure was used by 510 people in the reporting year.

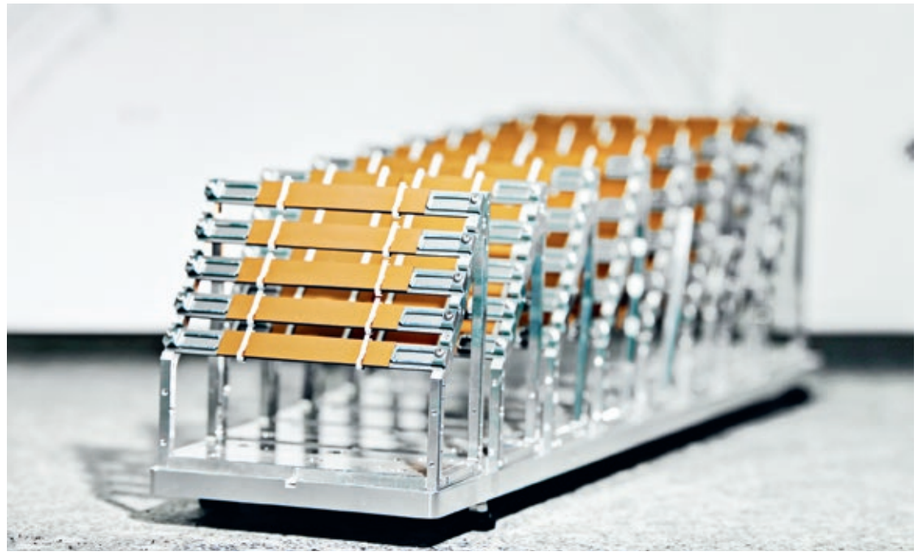
Swiss road map for research infrastructure: implementation of the strategic projects

The Swiss roadmap for research infrastructures is one of the Federal Government's planning tools. It serves as a basis for future investment in research infrastructure of national importance and in international infrastructure with Swiss involvement. The following strategic projects in the roadmap infrastructure reached important implementation milestones in 2018.

The Sustained Scientific User Lab for Simulation-based Science at ETH Zurich's National Supercomputing Centre (CSCS) is important infrastructure for Swiss researchers, providing them with access to extremely powerful computer systems for supercomputing. This user lab is working to full capacity. The applications for computing time exceed the available capacity by a factor of two to three. The number of ongoing projects and the number of users is rising steadily: in 2018 there were 132 projects with 1,584 users compared to 116 projects with 1,213 users in 2017 and 109 projects with 1190 users in 2016. In addition to providing computing capacity for Swiss researchers, the CSCS is also a member of the PRACE (Partnership for Advanced Computing in Europe) initiative, which seeks to provide world-class computing and data processing services to European researchers. The CSCS provides access to the Piz Daint supercomputer and, in return, Swiss researchers can use the facilities of the other PRACE host countries.

EPFL's Blue Brain Project (BBP) is aimed at digitally reconstructing and simulating the brain of rodents and ultimately that of humans. The project, which is an integral part of the EU FET flagship initiative Human Brain Project (HBP, see p. 54), is doing ground-breaking work in the application of computer simulation and Big Data and open science concepts in the neurosciences. For example, the NEXUS tool developed by the project team and launched in early 2018 allows data to be shared with the neuro-scientific community. In addition, the BBP has upgraded its key infrastructure by installing a state-of-the-art supercomputer at CSCS. It is also worth noting that EPFL had the project evaluated academically by international experts in autumn 2018.

The construction of the ATHOS beamline for soft X-ray radiation at the PSI's SwissFEL continued on schedule. The first light on the beamline is expected by the end of 2019, and the first pilot experiments are scheduled for 2021. With the commissioning of the ATHOS beamline, the SwissFEL will enable broader fields of application, which in turn will attract a wider circle of scientists. The second beamline was built up step by step in parallel with the first pilot experiments on the ARAMIS beamline.



Neutron optics and other tools are currently being upgraded at SINQ. Following the refurbishment, the source will boast the best lens in the world (see p. 23 f.). This is the analyser unit of the CAMEA spectrometer for simultaneous energy measurements (PSI/EPFL).

The upgrade of the CMS (Compact Muon Solenoid) detector at CERN's Large Hadron Collider will continue in order to provide an ideal environment for research into basic physical phenomena. A number of sub-projects led by ETH Zurich and the PSI were evaluated academically and approved by CERN in 2018. This will enable the next phase of these projects, which will include the final research and development, production and testing of prototypes, to begin.

In light of the ERI dispatch for the years 2021 to 2024, the SERI will publish an updated Swiss roadmap for research infrastructure in 2019. Following a completed multi-stage process including a scientific evaluation by the SNSF and a feasibility and financing assessment by the ETH Board, the plan is to include three research infrastructures from the ETH Domain in the 2019 roadmap, HPCN-24, SLS 2.0 and the Catalysis Hub. The first infrastructure is the next phase of the High-Performance Computing and Networking (HPCN) strategy, which will lead to the construction of the next generation of high-performance computing systems at ETH Zurich's CSCS. SLS 2.0 is a major upgrade of the PSI's Swiss Light Source (SLS), which will make it a fourth generation light source. This will result in a significantly higher intensity of X-ray radiation at the SLS, which will enable innovative experiments to be performed. The Catalysis Hub is intended to create new research infrastructure at ETH Zurich and EPFL that will contribute towards research into new catalyst technologies for chemical conversion processes and energy research. These three areas of research infrastructure and the BBP are included in the ETH Board's 2021–2024 strategic planning for the ETH Domain.

Involvement in international research infrastructure

The institutions of the ETH Domain are also involved in major research infrastructure and important projects at European and international level. The EuroHPC (European High-Performance Computing) initiative was launched by the European Union in 2017 to develop an exascale supercomputer based upon European technologies. Thanks to the experience of ETH Zurich's CSCS in this field, Switzerland is well positioned to participate in the project preparation work and in the formulation of objectives and targets.

The EU FET flagship HBP is designed to build a high-performance research infrastructure that will lead to new discoveries in neuroscience, information technology and brain medicine. Ongoing work on the permanent consolidation of this infrastructure is likely to lead to the creation of an external legal entity in 2019.

Headed by the PSI, the CHART collaboration (Swiss Center for Accelerator Research and Technology) is striving to promote the Future Circular Collider (FCC) project at CERN. In addition, the project is aiming to underpin the long-term competitiveness of accelerator research and its applications in Switzerland as a hub of research and industry. Among other things, CHART brings together researchers from three of the institutions of the ETH Domain, the PSI, ETH Zurich and EPFL. The first phase of this project was completed in 2018. The second phase is due to begin in 2019 and will receive financial support from CERN, the ETH Board, SERI and the CHART partner institutions.

The European ICOS network (Integrated Carbon Observation System) is intended to provide data for a better understanding of the global carbon cycle and the impact of human activities on it. Several Swiss institutions are involved, including ETH Zurich (leading house for the Swiss contribution), WSL and Empa. ICOS is backed by a network of stations that have to meet strict quality criteria. In 2018, the research station on the Jungfraujoch which Empa researchers use to collect this data was officially certified by ICOS and included in this network.

To round off this incomplete list of international research infrastructures in which the ETH Domain is involved, it should be noted that the PSI is taking part in the development of various instruments for the ESS, the European Spallation Source in Sweden, which will be the strongest neutron source in the world. This involvement and further requests for international cooperation can be attributed to the expertise that the PSI has acquired in the construction and operation of the national installations.

Strategic objective

KNOWLEDGE AND TECHNOLOGY TRANSFER

The figures on spin-offs, patents and cooperation agreements show that the institutions of the ETH Domain have been very successful in transferring their scientific discoveries to industry and the public sector. With steady growth in the continuing education programme, the institutions are also specifically promoting skills in business and society.

Enhancing Switzerland's innovative strength and competitiveness

By transforming scientific findings into marketable innovations, the ETH Domain plays a key role in Switzerland's competitiveness. This knowledge and technology transfer is documented in the current period by 358 invention and 36 software registrations as well as 230 patents and 341 licences (see Fig. 14, p. 89). Furthermore, a total of 55 spin-offs were founded by employees and graduates of the ETH Domain in 2018. There has been a noticeable trend towards digitalisation in these new startups. For example, a number of companies have been founded in the fields of artificial intelligence, machine learning, robotics and augmented reality. In the EPFL environment, the spin-off MindMaze, which specialises in augmented reality solutions for healthcare, acquired two further EPFL spin-offs from the Orthotec sector in order to strengthen its position. Most of the spin-offs from the ETH Domain have been extremely successful. In the current ranking of the "Top 100 Swiss Startups", the top 10 includes four spin-offs from EPFL and two from ETH Zurich. "Optotune" is an example of a spin-off from ETH Zurich that has become established solely through partnerships and without investors. It celebrated its 10th anniversary in 2018 and recruited its 150th employee.

In order to promote the emergence of spin-offs and maintain a close exchange with industry, the two Federal Institutes of Technology regularly organise major events with local SMEs. The first very successful innovation forum for SMEs "FORWARD" was held at EPFL in 2018, where almost 1,000 people had the opportunity to find out about EPFL's study programmes in the digital field. More than 600 people attended ETH Zurich's "Industry Day", and exhibitors and speakers rated it as extremely valuable.

The institutions are also working directly with stakeholders from private enterprise and the public sector. In the current period, they concluded 594 new cooperation agreements with the private sector and 261 with the public sector, each with a volume of over CHF 50,000 (see Fig. 15, p. 90). A typical example of the latter is WSL's Forest and Climate Change research programme with the Federal Office for the Environment (FOEN), which was launched in 2009 and has since ended. The resulting report, among other things, entitled "The principles of location knowledge for forest management in climate change", provides important decision-making aids for forestry practice in the cantons. Empa is working particularly closely with industry on its Future Mobility Demonstrator "move" for sustainable mobility and on the NEST research and innovation building, whose network has now grown to over 120 partners. The network of technology transfer centres currently being established in the area of Advanced Manufacturing also aims to make maximum use of the opportunities offered by close collaboration between science and industry. The various centres, each planned as public-private partnerships (PPPs), will develop and operate the infrastructures necessary for upscaling and transferring new production technolo-

gies into industrial applications. At the end of November, the technology briefing on "Advanced Manufacturing", which was organised in conjunction with Empa among others, took place at the PSI and was aimed at partner companies from industry and attracted more than 100 delegates.

Innovation networks and cooperation between institutions and international companies also have an important part to play in bolstering Switzerland's competitiveness. The Technology Transfer Office at ETH Zurich is a member of the programme committee of ASTP-Proton, the largest technology transfer company in Europe. In this capacity, it hosted a delegation of members from various European countries in the autumn to share best practices in knowledge and technology transfer. Another special highlight for ETH Zurich in 2018 was the tenth anniversary of Disney Research Zurich. At the Swiss research and development site of the US entertainment group, around 50 specialist staff – including 20 doctoral students from ETH Zurich – are working on innovations that will be incorporated into all Disney divisions. Thanks to the imaging process with neutrons, the PSI, collaborating with ABB, succeeded in laying the foundations in the current period for achieving significant process improvements in the production of ceramic components by the technology company. At EPFL, the "Large Enterprises" entity of the Vice Presidency for Innovation has been strengthened to actively address new partnerships with large enterprises.

Another form of international knowledge and technology transfer takes place wherever researchers from the ETH Domain make their knowledge and skills available in other countries near and far – often in collaboration with other scientific institutions. Liaising with Eawag, Spanish researchers have modelled the underground water flows in the over-fertilised lagoon of the "Mar Menor" in order to develop better management scenarios. WSL is involved in the new EU PROSNOW project. It is bringing together 13 European project partners and eight ski resorts and is aimed at developing a web-based platform for the economic and ecological optimisation of snow management for ski resorts.

Continuing education programme

The institutions are contributing towards the transfer of knowledge and skills to society and the economy through their continuing education programmes. Some continuing education courses are very specific and shape individual occupational groups, for example in the upkeep of public assets. The practical Eawag courses (PEAK), which celebrated their 25th anniversary this year, are a typical example of this. The anniversary event was well attended by guests from past PEAK courses, and this typified how the courses have fostered a culture of networking among researchers and professionals from various government agencies, as well as engineering and environmental offices, in addition to imparting practical scientific knowledge. In addition to the internal PSI Academy, the PSI's institutionalised continuing education programme primarily consists of the Radiation Protection School and the Reactor School. Some 3,330 people attended the Radiation Protection School in 2018, while the Reactor School welcomed 170 participants. WSL's continuing education programmes focus on snow-related themes, among others. The training curriculum of the WSL Institute for Snow and Avalanche Research SLF on "Piste Preparation and Piste Maintenance" was reissued in 2018 and offers professionals in piste preparation information with unparalleled substance. The Empa Academy hosted around 25 specialist and continuing education events for industry with almost 1,600 participants in 2018. Empa has also set up a new web-based help desk especially for innovative Swiss nanoscale companies.

Efforts have been made at both Federal Institutes of Technology this year and last year to make continuing education more compact and accessible. ETH Zurich, for example, launched the "School for Continuing Education", which focuses on new courses in the areas of cybersecurity and data science as well as personalised continuing education programmes that are particularly attractive to Swiss industry (also refer to p. 18). The existing continuing education courses will also be integrated within this structure. Nine CAS, two DAS and one MAS were added in 2018. EPFL, in collaboration with the University of Lausanne, offers a wide range of continuing education courses. Last year, the "Extension School" was also established, which offers further training in the field of digital technologies. The Extension School currently comprises three courses and two more extensive programmes, leading to a Certificate of Open Studies (COS) awarded for the first time in November. A COS does not require an academic degree, but provides participants with specialised knowledge in a field that is in high demand by industry. EPFL's "Center for Digital Education" has headed the development of the "Swiss MOOC Service" since 2018. This national platform is used to provide online courses such as those that have already been delivered in large numbers at EPFL since 2012.

Favourable conditions for KTT & enterprise

The institutions use a variety of tools to promote the entrepreneurial spirit of their students and researchers. They help to support emerging scientists in developing innovative products or services based on their academic work. ETH Zurich has been awarding "Pioneer Fellowships" since 2010; successful applicants may avail of the premises and support offered by the "Innovation & Entrepreneurship Lab". ETH Zurich awarded seven of these "Pioneer Fellowships" in 2018. Ten scholarships were awarded under the similarly structured "Innogrants" programme at EPFL, which is now complemented by the "Xgrants", which are aimed at Bachelor's and Master's degree students. 20 projects have received support since their introduction at the end of 2017.

The Empa spin-off CTsystems and Datwyler are in collaboration. Their aim is to market and industrialise a new technology for electromechanical polymer converters in a stacked configuration (see p. 29 f.).

The PSI awarded three of its "Founder Fellowships" for the second time in 2018. In an 18-month support programme, the fellows are supported in developing their business ideas and establishing contact with potential customers. In addition, the pilot phase for the creation of a PSI Career Center got under way, which will offer scientists and professionals structured career support and smooth the way for any transition to the private sector.

Led by the PSI, the institutions of the ETH Domain also launched the "Connecting Women's Careers in Academia and Industry" project together with the University of Zurich in 2018. It is funded by swissuniversities within the framework of project-related contributions and is intended to contribute to the networking of female scientists from the STEM sector, particularly in academia and in the private sector.

Strong involvement in "Switzerland Innovation"

The institutions of the ETH Domain are intensively involved in the generational project involving the Swiss Innovation Park, "Switzerland Innovation". The ETH Domain has several members on the board of trustees of this major project. EPFL is responsible for coordinating "Switzerland Innovation" in the French-speaking part of Switzerland. In this capacity, it organised an event in 2018 for over 300 representatives of foreign companies which are interested in research and development activities in the various areas of competence of Park Network West EPFL. The EPFL Innovation Park Lausanne, which currently has a 99% occupancy rate, was home to the American company Magic Leap in 2018. This fast-growing technology company intends to expand its research and development activities further in the field of optics and mixed reality in EPFL's innovative environment. ETH Zurich has a presence at Zurich Park in Dübendorf with its core topic of "Robotics & Mobility". Both professorships and spin-offs at ETH Zurich use the existing infrastructure of Hangar 3 for their research projects. Empa has plans to become involved in the field of modern manufacturing technologies at Zurich Park, and the theme of Advanced Manufacturing and Additive Manufacturing Technologies is also being promoted with partners at Biel Innovation Park. In the meantime, 14 companies have moved into PARK INNOVAARE, which is being set up in the vicinity of the PSI. This is where the new "Business Incubation Centre of CERN Technologies" is currently being set up, which is intended to promote business startups with links to accelerator technologies. Finally, the ESA Business Incubation Center Switzerland, which is managed by ETH Zurich, provided funding in 2018 for ten further startups in the field of aerospace technologies, the majority of which were funded by ETH Zurich and EPFL.

Strategic objective

NATIONAL COOPERATION AND COORDINATION

The institutions of the ETH Domain cooperated closely with each other and with national education and research institutions in the year under review. The strategic alliances with Federal Government-funded research institutions and activities in the field of medicine were of particular importance. Collaborations with universities and hospitals were further expanded here.

Cooperation within and outside the ETH Domain
Cooperation within the ETH Domain and with educational and research institutions in Switzerland creates added value for all participants by leveraging synergies. The forms of this cooperation are extremely diverse and are based on the initiative of the stakeholders involved, who are familiar with the respective framework conditions. The two Federal Institutes of Technology are seeking cooperation in teaching, for example through the joint development of study courses and summer schools. Seven ETH Zurich–EPFL Summer Schools were held in 2018, and in October the two senior management teams decided to launch the joint Master's degree programme in Cybersecurity, which is due to start in 2019. There is an intensive exchange going on between the two Federal Institutes of Technology and the research institutes through the involvement of the research institutes in teaching and through the joint financing of professorships (see objective 1, p. 46 ff.). In the field of research, the six institutions are particularly closely linked via the strategic focus areas or shared use and operation of research infrastructure. In the NEST research and innovation building run by Empa and Eawag, for example, ETH Zurich and Empa currently operate two units each, and EPFL and Eawag one each. More than half of all scientists from Swiss institutions who carry out their experiments at PSI's large-scale research facilities come from the ETH Domain. In addition, researchers from the various institutions of the ETH Domain often participate jointly in calls for proposals such as those for the new National Centres of Competence in Research of the Swiss National Science Foundation (SNSF) (also refer to objective 2, p. 49 ff.).

A large number of projects are carried out in direct collaboration between researchers from the various institutions of the ETH Domain and experts from other national education and research institutions. For example, fish biologists at Eawag and the University of Bern have discovered a new species of fish in Lake Thun that is markedly different morphologically, ecologically and genetically from the previously known species. The SwissForestLab, an idea conceived by WSL and which opened at the end of 2017, connects various institutions such as the Universities of Zurich, Bern and Basel as well as ETH Zurich in the field of forest research. The doctoral programme on "Epistemologies of Aesthetic Practices", which has been newly launched by ETH Zurich in cooperation with the University of Zurich and the Zurich University of the Arts, promotes doctoral projects at the interface between art and science. This swissuniversities-supported programme specifically gives graduates from universities of applied sciences the opportunity to write their dissertation at a university. The Swiss Polar Institute, founded on the initiative of EPFL, also pursues an interdisciplinary approach. The circumnavigation of Greenland, which is scheduled for 2019, will bring together researchers and students from various countries and disciplines who will scientifically study the extremely sensitive and threatened ecosystem around the North Pole.

WSL stepped up its monitoring. It has been measuring the drought damage on 1000 trees in order to understand how the trees affected have "digested" the dry summer of 2018. The timber industry could also benefit from this (see p. 26 f.).

Strategic alliances
After all, strategic research alliances are a special form of cooperation. The institutions of the ETH Domain cooperate with specific research institutions of national importance funded by the Federal Government that are active in special fields. Six professors from ETH Zurich are currently working at the competence centre for technology transfer to the machine, electrical and metal industry, inspire AG, providing specialist support to inspire AG. The competence centre's services are aimed in particular at SMEs, which often do not have their own research department. Over 70 researchers are currently working in ten research groups for inspire AG. In 2018, the Swiss Centre for Electronics and Microtechnology CSEM in Neuchâtel celebrated the 50th anniversary of the world's first quartz watch developed by the predecessor institution of CSEM. The celebrations were also attended by representatives of EPFL, which is closely linked to the CSEM thanks to the close proximity of the EPFL Neuchâtel site, various research projects and a joint professorship. EPFL also stepped up its cooperation in research and teaching with the Swiss Tropical and Public Health Institute, Swiss TPH, in Basel in the current period. Lecturers from both institutions gave seminars in Basel and Lausanne, and February saw the launch of a four-year interdisciplinary project conducted by the Swiss TPH on tuberculosis, in which the EPFL is also involved. Finally, the collaboration between EPFL and the Idiap research institution is particularly close. 40 doctoral students at the Idiap are taking part in the "Electrical Engineering" doctoral programme at EPFL. The Idiap's "Social Computing" research group and EPFL's "Digital Humanities Centre" have collaborated on various projects, including with Nestlé Research.

[1] Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA)

Implementation of the HEdA[1] in the Swiss higher education sector
The ETH Domain's large, high-cost research infrastructure, which is of nationwide importance (also refer to objective 3, p. 52 ff.), is an important contribution by the ETH Domain towards shaping the Swiss higher education sector. In addition, the two Federal Institutes of Technology are participating in the ongoing work by swissuniversities on harmonisation and coordination within the Swiss higher education landscape. The institutions of the ETH Domain are also participating in cooperation projects of nationwide significance to higher education policy that are funded by the Federal Government with project-related contributions. For instance, Swiss Library Service Platform AG began its work in the summer, which was initiated and implemented with substantial support from the ETH library. The platform is intended to unite all the university library networks in Switzerland under one roof.

Activities in the area of medicine and medical technology
The institutions of the ETH Domain also play an important role in the further development of Switzerland's healthcare system. The ETH Domain's strategic focus area "Personalized Health and Related Technologies" (PHRT) for the years 2017 to 2020 is intended to boost cooperation between hospitals, universities and the institutions of the ETH Domain in the field of highly data-led, personalized health. At the start of 2018, the 27 PHRT projects from the first calls for proposals were launched. In addition, two technology platforms for genomics and proteomics were launched. The first "Joint Personalized Health Day Switzerland" took place in March 2018 in conjunction with the Swiss Data Science Center and the Swiss Personalized Health Network (SPHN). More than 200 representatives from politics, the business world and science exchanged views on the opportunities and challenges of personalized

medicine. Within the framework of the second round of PHRT calls for proposals, a total of 24 further projects were approved in autumn 2018.

Outside the strategic focus area, the institutions of the ETH Domain are also stepping up their cooperation with medical faculties, university and cantonal hospitals, as well as specialised clinics and companies in the field of medicine and medical technology. Empa is currently engaged in three projects with the St. Gallen Cantonal Hospital. Under the auspices of Zurich University Medicine, an institutional cooperation between ETH Zurich, the University of Zurich and Zurich University Hospitals, it is also involved in major projects entitled SKINTEGRITY and "Zurich Heart". Empa researchers made important progress in growing functional heart tissue in the year under review. In the field of proton-therapy at the PSI, the inauguration of the "Gantry 3" irradiation facility marked a significant increase in capacity for patient treatment. The project was developed in association with the University of Zurich, Zurich University Hospital and an industrial partner over the past four years (also refer to objective 7, p. 64 ff.). The first researchers moved into the new AGORA building in Lausanne in October 2018. This translational cancer research cluster, in which EPFL is involved, is located at the interface of research and clinical practice and offers unique opportunities for cooperation for the entire scientific community in western Switzerland. The collaboration with the Clinique Romande de Réadaptation SuvaCare was also increased at the EPFL site in Sion.

Researchers from EPFL liaise with specialists from the clinic in the EPFL laboratories in Valais. Two major collaborations in the field of medicine were launched at ETH Zurich in 2018. In addition to the "Botnar Research Center for Child Health" located in Basel (see p. 18), there is also the "Center for Precision Medicine Research (CPMR)", which ETH Zurich founded together with the University of Zurich and Zurich University Hospitals. The CPMR is seeking to establish state-of-the-art research platforms in the field of precision medicine and improve access to patient data and samples.

Finally, an important aspect of the institutions' commitment to medicine is the training of the next generation of professionals. ETH Zurich has been running a Bachelor's degree course in Human Medicine since the autumn semester of 2017, offering 100 places per year. The course focuses on clinical aspects at an early stage and illustrates the relationship with medical practice. A further cohort embarked on a Bachelor's degree course in medicine in the autumn of 2018. ETH Zurich also filled four new professorships in the fields of medicine and medical technology in the current period. The transition between the Bachelor's degree course in Life Sciences Engineering at the EPFL and the Master's programme at the Medical Faculties of the universities of Lausanne and Geneva was further strengthened at EPFL.

Strategic objective

INTERNATIONAL POSITIONING AND COOPERATION

In 2018, the ETH Domain was able to further expand its cooperation activities with the world's leading institutions and boost its global profile. The means for this varied greatly, ranging from exchange programmes for researchers from all over the world to bottom-up initiatives for international co-operation and university alliances.

Attractiveness of the ETH Domain

The international exchange programmes are an essential part of the ETH Domain's attractiveness for the best foreign researchers. Their recruitment contributes significantly to the quality of the institutions. In particular, the European Marie Skłodowska Curie COFUND programme enables various institutions to fund promising young researchers from all over the world. For example, this programme co-finances the ETH Fellows programme, which allowed ETH Zurich to support another 33 postdoc students in 2018. Thanks to this European programme, EPFL was also able to recruit 23 doctoral students. Empa's EMPAPOSTDOCS-II programme is also a COFUND programme. 20 postdoc projects were approved in the first call for proposals. The evaluation of the projects submitted as part of the second call for proposals was completed at the end of 2018 with a further 23 postdoc projects approved.

The PSI will be employing 30 post-doctoral students on two-year contracts through the second call for proposals on the PSI-Fellow-II-3i programme, which was published in autumn 2018. These opportunities are supplemented by various other programmes. At ETH Zurich, for example, the "Society in Science – The Branco Weiss Fellowships" programme in 2018 provided support for six postdocs who are engaged in dialogue between their discipline and society. And finally, four experienced scientists from various institutions worked at WSL in 2018. The visiting fellows collaborated with WSL scientists on various projects.

Numerous efforts are being made at both Federal Institutes of Technology to attract the best foreign students. As in previous years, EPFL and ETH Zurich granted internal students and students from abroad Excellence Scholarships at Master's level. The two Federal Institutes of Technology also organise research internships for selected Bachelor's and Master's degree students. In addition, the EPFL doctoral school invites foreign students and doctoral students to participate in its summer schools. EPFL develops double diploma programmes in cooperation with various high-level foreign institutions. Among the partner universities are several renowned French universities, Polytechnique Montréal, Munich Technical University and Politecnico di Milano. Negotiations on continuing to offer some of these double diplomas are currently under way. The attractiveness of the two Federal Institutes of Technology as educational institutions is also reflected in the increase in applications from foreign students for the Master's programme. The number of enquiries increased by approximately 22% in 2018, exceeding 7,100 applications. Almost 2,000 of these were approved. In the end, 1,080 students actually started a Master's degree at one of the two Federal Institutes of Technology.

International cooperation

The institutions of the ETH Domain nurture the numerous existing and new partnerships with the international scientific community which are central to scientific excellence. The means for this networking are

very different and range from the many individual research projects with foreign partners to the external facilities of the two Federal Institutes of Technology and the numerous strategic alliances and university networks in which the two Federal Institutes of Technology are members.

ETH Zurich is, for example, a member of the International Alliance of Research Universities (IARU) or the IDEA League, for whose students ETH Zurich offered a summer school in 2018 on "Assessing and reducing society's environmental footprint". Both Federal Institutes of Technology are also members of CESAER, the European Network of Technical Universities, ISCN, the International Sustainable Campus Network and GULF, the Global University Leaders Forum, a platform of presidents of leading universities initiated by the World Economic Forum (WEF). During the Annual Meeting of the WEF in Davos in January 2018, the institutions of the ETH Domain were represented at two locations: at the exhibition on "R**ETH**INKING Intelligence" in the pavilion of the ETH Zurich and at the SLF, the Institute for Snow and Avalanche Research of the WSL. This gave the institutions the opportunity to maintain their national and international networks and to exchange ideas with policy-makers, authorities and representatives of industry. In 2018, EPFL was also active in the EuroTech Universities Alliance and RESCIF networks. EuroTech is a network of six major institutions in Europe and Israel. The network's office in Brussels focuses on monitoring science policy and on representing interests in the European Union. RESCIF is made up of 14 French-speaking universities from 11 countries. The presidents of this network gathered for a meeting in Lausanne in 2018. After several years at the helm, EPFL handed over the General Secretariat and the Bureau to the INP-HB institution in Côte d'Ivoire.

One of the bottom-up initiatives in the area of international cooperation is the new Materials Science and Technology Center for Robotics, which Empa has set up together with Imperial College London. This centre, which will start operations in January 2019, develops drones whose designs are inspired by biology. Empa and the Fraunhofer Institute for Silicate Research have signed a strategic partnership for the development of solid batteries. This cooperation starts with a project within the ICON program (International Cooperation and Networking) of the Fraunhofer Society. This is the first ICON project conducted with Switzerland. The German Ministry of Education and Research launched a funding programme in the field of "Research on Matter at Large Facilities" in September 2018. Although foreign institutions are normally not allowed to participate, this programme has been made available to a selection of foreign institutions, including the PSI. This is a strong indication of recognition of the excellence of the ETH Domain. Another individual international project in which one of the institutions of the ETH Domain is involved is the European CENTAUR project (Cost-Effective Neural Technique for Alleviation of Urban Flood Risk). Researchers from Eawag are helping to manage flood situations much more effectively thanks to sophisticated technology that is based on artificial intelligence. This sewer control system was awarded the "Most Innovative Technical Innovation of the Year" prize at the Water Industry Awards 2018. An international research network headed by the SLF, investigating the vegetation on 302 mountain peaks throughout Europe, also merits a mention. The resulting data set will be of great value for climate research and has already produced interesting findings.

The external locations of the two Federal Institutes of Technology abroad play a major role in the international reputation of the ETH Domain. Following a comprehensive evaluation, the ETH Zurich Singapore-ETH Centre (SEC) took the decision in 2018 to continue the Future Resilient Systems (FRS) programme. The aim of this programme, in which PSI researchers are also involved, is to reduce the susceptibility of important complex infrastructures such as energy, transport and communication systems to failure. In addition, a new programme – Future Health Technologies – is in preparation. ETH Studio New York organised the New York Security Challenge in 2018 together with the Zurich Information Security & Privacy Center and Bloomberg. At the EPFL Middle East site in Ras al Khaimah (United Arab Emirates), various energy management and sustainable development projects have led to a reduction in CO_2 emissions in the Emirates. In 2018, the savings exceeded 150,000 tonnes of CO_2 per year, seven times the CO_2 footprint of the EPFL campus in Lausanne. In September 2018, the EPFL executive management approved the application of the government of Ras Al Khaimah to extend the activities of the site by one year until the end of September 2020. The final decision on EPFL's continued presence in the United Arab Emirates will be taken in 2019. The basis for this is the scientific planning approved by the EPFL executive management in April 2018. In addition to the extension, any more long-term commitment would also be financed by local donors.

The economic prospects for Eawag's dried faecal sludge pellets, which can be burned, are excellent, including for the southern hemisphere (see p. 32 f.).

Active role in the framework of the bilateral cooperation with emerging economies

ETH Zurich is the leading house for Switzerland's bilateral research collaboration with China, Japan, South Korea and the Association of Southeast Asian Nations, ASEAN. In 2018, the "Seed Money Grants" and "Bridging Grants" programmes financed nine projects in which Swiss researchers collaborated with scientists from the partner countries. In addition, a new section devoted to innovation has been added to the Leading House Action Plan for 2018 to 2020 to enhance cooperation in research and technology. Within this framework, for example, the first call for proposals of the "Asia Entrepreneurship Training Program" has been launched. This programme, which is available from ETH Zurich and the ZHAW (Zurich University of Applied Sciences), aims to give Swiss start-ups access to the ASEAN market, and in particular to the Indonesian market.

The very close cooperation between the institutions of the ETH Domain and the emerging economies goes beyond the bilateral programmes defined by the SERI. At EPFL, for example, the "MOOCs4DEV" programme supported 34 MOOCs for Africa with over 750,000 registrations. Likewise at EPFL, a Seed Money programme, in collaboration with partners from Iran, India, Chile and the Philippines, made it possible to finance six transdisciplinary research projects on themes in line with the objectives of the UN's Agenda 2030 for Sustainable Development. Research in low and middle-income countries is also an important area of Eawag's activities. 2018 was marked by the tenth anniversary of the Eawag Partnership Programme for Developing Countries (EPP). Over the course of this decade, more than 80 scholar-ships have been awarded to people from more than 28 different countries.

A bibliometric analysis of the ETH Domain was conducted in 2018 (also refer to objective 2, p. 49 ff.). This study revealed that there is a clear correlation between the international direction of the research collaboration and the impact of the resulting publications. Publications with at least one foreign author not only account for the majority of the ETH Domain's publications (between 59% and 73%, depending on the institution), but also have a greater impact on all six institutions than the other types of publication.

Strategic objective

ROLE IN SOCIETY AND NATIONAL TASKS

All the institutions of the ETH Domain cultivated an exchange with society in a variety of ways in 2018. Particular emphasis was placed on cooperation with primary schools, as well as the lower and upper key stages of secondary schools, to strengthen the teaching of IT. As usual, the institutions performed the important national tasks that they take on in the public interest.

Dialogue with society

With their research, the institutions of the ETH Domain contribute to addressing socially relevant topics from a scientific perspective. Central to this is direct dialogue with the public in order to make scientific facts, problems and new findings accessible to a wider public. The six institutions nurtured this exchange in a variety of ways during the current period. In addition to well-established and very popular events for the public, such as the "Scientastic" festival at EPFL or "Treffpunkt Science City" at ETH Zurich, many one-off themed events were based on specific historical or current events. To mark the 50th anniversary of the avalanche disaster in January 1968, the WSL Institute for Snow and Avalanche Research SLF, in association with the local authority from Davos, took a look back at this accident and its aftermath. In addition to the description of the events at that time by experts and contemporary witnesses, the SLF showed what had been done in the meantime to safeguard against avalanches. Attracting some 700 visitors, local interest in this event was extremely high. The importance of dealing with the risk of avalanches is also recognised internationally. In 2018, UNESCO included this topic in the list of mankind's intangible cultural heritage – the SLF played a key role in defining the application file. In June 2018, ETH Zurich put an event of a completely different nature into a scientific context. It was involved in the fringe programme for the first Formula E race to be staged in Switzerland. In addition to an all-day symposium on "Intelligent ways towards the mobility of the future", students from ETH Zurich presented pioneering projects on the festival site over the race weekend. Another way of communicating scientific findings and the importance of research and development is via the media. The PSI marked its 30th anniversary on 15 October with a major celebration and a review of the main themes of three decades of research. The event was attended by the NZZ and LeTemps, whose special supplements on the topic reached a broad readership. "The Technologist", a journal published by EPFL in collaboration with partner universities in Europe, highlights ground-breaking research and developments and their impact on society and industry with professional articles and excellent information graphics.

The ETH Domain has particular responsibility for the sustainable development of our society, economy and environment. In their various areas of expertise, the institutions promote the networking of the relevant stakeholders and provide platforms for the scientific discussion of current issues. The new web platform for climate services of the National Centre for Climate Services was launched in November. This provides authorities, policy-makers, industry and society with a wide range of climate services. In addition to various government offices, ETH Zurich and WSL are also involved in the centre's supporting organisation. The latter contributes to the service with its focus on forestry roles and climate change. The second edition of the Swiss Resource Forum was held at Empa in 2018 under the banner "Science, industry and cities working together for more resources". The conference aims to network decision-makers from the business and political communities as well as stakeholders from research, administration and civil society. Eawag is particularly committed to training and cooperation in the water sector. The two publicly accessible platforms "Process Engineering Micropollutants" and "Water Quality" are collaborations between Eawag, the Swiss Water Association and the Federal Office for the Environment (FOEN). The agriculture of the future was discussed at ETH Zurich in June, when Federal Councillor Johann Schneider-Ammann and experts from ETH Zurich entered into a dialogue with representatives of the agricultural sector on strategies for smart farming.

Proton therapy: built in collaborative research with Varian Medical Systems, Gantry 3 offers treatment options with a maximum irradiation field of 30 x 40 cm² so that the time required to treat each patient can be kept short.
› PSI

Commitment to STEM subjects

In order to nurture young people's interest in science, technology, engineering and mathematics (STEM), the institutions of the ETH Domain also staged a series of events in 2018. The PSI and the "Girls on Ice" association made it possible for a group of young women to go on a week-long expedition to the Findel Glacier area in the Valais. The young women slipped into the roles of glacier researchers at an altitude of over 2,800 metres, studied melting processes in situ and then analysed the glacier samples that they had taken, back at the PSI. Almost 40 children had a supervised holiday week at the WSL campus in summer in association with the kihz foundation, giving them a first insight into research into forests, snow and landscape. And ETH Zurich participated in the "Learning Field" environmental education and dialogue programme, which researches biodiversity and climate change in connection with agriculture, where young researchers got to carry out studies on farms. EPFL succeeded in providing a special opportunity to introduce children to issues arising in technology. The little "Thymio" is a robot developed in Lausanne with substantial involvement by EPFL, which allows children and young people to learn basic skills and knowledge about robotics and programming. Many of these robots are already in use in schools, and over 1,500 teachers have attended accompanying courses. Empa is also involved in a similar area with its participation in the "Smartfeld" education initiative in eastern Switzerland. The platform was officially launched by the Startfeld association in August. The basic "Smartfeld" package includes half-day programming workshops for school groups, as well as parallel courses for teachers. The first main topic is intelligent textiles.

Cooperation between institutions and schools is particularly important in promoting interest in STEM subjects. Likewise in 2018, around 200 school groups carried out experiments in the PSI's own student laboratory "iLab" and tried to uncover the secrets of waves, light and vacuums. About 50 school groups were given insights into snow and avalanche research at the WSL Institute SLF. EPFL and ETH Zurich organised study information and open days for secondary school students on their campuses. EPFL also toured around schools with its theme days, ETH Zurich as part of "ETH on the Move". Both ETH Zurich and EPFL have played a very key role in the training of STEM teachers for many years. A particular challenge is currently posed by the need to boost IT teaching in primary schools, as well as in the lower and upper key stages of secondary schools. Both Federal Institutes of Technology are very active in advising the cantons on the relevant teaching content and in the further training of teaching staff. Founded in 2005, the Training and Advisory Centre for Information Technology Education at ETH Zurich completed the ten-volume "einfach Informatik" teaching aid in 2018 and put various online platforms for schools into operation. In the current period, more than 1,400 teachers benefited from the free initial and continuous training

courses in computer science offered by ETH Zurich together with the College of Education Grisons. In October, EPFL marked the official opening of the new LEARN Centre, which aims to promote innovation in the field of teaching and to deal with all levels of the education system, including the training of IT teachers. The centre hopes to contribute to overcoming the challenges of the digital transformation (also refer to p. 48). LEARN also includes the new SwissEdTech Collider, which brings together 30 startups as a co-working space, all dedicated to the development of new learning technologies.

National tasks
The ETH Domain performs various national tasks in the interests of society and on behalf of policy-makers. This involves scientific services, research infrastructures of national importance and the long-term preservation of public assets. There is something special to report in 2018 for some of the numerous national tasks. The Swiss Centre for Applied Ecotoxicology (Eawag-EPFL Ecotox Centre) celebrated its tenth anniversary in the year under review. A two-day symposium on environmental monitoring with biotests brought together people from various agencies, the private sector and academia. Working together with the Federal Offices for the Environment and Agriculture, the specialists at the centre are currently developing a monitoring concept for pesticide residues in Swiss soils. The fifth data collection of the National Forest Inventory also began in 2018. In this joint project between the Federal Office for the Environment and WSL, an inventory of around 6,500 sample areas distributed over the entire Swiss woodland in a regular network is carried out periodically. WSL has been responsible for this scientific and practical survey, which is necessary for forest management and forestry policy, since 1983 and makes these valuable data collections available to the public as a service. For its part, Empa operates the National Air Pollution Monitoring Network NABEL. A new immission limit for particulate matter was introduced in June 2018 on the basis of studies accompanying NABEL. Polluting the air with these tiny dust particles remains one of the greatest challenges facing Swiss air pollution control policy. After four years in planning and construction, the "Gantry 3" was officially unveiled at the PSI. This new irradiation facility for proton therapy, which was built in close cooperation with a medical technology company, will significantly increase the capacity for the treatment of patients with tumours (also refer to objective 5, p. 58 ff.). Research in this field attracts numerous doctoral and postdoctoral students from Switzerland and abroad, contributing towards the further development of this cutting-edge technology.

Strategic objective

SOURCES OF FINANCING AND ALLOCATION OF FUNDS

The targeted expansion of the financing base is well on course. As a result of the stagnation in federal funding from the total federal contribution, the ETH Domain recorded a slight shift in the proportion of funding in favour of research contributions (Federal Government and private sector).

The share of third-party funding (measured in terms of operating income) in the financing of the ETH Domain increased to just under 29% in the current period (2017: 27%), which means that one of the objectives, to increase the share, was achieved. However, this development is also closely linked to the development in the total federal contribution. If the federal funds from the total federal contribution stagnate at the 2017 level, as they did in the current period, this leads to an unwanted effect and to a shift in the shares.

Synergy effects were again achieved in the current period. They were made possible by the promotion of joint initiatives and projects such as the strategic focus areas. Cross-divisional projects in upgrading infrastructure also contribute towards increasing the efficiency of the ETH Domain.

Total federal contribution
In the consultation on ERI Dispatch 2017–2020, Parliament approved a budgetary framework for the ETH Domain of CHF 10,337.8m. One project was blocked or delayed because of an objection to the award of a large construction contract by ETH Zurich. The Federal Council will submit the dispatch on the 2018 accounts to Parliament requesting the creation of dedicated reserves amounting to CHF 40m.

Allocation of funds based on relevant criteria
The ETH Board allocates federal funds (total federal contribution) in accordance with Section 33a of the ETH Act. This is based on its target agreements with the two Federal Institutes of Technology and the four research institutes. The allocation of funding within the ETH Domain is governed by Section 12(2) of the Ordinance for the ETH Domain.

The strategic objectives set by the Federal Council for the ETH Domain tailored to the 2017–2020 budgetary framework form the basis for the four-year target agreements of the ETH Board with the institutions. The annual allocations of funding to the institutions are adjusted in line with the annual payment credits decided on by Parliament. In making these decisions, the ETH Board draws upon the budget requests of the institutions and the assessment of their performance.

The ETH Board allocated the available funds from the two loans, offset against the payment framework of CHF 2,530.9m (2017: CHF 2,530.8m), as follows, with a slight proportional shift in favour of the ETH Domain's strategic projects compared with the previous year:

Basic mandate/base budget including the performance-oriented award of CHF 43.4m (2018: total CHF 2,401.7m):
- ETH Zurich 1,257.0 m
- EPFL 626.1 m
- PSI 291,9 m
- WSL 58.2 m
- Empa 106.7 m
- Eawag 61.8 m

Funding for the strategic projects of the ETH Domain:
- Research infrastructure / large-scale research projects: CHF 59.6m
- Strategic focus areas: CHF 23.9m

Fig. 1: Payment framework for the ETH Domain in the ERI period 2017–2020 (status as at December 2018)

CHF millions	2016	2017	2018	2019	2020	2017–2020
ERI Dispatch of 24 February 2016 (16.025)	**2,453.8**	**2,489.1**	**2,524.3**	**2,561.6**	**2,602.8**	**10,177.8**
FD 4 budgetary framework for the ETH Domain – top-up		**40.0**	**40.0**	**40.0**	**40.0**	**160.0**
Budgetary framework for the ETH Domain 2017–2020 FD of 16 September 2016	**2,453.8**	**2,529.1**	**2,564.3**	**2,601.6**	**2,642.8**	**10,337.8**
Nominal growth in CHF		75.3	35.2	37.3	41.2	
Nominal growth in %		3.1	1.4	1.5	1.6	
Ø annual growth 2017–2020 (based on 2016 budget) in %						1.9

Fig. 2: Credits taking into account the budgetary framework of the ETH Domain (as of December 2018)

CHF millions	2016	2017	2018	2019*	2020	2017–2020
A231.0181 Federal financial contribution	2,288.7	2,377.9	2,356.7	2,365.4	2,344.3	9,444.3
A202.0134 Investment credit for ETH Domain constructions	165.1	152.9	134.2	215.8	254.4	757.3
Total credits, taking into account the budgetary framework	**2,453.8**	**2,530.8**	**2,490.9**	**2,581.2**	**2,598.7**	**10,201.6**
Nominal growth in CHF		77.0	–39.9	90.3	17.6	
Nominal growth in %		3.1	–1.6	3.6	0.7	
Ø annual growth 2017–2020 (based on 2016 budget) in %						1.4
Expected utilisation of the credits taking into account the budgetary framework in %						98.7

Fig. 3: Allocation of funding to the institutions of the ETH Domain (after taking into account the shifts in credit/funds within 2018)

						Δ 2017/2018	
CHF millions	2014	2015	2016	2017	2018	abs.	%
ETH Domain[1, 2, 9, 10]	**2,378.2**	**2,417.9**	**2,453.8**	**2,530.8**	**2,530.9**	**0.1**	**0.0**
ETH Zurich[3]	1,212.5	1,224.0	1,247.2	1,297.4	1,300.5	3.1	0.2
EPFL[4]	594.9	618.1	640.3	666.2	664.9	–1.3	–0.2
PSI[5, 8]	300.4	324.0	305.4	294.3	307.3	13.1	4.4
WSL	53.0	55.7	55.9	58.7	58.3	–0.4	–0.7
Empa[6]	106.8	106.7	110.7	114.7	105.2	–9.4	–8.2
Eawag	56.1	58.6	59.1	61.5	61.5	0.0	0.0
ETH Board[7]	54.6	30.7	35.1	38.2	33.2	–5.0	–13.2

Additional information on the 2018 financial statement:

1 Total allocation of funds in 2018 including an award (CHF 43.4m) for extraordinary achievements
2 Annual tranches in accordance with the approved budgetary framework for 2017–2020 (credits taking into account the budgetary framework of the ETH Domain): Annual tranche for 2018: CHF 2,564.3m /Federal resolution on the budget according to Federal resolution Ia estimate for 2017: CHF 2,530.9m
3 Including sustained scientific user lab for simulation based science at the CSCS: CHF 22.9m, start-up funding President: CHF 3.0m, additional costs Serious earthquake measurement network: CHF 0.8m
4 Including the neuro information technology project, the Blue Brain Project: CHF 23.2m, start-up funding President: CHF 3.0m
5 Including ATHOS / SwissFEL: CHF 8.0m, Action Plan Energy PSI: CHF 3.0m
6 Including real estate portfolio adjustment: 2018: –
7 Including strategic projects, financing the dismantling of accelerator systems at the PSI (CHF 8.0m), contributions towards the ETH Domain's pension fund with PUBLICA (degree of cover provided CHF 3.5m /fundamental change CHF 5.0m)
8 Including special funds (CHF 4.2m)
9 Including strategic focus areas (personalised health and related technologies, data science, advanced manufacturing) (total: CHF 23.9m)
10 Including research infrastructure (upgrade to CMS detectors at CERN, Swiss Plasma Center) (total: CHF 5.5m)

– Incentive and initial funding, as well as other central expenses: CHF 30.7m

Own consumption by staff of the ETH Board:
– Administration of the ETH Board and Appeals Commission: CHF 15.0m

Increase in the share of third-party funding

A considerable share of the financing for the ETH Domain is done via third-party funding.[1] Increasing the proportion of third-party funding as one of the goals of strategic objective 8 is in keeping with one of the expectations of the Federal Council, and these efforts are intended to broaden the funding base of the ETH Domain.

The total of the federal research contributions within third-party funding was just below the previous year's high figure (2018: CHF 533m; 2017: CHF 540m). The forecast (2018 budget: CHF 532m) proved correct. Research contributions from cooperation with the private sector and other project-oriented research (CHF 222m) exceeded the budgeted value (2018 budget: CHF 201m). Growth was also recorded (+9%) compared with 2017 (2017: CHF 203m). This also applies to the total of other third-party funds such as donations and various revenue with a total of CHF 292m, which thus also significantly exceeded expectations (2018 budget: CHF 190m).

The share of the entire third-party funding, measured by operating revenue, was 28.2% in the current period. Compared to the previous year (2017 financial statements: 27.1%), there was a noticeable shift in the shares and in absolute terms the total third-party funding was up in 2018 (2018: CHF 1,048m) compared to 2017 (2017: CHF 1,003m). The assessment must also include the development of balance sheet transactions, in particular the development of dedicated third-party funds from contracts recognised in accordance with IPSAS 23. If the volume increases compared to the previous year, this could be a positive indication of the expansion of the financing base. This was the case in the current period. The dedicated third-party funds entered in the balance sheet rose (2018: CHF 1,510m; 2017: CHF 1,428m). With regard to research contributions, this higher volume will have an effect on the share of operating income in future, through the corresponding additional income (including in terms of absolute figures). A further criterion for assessing whether Objective 8 has been achieved is the development of federal funding (SNSF, Innosuisse and EU FP). The volume increased significantly compared with 2017 (2018: CHF 512m; 2017: CHF 422m). This confirms the positive conclusion regarding Objective 8.

The indirect costs are offset in each case, so that the basic mandate has not been affected by these costs, and they are therefore not cross-subsidised via the financial contribution.

An indicator for the expansion of the ETH Domain's financing base can be seen in the course of the years. The funds available for competitive, project-oriented research funding and grants (above all to ETH Zurich) have doubled in the period since 2000.

Maintaining teaching and research freedom

The two Federal Institutes of Technology and the four research institutes ensure independently that the research results of third party-funded projects can be published. The units of the ETH Domain guarantee unrestricted freedom of teaching and research. The publication freedom of and with supported people and projects is also guaranteed at all times. The contracts contain a provision to that effect. The freedoms are also ensured contractually in the area of research cooperation. In addition, the handling of grants is regulated explicitly by the Code of Conduct.

[1] Second-party and third-party funding are the categories used prior to the conversion to IPSAS (International Public Sector Accounting Standards). Since 2015, these have been part of the category Research contributions (Federal Government: SNSF, Innosuisse, departmental research, EU FP), research mandates and scientific services. The former third-party funding includes industry-oriented research (private sector), the remaining project-oriented third-party resources (including cantons, municipalities, international organisations), donations and bequests, and other revenue streams (see Fig. 33, p. 102).

Increase in efficiency and use of synergy effects
Joint initiatives such as KoBe-ETH+ (Coordinated Procurement in the ETH Domain + Partners), SAP4Four (joint solution of research institutes for the management of business processes and reporting) or Lib4RI (amalgamating the libraries of the four research institutes) reduce expenses in the medium and long term. Furthermore, the joint SAP FC-based reporting platform in the ETH Domain has proved to be effective. In order to ensure that everything runs efficiently, the pooling of liquidity for the entire ETH Domain is handled by ETH Zurich. The "refine" project serves to renew ETH Zurich's resource and financial platform. It contributes towards increasing efficiency and makes use of synergies.

Contributions to increasing efficiency within the ETH Domain include a number of joint research platforms or programmes supported by several institutions of the ETH Domain to allow full networking and use of complementary research expertise. For example, the Swiss Data Science Center (SDCSC) of EPFL and ETH Zurich and the Energy System Integration (ESI) platform of the PSI, Empa, EPFL and ETH Zurich. The joint EPFL and Empa Laboratory of Materials for Renewable Energy (LMER) exists at the EPFL Valais Wallis site. Significant synergy gains will be achieved through the sharing of research infrastructure.

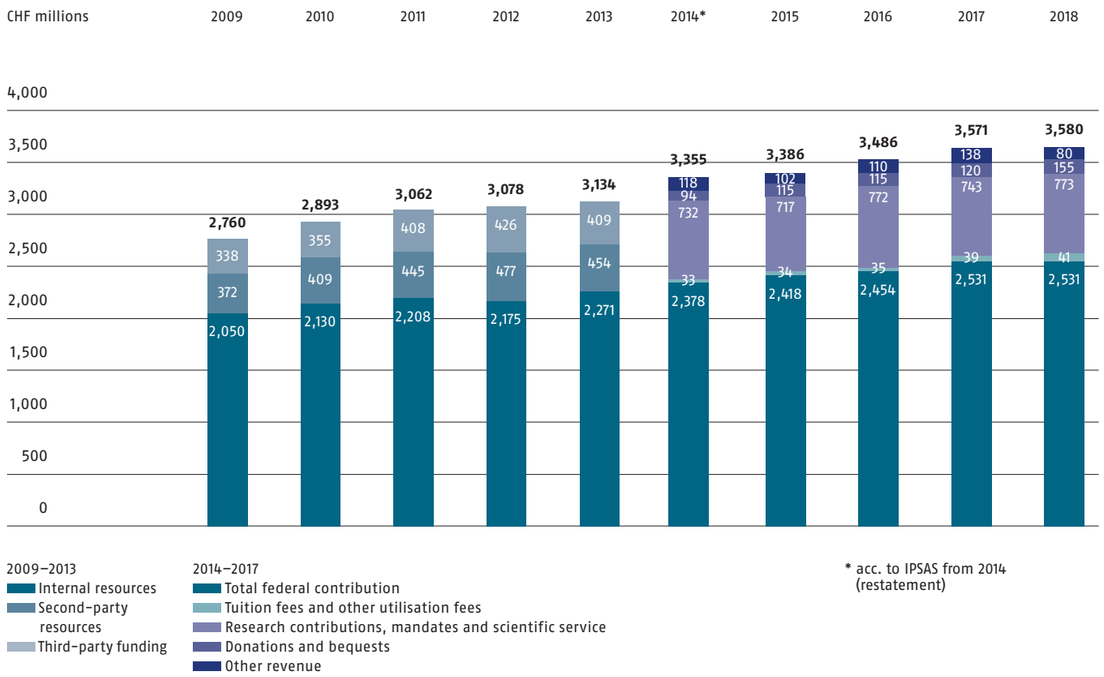
Dismantling and disposal of the PSI accelerator plants
Radioactive waste arises from the use of nuclear energy or ionising radiation applications in medicine, industry and research (MIR waste). The Nuclear Energy Act and the Radiation Protection Act set out the requirements for disposal.

The financing of the provision of a total of CHF 631m for the decommissioning of the accelerator facilities at the PSI is to be financed through annual savings amounts debited to the federal financial contribution credit. The increase in the provision compared to 2017 (CHF 426m) is based on the updated cost estimate of the Federal Government.

By the end of 2018, the savings amounted to a total of CHF 20.0m (2018: +CHF 8.0m). The PSI used around CHF 1.3m of that in the reporting period for initial measures in connection with the dismantling.

Management of core risks
To that end, we refer to the report on the risk situation and risk management in the chapter on Governance, p. 44.

Fig. 4: Development of the sources of financing



Strategic objective

REAL ESTATE MANAGEMENT

Real estate management was characterised in the current period by specific challenges such as investments in buildings with disabled access, earthquake stabilisation or dealing with contaminated sites. In addition, there was an appeal against the award procedure for a major project, the introduction of risk management and the project start of possible transfer of ownership of the real estate from the Federal Government to the ETH Domain.

Strategy and long-term portfolio development
With a view to the coming 2021–2024 performance period, 2018 saw the start of the first preparations for long-term portfolio planning which result in the so called "spatial and financial master plans" (SFMP). The first drafting and application of the SFMP for the current 2017–2020 performance period has already yielded significant findings that are factored into the planning process. A planning timeframe of twelve years is very ambitious in the academic environment, since the dynamics of teaching and research are difficult to predict and plan. In addition, the events that actually occur in the first four years of this planning period have a softening effect in part, which deprives the planning for the last four years of the period of actual significance.

In connection with the annual reduction in construction investments of 5%, the Federal Council instructed its building and real estate bodies to review the rules and standards. The ETH Domain is endeavouring to adhere to the high objectives of the Federal Government's function as a role model in the field of energy and sustainability, to ensure that values and functionality are preserved and to continue to provide best framework conditions for teaching and research in good time. Investment planning had to be revised, which had a bearing upon project planning which was already scheduled or under way in the reporting year.

In 2018, ETH Zurich started reflecting on its involvement in the digitalisation initiative at the Dübendorf Innovation Park and in medical research at the Lengg site, although this has not yet affect long-term real estate planning. On the basis of current academic planning, ETH Zurich's previous quantitative growth will be consolidated until 2021 and replaced by qualitative development. In this context, the preservation of substance and the increase in efficiency in the use of buildings are being compared against the overall growth of ETH Zurich in the case of a disproportionately small increase in space, and are perceived as prerequisites for annual investments of around CHF 200m. The ETH+ initiative launched by the Executive Board has awarded financial support to nine projects in the first round. Investment funds are to be used primarily for academic buildings, while properties for administration and central services are increasingly being rented. The partial revision of the cantonal outline plan for the Zurich-Zentrum university area was approved by the Cantonal Council; approval by the Federal Council has also taken place in the meantime. The special building regulations to increase the permissible building mass in Hönggerberg, including the planning report and open space and mobility concept, were drafted and discussed in advance with the authorities, and the public edition has been completed.

EPFL wishes to preserve its architectural heritage and to develop the real estate portfolio in line with usage needs within the financial budget. In order to absorb

budget cuts, alternative financing models have also been examined. Particular interest is given to the new forms of teaching, with interdisciplinary and practical workplaces for the flexible use of the steadily growing Massive Open Online Courses (MOOCs). The discussions held in 2016 with the canton of Vaud and the city of Lausanne showed that part of the northern site (currently sports facilities) must be made available to EPFL so that it can develop its activities further. Discussions on the possibilities of relocating these sports facilities are still ongoing. In collaboration with UNIL, steps have also been taken towards the future of the Cubotron building used by EPFL. This is in connection with the reshuffling (overflow space) that the new chemistry and physics building, the "Advanced Science Building", has triggered. The latter is the subject of the provisional 2023 construction programme. At the same time, EPFL and UNIL have jointly launched the preparation of a master plan for their universities, to be completed in the second quarter of 2019.

At the PSI, the focus for the next few years will be on the development of PARK INNOVAARE and thus on the relocation of two units with almost 400 employees. Until then, the space constraints will also be relieved for the companies already located in PARK INNOVAARE by optimisations, conversions and temporary arrangements. The planning of the subsequent use of the remaining buildings has already begun.

Real estate management in figures

The purchase value of the ETH Domain's real estate portfolio at the end of 2018 amounted to CHF 7.83bn. In terms of value, this represents about one third of the entire real estate portfolio of the Federal Government. The book value is around CHF 4.11bn. The ETH Domain uses around 390 buildings on 130 plots of land. The main usable area reported at the end of 2018, which covers 972,740 m^2 is up on 2017. A portfolio streamlining took place through an exchange transaction at ETH Zurich. ETH Zurich is creating new buildings in Zentrum, at Hönggerberg and also in Basel. Growth in space at EPFL is mainly happening at the new external sites in Geneva, Neuchâtel, Sion and Fribourg. Growth in EPFL stands out in the diagram of the percentage development in main usable area since 2009 (see Fig. 27, p. 96). The Biotech Campus in Geneva made a significant contribution to this.

The mix of space (see Fig. 28, p. 96) with state-owned buildings for own use and use by others, and buildings rented by third parties (in m^2 of main usable area since 2010), shows how some of the growth in recent years could only be covered using additional leased space. The growth in leased space is attributable to the changes in the statistical allocation of space after 2013. Without this effect, there would be a steady decrease in the leased space. A levy is now payable to the Federal Government for areas not let for operational reasons.

Ongoing and completed projects of 2018

Investments in new-builds, extensions and repairs not only lead to selective optimisation of use, but also improve the state of energy efficiency, the indoor climate, accessibility for the disabled, fire protection, earthquake resistance and running costs.

The following major projects occurred in 2018: at ETH Zurich, there was the ongoing development of the new GLC research building with laboratory and office space at Gloriastrasse for the Department D-HEST; at the Hönggerberg Campus there was firstly the planning of the overall refurbishment and expansion of the HIF building for teaching and research of the Department D-BAUG (*Bau, Umwelt und Geomatik*), and secondly the modernisation of the HPM frontage as a versatile laboratory building with a two-storey extension; and in the Zurich-Zentrum area, there was the further continuation of the refurbishment and extension of the listed Machinery Laboratory (ML/FHK).

In the case of the new BSS project on the Schällemätteli campus in Basel, a modern research building, the long-term discussion took place on the objection and how to deal with it. The appeal against the award to a general contractor approved by the competent court blocked the construction work for three quarters of a year. The funds earmarked for this major project, which had not been spent by the end of the year, led to the first application for the creation of a dedicated reserve of CHF 40m in the Federal Government-owned parent enterprise in accordance with the Finance Budget Act (Section 32a *Finanzhaushaltsgesetz*, FHG). These funds will be returned to the project at a later date. As a result of the complaint, the award decision had to be withdrawn and a re-evaluation carried out. The award decision was finally made on 24 February 2018 and upheld the original decision.

EPFL implemented the first part of the Energy Master Plan with the installation of a new 50/20 kV transformer station. The second part consisted of the upgrading and expansion of the central heating and cooling plant, which was opened at the end of 2018. In spring 2018, the new day nursery was officially opened, which was financed with third-party funds.

The new laundry for radioactive materials (OIPA building) was occupied at the PSI in September, and the expansion of the fire brigade store (OFMA) was also started in 2018. The PSI continued the project for the dismantling of the Proteus research reactor and initiated the approval procedure for the ORAB new-build project (store for low-level radioactive waste from medicine, industry and research, MIF). The PSI has already received H2-level approval from ENSI. At WSL, geological and hydrogeological test drillings were carried out for the SLF in Davos, as well as preparatory work for the extension of Building D and the replacement of the oil heating system with a groundwater heat pump. In Dübendorf and St. Gallen, Empa continued several renovations and refurbishments, and Eawag continued to develop the new FLUX building for teaching and research, i.e. the building application was submitted in spring 2018 and tender planning was begun. In addition, two new NEST units (Urban Mining and Solace) were commissioned in 2018.

Investments and source of funds in 2018

The investment credit for buildings in the ETH Domain in 2018 was CHF 174.2m following a necessary credit reallocation in the financial contribution of CHF 24.2m (12.2 %), i.e. above the previous year's value (CHF 152.9m). The main reason for the credit reallocation was reduced spending due to building delays. As a result of an appeal, an application was made for the creation of a dedicated reserve of CHF 40m for the Biosystems project in Basel. 27.3% of the investments were accounted for by new buildings, and 72.7% by preserving value and functionality. Furthermore, third-party funding of around CHF 11.9m was used for building measures, and CHF 80.4m was used from the Federal Government's financial contributions for investments in user-specific operating facilities which will be owned by the institutions. The volume of construction authorised by the ETH Domain in 2018 amounted to CHF 226.5m (see Fig. 25, p. 95). The ETH Domain received an accommodation loan of CHF 268.6m in 2018 for the calculated rent on the state-owned real estate. The Source of Funds chart (see Fig. 25, p. 95) shows the sources of funds for the buildings in the ETH Domain since 2010. The annual fluctuations are dependent on the type of grant and the scope of the current construction projects. External funds raised relate to individual projects and vary from year to year. Further plans were made for the PARK INNOVAARE project at the PSI in 2018 and investors were sought. The total requirement for investor funding for the first phase is approximately CHF 160m.

2019 construction programme: major ETH Domain projects

The ETH Domain has applied for contingent credit for planned new-build projects with its annual construction programmes. These were approved by the Federal parliament with Federal Decree Ia regarding the 2019 estimate on 13 December 2018. The 2019 construction programme for a total of CHF 269.4M (total credit), proposed by the ETH Board in 2018 and approved by the Federal Council in December 2018, includes the following three major projects: the refurbishment and extension of the ETH Zurich HIF building on the Hönggerberg campus at a cost of CHF 112.7m. The building is the head office of the D-BAUG department and was occupied in the mid-1970s. A first, extensive refurbishment is now required. Not only the extension, but also the existing building will more or less be the same as a new building after the complete refurbishment. Another major project was the application for the new FLUX laboratory building at Eawag in Dübendorf at a cost of CHF 22.7m. This will replace the 30-year-old pavilion, which no longer meets demand, and will create the necessary additional laboratory, office and seminar space. The new EPFL data centre in Ecublens at a cost of CHF 14m – in conjunction with the aforementioned central heating and cooling plant – is the third major construction project. A credit line of CHF 120.4m has also been requested for 2019. Credit lines make it possible to carry out construction projects costing up to CHF 10m, and to plan projects over CHF 10m.

Maintaining value and functionality

The ETH Board is legally obliged to maintain the value and functionality of the properties of the ETH Domain, and this is in the immediate interests of the Federal Government as the owner of the real estate and of the entire ETH Domain as its user. The state of the individual properties will be determined applying standard methodology, will be accumulated at portfolio level

Strategic real estate management in the ETH Domain

Efficient building infrastructure is a central requirement for enabling both Federal Institutes of Technology and the four research institutes to achieve their targets in teaching and research and to fulfil their performance mandate and meet the required quality standards. The real estate of the ETH Domain is owned by the Federal Government. The investment credit for construction is kept separate from the annual instalments from the Federal Government to the ETH Domain that have a different purpose. It appears in the state accounts under the Federal Office for Buildings and Logistics (FBL) and, thus, under the Federal Department of Finance. The ETH Board assumes the ownership role in trust (as one of the Federal Government's three building and real estate authorities: FBL, armasuisse and the ETH Board). It is responsible for the real estate portfolio of the ETH Domain and consults the institutions on strategic real estate management. It is the job of the ETH Domain's real estate management to ensure the functionality of the real estate portfolio in the short, medium and long term, and to preserve its cultural value. Needs-based planning, and the timely realisation of new construction projects, conversions and refurbishments, are at the heart of its remit. The preservation of value and functionality is the result of needs-based planning, geared – also in the interests of the owner – towards cost/benefit considerations, as well as corresponding controlling at ETH Board level. The owner is kept abreast of this by way of reports from the ETH Board. The ETH Domain is committed to the sustainable development of its real estate portfolio. It does so in compliance with the Federal Council mandate under Art. 73 of the Federal Constitution, as well as the government's strategy for sustainability. Targeted cooperation within the ETH Domain, based on a common environmental concept, contributes towards ensuring sustainable management of the real estate, enhancing the energy efficiency, and reducing the consumption of resources wherever possible – with a long-term focus and in an exemplary manner.

and will be compared against multi-year trends. Despite the advanced age of some of the buildings and their intensive use, the state value of 83% determined in 2018 remains constantly high in relation to the new value (see Fig. 26, p. 95). The refurbishment work on the historical building stock, in particular, is considerable in some cases, leading to challenging construction projects, due, not least of all, to new regulations and to the proper disposal of hazardous waste materials. Renovation projects in excess of CHF 770m are currently included in the 2019–2022 real estate investment plan. They triggered an investment volume of some CHF 98m in 2018. In addition, ongoing maintenance work amounting to some CHF 50m was funded from the state financial contribution. Consequently, the ETH Domain has demonstrated that it is using the building stock provided by the Federal Government responsibly and sustainably.

Coordination tasks
The Federal Council's "Sustainable Development Strategy" and the FDF's resulting guidance on sustainable real estate management have resulted in numerous standards and directives for the ETH Board as the Federal Construction and Properties Service (*Bau- und Liegenschaftsorgan*, BLO). They are drawn up by the competent government agencies concerned and those affected by the implementation. The Real Estate department, acting on behalf of the ETH Board as the BLO, performs the task of coordinating the interests of the government agencies and those of the institutions of the ETH Domain and seeks viable solutions to specific conflicts of interest. It sits on a wide range of committees, specialist and working groups on the interdisciplinary topic of sustainable construction. The variety of topics ranges from questions of procurement and contract management to numerous aspects from the environmental and energy sector, contaminated sites and earthquake prevention to social questions on the quality of building culture and landscape. In addition, the ETH Board also performs an important coordinating role as a member of the commission in the Office for University Buildings to prepare the business activities of building investment and building use contributions to the University Board.

Governance
In collaboration with the institutions, the ETH Board has introduced risk management in real estate management. This systematically checks the real estate portfolio for risks to the owner and leads to selective measures to address the identified risks adequately. With this extract from the entire risk portfolio, which is specifically tailored to real estate risks, the ETH Domain is making a further contribution to the careful handling of the Federal Government's real estate entrusted to it for use.

In 2018, the EAER and the FDF, commissioned by the Federal Council and as part of the agreed "structural reform" measures, examined options for a possible transfer of ownership of the real estate to the ETH Domain. The ETH Board will be involved on an ongoing basis and will also examine the impact of any transfer internally with the institutions. The results will be available in 2019. Whether one of the proposed options will be implemented and what impact this will have on the long-term planning of the real estate portfolio is not yet clear.

Together with the Federal Government, a monitoring system has been designed and introduced which covers current and future projects to dismantle nuclear facilities owned by the Federal Government. Most of the research facilities built and operated in the 1950s and 1960s have since been shut down. In accordance with the Federal Council's decision, the institutions of the ETH Domain are entrusted on a project-by-project basis to carry out decommissioning and dismantling measures as well as the interim storage of waste, and they are paid for this separately.

By creating a legal basis, Parliament enabled the ETH Domain to allow a modest amount of land which was currently not needed to be used by third parties, with the Federal Government sharing in the profits. In 2018, work was carried out with the Federal Finance Administration on an adaptation of the current ordinance, which differentiates the leasing arrangements and the duty to pay charges according to the other assignments of use necessary for the fulfilment of tasks.

Environment and energy

Energy demand: efficient and effective
The ETH Domain has been involved in The Confederation: Exemplary in Energy initiative since 2014. By the end of 2017, efficiency had increased by 34.8% compared to 2006, exceeding the original 25% target of the initiative by 2020. Continuous optimisation-measures ensure that energy will continue to be used as efficiently as possible for the core tasks of the institutions in the future.

The implementation of measures within the framework of The Confederation: Exemplary in Energy initiative was a focal point of the year under review in the area of environment and energy. Mobility was an important field of activity. In recent years, the institutions have developed their own mobility management systems in order to analyse and control the mobility behaviour of employees and students as a result of their activities. The exchange between the institutions on measures for sustainable mobility was stepped up in 2018. All of them rely on mobility monitoring in order to optimise the incentives for adapting behaviour in the areas of business travel, commuter and campus mobility and to achieve a reduction in CO_2 emissions.

The Machinery Laboratory/District Heating Plant (ML/FHK) belonging to ETH Zurich at Zurich Zentrum – a refurbishment performed under strict heritage conservation regulations.
› Luca Zanier/ETH Zurich

Reducing energy and electricity demand is one of the key objectives of the Federal Council's 2050 Energy Strategy, which aims to reduce end energy demand considerably by 2050. The economical use of energy in general, and electricity in particular, is to be promoted with increased efficiency measures. The institutions of the ETH Domain have been embedding this principle of action in their own environmental and energy models for years and are constantly striving to optimise their infrastructure in terms of energy efficiency. They follow a path of reduction, some of which is more ambitious than the Federal Government's guidelines. Efforts to increase efficiency must not affect the basic mandate of the institutions (such as the operation of large-scale research facilities at the PSI). This limits certain scope for activity. In a further area of conflict between the reduction in energy demand and the quantitative and qualitative growth in the demands of teaching and research, the institutions of the ETH Domain are concentrating on applying good practice to reduce relative consumption per reference quantity (full-time equivalents, energy reference area, number of measuring days for scientific experiments on large-scale research facilities, etc.) and to increase energy efficiency.

The basis for monitoring savings and efficiency gains effectively is a consistent measurement concept that captures the energy flows in buildings or plants in a precise manner. EPFL has started to develop such a measurement system in 2018. Together with the automation of the meters and new energy consumption analysis software, improved data evaluation and optimisation planning is made possible.

It is also becoming more and more apparent that the efficient supply of energy for cooling buildings represents a very great challenge, given the high level of technology in the portfolio. ETH Zurich has, therefore, placed a great deal of emphasis on increasing the efficiency of cooling production: measures implemented in 2018 include the systematic operational improvement of cooling systems, maximising free cooling and raising the temperature of cooling water. With the implementation of the Energy Master Plan at ETH Zentrum, the Executive Board intends to replace the existing decentralised cooling system with a cooling network by 2025 and, where economically and ecologically viable, to connect it to a lake water pipeline to supply the university area. In addition to energy efficiency, this will also increase the security of supply.

The improvement of the energy network has also been advanced on the Empa/Eawag campus. The new district heating network built in 2018, the so-called medium-temperature network, is set to go into operation shortly. The new heat pump will also be installed in 2019, efficiently refining the heat stored in the medium-temperature network (or in the seasonal accumulator) into high temperature.

The ETH Domain uses the life cycle cost approach to demonstrate the cost-effectiveness of all efficiency measures. The lighting level at the PSI was increased by 100% by replacing the existing luminaires on the SLS with state-of-the-art LED technology and their arrangement. At the same time, these measures are intended to bring about a 50% reduction in energy costs while reducing maintenance costs substantially. New technology also leads to added value when replacing helium compressors: modern screw compressors have replaced old piston compressors and reduce energy consumption (savings of approx. 1.3 GWh/a) as well as disruptive vibrations on the SLS.

The institutions of the ETH Domain are already on the right track thanks to their many years of efforts to implement energy-saving measures. In recent years, the energy systems in the buildings at the WSL sites have been refurbished and the cold cells renovated. The obvious savings potential has therefore already been tapped as far as possible. Further increases in efficiency are of course possible, but are also becoming more and more costly to achieve. In addition to ongoing system monitoring and optimisation, measures are planned in other areas, such as energy-saving weeks to raise awareness among employees. This underlines the ETH Domain's commitment to exemplary environmental and energy performance.

Strategic objective

WORKING CONDITIONS, EQUAL OPPORTUNITIES AND YOUNG SCIENTIFIC TALENT

Leadership culture, human resources work and equal opportunities are high on the ETH Domain's agenda. The quality of the personnel work is regularly proven by national and international seals of approval as well as various awards, equal opportunities are promoted by a number of measures, and conditions are created for fair and respectful cooperation.

Focus on human resources policy in 2018: leadership competency and code of conduct
The institutions of the ETH Domain have a large number of tools at their disposal to support employees with regard to leadership, social, methodological and professional competencies. In addition to the "Respect" campaign launched in 2017, ETH Zurich distributed the associated code of conduct "Respect" to all professors, employees and students in 2018. It embodies the shared values that inappropriate behaviour such as sexual harassment, discrimination, bullying, threats and violence will not be tolerated. The Directorate of EPFL elected a special body responsible for the introduction and smooth operation of prevention, support and response measures in cases of harassment and for dealing with the cases in question. The research institutes, i.e. the PSI, Empa and Eawag, revised their existing Codes of Conduct. WSL drafted new Directoral Guidance on the "Protection of the Individual" and its own Code of Conduct, RESPECT, in 2018.

Further development of the salary system
The "Revision of the requirements profiles" project, launched throughout the ETH Domain and commissioned by the ETH Board on the basis of recommendations from the evaluation of the new salary system, requirement profiles were updated, clarified and further standardised with the involvement of HR experts and personnel representatives from the entire ETH Domain. The aim of the project was to harmonise job profiles (introduced in 2006/2007) at ETH Domain level and to ensure that new positions are classified equally in all institutions in order to avoid system-related disparities in pay between the institutions in the future as well as to promote internal staff rotation.

Executive promotion and management development
ETH Zurich has developed a new, modular introduction concept for newly appointed professors in order to make their induction phase efficient and to introduce them to the values, culture and processes of ETH Zurich. The redesign of the training of all managers and specialists as a joint venture with the University of Applied Sciences Northwestern Switzerland (FHNW), in which PSI, WSL, Empa and Eawag are involved, is also specific to senior management development. Two pilot courses of the CAS in "Leadership in Science" have been held in German and English to date; managerial staff from the research institutes and ETH Zurich have already taken part. In addition, numerous workshops were held in all the research institutions. At WSL, for example, the topic was "Difficult dialogue situations"; at Empa, the topics included recruiting, conflict management, health promotion and negotiation skills. Eawag held numerous workshops for departmental and group leaders, as well as for PhD supervisors. In addition, new managers are supported in the first few months after joining WSL and Empa with external coaching and at the PSI with an internal mentoring programme.

Strategic objectives Objective 10 Working conditions, equal opportunities and young scientific talent

Honing scientific careers
Senior scientists play an important role in the quality of teaching and research. For this reason, ETH Zurich honed the profiles and careers of scientific personnel on permanent contracts (senior scientists) in all departments in a broad consultation in 2018. In particular, it defined four profile focal points as well as criteria such as being assigned to a professor and long-term organisational integration or financing in a department. EPFL runs training courses (including distance learning) for different categories of staff according to their needs. Among other things, certified courses in project management and a management training course for assistant professors with a tenure track were developed, which will enable them to improve the necessary organisational and people management skills from 2019 onwards.

Supporting young scientists
In order to develop its leadership function, ETH Zurich introduced new opportunities for professors and scientific personnel. For example, the series of "leadership 4to7" events offers assistant professors, in particular, the opportunity to obtain information on current issues such as recruitment or doctoral supervision, to exchange information with an established professor or to expand their own network. The course on "Lateral Leadership" is aimed at scientific personnel who do not hold a formal leadership function but who have a significant influence on how well a research group performs in practice.

In order to improve the supervision of young scientists, ETH Zurich has also developed guidelines for the mentoring of assistant professors. The purpose of this is to clarify the goals and substance of mentoring and contribute to-wards a successful relationship between mentee and mentor. An annual networking event for assistant professors with smaller workshops, "Pitch your Research-Events" and keynote speeches by former assistant professors has already been established.

The EPFL places a special emphasis on doctoral schools and the establishment of assistant professorships with tenure track (APTT) for young researchers. All incoming doctoral students were integrated into one of the twenty doctoral programmes of the EPFL, providing a platform for an intensive exchange with other doctoral students and professors. Almost half of the professorships were filled with APTTs. It also attaches great importance to promoting and supporting the career and mobility opportunities of internal candidates so that they can continue to pursue their careers at EPFL. Thanks to the collaboration with the Career Center at EPFL, the training course on "Tackling the job market successfully" was developed and run in order to prepare scientific personnel for the job market.

The PSI offers the "Transferable Skills Programme" for doctoral and postdoctoral students in order to promote interdisciplinary competencies. The "Professional Development Support" concept for the model supervision of doctoral and postdoctoral students was developed with the mandatory involvement of all scientists with mentoring tasks. Eawag stages PhD workshops; there are the Eawag Postdoc Fellowship and the "Eawag partnership program for developing countries" (EPP), which supports individuals and institutions in developing countries. "wsl-junior.ch" introduces children and young people to the world of research online and every summer Empa and PSI organise camps for children of primary school age. Year in, year out, countless children get inspired by science and research on National Future Day.

Career opportunities for all roles
In addition to annual personal development planning, there are also special courses for career planning at all functional levels as well as specific courses for doctoral and postdoctoral students to plan their professional careers (see section on the left side).

At ETH Zurich, for example, the "Individual Development Plan" (IDP) pilot project for technical and administrative staff was completed with a positive response and will be rolled out in 2019. The PSI developed a concept to strengthen diversity and inclusion, which includes mandatory training for researchers with a mentoring function. At Empa, specialist careers are treated in the same way as management careers and extend to the level of "Distinguished Senior Researcher", which corresponds to classification as a head of department. Regular management training seminars are held to ensure that the applicable management principles are adhered to. Eawag promotes internal careers such as succession arrangements for department heads and professional and personal further training with the aim of giving employees good prospects on the job market. In discussion about the careers of postdoctoral students and research associates, ETH Zurich is seeking to create priorities and framework conditions for young scientists.

Improving the supervision of doctoral students
In order to support doctoral students, the two Federal Institutes of Technology and the research institutes developed measures ranging from regular site and staff meetings to the clarification of basic questions regarding the recruitment of doctoral students. All institutions have now set up Career Centers with a view towards improving career support for doctoral and postdoctoral students, promoting the careers of women in STEM subjects and facilitating better cooperation with regional companies through networking with graduates from the ETH Domain.

Domestic labour force potential
All the institutions of the ETH Domain have consistently implemented the regulations on the obligation to register jobs that have been in force since 1 July 2018.

Appropriate measures have been taken to give priority to domestic workers in response to the mass immigration initiative. The corresponding statutory criteria and recommendations are taken into consideration in the recruitment of new employees. Vacancies in the administrative and technical fields are reported to the responsible regional employment agencies (RAV) and published on Swiss job sites.

Professional integration
ETH Zurich and Empa set up a case management system to advise and support line managers and employees who are absent for long periods, thereby promoting reintegration into the workplace. Employees are supported in building their capabilities and identifying internal reintegration opportunities. For several years now, all institutions of the ETH Domain have been offering jobs for people with employment and performance difficulties. The PSI was awarded the national prize for exemplary personnel work in the areas of health, safety and well-being of employees (Grand Prix Suisse from "Citizen at Work") for its programme for the reintegration of long-term absentees. In the case of job-related incapacity to work, possibilities for internal relocation are examined and, if necessary, internal employment opportunities are created. The focus is on vocational integration and the development of employability. EPFL achieved good results in this area by placing particular emphasis on strengthening relations between the agencies involved.

Promoting equal opportunities
In 2017, the ETH Board introduced the Gender Strategy 2017–2020. All the institutions of the ETH Domain are responsible for their own development and implementation and have professional tools at their disposal, such as the "Gender Action Plan". All institutions are participating in the "Fix the leaky pipeline" project. EPFL has been implementing the "Policy for equal opportunities in faculty recruitment" for a year now. In collaboration with UNIL, four seminars were held to raise awareness among members of the recruitment commissions of implicit bias and its implications. The action plan is intended to involve the faculties more closely in the implementation of measures to promote equal opportunities. EPFL also established a pilot process with the School of Basic Sciences to identify needs, priorities and specific actions to promote equal career opportunities and an inclusive study and work environment. The PSI carried out the "Smart Staffing – Hinder Bias" project to review and further optimise the recruitment processes with regard to open, transparent and performance-dependent standards. This explicitly addresses the possibility of advertising management positions at the PSI on a part-time basis. A specific mentoring programme for women with leadership ambitions was introduced in 2018. Several key scientific positions at WSL have been filled by women. Eawag has numerous programmes at its disposal, such as the directive on diversity, the Tailwind Grant for mothers and the automatic extension of maternity leave for group leaders in the tenure track system.

A healthy balance between work and family life
Childcare provision in the institutions of the ETH Domain is continually being expanded and adapted to current needs, and flexible working time models such as part-time work at all levels and working from home are offered as a way of reconciling work and family life. EPFL created new daycare places and introduced the "Stop the Clock" principle during maternity leave for doctoral and postdoctoral students. This serves to systematically extend contracts by the equivalent duration to support postdocs on their return from maternity leave. Since 2018, PSI employees have been able to benefit from the comprehensive flexible care offered by the KIHZ Foundation (KIHZ Flex, KIHZ Mobil) by joining the "Verbund hochschulnaher Kitas (University daycare facility network)" with the PSI's in-house daycare facility "Kiwi". In general, part-time work at all levels and lower workloads should be possible. Empa, in particular, has won a number of awards for its family-friendly employment conditions and for its well-embedded culture of diversity and equal opportunity. In addition to the award for "Familie UND Beruf" (Family AND Career), classified as "Best Practice", and the "Prix BalanceZH", the award for "HR Excellence in Research" was received from the European Commission Research & Innovation in 2018.

In 2018, the ETH Domain trained over 460 apprentices in over 20 occupations. In addition to physics and chemistry, the apprenticeship to become a biology laboratory assistant is particularly popular.
› Empa

Support for diversity
The main focus of the diversity activities remains equality between men and women. In 2019, EPFL will be taking part in the cooperation project financed by Diversity and Inclusion Benchmarking in Swiss universities. The PSI launched the "PSI Diversity Award" for senior managers for the first time in 2018. Employees got to nominate managers who promote equal opportunities and diversity. The award winner was announced and presented with the prize at the beginning of 2019. A workshop was held in 2018 for all people who act as points of contact in the PSI advisory network to improve the understanding of roles and for the purposes of networking. In addition, the PSI once again participated in the Diversity Index run by Lucerne University of Applied Sciences and Arts in 2018. The results are expected in the first semester of 2019 and will serve to determine the current situation and to define priorities and fields of action for the next period. As part of the newly created Equal Opportunities Committee, WSL dealt with diversity issues; Empa and Eawag staged events on Women in Science.

Occupational safety, protection of privacy and health
The PSI Directorate adopted a new safety mission statement in 2018. Empa developed a code of conduct that is implemented through regular campaigns. In addition, health management is regularly discussed in management training courses. Eawag and ETH Zurich (Safety, Health and Environment Department) also held various events, training courses and workshops on occupational health management.

Training of apprentices
ETH Zurich offers around 170 training places in 15 occupations and is committed to expanding the occupational fields of the future, such as computer science. There are continuing education programmes for apprentices and various measures to improve the quality of training, rotations, recruitment and supervision. EPFL's "Apprentices' Training" department coordinates the organisation and vocational training of the 100 or so apprentices. An internship application portal was specially created for school leavers in order to recruit potential candidates for future apprenticeships. The PSI trains more than 100 apprentices in 15 occupations. It has recently also started offering apprenticeships for the less able and young people with disabilities. PSI students are regular recipients of regional and national awards. National awards in 2018: at the SwissSkills, a silver medal and two diplomas went to apprentices from the PSI (apprenticeships for electronics technicians and computer scientists), as well as a "Pestalozzi-Stiftepriis" (category for best design engineers in Switzerland). WSL employs 14 apprentices. According to a study conducted by the "Great place to work" company, Empa is one of the best apprenticeship employers in Switzerland. It offers over 40 apprentices in ten different occupations a broad, thorough and varied vocational training. Eawag trains a total of 25 apprentices.

Conclusion, outlook and objectives
The focus has been on leadership and support, development and careers at all levels. Long-term strategic Human Resources issues have been addressed and at the same time the institutions have continuously improved the conditions for fair and respectful cooperation. As part of the further development of the appointment process and due to the importance of the topic of "leadership" among professors, ETH Zurich has defined leadership competencies and values that professors should possess, embody and develop. In the recruitment process, candidates are newly assessed in terms of teaching and research as well as leadership skills and personality. Two new Human Resources posts have been created at EPFL to improve coherence and efficiency and to strengthen HR processes by developing a digitalisation programme. WSL created the new female Head of Human Resources leadership role and an equal opportunities committee. In 2018, Empa developed a Code of Conduct that serves as a guideline for dealing with one another and underscores the values for which Empa stands.

Issues relating to "equal opportunities and diversity" are discussed openly and constructively and are increasingly factored into strategic decision-making. In the ETH Domain as a whole, particular importance is attached to recruiting women in scientific posts and increasing the proportion of women in management positions. The higher proportion of women in management positions shows that the efforts made are already beginning to bear fruit. Measures for the early detection and monitoring of critical situations are gaining in importance and the risk management of compliance issues such as internal mobility, data protection and digitalisation remains relevant.

Key figures personnel
On 31 December 2018, the headcount in the ETH Domain stood at 22,349 employment contracts (ECs), or 19,120.4 full-time equivalents (FTEs) (see Fig. 18, p. 92). With an increase of 859 ECs (+4%) or 488.8 FTEs, the reported growth in headcount was markedly higher than in previous years, where it ranged between 2% and 3%. Without the system-related additional 515 ECs of ETH Zurich, the growth in headcount in the ETH Domain would have been in line with previous years.[1]

The scientific personnel, which also includes doctoral students, remains the largest function group in the ETH Domain with 13,656 ECs (11,542.4 FTEs) (61.1% of the total headcount, see Fig. 18, p. 92), followed by the technical staff, which accounts for 3,838 ECs (3,494.0 FTEs) or 17.2% of the headcount. 15.8% of all employees or 3,542 ECs (2,804.7 FTEs) are administrative employees and 2.1% apprentices. The professorship with 851 ECs (818.3 FTEs) accounts for 3.8% of the total headcount.

Professors
In 2018, ETH Zurich and EPFL had a total of 687 full and associate professors and 108 assistant professors with tenure track (TT) and 56 assistant professors without TT (see Fig. 19, p. 92). The proportion of women in the three categories grew from 14.9% to 15.5% in 2018. The figures were 13.5 % for full and associate professors, 22.2% for assistant professors with TT and 26.8% for assistant professors without TT. In 2018, 67.1% of the total of 851 professors came from abroad (2017: 66.9%). 52.1% of them (2017: 53.3%) came from the EU area, and 15.0% from other countries (2017: 13.6%) (see Fig. 20, p. 93).

Financing
In 2018, 445.4 FTEs of the 511 professorships (492.1 FTEs) at ETH Zurich were financed by the total federal contribution, 17.9 FTEs by the SNSF, 5.8 FTEs with EU research programme funding and 23.0 FTEs with third-party financial research contributions, as well as with donations and bequests. 304.4 FTEs of the 340 professorships (326.1 FTEs) at EPFL were financed by the total federal contribution, 10.7 FTEs by the SNSF, 10.9 FTEs with third-party financial research contributions, as well as with donations and bequests.

Proportion of women
At the end of 2018, the proportion of women in the ETH Domain stood at 34% again. This figure practically rose in all institutions. However, the proportions vary according to discipline and institution. The lowest proportions of women are at the PSI and Empa; the highest are at Eawag (see Fig. 23, p. 94). As a result of the conversion of IT systems, the slight decline in the proportion of women at ETH Zurich is probably attributable to the 515 additional EC for teaching assistants listed.

Apprentices
The ETH Domain offered 462 apprentices an apprenticeship in more than twenty different career paths. Women accounted for 31.8% of apprentices in 2018 as well.

[1] The significantly higher headcount in the ETH Domain is due to the conversion of the IT systems at ETH Zurich on 1 January 2019. Due to project-related deadlines, the contracts of 515 teaching assistants (515 AV or 208.1 FTE) were issued until the end of January 2019 in order to migrate them to the new system and bill the hours of 2018 in January 2019. In previous years, these contracts were terminated in the course of December and the hours billed, which is why they never appeared on the 31.12. deadline. In the future, these contracts will be billed again as in the previous years before the 31.12. deadline.

KEY FIGURES

Monitoring table on the strategic objectives set by the Federal Council

Fig. 5: Monitoring table on the strategic objectives set by the Federal Council for the ETH Domain for 2017–2020

	Reference values			Monitoring	
Indicators	2008	2013	2016	2017	2018
TEACHING					
Students and doctoral students of ETH Zurich and EPFL (headcount)					
New admissions					
At Bachelor's level	4,052	5,255	5,531	4,756	4,827
Students	**16,233**	**22,099**	**24,217**	**25,059**	**26,140**
Proportion of women (%)	29.3	29.1	29.7	30.6	31.2
Proportion of foreign nationals (%)	27.3	35.5	37.4	38.4	39.3
At Bachelor's level	10,138	13,995	14,727	14,385	14,792
Proportion of women (%)	28.8	28.6	30.0	30.6	31.6
Proportion of foreign nationals (%)	23.8	30.9	31.6	29.4	30.4
At Master's level	4,649	7,241	8,662	8,895	9,517
Proportion of women (%)	28.0	29.4	28.5	29.4	29.6
Proportion of foreign nationals (%)	34.4	43.1	46.1	45.4	46.3
At Diploma level	751	0	0	0	0
On MAS/MBA programmes	695	863	828	840	827
Proportion of women (%)	34.2	34.6	37.9	38.8	40.6
Proportion of foreign nationals (%)	48.1	45.7	50.2	51.5	50.1
Mobility students [1]	–	–	–	939	1,004
Proportion of women (%)	–	–	–	35.5	32.9
Proportion of foreign nationals (%)	–	–	–	96.5	96.6
Supervision ratio					
Bachelor's and Master's students per professor	25.1	27.7	29.2	28.3	29.7
Doctoral students	**4,823**	**5,947**	**6,134**	**6,234**	**6,391**
Proportion of women (%)	28.6	30.4	31.0	30.8	31.4
Proportion of foreign nationals (%)	62.7	72.6	74.3	75.0	76.3
Supervision ratio					
Doctoral students per professor	7.8	7.7	7.7	7.6	7.8
Students and doctoral students	**21,056**	**28,046**	**30,351**	**31,293**	**32,531**
Proportion of women (%)	29.1	29.4	30.0	30.6	31.3
Proportion of foreign nationals (%)	35.4	43.3	44.9	45.7	46.6
Supervision ratio					
Students and doctoral students per professor	34.0	36.5	37.9	38.0	39.8
Degrees					
Bachelor	1,656	2,249	2,500	2,602	2,686
Diploma, Master	1,978	2,663	2,989	3,065	3,240
MAS/MBA	336	346	303	394	343
Doctorate	832	993	1,256	1,258	1,209
Teaching and supervision by the research institutes					
Teaching hours	15,569	15,670	18,023	17,992	18,659
Bachelor's, Master's and Diploma theses	391	532	575	602	623
Doctoral students	700	797	783	807	854
Proportion of women (%)	36.1	36.3	39.8	39.0	38.4
Proportion enrolled in the ETH Domain (%)	66.1	67.9	67.4	67.7	68.6
Proportion enrolled at a foreign university (%)	17.3	13.4	11.7	10.3	8.8

	Reference values			Monitoring	
Indicators	2008	2013	2016	2017	2018
RESEARCH					
Publications [2]	**–**	**–**	**–**	**–**	**–**
Research contributions, mandates and scientific services (in CHF millions)	**–**	**–**	**772.7**	**743.2**	**755.2**
of which Swiss National Science Foundation (SNSF)	141.6	209.0	257.4	260.3	254.7
of which Innosuisse	26.1	36.8	50.6	62.6	55.5
of which EU Framework programmes for Research and Innovation (FP)	97.7	135.2	142.1	139.2	141.8
KNOWLEDGE AND TECHNOLOGY TRANSFER (KTT)					
Invention disclosures [3]	–	–	–	343	358
Software notifications [3]	–	–	–	26	36
Patents	125	193	230	206	230
Licences	178	223	353	377	341
Spin-offs	46	43	50	48	55
STAFF (FTE)					
Professors	619.4	767.7	800.8	823.8	818.3
Proportion of women (%)	10.7	12.4	13.9	14.8	15.4
Proportion of foreign nationals (%)	61.8	67.1	68.0	67.2	67.3
Scientific staff	7,956.5	9,927.3	11,053.9	11,204.4	11,542.3
Technical staff	2,957.6	3,157.3	3,355.1	3,439.8	3,494.0
Administrative staff	1,771.2	2,279.0	2,577.8	2,690.0	2,804.7
Apprentices	386.0	435.0	463.7	473.6	461.1
FINANCES/REAL ESTATE					
Total federal contribution (perceived budgetary framework) (in CHF millions)	**1,949.4**	**2,271.4**	**2,453.8**	**2,530.8**	**2,530.9**
of which federal financial contribution	1,778.4	2,073.9	2,288.7	2,377.9	2,356.7
of which investment credit for construction in the ETH Domain	170.9	197.5	165.1	152.9	174.2

[1] Mobility students have constituted a separate student category since 2017.
[2] Publishing activity is assessed every four years as part of the intermediate evaluation (see p. 50 and p. 63).
[3] Additional KTT indicators introduced in 2017.

Indicators and counting methods for the monitoring table and the academic achievement report

If not specified in more detail, the term 'students' is always understood to mean students at Bachelor's and Master's levels, students on Master of Advanced Studies and Master of Business Administration (MAS/MBA) continuing education programmes, and mobility students (students who are studying at one of the Federal Institutes of Technology for one or two semesters but are registered at another university). In cases of simultaneous enrolment on several disciplines or academic levels, the prioritised discipline or level is counted. Mobility students have constituted a separate student category since 2017. Prior to then, mobility students had been included in the figures for students at Bachelor's and Master's levels. This should be borne in mind when comparing with previous years. Doctoral students, however, are defined as a separate category. Students and doctoral students are counted in 'Headcount'. Foreign students and doctoral students form two sub-categories: foreign-educated foreign nationals who were resident abroad while obtaining the relevant necessary qualifications, and Swiss-educated foreign nationals who were resident in Switzerland while obtaining the relevant necessary qualifications. The employment level of all staff is counted in terms of full-time equivalents (FTE). Professors – both full and associate, as well as assistant professors, including those holding Swiss National ScienceFoundation (SNSF) professorships – who are employed at one of the two Federal Institutes of Technology are taken into account in calculating the supervision ratio. Senior Scientists and *Maîtres d'enseignement et de recherche* (MER) from both Federal Institutes of Technology correspond to the academic staff in management roles or senior management staff. Some of them are adjunct professors. To determine the 'expanded' supervision ratio, the Senior Scientists and MER of both Federal Institutes of technology are added to the professors. The teaching hours delivered by the research institutes do not include preparation time, only the time spent in the presence of students.

Academic achievement report

Fig. 6: Students and doctoral students by discipline

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Δ 2017/2018	in %
Architecture	**2,743**	**2,994**	**3,098**	**3,177**	**3,097**	**3,066**	**3,060**	**3,030**	**3,047**	**3,041**	**−6**	**−0.2**
ETH Zurich	1,697	1,848	1,900	1,950	1,852	1,783	1,805	1,771	1,823	1,855	32	1.8
EPFL	1,046	1,146	1,198	1,227	1,245	1,283	1,255	1,259	1,224	1,186	−38	−3.1
Civil and Geomatic Engineering	**2,170**	**2,405**	**2,727**	**2,900**	**3,074**	**2,946**	**2,882**	**2,860**	**2,791**	**2,777**	**−14**	**−0.5**
ETH Zurich	1,278	1,434	1,576	1,629	1,740	1,731	1,716	1,701	1,688	1,667	−21	−1.2
EPFL	892	971	1,151	1,271	1,334	1,215	1,166	1,159	1,103	1,110	7	0.6
Engineering Sciences	**5,597**	**5,985**	**6,391**	**6,816**	**7,245**	**7,502**	**7,903**	**8,069**	**8,398**	**8,699**	**301**	**3.6**
ETH Zurich	3,677	3,901	4,167	4,341	4,549	4,729	4,930	4,993	5,135	5,224	89	1.7
EPFL	1,920	2,084	2,224	2,475	2,696	2,773	2,973	3,076	3,263	3,475	212	6.5
Information and Communications Technology	**1,929**	**2,070**	**2,253**	**2,367**	**2,536**	**2,665**	**2,809**	**3,033**	**3,261**	**3,648**	**387**	**11.9**
ETH Zurich	997	1,029	1,082	1,083	1,158	1,247	1,405	1,536	1,753	1,991	238	13.6
EPFL	932	1,041	1,171	1,284	1,378	1,418	1,404	1,497	1,508	1,657	149	9.9
Exact and Natural Sciences	**3,942**	**4,155**	**4,476**	**4,780**	**4,883**	**4,944**	**5,145**	**5,442**	**5,595**	**5,810**	**215**	**3.8**
ETH Zurich	2,470	2,606	2,790	2,903	2,972	3,024	3,157	3,352	3,505	3,691	186	5.3
EPFL	1,472	1,549	1,686	1,877	1,911	1,920	1,988	2,090	2,090	2,119	29	1.4
Human Medicine[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**99**	**192**	**93**	**93.9**
Life Sciences	**3,034**	**3,176**	**3,314**	**3,708**	**3,879**	**3,990**	**4,051**	**4,216**	**4,312**	**4,500**	**188**	**4.4**
ETH Zurich	2,391	2,472	2,551	2,823	2,923	3,012	3,044	3,162	3,218	3,326	108	3.4
EPFL	643	704	763	885	956	978	1,007	1,054	1,094	1,174	80	7.3
System-oriented Natural Sciences	**2,104**	**2,205**	**2,261**	**2,201**	**2,159**	**2,211**	**2,284**	**2,411**	**2,437**	**2,520**	**83**	**3.4**
ETH Zurich	2,104	2,205	2,261	2,201	2,159	2,211	2,284	2,411	2,437	2,520	83	3.4
Management, Technology, Economics	**819**	**859**	**833**	**870**	**897**	**913**	**913**	**972**	**973**	**966**	**−7**	**−0.7**
ETH Zurich	562	592	584	583	549	579	582	571	583	573	−10	−1.7
EPFL	257	267	249	287	348	334	331	401	390	393	3	0.8
Humanities, Social and Political Sciences[2]	**202**	**255**	**276**	**268**	**276**	**300**	**310**	**318**	**380**	**378**	**−2**	**−0.5**
ETH Zurich	202	255	276	268	276	300	310	318	366	358	−8	−2.2
EPFL	–	–	–	–	–	–	–	–	14	20	6	42.9
Total students and doctoral students	**22,540**	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**32,531**	**1,238**	**4.0**
ETH Zurich	15,378	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	21,397	790	3.8
EPFL	7,162	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	11,134	448	4.2
Women	**6,627**	**7,149**	**7,585**	**7,973**	**8,238**	**8,414**	**8,677**	**9,091**	**9,587**	**10,167**	**580**	**6.0**
ETH Zurich	4,707	5,050	5,292	5,445	5,560	5,701	5,873	6,164	6,563	6,917	354	5.4
EPFL	1,920	2,099	2,293	2,528	2,678	2,713	2,804	2,927	3,024	3,250	226	7.5
Foreign nationals	**8,396**	**9,488**	**10,456**	**11,437**	**12,152**	**12,354**	**12,804**	**13,615**	**14,290**	**15,160**	**870**	**6.1**
ETH Zurich	5,113	5,698	6,205	6,559	6,751	6,949	7,226	7,563	7,972	8,433	461	5.8
EPFL	3,283	3,790	4,251	4,878	5,401	5,405	5,578	6,052	6,318	6,727	409	6.5

[1] ETH Zurich introduced a Bachelor's degree in Human Medicine in 2017.
[2] EPFL introduced a Master's degree in Digital Humanities in 2017.

Fig. 7: Students and doctoral students by academic level

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Δ 2017/2018	in %
Bachelor's programmes	**10,970**	**11,716**	**12,600**	**13,359**	**13,995**	**13,944**	**14,292**	**14,727**	**14,385**	**14,792**	**407**	**2.8**
ETH Zurich	7,344	7,757	8,236	8,468	8,817	8,820	9,087	9,309	9,262	9,517	255	2.8
EPFL	3,626	3,959	4,364	4,891	5,178	5,124	5,205	5,418	5,123	5,275	152	3.0
Master's programmes	**5,326**	**5,997**	**6,568**	**6,981**	**7,241**	**7,781**	**8,126**	**8,662**	**8,895**	**9,517**	**622**	**7.0**
ETH Zurich	3,749	4,281	4,607	4,755	4,811	5,187	5,480	5,861	6,158	6,590	432	7.0
EPFL	1,577	1,716	1,961	2,226	2,430	2,594	2,646	2,801	2,737	2,927	190	6.9
Diploma programmes	**395**	**191**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**–**	**–**
ETH Zurich	395	191	0	0	0	0	0	0	0	0	–	–
EPFL	0	0	0	0	0	0	0	0	0	0	–	–
MAS/MBA	**676**	**792**	**801**	**911**	**863**	**805**	**836**	**828**	**840**	**827**	**−13**	**−1.5**
ETH Zurich	502	606	659	763	661	634	640	635	646	635	−11	−1.7
EPFL	174	186	142	148	202	171	196	193	194	192	−2	−1.0
Mobility[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**939**	**1,004**	**65**	**6.9**
ETH Zurich	–	–	–	–	–	–	–	–	449	480	31	6.9
EPFL	–	–	–	–	–	–	–	–	490	524	34	6.9
Total number of students	**17,367**	**18,696**	**19,969**	**21,251**	**22,099**	**22,530**	**23,254**	**24,217**	**25,059**	**26,140**	**1,081**	**4.3**
ETH Zurich	11,990	12,835	13,502	13,986	14,289	14,641	15,207	15,805	16,515	17,222	707	4.3
EPFL	5,377	5,861	6,467	7,265	7,810	7,889	8,047	8,412	8,544	8,918	374	4.4
Doctoral programmes	**5,173**	**5,408**	**5,660**	**5,836**	**5,947**	**6,007**	**6,103**	**6,134**	**6,234**	**6,391**	**157**	**2.5**
ETH Zurich	3,388	3,507	3,685	3,795	3,889	3,975	4,026	4,010	4,092	4,175	83	2.0
EPFL	1,785	1,901	1,975	2,041	2,058	2,032	2,077	2,124	2,142	2,216	74	3.5
Total students and doctoral students	**22,540**	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**32,531**	**1,238**	**4.0**
ETH Zurich	15,378	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	21,397	790	3.8
EPFL	7,162	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	11,134	448	4.2

[1] Mobility students have constituted a separate student category since 2017.

Fig. 8: New admissions to the Bachelor's level at ETH Zurich and EPFL

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Δ 2017/2018	
												in %
Architecture	689	671	646	599	604	564	573	569	437	450	13	3.0
Civil and Geomatic Engineering	513	556	638	620	613	486	493	488	366	370	4	1.1
Engineering Sciences	1,201	1,183	1,240	1,354	1,429	1,393	1,550	1,518	1,350	1,303	−47	−3.5
Information and Communications Technology	396	425	448	465	547	595	596	679	582	662	80	13.7
Exact and Natural Sciences	810	832	954	986	969	952	1,001	1,108	985	928	−57	−5.8
Human Medicine[1]	–	–	–	–	–	–	–	–	100	100	0	0.0
Life Sciences	523	529	578	700	744	721	695	778	635	696	61	9.6
System-oriented Natural Sciences	276	318	321	336	335	316	366	372	288	307	19	6.6
Management, Technology, Economics	–	–	–	–	–	–	–	–	–	–	–	–
Humanities, Social and Political Sciences	18	13	13	12	14	14	16	19	13	11	−2	−15.4
Total	**4,426**	**4,527**	**4,838**	**5,072**	**5,255**	**5,041**	**5,290**	**5,531**	**4,756**	**4,827**	**71**	**1.5**

[1] ETH Zurich introduced a Bachelor's degree in Human Medicine in 2017. New admissions in this discipline are limited to 100 and will therefore remain stable over the years.

Fig. 9: Percentage of women among students and doctoral students at ETH Zurich and EPFL

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
% at Bachelor's level	28.9	28.9	29.4	29.2	28.6	28.7	29.2	30.0	30.6	31.6
% at Master's level	29.0	29.2	29.2	28.7	29.4	29.5	28.6	28.5	29.4	29.6
% on MAS/MBA programmes	34.8	37.0	37.1	36.7	34.6	35.0	38.6	37.9	38.8	40.6
% of mobility students	–	–	–	–	–	–	–	–	35.5	32.9
% at doctoral level	29.3	30.4	29.4	29.8	30.4	30.6	30.6	31.0	30.8	31.4

Fig. 10: Percentage of foreign nationals among students and doctoral students at ETH Zurich and EPFL

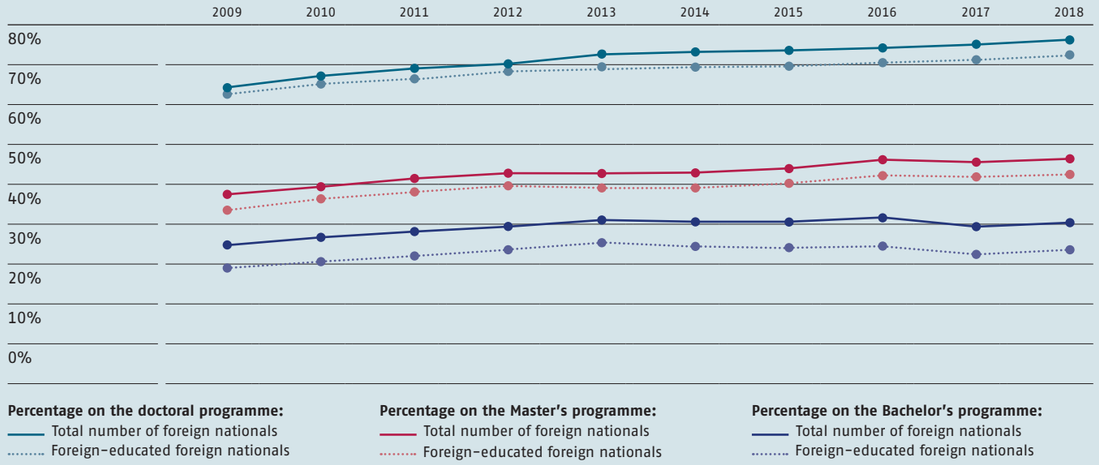


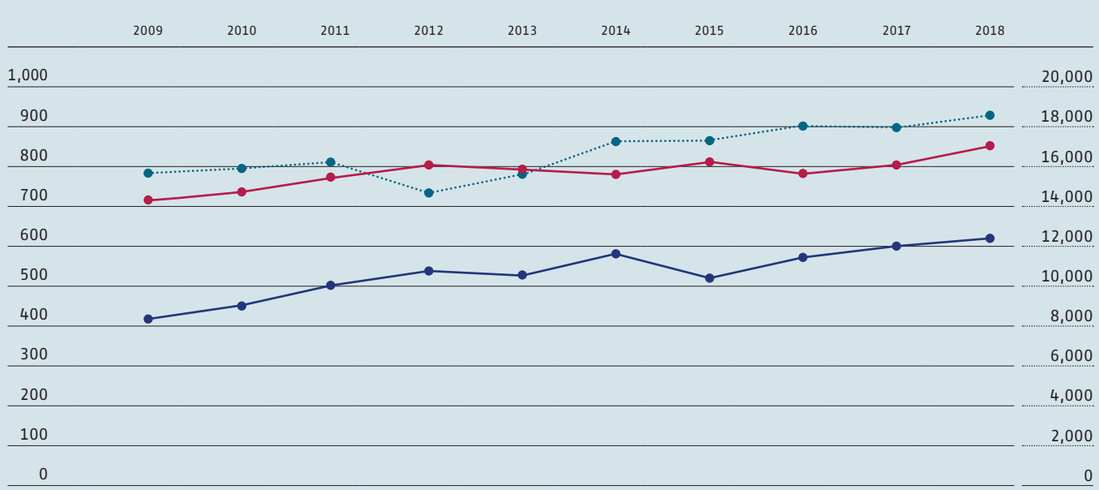
Fig. 11: Supervision ratios at ETH Zurich and EPFL

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Supervision ratio	**34.7**	**35.1**	**35.8**	**36.4**	**36.5**	**36.8**	**37.4**	**37.9**	**38.0**	**39.8**
at Bachelor's/Master's level	25.7	26.1	26.8	27.3	27.7	28.0	28.6	29.2	28.3	29.7
at doctoral level	8.0	7.9	7.9	7.8	7.7	7.8	7.8	7.7	7.6	7.8
Extended supervision ratio	**22.4**	**22.9**	**23.7**	**24.5**	**24.7**	**24.7**	**25.3**	**25.7**	**25.8**	**26.8**
at Bachelor's/Master's level	16.6	17.0	17.8	18.4	18.7	18.8	19.3	19.8	19.2	20.0
at doctoral level	5.1	5.1	5.2	5.3	5.2	5.2	5.3	5.2	5.1	5.3

Fig. 12: Degrees awarded by academic level

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Δ 2017/2018	
												in %
Bachelor	**1,835**	**1,900**	**1,988**	**2,216**	**2,249**	**2,538**	**2,528**	**2,500**	**2,602**	**2,686**	**84**	**3.2**
ETH Zurich	1,203	1,283	1,304	1,447	1,447	1,579	1,564	1,571	1,606	1,678	72	4.5
EPFL	632	617	684	769	802	959	964	929	996	1,008	12	1.2
Master/Diploma	**1,988**	**1,898**	**2,159**	**2,320**	**2,663**	**2,711**	**2,821**	**2,989**	**3,065**	**3,240**	**175**	**5.7**
ETH Zurich	1,317	1,270	1,506	1,650	1,847	1,839	1,879	2,015	2,072	2,196	124	6.0
EPFL	671	628	653	670	816	872	942	974	993	1,044	51	5.1
MAS/MBA	**400**	**283**	**301**	**256**	**346**	**260**	**254**	**303**	**394**	**343**	**–51**	**–12.9**
ETH Zurich	239	174	203	184	228	205	175	203	272	232	–40	–14.7
EPFL	161	109	98	72	118	55	79	100	122	111	–11	–9.0
Doctoral theses	**962**	**986**	**1,027**	**1,095**	**993**	**1,197**	**1,109**	**1,256**	**1,258**	**1,209**	**–49**	**–3.9**
ETH Zurich	651	650	696	747	579	769	718	851	827	802	–25	–3.0
EPFL	311	336	331	348	414	428	391	405	431	407	–24	–5.6

Fig. 13: Teaching and supervision by research institutes



Left axis: Number of supervised Bachelor's, Master's, Diploma and doctoral theses
Right axis: Number of teaching hours per year

Number of supervised doctoral theses
Number of supervised Bachelor's, Master's and Diploma theses
Number of teaching hour per year

Knowledge and technology transfer

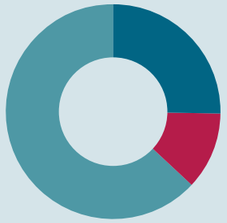
Fig. 14: Knowledge and technology transfer in the ETH Domain

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Invention disclosures	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**343**	**358**
ETH Zurich	–	–	–	–	–	–	–	–	171	205
EPFL	–	–	–	–	–	–	–	–	134	119
Research institutes	–	–	–	–	–	–	–	–	38	34
Software notifications	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**26**	**36**
ETH Zurich	–	–	–	–	–	–	–	–	20	19
EPFL	–	–	–	–	–	–	–	–	6	13
Research institutes	–	–	–	–	–	–	–	–	0	4
Patents	**155**	**128**	**147**	**195**	**193**	**211**	**219**	**230**	**206**	**230**
ETH Zurich	78	63	72	87	103	82	98	109	84	109
EPFL	44	47	52	75	66	99	88	100	95	95
Research institutes	33	18	23	33	24	30	33	21	27	26
Licences	**176**	**178**	**194**	**230**	**223**	**270**	**311**	**353**	**377**	**341**
ETH Zurich	37	39	45	35	38	35	50	78	82	87
EPFL	47	45	50	31	41	46	48	58	50	39
Research institutes	92	94	99	164	144	189	213	217	245	215
Spin-offs	**45**	**38**	**40**	**38**	**43**	**49**	**48**	**50**	**48**	**55**
ETH Zurich	24	20	22	22	24	22	25	25	25	27
EPFL	20	14	15	12	12	24	18	20	15	25
Research institutes	1	4	3	4	7	3	5	5	8	3

Invention disclosures and software notifications were introduced in 2017 as additional KTT indicators.

Licences

341



ETH Zurich	87
EPFL	39
Research institutes	215

Invention disclosures

358

Software notifications

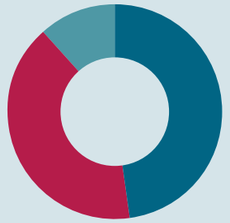
36

Spin-offs

55

Patents

230



ETH Zurich	109
EPFL	95
Research institutes	26

Fig. 15: Cooperation with the private and public sector

	2018	2017
Collaboration contracts with the private sector	**594**	**507**
Financed by the private sector	**415**	**316**
ETH Zurich	149	122
EPFL	120	99
Research institutions	146	95
Financed by Innosuisse/FP*	**179**	**191**
ETH Zurich	74	57
EPFL	49	66
Research institutions	56	68
Collaboration contracts with the Swiss public sector	**261**	**285**
ETH Zurich	100	88
EPFL	43	54
Research institutions	118	143

Number of new cooperation agreements (research agreements and scientific services) with the private and Swiss public sector involving a volume of at least CHF 50,000 per contract. These indicators were introduced in 2017.
* FP: EU Framework Programmes for Research and Innovation

KTT indicators and counting methods

The patents correspond only to priority applications, and the licences also include technology transfer agreements. The invention disclosures and software notifications correspond to the reports and notifications submitted in writing to the Technology Transfer Offices of the institutions of the ETH Domain in the year under review. They reflect activities in the early phases of the innovation process, thereby supplementing the other KTT indicators.

In order to reflect the cooperation between the institutions and private enterprise and the public sector, only recently concluded cooperation agreements are included. These are only research agreements and scientific services with a volume of at least CHF 50,000 per contract.

Cooperation with the private sector is divided into two categories: projects that are directly financed by industry in Switzerland or abroad; and those funded by Innosuisse or the EU Research Framework Programme for Research and Innovation (FP). Cooperation with the public sector includes contracts with public sector institutions in Switzerland, but not those with national or international research funding organisations and foundations.

University rankings

Fig. 16: Rankings of ETH Zurich (blue) and EPFL (red) according to the THE, QS, ARWU and CWTS Leiden Rankings in 2018/2019

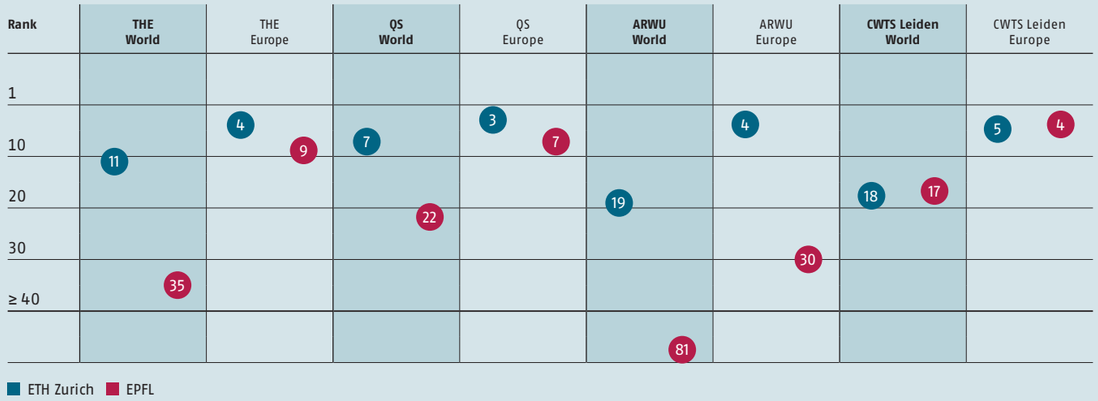
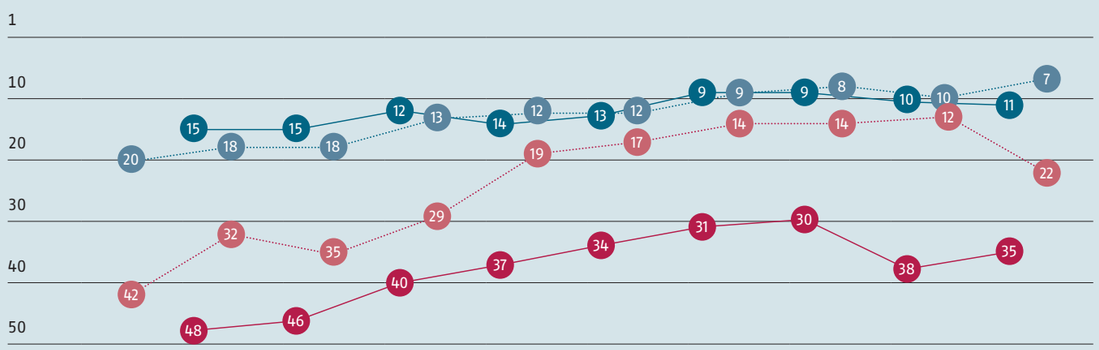


Fig. 17: Rankings of ETH Zurich (blue) and EPFL (red) according to the THE and QS World Rankings 2009–2018



THE **Times Higher Education World University Rankings** from TES Global Limited, London
QS **QS World University Rankings** from Quacquarelli Symonds Limited, London
ARWU **Academic Ranking of World Universities** from ShanghaiRanking Consultancy
CWTS Leiden **CWTS Leiden Ranking** from the Centre for Science and Technology Studies (CWTS) of the University of Leiden, Netherlands; Indicator used PP(top 10%) (s. box below)

Rankings observed worldwide

The universities are assessed and ranked by institutions and businesses using various methods. THE (Times Higher Education World University Rankings) uses 13 key performance indicators for teaching (30% weighting), research (30%), citations (30%), international outlook (7.5%) and funding by industry (2.5%). QS (QS World University Rankings) focuses mainly on reputation (with a 40% weighting on academic reputation and 10% on reputation of graduates among employers), followed by the supervision ratio (20%), citations (20%) and international outlook (10%). ARWU (Academic Rankingof World Universities of ShanghaiRanking Consultancy) makes use of performance indicators for the quality of graduates and teaching staff that are based on the number of prestigious awards received (Nobel Prize, Fields Medal) and the number of frequently-cited researchers. The publication activity is judged on the basis of the number of publications that have appeared in a select group of the most respected journals, and the ratio between the number of publications and the number of researchers at an institution. CWTS Leiden (Centre for Science and Technology Studies Leiden Ranking) is based solely on the publication activity of the universities, using this to calculate the indicators to assess research performance. One commonly used indicator for ranking the universities in the CWTS Leiden ranking is the proportion of publications each university has among the top 10% of the most-cited publications in the relevant discipline (PP(top 10%)). The rankings shown for both Federal Institutes of Technology shown (see Fig. 16) are based on this indicator.

Personnel

Fig. 18: Headcount and employment level by function group

	Men			Women			ETH Domain		
2018	EC	FTE	ø EL %	EC	FTE	ø EL %	EC	FTE	ø EL %
Professors (F/A)	594	569.1	95.8	93	88.6	95.3	687	657.7	95.7
Assistant professors with tenure track	84	84.0	100.1	24	24.0	100.0	108	108.0	100.0
Assistant professors without tenure track	41	39.4	96.1	15	13.2	88.0	56	52.6	93.9
Scientific personnel	9,550	8,170.4	85.6	4,106	3,372.0	82.1	13,656	11,542.3	84.5
of whom senior scientific personnel	688	659.6	95.9	108	96.8	89.6	796	756.4	95.0
Technical personnel	2,972	2,815.8	94.7	866	678.2	78.3	3,838	3,494.0	91.0
Administrative personnel	1,190	1,032.0	86.7	2,352	1,772.7	75.4	3,542	2,804.7	79.2
Apprentices	315	314.7	99.9	147	146.4	99.6	462	461.1	99.8
Total	**14,746**	**13,025.4**	**88.3**	**7,603**	**6,095.1**	**80.2**	**22,349**	**19,120.4**	**85.6**

Headcount (employment contracts, EC) and employment level (EL) of men, women and the entire ETH Domain by function group. As of 2010, the senior scientists, maîtres d'enseignement et de recherche (MER) and other senior personnel are counted separately, but nevertheless are still included under scientific personnel. A total of 6,391 doctoral students are enrolled at the two Federal Institutes of Technology. Of these, all who are employed in the ETH Domain are included under scientific personnel.

The significantly higher headcount in the ETH Domain is due to the conversion of the IT systems at ETH Zurich on 1 January 2019. Due to project-related deadlines, the contracts of 515 teaching assistants (515 EC or 208.1 FTE) were issued by the end of January 2019 in order to migrate them to the new system and bill the hours worked in 2018 in January 2019. In previous years, these contracts were terminated in the course of December and the hours billed, which is why they never appeared on the 31.12. deadline. In the future, these contracts will be billed again as in the previous years before the 31.12. deadline.

Fig. 19: Development in the numbers of female and male professors

	2018			2017			Changes		
	Men	Women	Total	Men	Women	Total	Men in %	Women in %	Total in %
Professors (F/A)	594	93	687	598	88	686	−0.7	5.7	0.1
Assistant professors with tenure track	84	24	108	85	24	109	−1.2	0.0	−0.9
Assistant professors without tenure track	41	15	56	40	15	55	2.5	0.0	1.8
Total professors	**719**	**132**	**851**	**723**	**127**	**850**	**−0.6**	**3.9**	**0.1**

Changes in the number of professors according to: full and associate professors, assistant professors with tenure track and assistant professors without tenure track. The three last columns show the percentage change since the previous year.

Professorial categories

The various professorial categories differ with regard to status and employment conditions. Full (F) and associate (A) professors, and assistant professors with and without tenure track (TT) teach and undertake research at both Federal Institutes of Technology. The latter can become permanently employed as full or associate professors if they meet a certain performance target. Full and associate professors are appointed permanently, while assistant professors sign employment contracts for a maximum of four years. The latter can be renewed for up to another four years.

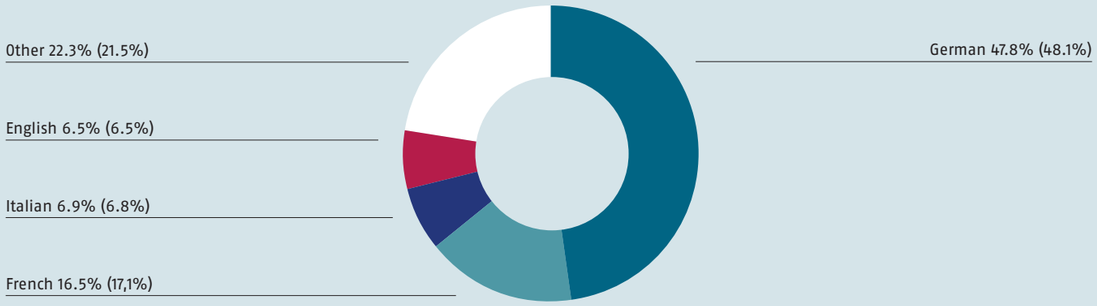
From 1 March 2017, a new provision in the ETH Ordinance concerning Professors came into force, expanding the category of full professors and regulating the framework conditions for the appointment of the affiliated professors. The embedding of the framework conditions will enable both Federal Institutes of Technology to pursue more selective and intensive cooperation with research institutions at home and abroad. On the basis of a pre-existing institutional cooperation agreement, selected individuals from domestic and foreign research institutions may be appointed as affiliated professors at one of the two Federal Institutes of Technology

Fig. 20: Origin of male and female professors

	Switzerland			EU			Other		
2018	Men	Women	Total	Men	Women	Total	Men	Women	Total
Professors (F/A)	220	28	248	301	51	352	73	14	87
Assistant professors with tenure track	13	6	19	46	12	58	25	6	31
Assistant professors without tenure track	11	2	13	22	11	33	8	2	10
Total professors	**244**	**36**	**280**	**369**	**74**	**443**	**106**	**22**	**128**

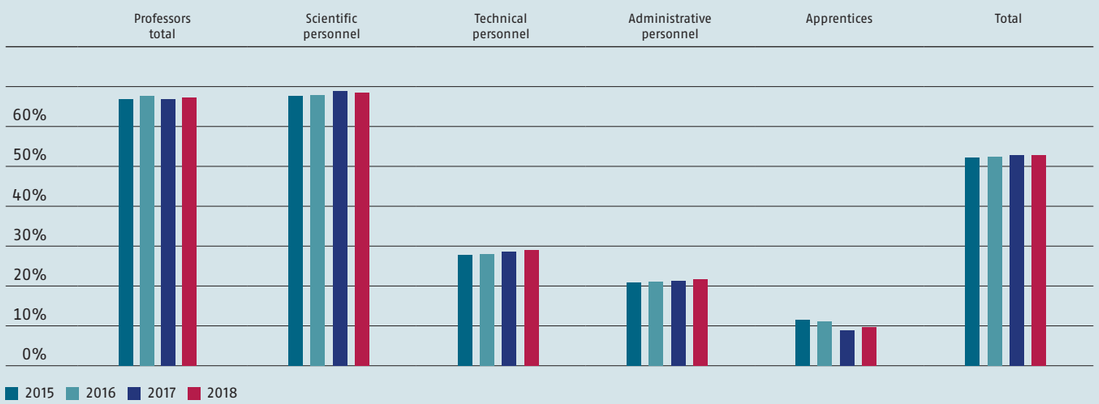
Number of professors broken down by origin: Switzerland, the EU and other countries.

Fig. 21: Employees' native languages



Native languages of employees in the ETH Domain in 2018. Figures for the previous years are shown in brackets.

Fig. 22: Development in the proportions of foreign employees by function group



Development in the proportions of foreign employees in ETH Domain by function group (in relation to the number of employment contracts).

Fig. 23: Development in the proportion of women by institution

Development in the proportion of women by institution over the past four years (in relation to the number of employment contracts).

Fig. 24: Source of funds by function group

Function group		Professors (all)	Scientific personnel	Technical personnel	Administrative personnel	Total
Source of funds						
Total federal contribution	2017	756.7	5,955.0	2,858.1	2,393.4	**11,963.2**
Federal financial contribution	2018	749.8	6,254.2	2,920.1	2,502.7	**12,426.8**
	Δ 2017/2018	−6.9	299.2	62.0	109.3	**463.6**
Third-party resources	2017	35.4	3,902.7	225.6	106.1	**4,269.8**
Research funding (SNSF, Innosuisse, further), government-funded research and EU research programmes	2018	34.5	3,833.4	193.9	99.0	**4,160.8**
	Δ 2017/2018	−0.9	−69.3	−31.7	−7.1	**−109.0**
Industry-oriented research, donations/bequests	2017	31.4	1,348.1	355.4	190.1	**1,925.0**
	2018	33.9	1,461.9	371.9	204.0	**2,071.7**
	Δ 2017/2018	2.5	113.8	16.5	13.9	**146.7**
Total	2017	823.5	11,205.8	3,439.1	2,689.6	**18,158.0**
	2018	818.2	11,549.5	3,485.9	2,805.7	**18,659.3**
	Δ 2017/2018	−5.3	343.7	46.8	116.1	**501.3**

Source of funds according to function groups (in FTEs) in 2018 compared to 2017. Δ (delta) shows the absolute change compared to the previous year. Figures exclude apprentices (461.1 FTEs) and trainees.

Real estate

Fig. 25: Source of funds for ETH Domain constructions (in CHF millions)

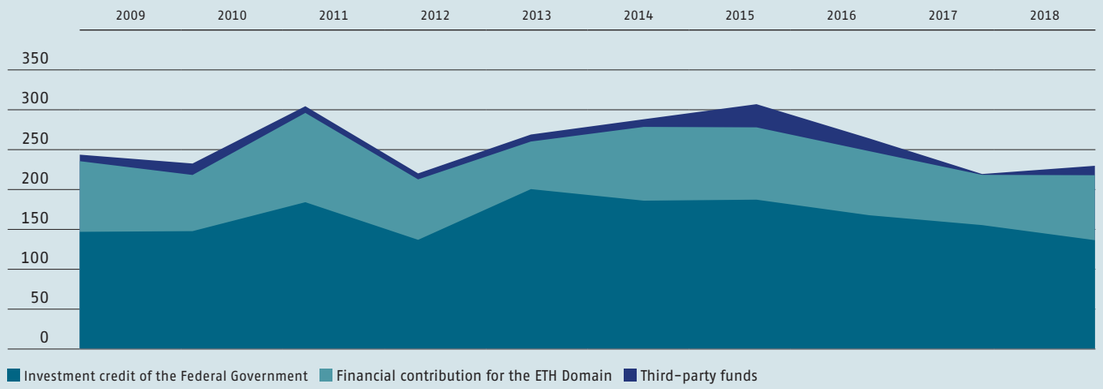
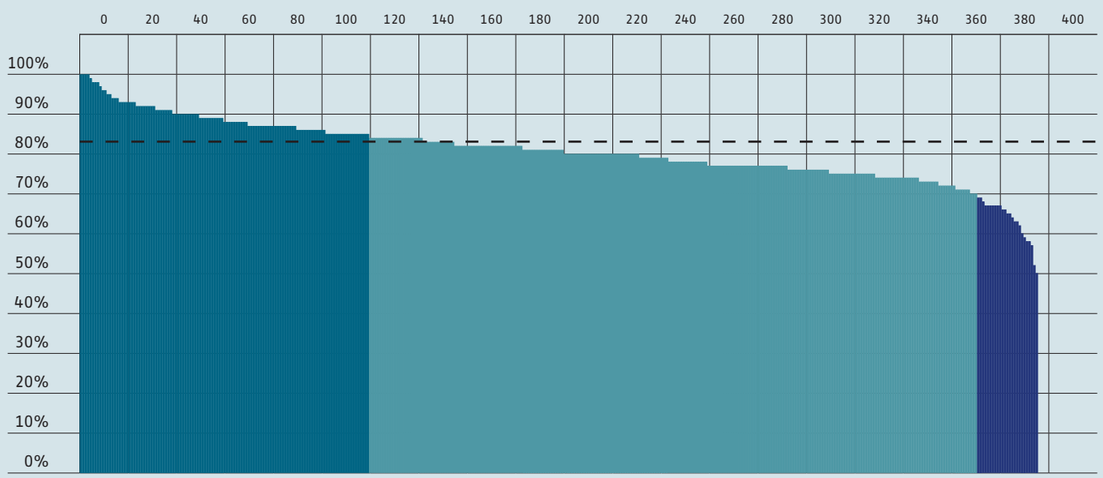


Fig. 26: Condition value as of 31 December 2018



Number of properties recorded: 394

- Very good condition, as new
- Good condition, no measures needed
- -- Average weighted by original value of properties: 83 %
- Average condition, plan and implement measures
- Poor condition, measures needed

Fig. 27: Development of the main usable area by institution in %

Fig. 28: Mix of areas (in 1,000 m²)

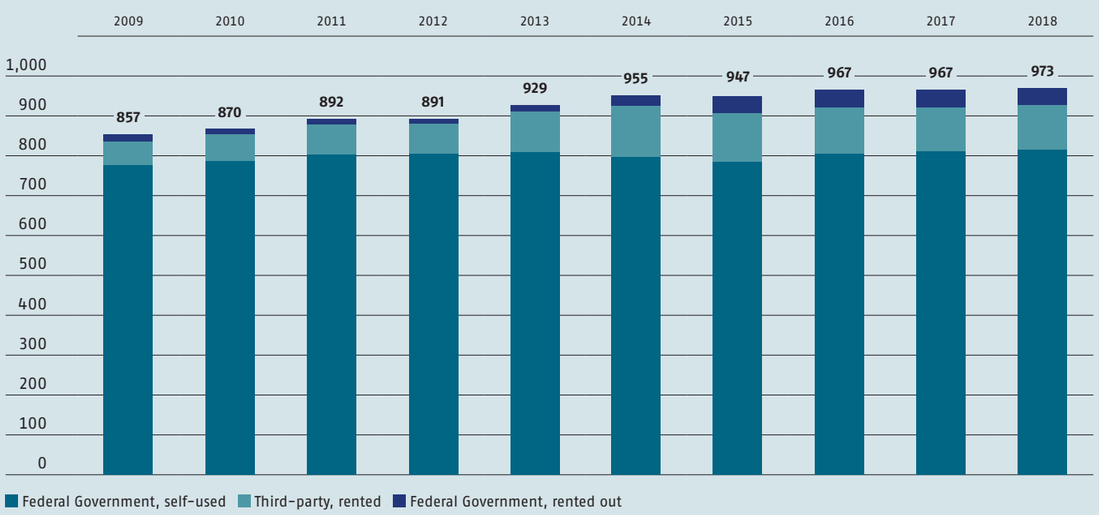


Fig. 29: Quantity structure of the ETH Domain portfolio

CHF millions	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Buildings/facilities							
Quantity	162	83	138	24	28	13	448
Original value	3,565	1,669	627	103	362	102	6,428
Book value	1,350	912	243	47	105	52	2,709
Plots							
Quantity	69	20	15	16	4	4	128
Book value	691	246	30	24	63	10	1,064
Book value of installations under construction	270	45	12	1	5	4	337
Building rights (not valued, in compliance with regulations)							0
Total assets (book value of real estate)	**2,311**	**1,203**	**285**	**72**	**174**	**67**	**4,110**
Provisions (e.g. for polluted sites, asbestos, radioactive waste)							306

Quantity and value of all government-owned real estate allocated to the institutions of the ETH Domain.

Fig. 30: Investments

CHF 1,000	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Investment credit from Federal Government	83,500	32,000	10,750	1,235	4,250	2,475	134,210
of which for new or replacement constructions	26,511	1,171	5,879	10	900	2,154	36,625
of which for maintenance of value and functionality	56,989	30,829	4,871	1,225	3,350	321	97,585
Financial contribution investments (for user-specific construction)	57,267	14,371	5,260	261	2,971	245	80,374
Third-party resources	1,125	7,776	0	0	3,008	0	11,909
Construction expenses of the Institutions	141,891	54,147	16,010	1,496	10,228	2,720	226,493
Main usable area (m²)	479,050	283,970	112,410	20,080	59,850	17,380	972,740
Construction expenses per m² main usable area (CHF / m²)	296	191	142	74	171	156	233

2018 investments in the ETH Domain portfolio, based on the main usable area (in m²). This is the part of the usable area that is directly allocated to the core task of teaching and research. Because the research institutes themselves do not provide teaching, a figure for the area across the entire Domain – for example in relation to the number of students – would not be very informative.

Environment and energy

Fig. 31: Environment and energy data

		ETH Domain 2016	ETH Domain 2017	ETH Zurich Total	EPFL Total	PSI Total	WSL Total	Empa Total	Eawag Total	ETH Domain Trend 2018[1]
BASIC DATA										
Energy reference area (ERA)[2]	m²	1,471,508	1,475,985	692,662	437,415	166,750	28,246	122,812	28,100	1,470,019
Full-time equivalent[3]	FTE	35,310	36,103	20,415	11,373	2,031	610	1,018	656	37,378
ENERGY[4]										
Final energy, net[7]	**kWh/a**	**430,768,848**	**429,011,863**	**167,376,588**	**97,228,239**	**137,308,911**	**4,729,615**	**17,968,245**	**4,400,265**	**428,986,372**
Electricity, net (not incl. self-produced)	**kWh/a**	**360,612,906**	**357,484,834**	**132,953,000**	**77,333,271**	**129,992,836**	**2,897,976**	**10,941,611**	**3,366,140**	**346,989,828**
Consumption of uncertified electricity	kWh/a	60,638,256	50,939,413	4,590,000	1,356,577	44,992,836	0	0	0	
Consumption of certified electricity	kWh/a	306,751,078	306,545,421	128,363,000	75,976,694	85,000,000	2,897,976	10,941,611	3,366,140	
Electricity (without naturemade star)	kWh/a	292,399,481	298,164,120	124,363,000	74,614,207	85,000,000	858,063	13,328,850	0	
Photovoltaic naturemade star	kWh/a	2,078,078	2,084,150	0	2,000,000	0	0	0	84,150	
Hydro power naturemade star	kWh/a	12,214,009	13,936,394	4,000,000	4,716,487	0	1,937,917	0	3,281,990	
Wind naturemade star	kWh/a	0	101,996	0	0	0	101,996	0	0	
Sale of electricity	kWh/a	−6,776,428	−7,741,239	0	−5,354,000	0	0	−2,387,239	0	
Heat	**kWh/a**	**67,627,075**	**69,191,978**	**33,537,000**	**19,544,968**	**6,993,075**	**1,400,942**	**6,827,953**	**888,040**	
Fuel oil	kWh/a	4,540,980	7,918,044	308,000	6,885,131	420,175	300,258	0	4,480	
Natural gas	kWh/a	59,752,463	53,911,698	34,287,000	12,619,686	0	0	6,997,982	7,030	
District heating	kWh/a	28,730,003	33,038,081	24,532,000	350,151	6,572,900	0	706,500	876,530	
Woodchip	kWh/a	1,463,127	1,100,684	0	0	0	1,100,684	0	0	
Sale of heat	kWh/a	−26,859,498	−26,776,529	−25,590,000	−310,000	0	0	−876,529	0	
Fuels (own vehicles)	**kWh/a**	**2,528,867**	**2,335,051**	**886,588**	**350,000**	**323,000**	**430,697**	**198,681**	**146,085**	
Energy: additional information										
Energy costs, electricity and heat[5]	CHF/a	47,499,551	47,371,233	24,430,920	9,966,132	10,360,802	447,826	1,699,030	466,523	48,660,186
Self-generated renewable electricity	kWh/a	520,813	622,450	205,253	0	0	128,420	125,532	163,245	
Total sale to third parties	kWh/a	−33,635,926	−34,517,768	−25,590,000	−5,664,000	0	0	−3,263,768	0	
WATER (DRINKING WATER)	m³	649,066	663,418	355,756	182,098	94,366	8,318	19,905	2,975	680,576
MATERIALS										
Paper	**kg**	**411,592**	**344,133**	**211,000**	**87,990**	**25,687**	**5,775**	**7,968**	**5,713**	**368,649**
Paper, new fibre	kg	173,722	114,284	85,750	13,683	7,724	1,476	5,578	73	62,507
Paper, recycled	kg	237,870	229,849	125,250	74,307	17,963	4,299	2,390	5,640	306,124
KEY FIGURES: ENVIRONMENTAL IMPACT										
Primary energy[6]	**kWh/a**	**616,876,534**	**597,739,400**	**200,930,119**	**118,674,228**	**243,574,309**	**7,209,525**	**21,645,330**	**5,705,889**	
Proportion of renewable energies	**%**	**65**	**68**	**62**	**65**	**75**	**55**	**60**	**70**	
CO_2 emissions	**t CO_2/a**	**36,776**	**35,553**	**13,724**	**8,103**	**10,409**	**412**	**2,508**	**396**	

[1] Provisional figures for the year under review (trend), as at: start of March 2018.
[2] The energy reference area is the sum of all gross floor areas, above and below ground, which must be heated or air-conditioned in order to be used.
[3] The FTE (full-time equivalent) value listed here was supplemented by the number of students with an FTE value of 0.68 to produce the consumption per person.
[4] The key figures indicated for electricity and heat show the total consumption of both for buildings, as well as for teaching and research activities.
[5] The key indicator "energy costs" shows all expenditure (cash out) for the provision of energy (heat and electricity).
[6] In energy economics, one refers to primary energy as the energy that is available using the original forms or resources of energy, such as fuel (e. g. coal or natural gas), as well as energy carriers such as sun, wind or nuclear fuels.
[7] Final energy is the portion of the primary energy that is left after losses due to energy conversion and transmission, after it is supplied via the consumer's domestic connection. The final energy basically corresponds to the energy that is purchased.

FINANCES

* Extract of the Financial Report 2018

Financial report:
www.ethboard.ch/financialreport2018

Financing statement

The Federal Government subsidises the ETH Domain to the tune of around 70% via the total federal contribution. A further 20% is financed through competitive federal research contributions. The private sector contributes a significant part in the form of research contributions.

Source of funds (revenue) for financing
The total operating revenue of the ETH Domain was CHF 3,571m in the current period. This volume of revenue corresponds to the high volume of the previous year's total: (2017: CHF 3,572m). The expectations set out in the 2018 budget (CHF 3,490m including the top-up) were exceeded, however. The 2018 budget report did not include the top-up in the total federal contribution of CHF 52.9m in accordance with Federal Decree Ia to the 2018 budget under Revenue.

As in 2017, the Federal Government as owner financed the ETH Domain with an unchanged high share of just under 86%. The total federal contribution remained unchanged at 71%; its absolute amount was also identical to that of the previous year (CHF 2,531m).

The share of funding from research contributions raised via the two funding bodies SNSF and Innosuisse, federal government research and the EU Framework Programmes for Research and Innovation (FP), as well as the share contributed indirectly by the Federal Government also remained unchanged at a total of 15% of the financial volume. The share of third-party resources, measured in terms of operating revenue, remained constant (2018: 13.3%). This is in spite of the slight increase on 2017.

Total contribution by the Federal Government
Budgetary framework for the ETH Domain 2017–2020
The approved budgetary framework amounts to a maximum of CHF 10,337.8m (Ø annual growth: 1.9%). It is expected that 98.7% of the funds (CHF 10,201.6m) will have been used at the end of the performance period, corresponding to an average annual growth rate of 1.4% (see Fig. 1 and 2, objective 8, p. 68).

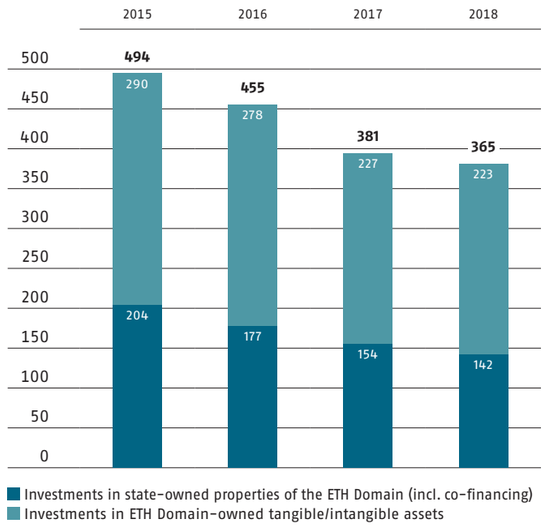
Credits taking into account the budgetary framework
The total of the two loans credited to the budgetary framework (budget 2018: total CHF 2,530.9m) remained at the level of the 2017 budget (CHF 2,530.8m). In addition to the credit reallocations in the budget process, which had a neutral effect on the budget, there was also another credit shift in 2018 (2018: CHF 24.2m) in favour of the total federal financial contribution. In addition, the ETH Domain is making use of the possibility of forming reserves at the federal parent enterprise. This concerns an application pursuant to Section 32a of the Federal Financial Budget Act (FBA) in the amount of CHF 40m in connection with a delayed construction project at ETH Zurich. The Federal Parliament will decide on the application in the 2019 summer session.

Federal and EU funding for applied research
In the current period, the Federal Government contributed a total of CHF 533m via its two sponsoring organisations SNSF and Innosuisse, as well as via federal government research and funding from the EU FP. Revenues stagnated at the high level and were slightly below the previous year's total of 2017 (2017: CHF 540m). The volume more or less equates to the value forecast for 2018 (2018 budget: CHF 531m). There have also been slight shifts in research contributions, but these are not very significant in absolute terms. The revenues of the two federal sponsoring organisations were slightly down on 2017. Additional income resulted from federal research funding and income from FPs. The proportion of these contributions made by the Federal Government towards research was unchanged at around 15% (2017: 15%).

Third-party funding
Total third-party funding amounted to CHF 466m (2017: CHF 462m). In addition to growth compared with 2017, expectations were also exceeded (2018 budget: CHF 421m). With the exception of other revenue, all categories of third-party funding showed an increase compared with the previous year.

The operating revenue from research contributions and from other operating revenue does not normally equate to the operating revenue in the statement of financial performance. However, the distinction between the two which should be made is not actually practicable. Consequently, identical values are shown in the transition from the financing statement to the statement of financial performance. In general, the development of the research contributions must be assessed taking into account the balance sheet and the federal funding (SNSF and Innosuisse funding bodies, special federal funding of applied research and EU FPs).

Fig. 32: Development of total investments (in CHF m)



Allocation of funds (expenses)
Expenses can be split into expenditure on human resources, on property, plant and equipment, and on investments. Human resources once again accounted for the largest proportion of the funds used (67%). Investments in property, plant and equipment accounted for 11%. The level of the other current operating expenses (around 22%) for infrastructure and for projects in teaching and research depends upon a number of factors (refer to the Financial Report at www.ethboard.ch/financialreport2018).

The total operating expenses in 2018 amounted to CHF 3,349m. The total is higher than the previous year's figure (2017: CHF 3,307m). However, the figure fell below the budget (2018: CHF 3,459m). Lower other expenditure and fewer investments were the main reasons for the deviation. Expenditure for personnel, on the other hand, is practically the same as that budgeted for 2018.

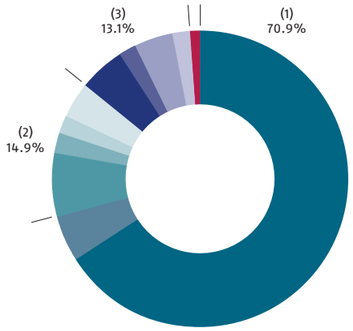
The pro rata distribution of the main components of expenditure remained relatively constant compared to the previous year.

CHF 2,232m was spent on human resources (2017: CHF 2,204m), which corresponds to a rise of 1.1% on 2017. 18,659.3 full-time equivalents (FTE; reporting date values) were financed. The largest share of this was accounted for by the total federal contribution (12,426.8 FTE), for which around CHF 1,600m was spent in 2018 according to the statistical survey. 4,160.8 FTE were financed through federal research contributions. A further sizeable portion of the workforce was once again funded through research collaborations with the private sector and donations / legacies (2,071.7 FTE). From these categories, which are grouped under the term third-party funding, a total of around CHF 630m was used for personnel expenses according to a statistical survey (see Fig. 24, Source of funds by function group; reporting date analysis, p. 94)

The employer's contributions in relation to salaries and wages in 2018 stood at 19.9% (2017: 20.0%). The calculations in the 2018 budget included an employer's contribution rate of a flat-rate of 20.2% in line with Federal Government practice (Federal Office of Personnel, FOPER).

The other current operating expenses (2018: CHF 753m) increased by around CHF 27m CHF (+4.4%) compared with the previous year, and its share of total expenses remained constant in 2018 at 22% (2017: 22%).

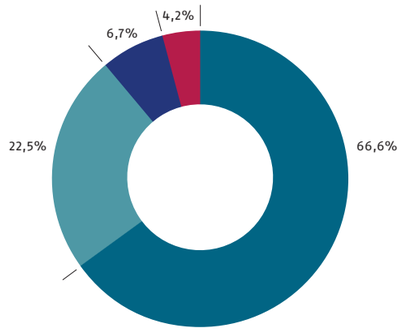
Investments
A distinction is made in investments between usage and ownership. All investments are shown under the total investments, irrespective of ownership and financing, i.e. they are the investments in the property used by the ETH Domain. Therefore, the investment in state-owned real estate, which is financed



Source of funds
Fig. 33*: Structure of revenues in %

Operating Income, 2018 Financial Statement: CHF 3,571m
(financing statement perspective)

(1) Total federal contribution (budgetary framework perspective)	**70.9%**
Federal financial contribution	66.0%
Investment credit for ETH Domain constructions	4.9%
(2) Indirect financial contributions from the Federal Government	**14.9%**
Swiss National Science Foundation (SNSF)	7.1%
Innosuisse	1.6%
Special federal funding of applied research	2.3%
EU Framework Programmes for Research and Innovation (FP)	4.0%
(3) Third-party funds	**13.1%**
Cooperation with the private sector	3.9%
Other third-party resources (universities, cantons etc.)	2.3%
Donations and bequests	4.3%
Other revenue	2.25%
Tuition fees and other utilisation fees	1.1%



Allocation of funds
Fig. 34**: Structure of expentiture in %

Operating expenses, 2018 Financial Statement: CHF 3,349m
(financing statement perspective)

Personnel	66.6%
Other expenditure	22.5%
Investments ETH Domain properties	6.7%
Investments state-owned properties	4.2%

* Fig. 33 shows the revenues from a financing perspective. They amount to CHF 3,571m and comprise the following: federal financial contribution; investment credit for constructions of the ETH Domain; donations and bequests; research contributions, mandates and scientific services; tuition fees and other utilisation fees; other revenues.

** Fig. 34 shows the expenditure from a financing perspective in terms of allocation of funds. It amounts to CHF 3,349m and comprises the following: personnel expenses; adjustment to the net pension expenditure in accordance with IPSAS 39; investments in state-owned properties; investments in tangible/intangible assets owned by the ETH Domain; materials expenses excl. accommodation expenditure; transfer expenses. Depreciation is also not part of the total after allocation of funds.

through credit A202.0134, Investment credit for ETH Domain construction work, is also shown.

The decrease by CHF 16m compared with the previous year (2018: CHF 365m; 2017: CHF 381m) primarily relates to building investments. The figure was well below the budgeted investments (2018 budget: CHF 438m). Delays in construction at ETH Zurich are the main reason for the lower investments. Investments accounted for almost 11% of total expenditure in 2018 (2017: 12%). This corresponds to the long-term average and also to the comparison with the central federal administration (12–15%). As in the previous year, the largest investments relate to the PSI (Gantry 3, ATHOS, SwissFEL).

In the same way as the source of funds, there were no significant changes in the allocation of funds compared with 2017.

Transition from the financing statement to the statement of financial performance

Unlike the financing view where total federal contribution and other sources of funding are allocated to the period in which the funds are received, the revenue and expenses in the statement of financial performance are posted to the period to which they belong in business management terms. This view is in line with accrual accounting. Therefore, the total federal contribution in the statement of financial performance comprises the credits A231.0181, the federal financial contribution to the ETH Domain, and A231.0182, the federal contribution to accommodation in the ETH Domain, and does not comprise A231.0181, the federal financial contribution to the ETH Domain, and A202.0134, investments in ETH Domain construction work, as per the financing statement.

Due to system constraints, the difference between the financing statement and the statement of financial performance cannot be calculated and depicted for the research contributions. Analogous figures are, therefore, shown. The most important differences between expenses and expenditure (net pension costs according to IPSAS 39, accommodation, write-offs) are disclosed individually in the transition.

Another aspect of the transition concerns the effect of the sub-consolidations in the ETH Domain, which is not taken into account in the statement of financial performance. The effects of in-kind contributions are marginal and are only taken into account from an accrual perspective.

Fig. 35: Transition from the financing statement to the statement of financial performance

CHF millions	Financing statement 2018	Transition Decrease (–)	Transition Increase (+)	Transition Consolidation (+/–)	Income statement 2018
EXPENSES (ALLOCATION OF FUNDS)/ OPERATING EXPENSES					
Income (source of funds)/Operating revenue	**3,571**	**–174**	**269**	**49**	**3,714**
Total federal contribution	**2,531**	**–174**	**269**	**–**	**2,625**
Federal financial contribution	2,357				2,357
Investments in constructions of the ETH Domain	174	–174			–
Federal contribution to accommodation	–		269		269
Special federal funding of applied research	533				533
Project-oriented third-party funding/various income	507			49	556
Expenses (allocation of funds)/Operating expenses	**3,349**	**–144**	**615**	**41**	**3,631**
Personnel expenses	2,232	–10	90	21	2,333
Other operating expenses/accommodation ETH Domain	–		269		269
Depreciation	–		256	9	266
Other ongoing operating and transfer expenses	753			11	764
Investments	**365**	**–134**	**–**	**–**	**231**
Government-owned properties ETH Domain	134	–134			–
Co-financing government-owned properties ETH Domain	7				7
Immovable property, plant and equipment (ETH Domain-owned)	40				40
Movable non-current assets (ETH Domain-owned)	180				180
Intangible non-current assets (ETH Domain-owned)	4				4

Financing statement view – revenue/expenditure and statement of financial performance view – expense/income

Consolidated financial statements

Table 1: Statement of financial performance of the ETH Domain (consolidated)

CHF millions	Notes	Budget 2018	Actual 2018	Actual 2017	Change to Actual absolute
Federal financial contribution		2,357	2,357	2,378	–21
Federal contribution to accommodation		269	269	278	–10
Total federal contribution	7	**2,625**	**2,625**	**2,656**	**–31**
Tuition fees and other utilisation fees	8	**37**	**41**	**39**	**2**
Swiss National Science Foundation (SNSF)		252	255	260	–6
Swiss Innovation Agency (Innosuisse)*		60	56	63	–7
Special federal funding of applied research		75	81	78	3
EU Framework Programmes for Research and Innovation (FP)		144	142	139	3
Industry-oriented research (private sector)		129	139	129	9
Other project-oriented third-party funding (incl. cantons, municipalities, international organisations)		71	84	74	10
Research contributions, mandates and scientific services	9	**732**	**755**	**743**	**12**
Donations and bequests	10	**76**	**155**	**120**	**35**
Other revenue	11	**114**	**138**	**140**	**–2**
Operating revenue		**3,585**	**3,714**	**3,698**	**16**
Personnel expenses	12, 28	2,306	2,333	2,303	30
Other operating expenses	13	979	990	958	32
Depreciation	21, 23	215	266	212	53
Transfer expenses	14	179	43	42	1
Operating expenses		**3,679**	**3,631**	**3,515**	**116**
OPERATING RESULT		**–94**	**83**	**182**	**–100**
NET FINANCE INCOME/EXPENSE	15	**7**	**–22**	**13**	**–35**
Share of surplus/deficit of associated entities and joint ventures	20	–	–11	14	–24
SURPLUS (+) OR DEFICIT (–)		**–87**	**50**	**209**	**–159**

* Innosuisse, the Swiss Innovation Agency, took over the role of the Commission for Technology and Innovation (CTI) on 1 January 2018.

Table 2: Balance sheet of the ETH Domain (consolidated)

CHF millions	Notes	31.12.2018	31.12.2017	Change absolute
CURRENT ASSETS				
Cash and cash equivalents	16	852	733	118
Current receivables from non-exchange transactions	17	558	555	3
Current receivables from exchange transactions	17	36	38	–2
Current financial assets and loans	22	1,409	1,389	20
Inventories	18	10	10	–1
Prepaid expenses and accrued income	19	48	45	3
Total current assets		**2,913**	**2,771**	**141**
NON-CURRENT ASSETS				
Property, plant and equipment	21	2,023	1,863	161
Intangible assets	21	67	68	–1
Non-current receivables from non-exchange transactions	17	970	838	132
Non-current receivables from exchange transactions	17	–	–	–
Investments in associated entities and joint ventures	20	135	147	–12
Non-current financial assets and loans	22	32	26	6
Co-financing	23	128	125	3
Total non-current assets		**3,354**	**3,066**	**288**
TOTAL ASSETS		**6,267**	**5,837**	**429**
LIABILITIES				
Current liabilities	24	179	172	7
Current financial liabilities	25	16	16	1
Accrued expenses and deferred income	26	142	134	7
Short-term provisions	27	109	103	6
Short-term liabilities		**446**	**425**	**21**
Dedicated third-party funds	29	1,510	1,428	83
Non-current financial liabilities	25	361	374	–12
Net defined benefit liabilities	28	2,239	1,894	344
Long-term provisions	27	705	505	199
Long-term liabilities		**4,815**	**4,201**	**614**
Total liabilities		**5,261**	**4,626**	**635**
EQUITY				
Valuation reserves		–1,364	–1,109	–255
Dedicated reserves		1,123	949	174
Free reserves		967	965	2
Co-financing	23	128	125	3
Reserves from associated entities	20	135	147	–12
Accumulated surplus (+)/deficit (–)		17	135	–118
Total equity		**1,006**	**1,212**	**–206**
TOTAL LIABILITIES AND EQUITY		**6,267**	**5,837**	**429**

Publication data

Publisher: ETH Board, Häldeliweg 15, CH–8092 Zurich
kommunikation@ethrat.ch
Project lead and editorial office: ETH Board Communication, Zurich
Design and layout: Hej GmbH, Zurich
Reports: Roland Fischer, Bern
and institutions of the ETH Domain
Photography: Basil Stücheli, Aeugstertal
or as per image credits
Translation and proofreading: comtexto AG, Zurich
Publishing system: ns.publish, mms solutions AG, Zurich
Printing: Kromer Print AG, Lenzburg
Press date: 21 March 2019

The Annual Report is published in German, French and English. The German version of the annual financial statements shall be binding. The Annual Report is available electronically at www.ethboard.ch/annualreport2018.

Special thanks are due to the following people for their contributions and involvement:
- all scientists in the ETH Domain's institutions in the preparation of the reports,
- the members of the ISP Group of the ETH Domain (Implementation of Strategic Planning),
- the members of the ETH Domain ComTeam (Heads of Communication and their staff),
- and the departmental heads and employees of the ETH Board staff and of the institutions of the ETH Domain.

© ETH Board, March 2019

MIX
Paper from responsible sources
FSC® C008110

Cover page
EPFL Professor Tom Battin, research director of the NOMIS project, will investigate around 200 glacial streams worldwide over the next few years in order to better understand microbial life in disappearing ecosystems.

ETH Board
Board of the Swiss Federal Institutes
of Technology

Zürich:
Häldeliweg 15
8092 Zurich

Bern:
Hirschengraben 3
3011 Bern

www.ethboard.ch